National Organic Program (NOP)
National Organic Standards Board (NOSB)

Materials Petition for the National List

Fatty Alcohols

Green Ag Supply, LLC

Petitioner:

Green Ag Supply, LLC
PO Box 386
Cary, NC 27512

Submitter/consultant:

T. B. Harding, Jr., LVOG Inc.
125 W. 7th Street
Wind Gap, PA 18091

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COVER
LETTER

Lehigh Valley Organic Growers, Inc.

125 West Seventh Street
Wind Gap, Pennsylvania 18091 USA

A Company of LVOG Inc.

Telephone: 610 863-6700
Facsimile: 610 863-4622
Email : agrisys1@aoil.com

October 19, 2015

Dear Dr. Brines:

The purpose of this correspondence is to respond to your September 25, 2015 letter that addresses your comments pertaining to the petition filed on June 24, 2015 which requested the inclusion of natural fatty alcohols in Section 205.601 of the National Organic Program's (NOP) National List of Allowed and Prohibited Substances (National List).

We are modifying the previous petition and resubmitting petition which includes the following actions / modifications:

Item A – Section of the National List:

We agree that since the fatty alcohol blend (natural fatty alcohol – Mascol 80) is registered by EPA as a growth regulator and that it will be considered by the National Organic Standards Board under section 205.601 (k)(2) rather than 205.601 (a).

Item B- 1 The Substance's Chemical or Material Common Name:

Clarification on the names of Alcohol in the petition:
The terms C_{8-10} fatty alcohol (Mascol 80), fatty alcohol blend, Octyl – Decyl alcohol blend, aliphatic alcohol (see Item B-1 page 1) refer to a blend of C_8 and C_{10} alcohol (42.6% / 56.7%) and has the EPA Reg. No. 63896-1 and is the product being focused on in this petition.

With respect to your point "The petition should also clearly indicated why a single petition is needed for the fatty alcohols mixture (ie blend of octanol and decanol) instead of separate petitions for octanol and decanol as individual active ingredients," the blend of C_8C_{10} fatty alcohol is the product that is specifically manufactured for use in the end products, (eg N-TAC, O-TAC PLANT CONTACT AGENT). The only other registered uses for individual fatty alcohols is for C_{10} (decanol) – EPA Reg. No. 63896-2 and is not included in this petition. There is no EPA registered use for C_8 (octanol) fatty alcohol. The raw material for this alcohol is derived primarily from Palm Kernel Oil and Palm Oil, not synthetic alcohol.

Item B – 6 Previous Reviews:
We have added the following summary of the information provided in Tab 2 of the petition:

The information provided in Tab 2 (Industry Experts OMRI Reviews & Industry Certifications) concerns the debate on whether the naturally derived fatty alcohol (Mascol 80) from the natural sources of palm oil, coconut oil, etc. are considered natural alcohols. Apparently OMRI's classification would depend on the review the specific ingredients and manufacturing processes to be sure about the classification as a synthetic or natural alcohol. We believe that an alcohol derived from natural plant sources should be classified as a natural alcohol as does Franco X. Milani, Assistant Professor, Extension Food Manufacturing Specialist, University of Wisconsin and Dr. James K. Whitesell, Professor of Organic and Materials Chemistry, University of California, San Diego.

Additional information provided in this section of the petition included:

- GMO Free Statement Letter for Mascol 80

- Various certifications
  a. Certified Kosher
  b. Compliance with RSPO (Roundtable on Sustainable Palm Oil) Supply Chain Certification Systems
  c. Certified as to meeting the requirements of GMP Codex Alimentarius – Recommended International Code of Practice General Principles of Food Hygiene
  d. Certification of the Mascol 80 supplier, P.T. Musim Mas has met the requirements of ISO 14001: 2004, ISO 9001: 2008 and OHSAS 189001: 2007 for the manufacture of Oleochemicals.

Item B - 7 Information Regarding EPA Registrations:
Item B – 8 Product Labels:

You are correct in noting that the products O-TAC PLANT CONTACT AGENT and N-TAC are labeled only for use on tobacco. Petitions for the other uses are pending with EPA and are not currently permitted by EPA; therefore, we have amended the petition to remove the following uses

- Sucker control on tomatoes
- Meristematic regrowth on vegetable grafts
- Desiccant/defoliant on cotton

As an addendum, we have included copies of the submission correspondence and subsequent EPA actions and communications on these pending uses (see tab 9)

Therefore, we are resubmitting our petition that has been revised per the following- note the changes are in blue:

1. Page 1 Item A
   NOP Reference changed to 205.601 (k)(2) and Requested annotation changed to "For use **as a sucker control on organic crops."**

2. Page 1 Item B – 1 addition of the following statement:
   Rather than filing separate petitions for octanol (C_8) and decanol (C_{10}) this single petition focuses on the blend of C_8C_{10} fatty alcohol (EPA Reg. No. 63896-1) since it is the product that is specifically manufactured for use in the end products N-TAC and O-TAC PLANT CONTACT AGENT. The only other registered uses for individual fatty alcohols is the C_{10} (decanol) – EPA Reg. No. 63896-2 and it is not included in this petition. There is no EPA registered use for C_8 (octanol) fatty alcohol.

3. Page 2 Item B – 3
   Intended Use: **As a sucker control on organic crops** (the other proposed uses have been deleted)

4. Page 2 Item B – 4
   List of Activities for which the substance will be used:
   4 A - **delete on tobacco and tomatoes: Change to: Sucker Control on organic crops:**
   4 B and 4 C have been deleted.

5. Page 3 Item B – 6
   Previous reviews
   The information provided in Tab 2 (Industry Experts OMRI Reviews & Industry Certifications) concerns the debate on whether the naturally derived fatty alcohol (Mascol 80) from the natural sources of palm oil, coconut oil, etc. are considered natural alcohols. Apparently OMRI's classification would depend on the review the specific ingredients and manufacturing processes to be sure about the classification as a synthetic or natural alcohol. We believe that an alcohol derived from natural plant sources should be classified as a natural alcohol as does Franco X. Milani, Assistant Professor, Extension Food Manufacturing Specialist, University of Wisconsin and Dr. James K. Whitesell, Professor of Organic and Materials Chemistry, University of California, San Diego.

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  d. Certification of the Mascol 80 supplier, P.T. Musim Mas has met the requirements of ISO 14001: 2004, ISO 9001: 2008 and OHSAS 189001: 2007 for the manufacture of Oleochemicals.

6. Page 4 Item B – 7
   Information regarding EPA, FDA and State regulatory Authority Registrations: We have added the following

Active substance	EPA Reg. No.
C_8C_{10} fatty alcohol blend	63896-1

7. Tab 1
   List of Activities for which the substance will be used:
   1 A - **delete on tobacco and tomatoes: Change to: Sucker Control on organic crops:**
   1 B and 1 C have been deleted.

8. **Tab 3**
   Removed all the information on rootstock and cotton after the NC Department of Agriculture registration of product and license renewal. Move to TAB 9.

9. Tab 7
   Under Petition Justification Statement:
   We have deleted; "Crop sucker control and Plant Desiccant/Defoliant Use" and replaced it with **Sucker Control on organic crops".**
   In the last paragraph on this page we have replaced the words "various production crops" to **organic crops**. On the second page "Meristematic Regrowth Control Use:" has been deleted.

10. Tab 9
    Information (EPA Communications) pertaining to pending petitions / actions for uses other than tobacco

We trust that the information provided here answers the questions that you raised and that the updated; revised petition will progress smoothly towards approval.

Please do not hesitate in contacting me regarding any comments or questions.

Sincerely,

Thomas Harding

Thomas B. Harding, Jr.
President & CEO
Organic Program Consultant
Lehigh Valley Organic Growers, Inc.
(LVOG, Inc.)

PETITION

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ITEM A

National List Category Being Petitioned

Category: Synthetic Substance Allowed for Use in Organic Crop Production

NOP Reference: 205.601(k) (2) – Synthetic Substance Allowed for use in Organic Crop Production.

NOP Section: 205.601 (k) (2) – As a Plant Growth Regulator

Requested Annotation: As a sucker control on organic crops

ITEM B

1. **Product's common Name: C_8-C_{10} Fatty Alcohol (MASCOL 80)**

   Substances Common Name: Octyl- Decyl Alcohol Blend **CAS # 68603-15-6**
   EINES # 271-642-9

   IUPAC Name: 1-octanol **CAS# 111-87-5** **EINECES/ELINCS# 203-912-6**
   FEMA# 2800

   1-decanol **CAS# 112-30-1** **EINECS/ELINCS# 203-956-9**
   FEMA# 2365

   Other Names: Fatty Alcohol Blend **EINECES # 687-889**
   Aliphatic Alcohol

Rather than filing separate petitions for octanol (C_8) and decanol (C_{10}) this single petition focuses on the blend of C_8C_{10} fatty alcohol (EPA Reg. No. 63896-1) since it is the product that is specifically manufactured for use in the end products N-TAC and O-TAC PLANT CONTACT AGENT. The raw material for this alcohol is derived primarily from Palm Kernel Oil and Palm Oil, not synthetic alcohol. The only other registered uses for individual fatty alcohols is the C_{10} (decanol) – EPA Reg. No. 63896-2 and it is not included in this petition. There is no EPA registered use for C_8 (octanol) fatty alcohol.

2. **Manufacturer's Name, Address and Telephone Number:**

   ICOF America, Inc.
   5420 North Bend Road
   Suite 202
   Cincinnati, OH 45247
   513-741-6813

3. **Intended use:**
Sucker control on organic crops

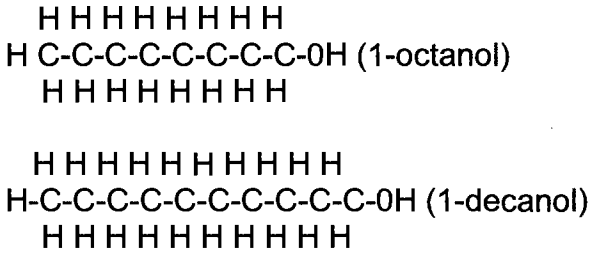
4. **List of Activities for which the substance will be Used:**

a. Sucker control on organic crops: 4-6% solution of the formulated product applied directed broadcast over the top of tobacco plants in the early button to early flower stage of growth when suckers, axillary buds are succulent tender, utilizing 50 gallons of spray solution per acre.

Mode of Action:

Upon contacting the axillary buds/suckers at the leaf axils, the solution containing the active substance quickly dissolves the thin undeveloped cuticle or waxy area and results in desiccation of the axillary bud/ sucker by rupturing cell walls and rapidly evaporating liquids.

Chemical Structure:



5. Source of the substance and description of manufacturing procedure:

The alcohols derived from natural sources are generally isolated from any of a variety of natural occurring fats, oils and waxes of either animal or vegetable origin. The most commonly used sources are coconut oil, palm kernel oil, palm oil, lard and tallow. The alcohols are prepared by a transesterification of the fatty acids in the triglycerides found in natural oils and fats followed by a catalytic hydrogenolysis of the resulting esters. Purification and fraction of the resulting alcohols is similar to the synthetically produced materials.

6. Previous reviews:

The information provided in Tab 2 (Industry Experts OMRI Reviews & Industry Certifications) concerns the debate on whether the naturally derived fatty alcohol (Mascol 80) from the natural sources of palm oil, coconut oil, etc. are considered natural alcohols. Apparently OMRI's classification would depend on the review the specific ingredients and manufacturing processes to be sure about the classification as a synthetic or natural alcohol. We believe that an alcohol derived from natural plant sources should be classified as a natural alcohol as does Franco X. Milani, Assistant Professor, Extension Food Manufacturing Specialist, University of Wisconsin and Dr. James K. Whitesell, Professor of Organic and Materials Chemistry, University of California, San Diego.

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  d. Certification of the Mascol 80 supplier, P.T. Musim Mas has met the requirements of ISO 14001: 2004, ISO 9001: 2008 and OHSAS 189001: 2007 for the manufacture of Oleochemicals.

7. **Information regarding EPA, FDA and State regulatory Authority registrations, including registration numbers:**

EPA & State Registration Numbers:

End Use Product	**EPA Reg. No.**	**States Registered**
O-TAC PLANT CONTACT AGENT	51873-18	NC, OH, SC, TN, VA, GA, KY, CA
N-TAC (As a Plant contact Agent)	51873-20	NC

Active Substance	**EPA Reg. No.**
C_8C_{10} Fatty Alcohol Blend	63896-1

Reference Tabs 3, 4, 5 & 6

FDA Information:

Documentation that the Active Substance (fatty alcohol blend) and inert ingredients (polysorbate 80) used in the formulated products, Fair 85, N-TAC and O-TAC PLANT CONTACT AGENT, are approved as food additives by the U.S. Food and Drug Administration.

References (fatty alcohol):
Code of Federal Registrations, Title 21, Volume 3; Revised as of April 1, 2011; 21CFR172. 864, 6pp.

References (polysorbate 80):
Code of Federal Regulations, Title 21, Volume 3; Revised as of April 1, 2011; 21CFR172.840, 4pp.

8. **Chemical Abstract Service (CAS) Number or other Product Numbers:**

CAS Number:

1-octanol:	111-87-5
1-decanol:	112-30-1
Octyl – decyl alcohol:	68603-15-6

US EPA Pesticide Chemical Numbers

1-octanol:	079037
1-decanol:	079038
Fatty alcohol blend:	079029

Product Labels:
See Attached
O-TAC PLANT CONTACT AGENT
N-TAC (Use as Plant Contact Agent)

Reference Tabs 3 & 4

9. A. Substances physical properties and chemical mode of action:

PHYSICAL AND CHEMICAL PROPERTIES OF THE ACTIVE SUBSTANCE (FATTY ALCOHOL BLEND)

Test or Study & Data point	Guideline and method	Test material purity and specification	Findings	Comments	GLP	Reference
II A 2.1.1 Melting point	830.7200 (63-5)	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	Product is a liquid at room temperature		Y N	MRID 43127902 MRID 94313001 SASOL MSDS
II A 2.1.2 Boiling point	830-7200 (63-6)	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	209.9°C at 763.3 mm/Hg		Y	MRID 4312790. SASOL MSDS
II A 2.2 Density	830.7300 (63-7)	0.4% hexanol 45.1% octanol 54.5% decanol	6.93 lbs/gal at 15.5°C 0.831 g/ml at 16°C		N	MRID 94313001 SASOL MSDS
II A 2.3 Vapor pressure	830.7950 (63-9)	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	0.0423 torr; (68.4 mm Hg @ 52°C)		Y	MRID 43127903 SASOL MSDS

PHYSICAL AND CHEMICAL PROPERTIES OF THE ACTIVE SUBSTANCE (FATTY ALCOHOL BLEND)

Test or Study & Data point	Guideline and method	Test material purity and specification	Findings	Comments	GLP	Reference
II A 2.4.1 Physical State	830.6302 (63-2)	0.4% hexanol 45.1% octanol 54.5% decanol	Only colorless liquid		N	MRID 94313001 SASOL MSDS
II A 2.4.1 Color	830.6303 (63-3)	0.4% hexanol 45.1% octanol 54.5% decanol	Colorless liquid		N	MRID 94313001 SASOL MSDS
II A 2.4.2 Odor	830.6304 (63-4)	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	Musty		Y	MRID 43127903 SASOL MSDS
		0.4% hexanol 45.1% octanol 54.5% decanol	Slightly Aromatic		N	MRID 94313001
II A 2.5.1 UV Spectra	830.7050	Alfol 810 Lot 1169975	The product in basic methanol shows an absorbance maximum at 204 nm		Y	MRID 47589901
II A 2.6 Solubility in water	830.7840	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	0.0035 g/ml @ 25°C		Y	MRID 43127903 SASOL MSDS

PHYSICAL AND CHEMICAL PROPERTIES OF THE ACTIVE SUBSTANCE (FATTY ALCOHOL BLEND)

Test or Study & Data point	Guideline and method	Test material purity and specification	Findings	Comments	GLP	Reference
II A 2.7 Solubility in organic solvents	830.1000 (63-8)		No Data			
II A 2.8.1 n-octanol/water partition coefficient	830.7550 (63-11)	Alfol 810		Waiver requested to EPA		MRID 48100901
II A 2.9 Stability to sunlight	830.6313 (63-13)	Alfol 810		Waiver requested to EPA		MRID 48100901
II A 2.11 Flammability	830.6315 (63-15)	Alfol 810 Lot 1169975	Fire point at 105.9°C			MRID 47589901 SASOL MSDS
II A 2.13 Explodability	830.6316 (63-16)	Alfol 810 Lot 1169975		This product is not potentially explosive. Contains no nitrogen groups or explosive functional groups.	Y	MRID 47589901
II A 2.15 oxidation	830.6314 (63-14)	Alfol 810 Lot 1169975	No signs of reaction to these exposure systems: -Powdered iron -Potassium permanganate - Water -Mono-ammonium phosphate	Product contains no oxidizing or reducing agents.	Y	MRID 47589901

PHYSICAL AND CHEMICAL PROPERTIES OF THE ACTIVE SUBSTANCE (FATTY ALCOHOL BLEND)

Test or Study & Data point	Guideline and method	Test material purity and specification	Findings	Comments	GLP	Reference
II A 2.16 pH	830.7000 (63-12)	Technical Grade Fatty Alcohol (0.3% hexanol; 42.7% octanol; 56.7% decanol; 0.3% dodecanol)	pH = 6.17		Y	MRID 43127903
II A 2.17.1 Storage Stability	830.6317 (63-17)	Technical Grade Fatty Alcohols Lot No. 1169975 Alfol 810	No changes were noted for the test substance after 3,6,9 and 12 months of storage at Room Temperature (23°C)		Y	MRID 47589901
II A 2.17.2 Storage Stability (Temperature, metals)	830.6313 (63-13)	98.83% Fatty Alcohol Blend Lot ONT-0324	Fatty Alcohols remain stable for 14 days at room temperature and 54+/-2°C alone and when exposed to stainless steel, alumimum, alumimum acetate and iron. A decrease in the assay when the test substance was exposed to iron acetate at both room and elevated temperatures.		Y	MRID 48100901 MRID 47972901

PHYSICAL AND CHEMICAL PROPERTIES OF THE ACTIVE SUBSTANCE

(FATTY ALCOHOL BLEND)

Test or Study & Data point	Guideline and method	Test material purity and specification	Findings	Comments	GLP	Reference
II A 2 Corrosion Characteristics	830.6320 (63-20)	Technical Grade Fatty Alcohols Lot No. 1169975 Alfol 810	After 12 months at Room Temperature, no chemical or physical effects were noted on the commercial packaging material, HDPE		Y	MRID 47589901 MRID 47972901
II A 2 Viscosity	830.7100	Alfol 810 Lot 1169975	13.5 $mm^2/5$ at 22°C		Y	MRID 47589901
II A 2 Miscibility	830.6319 (63-19)		The product is not an emulsifiable concentrate and is not to be diluted with petroleum products			Fatty Alcohol Task Force Citations 6/4/08
II A 2 Dielectric Breakdown Voltage	830.6321 (63-21)		This product is not labeled to be used around electrical equipment			Fatty Alcohol Task Force Citations 6/4/08

REFERENCES
IDENTITY OF THE ACTIVE SUBSTANCE:

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Jacobson, S.	830.7200	1994	Determination of the Chemical Characteristics of a Fatty Alcohol Blend: Product Chemistry: Lab Project Number: FATF-9303C. Unpublished study prepared by Compliance Services International. 125 p.	Y	Fatty Alcohol Task Force	43127903
Jacobson, S.	830.7200	1994	Determination of the Chemical Characteristics of a Fatty Alcohol Blend: Product Chemistry: Lab Project Number: FATF-9303C. Unpublished study prepared by Compliance Services International. 125 p.	Y	Fatty Alcohol Task Force	43127903
Jacobson, S.	830.7200	1994	Determination of the Chemical Characteristics of a Fatty Alcohol Blend: Product Chemistry: Lab Project Number FATF-9301. Unpublished study prepared by Compliance Services International. 34p.	Y	Fatty Alcohol Task Force	43127901
Jacobson, S.	830.7200	1994	Determination of the Chemical Characteristics of a Fatty Alcohol Blend: Product Chemistry: Lab Project Number FATF-9302. Unpublished study prepared by Compliance Services International. 126p.	Y	Fatty Alcohol Task Force	43127902
Jacobson, S	830.7300	1990	Fatty Alcohol Task Force Phase 3 Summary of MRID: 00056022 and Related MRIDs 00056023, 00056025, 00056026, 00056027, 00056028, 00056029, 00056030. Product Chemistry: Fatty Alcohols. 20p.	Y	Fatty Alcohol Task Force	94313001
Sinning, D. J.	830.6317 830.6313	2/2010	Physical and Chemical Characteristic of Technical Grade Fatty alcohols: Storage Stability and Corrosion Characteristics. Study Number 4080-02; Case Consulting Laboratories, Inc. 2/3/2010, 23 p.	Y	Fatty Alcohol Task Force	To be assigned by EPA

a. **Chemical interactions with other substances, especially substances usual in organic production:**

None known

b. **Toxicity and environmental persistence's:**

FATE AND BEHAVIOR IN THE ENVIRONMENT:

There are no available studies on the environmental fate of the fatty alcohol blend/ aliphatic alcohols. It is important to remember that active substance, fatty alcohol blend, is classified and approved as food additives by the US food and Drug Administration. The following has been reproduced from EPA's document "Registrations Eligibility Decision for Aliphatic Alcohols, Case No. 4-004, March 2007, EPA 738-R-07-004.

1. Environmental Fate and Transport

Because environmental fate data are not available, physical and chemical properties for the aliphatic alcohols were estimated by Quantitative Structure-Activity Relationships (QSAR) using EPISuite v 3.21 (Estimation Programs Interface for Windows (EPIWIN)). The estimated properties of 1-octanol, 1-decanol and 1-dodecanol differ somewhat, due to the different lengths (i.e. number of carbons) in their straight, saturated carbon chains. As suggested by their common names, 1-octanol has 8 carbons in its chain, 1-decanol has 10 carbons, and 1 –dodecanol has 12 carbons.

In spite of these small differences, the expected behavior of these aliphatic alcohols in the environment is generally similar. The major route of dissipation in the field for these chemicals is likely to be volatilization. The volatility half-lives for 1-octanol and 1-decanol were estimated using the Dow Method described in the *Handbook of Chemical Property Estimation Methods* by Lyman, Reehl and Rosenblatt. The half-lives for volatility from soil for 1-octanol and 1-decanol were estimated to be 3.5 minutes and 1 minute, respectively. 1-dodecanol would likely volatilize even more quickly, but the half-life was not estimated, since volatility from pheromone traps is the known route of dissipation.

There is some uncertainty about the rate of volatility of 1-octanol and 1-decanol from plant surfaces, since aliphatic alcohols are hydrophobic and, therefore, have affinity for the waxy surfaces of plants. However, these volatility half-lives suggest that the aliphatic alcohols will not be available long to expose non-target terrestrial animals, nor to be transported to surface water bodies in runoff. Residues of 1-dodecanol are not expected on plants or in soil, since they are dispersed in the air from pheromone traps, and then degraded by photolysis. The ecological risk assessment concluded that except for terrestrial insects, which are the target for the pheromone use of 1-dodecanol, "environmental exposures resulting from this use are likely negligible." The risk assessment for this use was therefore qualitative.

Additional estimation of environmental fate parameters obtained from EPISuite provides a basic set of data to perform a screening-level environmental risk assessment. The model indicates that aliphatic alcohols have a moderate tendency to bind to soils. The portion of applied chemical that binds to the soil, rather than volatilizing, will be subject to biodegradation, with estimated half-lives for1-octanol and 1-decanol of 2.3 days. The portion of applied chemical that does volatilize is estimated to degrade in the air by reaction with hydroxyl radicals with half-lives of about 10 hours.

As mentioned above, dissipation via volatilization will greatly reduce the amount of aliphatic alcohols reaching surface-water bodies, and aliphatic alcohols will volatilize from water as well as soil. However, the fraction that does reach surface water will not be degraded by hydrolysis. These alcohols have the potential to bioaccumulate in fish, but the rates of uptake, metabolism, and depuration, as well as the nature of metabolites, are not known. However, the magnitude of the bioconcentration factors (BCF) suggests a low potential to bioconcentrate.

EPISuite does not provide information on the rates of formation/decline of product, the nature and relative amounts of transformation products, and their distribution in soil/sediment-water- air. Therefore, the specific nature and persistence of potential biotransformation products (primary biodegradation) are not known. However, the ultimate biotransformation products of the aliphatic alcohols are water and carbon dioxide.

2. Ecological Risk Assessment

The Agency uses a pesticide's use profile, exposure data, and toxicity information to determine risk estimates to non-target terrestrial and aquatic organisms. Estimated environmental concentrations (BECs) are used to calculate risk quotients (RQs). EECs are based on the maximum application rate(s) which would potentially yield the greatest exposure. An RQ is derived by dividing the EEC by a single estimate of toxicity. The Agency then compares an RQ to its Level of Concern (LOC) to determine if exposure to the aliphatic alcohols could potentially pose a risk to non-target organisms (RQs that exceed the LOC indicate potential risk).Table 5 outlines LOCs, and the Agency's corresponding risk presumptions.

Table 5 -Agency level of Concerns and Risk Presumptions

Risk Presumption	LOC Terrestrial Animals	LOC Aquatic Animals	LOC Plants
Acute Risk – there is a potential for acute risk	0.5	0.5	1
Acute Endangered Species – endangered species may be adversely affected	0.1	0.05	1
Chronic Risk – there is potential for chronic risk.	1	1	N/A

a. Exposure to Aquatic Organisms

The Agency ran a number of exposure modeling simulations to derive expected environmental concentrations of aliphatic alcohols in surface water. The Agency first ran the Tier I GENEEC model, which resulted in exceedences of the endangered species level of concern (LOC) for freshwater fish and estuarine/marine invertebrates for some application scenarios. However, these simulations did not consider the volatilization of aliphatic alcohols from soil, and each thereby overestimated potential exposure.

Although GENEEC is not designed to consider volatility from soil directly, the Agency used an indirect method to consider volatility with the GENEEC model and to refine the aquatic exposure assessment. As described above, the volatility half-lives for the aliphatic alcohols were estimated using the Dow Method described in the *Handbook of Chemical Property Estimation Methods* (Lyman, et al., 1982). The half-lives for volatility from soil for 1-octanol and 1-decanol were estimated to be 3.5 minutes and 1 minute, respectively. Such short volatility half-lives mean that little pesticide will remain by the time a runoff event occurred, unless rainfall began immediately after application.

To simulate this scenario using GENEEC, the Agency determined the amount of 1-octanol or 1-decanol that would remain in the field 3 to 4 minutes after application at the maximum rates allowed on the label. GENEEC was then run in the standard fashion, but with this "effective application rate." Even though this was done using estimated volatility half-lives on the order of a couple of minutes, the resulting EECs are still considered upper-bound.

GENEEC does not simulate a rainfall event until two days after application; if rainfall does not occur until two days after actual application of 1-octanol or 1-decanol, there could be very little product remaining to be subject to transport in runoff. For this reason, the simulations considered only a single application, although aliphatic alcohols can be used more than once within a single growing season.

b. Toxicity to Aquatic Organisms

Registrant-submitted data and open literature studies suggest that the aliphatic alcohols are "slightly" to "moderately" toxic to freshwater fish. Although the data base is not complete for all compounds in the aliphatic alcohol registration case, there are adequate data to assess the acute risk to freshwater fish. Although there are no registrant-submitted acute toxicity data available for estuarine/marine fish, data from the open literature provided the information to assess the acute risks of aliphatic alcohols to these organisms. The relevant study from the open literature indicates that 1-octanol is "slightly" toxic and 1 -decanol is "moderately" toxic to estuarine/marine fish.

No chronic toxicity guideline studies exist for any of the aliphatic alcohols. However, chronic data for freshwater fish from the open literature on 1-octanol provide an endpoint which the Agency used to calculate RQs. Chronic toxicity data for aquatic invertebrates on the aliphatic alcohols were also drawn from the open literature. The Agency used a chronic no observed adverse effect concentration (NOAEC) of I mg/L for reproductive effects for 1-octanol. The Agency notes that chronic toxicity data on 1-decanol for aquatic invertebrates would reduce the uncertainty posed by the lack of these data. A summary of all toxicity endpoints is presented below in Table 6.

Table 6 - Toxicity Reference Values Used to Calculate RQs for Aliphatic Alcohols

Taxonomic Group	Assessment Endpoint	1-Octanol	1-Decanol
		Species/ Toxicity Endpoint	Species/Toxicity Endpoint
Freshwater Fish	Survival	Fathead Minnow Acute LC_{50}=12.2 mg/L	Fathead minnow Acute LC_{50}=2.3 mg/L
	Reproduction, Growth	Fathead minnow NOAEC=0.75 mg/L	No data available
Freshwater Invertebrates	Survival	Water flea Acute LC_{50}=4.16 mg/L	Water flea Acute LC_{50}=6.5 mg/L
	Reproduction, Growth	Water flea Chronic NOAEC=1 mg/L	No data available
Estuarine/marine fish	Survival	Bleak Acute LC_{50}=15 mg/L	Bleak Acute LC_{50}=7.2 mg/L
	Reproduction, Growth	No data available	No data available
Estuarine/marine Invertebrates	Survival	Harpacticoid copepod LC_{50}=58 mg/L	Harpacticoid copepod LC_{50}=4 mg/L
	Reproduction, Growth	No data available	No data available
Aquatic Plants	Survival, Growth	*Scenedesmus subspicatus* EC_{50}-6.5 mg/L; EC_{10}-2.8 mg/L	No data available

LC_{50} - Median Lethal Concentration, statistically derived single concentration that can be expected to cause death In 50% of the test animals; EC_{50} - Median Effect Concentration, statistically derived single concentration that can be expected to cause an adverse effect in 50% of the test animals or plants; EC_{10} - statistically derived single concentration that can be expected to cause an adverse effect in 10% of the test animals or plants; NOAEC – no observed adverse effect concentration.

c. Risk to Aquatic Organisms

Based on the refined surface water EECs and the available ecotoxicity data for 1-octanol and 1 -decanol, RQs for aquatic animals do not exceed acute LOCs. In addition, although chronic toxicity data are available for 1-octanol, but not 1-decanol, aliphatic alcohols do not appear to pose a chronic risk to freshwater aquatic animals. No chronic toxicity data are available for estuarine/marine fish and invertebrates. In spite of these data gaps, the Agency does not anticipate chronic risk to estuarine marine fish and invertebrates. As described above, little 1-octanol or 1 -decanol would likely be available for transport in runoff if a significant rain event did not occur within a few hours of application. Estimated RQs for 1-decanol and 1-octanol are summarized in Tables 7 - 10 below.

Table 7- Acute and Chronic RQs for Freshwater Fish

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50}=2300 NOAEC-nd	0.02	13	nd
1-Octanol	4.4,1 application	140	LC_{50}=12200 NOAEC=750	0.01	29	<1

Table 8 - Acute and Chronic RQ's for Estuarine/Marine Fish

Chemical	Effective Application Rate (lbs. a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50}=7200 NOAEC-nd	<0.01	13	nd
1-Octanol	4.4,1 application	140	LC_{50}=15000 NOAEC=nd	<0.01	29	nd

Table 9 - Acute and Chronic RQs for Freshwater Invertebrates

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50}=6500 NOAEC-nd	<0.01	29	nd
1-Octanol	4.4,1 application	140	LC_{50}= 4160 NOAEC=1000	0.03	70	<1

Table 10 - Acute and Chronic RQs for Estuarine/Marine Invertebrates

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50}=4000 NOAEC-nd	0.01	29	nd
1-Octanol	4.4,1 application	140	LC_{50}=58000 NOAEC=nd	<0.01	70	nd

nd no data

Aquatic plant toxicity data from open literature were only available for 1-octanol. Based on these data, the acute RQs for aquatic plants do not exceed the Agency's acute and endangered given that the NOAEC for 1-octanol is unknown, and no aquatic phytotoxicity data are available for 1-decanol. The NOAEC is used to calculate an RQ to evaluate potential risk to endangered species. Because the NOAEC was not established, the EC_{10} for 1-octanol was used. Since the LOC for endangered aquatic plants is 1.0, and the RQ derived using the EC_{10} is 0.05, the NOAEC would have to be at least 20 times lower than the EC_{10} for the Agency to have an endangered species concern for aquatic plants.

Based on the analysis of the volatility of the aliphatic alcohols, aquatic exposures resulting from the labeled use of 1-decanol and 1-octanol are unlikely to reach concentrations that exceed the Agency's LOC. As a result, the value of additional aquatic plant studies for the aliphatic alcohols is low.

Table 11- Risk to Aquatic Plants

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ
1-Octanol	4.4,1 application	140	LC_{50}=6500 EC_{10}=2800	0.02 0.05
1-Decanol	1.95, 1 application	57	No data	----

d. Exposure, Toxicity and Risk to Terrestrial Organisms

Birds

Available toxicity data indicate that the aliphatic alcohols are categorized as "practically non-toxic" to birds on acute oral and dietary bases. Acute risks to birds were not quantified, because no discreet median lethal doses or concentrations were established in the acute oral and dietary studies. An acute dietary study from the open literature reported a dietary LC_{50} for bantam chickens of 201,000 ppm (100% 1-decanol). This level is more than 20 times greater than the highest predicted dietary exposure level (~ 10,000 ppm). Therefore, the Agency concludes that the aliphatic alcohols do not pose an acute risk to birds. No avian chronic toxicity studies were available for any of the aliphatic alcohols and, therefore, the Agency cannot directly assess the potential chronic risk to avian species. However, since 1) the aliphatic alcohols are not acutely toxic to birds at doses many times higher than expected exposure, 2) the volatility of the aliphatic alcohols makes chronic exposure unlikely, with EECs dropping more than an order of magnitude within 30 minutes, 3) the aliphatic alcohols assessed are listed as food additives and are "Generally Recognized as Safe" (GRAS) by the U.S. Food and Drug Administration[1], and 4) a mammalian chronic toxicity study indicates the aliphatic alcohols are not chronically toxic to mammals, the Agency does not expect a chronic risk to birds, and will not require chronic avian toxicity studies at this time.

Mammals

Acute oral mammalian toxicity data indicate that the aliphatic alcohols are "practically non-toxic" to mammals on an acute oral basis. Four studies performed with laboratory rats did not result in LC_{50} endpoints with which RQs could be calculated. The Agency concludes that aliphatic alcohols do not pose an acute dietary risk to mammals.

In the single chronic mammalian developmental toxicity study, which used a 1- decanol / 1-octanol blend, no chronic effects were observed in laboratory rats, even at the maximum tested dose of 957 mg/kg bw/day. It is unknown if the predicted exposures approach the level at which effects may occur since no LOAEC was identified in the chronic study. However, the Agency does not anticipate chronic risk to mammals, considering the volatility of the aliphatic alcohols, and the acceptance of these chemicals as food additives, as described above.

Terrestrial Insects

Available toxicity data indicate that aliphatic alcohols are "practically non-toxic" to honey bees (acute contact $LD_{50} > 25$ µg/bee). However, given that aliphatic alcohols can be used as Lepidopteran sex inhibitors, there is a potential for sublethal (e.g., reproductive) effects on non-target Lepidopterans, such as butterflies. This potential effect cannot be quantified at this time.

[1]http://vm.cfsan.fda.gov/- dms/eafus.html

Terrestrial Plants

Tier-I terrestrial plant seedling emergence study data suggest a fatty alcohol blend (1-decanol and 1-octanol) is not toxic to most plants at the maximum rate tested (18.03 lbs ai/A). An EC_{25} could not be established for tested species, although lesser effects were observed in cucumbers, carrots and tomatoes. Therefore, the Agency did not calculate RQs based on seedling emergence effects.

EC_{25} values and related no-effect levels were established for two (corn and cucumber) of 10 crop plants tested in a submitted vegetative vigor study. The Agency used these endpoints in the TerrPlant model to calculate RQs (Table 12). All were below the Agency's LOC of 1.

Table 12 - Terrestrial Plant Vegetative Vigor RQs from Drift only for Terrestrial Plants*

Class of Terrestrial Plant	Monocot	Dicot
Non-endangered species	0.02	0.01
Endangered species	0.19	0.36
*based on vegetative vigor monocot NOAEL=1.12 lbs a.i/A, EC_{25}=9.02 lbsa i./A; dicot NOAEL=0.58 lbs a.i./A EC_{25}=14.8 lbs a.i. /A (MRIDs 42514701,43379602)		

e. Adverse Ecological Incidents

There are currently no adverse ecological incidents listed in the Ecological Incident Information System (EIIS) that are associated with the aliphatic alcohols.

f. Endangered Species

Based upon the screening-level assessment conducted on aliphatic alcohols, the Agency has not definitively identified exceedences of endangered species LOCs for direct effects to non-target animals or plants. Acute RQs did not exceed endangered species LOCs for birds, mammals, terrestrial plants, freshwater fish and invertebrates, or estuarine/marine fish and invertebrates. Chronic data were not available for birds and estuarine/marine fish and invertebrates. As described above, the Agency believes that the volatility and low toxicity in

available acute and chronic toxicity studies for mammals and freshwater animals suggest that chronic risk to birds and estuarine/marine animals is unlikely. However, because the toxicity data are not available, the Agency cannot completely preclude risk to listed birds and estuarine/marine animals at this time. Similarly, since a no-effect level was not determined for aquatic plants, the Agency cannot preclude direct effects on these organisms, although exposure is expected to be negligible.

The Agency considers a potential for not only direct effects, but also adverse indirect effects to listed species that rely on other affected organisms. Because direct effects to aquatic plants cannot be precluded, indirect effects to listed aquatic species which rely on aquatic plants can also not be dismissed. Similarly, indirect effects to terrestrial plants and animals cannot be precluded because of potential reproductive effects of aliphatic alcohols to some terrestrial insects.

Table 13 - Potential Listed Species Risks Associated with Direct or Indirect Effects Due to Applications of Aliphatic Alcohols as Shoot inhibitors on Tobacco.

	Direct Effects		
Listed Taxon	**Acute**	**Chronic**	**Indirect Effects to Endangered Species**
Terrestrial and semi-aquatic plants-monocots	No	N/A	Possible
Terrestrial and semi-aquatic plants-dicots	No	N/A	Possible
Birds	No	N/A	Possible
Terrestrial –phase amphibians	No	No Data	Possible
Reptiles	No	No Data	Possible
Mammals	No	No Data	Possible
Aquatic non=vascular plants*	Insufficient data	N/A	N/A
Aquatic vascular plants	Insufficient data	N/A	N/A
Freshwater fish	No	No	Possible
Aquatic-phase amphibians	No	No	Possible
Freshwater crustaceans	No	No	Possible
Mollusks	No	N/A	Possible
Marine/ estuarine fish	No	No Data	Possible
Marine/estuarine crustaceans	No	No Data	Possible

• At the present time, no aquatic non-vascular plants are included In Federal listings of threatened and endangered species. The taxonomic group is included here for the purposes of evaluating potential contributions to indirect effects to other taxa and as a record of exceedances should future listings of non-vascular aquatic plants warrant additional evaluation of Federal actions.

Further analysis regarding the overlap of individual species with each use site is required prior to determining the likelihood of potential impact to listed species. At the screening level, this analysis is accomplished using the Location of Crops and Threatened and Endangered Species (LOCATES) data base, which uses location information for listed species at the county level and compares it to agricultural census data for crop production at the same county level of resolution. The ecological risk assessment includes a complete listing of aquatic plants, birds, reptiles, terrestrial-phase amphibians, mammals, and terrestrial invertebrates associated with the States where the aliphatic alcohols are use as a plant growth regulator on tobacco.

SUPPLEMENTAL INFORMATION:

A monograph entitled "Literature Review on Fatty Alcohol Compounds" (MRID 42135801) prepared by B.D. McGaughey of Compliance Services International provides additional information pertaining to the behavior of fatty alcohols in the environment. The areas pertaining to the following Data Requirement for EPA Pesticide Guidelines were addressed.

OPP	**GUIDELINE NUMBER**	**STUDY Chemical Identity**
160-5	Form 8570-4	Chemical Identity
161-1	835.2120	Hydrolysis
161-2	835.2240	Photodegradation – Water
161-3	835-2410	Soil photolysis
162-1	835.4100	Aerobic Soil Degradation
162.3	835.4400	Anaerobic Aquatic Degradation
163-1	835.1230	Leaching , Adsorption Desorption
163-1	835.1240	
164-1	835.6100	Terrestrial Field Dissipation
165-4	850.1730	Bioaccumulation in Fish

The conclusions reached as a result of this study/ literature review were as follows:

OPP Guideline Number 160-5, OPPTS (form 8570-4), OECD data point (II A 1.10), ***Chemical Identity***: Normal fatty alcohols are considered chemically "inert" and are precursors to fatty acids. Their production and manufacture yields a relatively pure product mixture, depending upon the "cut" desired. The C_6-C_{12} alcohols used in tobacco sucker control agents would be expected to contain no unusual or high levels of impurities.

OPP Guideline Number 161-1, OPPTS (835.2120), OECD data point (II A 7.5) ***Hydrolysis:*** Hydrolysis is not a major pathway of degradation for C_6-C_{12} alcohols.

OPP Guideline Number 161-2, OPPTS (835.2240), OECD data point (II A 7.6) ***Photodegradation in Water:*** Photolysis of C_6-C_{12} n-alcohols in water would not be expected to occur.

OPP Guideline Number 161-3, OPPTS (835.2410), OECD data point (II A 7.1.3) ***Photodegradation in Soil:*** Photolysis of C_6-C_{12} n-alcohols in soil would not be expected to occur.

OPP Guideline Number 162-1, OPPTS (835.4100), OECD data point (II A 7.1.1***) Aerobic Soil Metabolism:*** Aerobic soil metabolism is the major degradation pathway for C_6-C_{12} n-alcohols. Breakdown or assimilation by microbial organisms is rapid and complete. Half-lives may be as short as a matter of hours, and would not be expected to exceed 3 to 5 days.

OPP Guideline Number 162-3, OPPTS (835.4400), OECD data point (II A 7.8.2) ***Anaerobic Aquatic Metabolism:*** Anaerobic aquatic metabolism is similar to other microbial metabolism pathways for C_6-C_{12} n-alcohols. End products may differ due to individual organism output, but products will be natural components of the aquatic system. Breakdown or assimilation by microbial organisms is rapid and complete. Half-lives may be as short as a matter of hours and would not be expected to exceed on day.

OPP Guideline number 163-1, OPPTS (835.1230, 835.1240); OECD data point (II A7.4.1, II A 7.4.3) ***Leaching/adsorption/desorption:*** C_6-C_{12} fatty alcohols strongly adsorb to soil and would not be expected to move through the soil column. Desorption is expected to be minimal.

OPP Guideline Number 164-1, OPPTS (835.6100), OECD data point(II A 7.3.1) ***Terrestrial Field Dissipation:*** Dissipation of C_6-C_{12} fatty alcohols under field rates and conditions is rapid and complete. Half-lives as short as a matter of hours could be possible. Half-lives would not be expected to exceed 3 to 5 days.

OPP Guideline number 165-4, OPPTS (835.1730), OECD data point (II A 8.2.6.1) ***Bioaccumulation in Fish:*** C_6-C_{12} fatty alcohols will not bioaccumulate in fish.

REFERENCES
FATE AND BEHAVIOR IN THE ENVIRONMENT:

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
EPA		3/2007	Reregistration Eligibility Decision for Aliphatic Alcohols, United States Environmental Protection Agency; Document EPA 738-R-07-004	NO	EPA	NONE
McGaughey, B.	835.2120 835.2240 835.2410 835.4100 835.4400 835.1230 835.1240 835.6100 835.1730	1991	Literature Review on Fatty Alcohol Compounds: Lab Project Number: FATF-9101; Unpublished Study Prepared by Compliance Services International. November 15, 1991, 60 p.	Y	Fatty Alcohol Task Force	42135801

c. Environmental impact from its use or manufacture:

Acute Oral Toxicity to Quail, Mallard Duck

Summary of Conclusions

The report is dated September 17, 1975. Test material was received on August 14, 1975. Specific dates of testing are not reported. The results of the acute oral toxicity study conducted with Alfol 810 in mallard ducks showed the LD_{50} to be in excess of 4640 mg Alfol 810 per kg body weight.

Avain dietary Toxicity in Quail or Mallard Duck

Summary of Conclusions

The test material was received on August 14, 1975. The report is dated September 17, 1975. The exact dates of testing are not reported. The acute LC_{50} of Alfol 10 was determined to be in excess of 10,000 ppm in bob-white quail.

Summary of Conclusions

The test material was received on August 14, 1975. The report is dated September 17, 1975. The exact dates of testing are not reported. The acute LC_{50} of Alfol 810 was determined to be in excess of 10,000 ppm in mallard ducks.

Fish Toxicity

Summary of Conclusions

The report is dated September, 1975. Specific dates of testing are not reported. Acute 96 hour LC_{50} values are reported in parts per million for two species (with 95% confidence intervals) as follows:

Species	Alfol 810 Alcohol	Alfol 10 Alcohol
Rainbow Trout	20.40 (16.10-25.70)	>5.60<7.50 --
Bluegills	9.96 (7.68-12.90)	5.64 (4.14-7.69)

(all values are in ppm test material)

Acute Toxicity to Aquatic invertebrates:

Table 1 -- Acute toxicity of Alfol 810 Alcohol and Alfol 10 Alcohol to the water flea[a] (Daphnia magna). These date are baed on the results of bioassays conducted at the Aquatic Toxicology Laboratory of E G & G, Bionomics, Wareham, Massachusetts.

Compound	LC50 (milligrams active ingredient/liter) 24-hour	48-hour	No discernible effect level at 48 hours (mg/l)
Alfol 810 Alcohol	11.6 (5.98-22.3)[b]	8.24 (5.52-12.3)	1.80
Alfol 10 Alcohol	9.80 (6.88-14.0)	6.51 (4.78-8.87)	2.80

[a] Bioassay conducted at 22 ± 1.0°C, Daphnia ≤ 24 hour old at initiation of test.

[b] 95% confidence interval.

Effects on Bees:

1. Active Substance:

CONCLUSION

The honey bee 48 hour contact LD50 value for Fatty Alcohol Blend; Lot #CSI-91FA01-27 was determined to be greater than 25 µg/bee, the highest dose tested. Based upon the LD50 value, Fatty Alcohol Blend; Lot #CSI-91FA01-27 was classified as relatively non-toxic according to the toxicity categories of Atkin (6). The no observed effect dose was 6.3 µg/bee, based on possible treatment related mortality and signs of toxicity at doses ≥ 12.5 µg/bee.

REFERENCES
ECOTOXICOLOGICAL STUDIES:

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
McGaughey, B.	850.2100	1990	Fatty Alcohol Task Force Phase 3 Summary of MRID 00046991. Acute Oral LD_{50} – Mallard Duck: Alfol 810 Alcohol: VISDUCK2: Prepared by Truslow Farms, Inc. 11 p.	Y	Fatty Alcohol Task Force	94313004
McGaughey, B.	850.2200	1990	Fatty Alcohol Task Force Phase 3 Summary of MRID 00058024 Eight Day Dietary LC_{50} Bobwhite Quail: Alfol 810 Alcohol: VISQUL2: Prepared by Truslow Farms, Inc. 10 p.	Y	Fatty Alcohol Task Force	94313006
McGaughey, B.	850.2200	1990	Fatty Alcohol Task Force Phase 3 Summary of MRID 00058025. Eight Day Dietary LC_{50} – Mallard Duck: Alfol 810 Alcohol: VISLCDK2: Prepared by Truslow Farms, Inc. 10 p.	Y	Fatty Alcohol Task Force	94313010
McGaughey, B.	850.1075	1990	Fatty Alcohol Task Force Phase 3 Summary of MRID 00122381. Acute Toxicity of Two Conoco Compounds to Bluegill and Rainbow Trout: VISFISH. Prepared by Bionomics, Inc. 15 p.	Y	Fatty Alcohol Task Force	94313012
LeBlanc G. A.	850.1010	1976	Study of the Effects of Fatty Alcohols on Acute LC50 Freshwater Invertebrates (Daphnia); Report Number: CSI-FATF-TX-9301; EG & Bionomics Aquatic Toxicity Laboratory 13 p.	Y	Fatty Alcohol Task Force	42847201
Hoxter, J. A. and Jaber, M.	850.3020	1992	Fatty Alcohol Blend; Lot # CSI-91FA01-27: An Acute Contact Toxicity Study with the Honey Bee; Project Number. 346-101A: Wildlife International Ltd. 44 p.	Y	Fatty Alcohol Task Force	42495102

d. Effects on human health

1. Active Substance:

Short Term Summary of Mammalian Toxicity:

SPECIES	TEST & EPA Guideline Number	DURATION AND CONDITIONS OR GUIDE LINE ADOPTED	TEST MATERIAL	RESULT	MRID#
Rat	Acute Oral 870.1100	Single Dose Via Oral Route; Observed for 14 Days	Alfol 810 DF Lot# 1169975	>5000 mg/kg	47589902
Rat	Acute Dermal 870.1200	Single Dose; 24 hour Exposure; observed for 14 Days	Alfol 810 DF Lot# 1169975	>5000 mg/kg	47589903
Rabbits	Primary Eye Irritation 870.2400	Observations Post Instillation at 1 HR, 24 HRS, 48 HRS, 72 HRS, 4 Days, 7 Days	Alfol 810 DF Lot# 1169975	Moderately Irritating	47589904
Rabbits	Primary Skin Irritation 870.2500	Single Topical Exposure for 4 Hours with Evaluations Made After patch Removal at 30 -60 Minutes, 24 HRS, 48 HRS, 72 HRS, 7 days	Alfol 810 DF Lot# 1169975	Moderately Irritating	47589905
Rats	Acute Inhalation 870.1300	Single Nose-Only Exposure for 4 Hours	Alfol 810 DF Lot# 1169975	LC_{50}>2.07 mg/L	47777501
Guinea Pigs	Skin Sensitization 870.2600	Buehler Test For Sensitization	Fatty Alcohol Blend, Batch No. CSI-91FAO1-27	Not a Sensitizer	43380201

Summary of Mammalian Toxicity (CONT):

SPECIES	TEST & EPA GUIDELINE NUMBER	DURATION AND CONDITIONS OR GUIDE LINE ADOPTED	TEST MATERIAL	RESULT	MRID#
Salmonela Typhimurium Strains: TA 1535 TA 1537, TA 1538, TA 98 and TA100	Mutagenicity 870.5140		Fatty Alcohol Blend, Batch No. CSI-91FAO1-27	No Mutagenic Activity in any of the 5 Bacterial Strains Used	42372002
Mice	Micronucleus Test in Bone Marrow 870.8380		Fatty Alcohol Blend, Batch No. CSI-91FAO1-27	Maximum Tolerated Dose in the Toxicity Study >2000 mg/kg/day No Evidence of Micronucleus Induction was Detected in Bone Marrow Erythrocytes	42372001
Mice	Mouse Lymphoma L5178Y Mutation Assay 870.5100		Fatty Alcohol Blend, Batch No. CSI-91FAO1-27	No Evidence of Mutagenic Activity in any of the 4 assays Evaluated	4237206
Sprague-Dawley Rats	Teratogenicity Using Dose Levels of 0,125,375,1000 mg/kg/day 870.3700		Fatty Alcohol Blend, Batch No. CSI-91FAO1-27	No Notable Effects on the Dam or the Conceptus at Dose Levels of up to 1000 mg/kg/day	42609301

REFERENCES

TOXICOLOGICAL AND METABOLISM STUDIES

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Moore, G. E.	870.1100	10/2008	Alfol 810 DF: Acute Oral Toxicity Up and Down Procedure in Rats: Laboratory Study Number: 25549: Eurofins/ Product Safety Laboratories: 10/14/2008; 16 p.	Y	Fatty Alcohol Task Force	47589902
Moore, G. E.	870.1200	10/2008	Alfol 810 DF: Acute Dermal Toxicity Study procedure in Rats: Laboratory Study Number: 25541: Eurofins/ Product Safety Laboratories: 10/14/2008; 15 p.	**Y**	**Fatty Alcohol Task Force**	**47589903**
oore, G. E.	870.2400	10/2008	Alfol 810 DF: Primary Eye Irritation Study in Rabbits; Eurofin/ Product Safety Laboratories, Laboratory Study Number: 25543; 10/14/2008 18 p.	Y	Fatty Alcohol Task Force	47589904
Moore, G. E.	870.2500	10/2008	Alfol 810 DF: Primary Skin Irritation Study in Rabbits; Laboratory Study Number: 25544 Eurofins/Product Safety Laboratories; 10/14/2008, 16 p.	Y	Fatty Alcohol Task Force	47589905

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Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Wilson, J.		1991	Fatty Alcohol Blend (FAB): Dose Range finding Study in Rats: Lab Study Number: 490311: 7768. Unpublished study prepared by Inveresk Research International. 42 p.	Y	Fatty Alcohol Task Force	42634201
Jackson, D.; Wilson, J.	870.2600	1994	Fatty Alcohol Blend C_6-C_{12}: Buehler Skin Sensitization Test in Guinea Pigs: Lab Project Number: 555677: 10500: 94014 / FATF. Unpublished study prepared by Inveresk Research International. 65p.	Y	Fatty Alcohol Task Force	43386201
Naas, D.	870.3250	1994	A 90-Day Dermal Toxicity Study of Fatty Alcohol Blend in rats: Final Report: Lab Project Number: WIL-241001: 94013-FATF. Unpublished Study prepared by WIL Research Labs, Inc. 486 p.	Y	Fatty Alcohol Task Force	43701201
Durando, J.	870.1300	5/2009	Alfol 810 DF; Acute Inhalation Toxicity Study in Rats-Limit Test; Lab Study Number 26969; Eurofins/ Product Safety Laboratories, 5/5/09, 23 p.	Y	Fatty Alcohol Task Force	47777501

TOXICOLOGICAL AND METABOLISM STUDIES

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Holstrom, M.; Innes, D.	870.8380	1992	Fatty alcohol Blend Micronucleus test in Bone Marrow of CD-1 Mice: Lab Project Number: 8568: 751943. Unpublished study prepared by Inveresk Research International. 39 p.	Y	Fatty Alcohol Task Force	42372001
Dillon, D.; McCartney, M.	870.5140	1992	Fatty Alcohol Blend Lot No. CSI-91FA01-27" Testing for Mutagenic Activity with Salmonella typhimurium TA 1537, TA 1538, TA 98 and TA 100: Lab Project Number: 751938; 8604. Unpublished study prepared by Inveresk Research International. 49 p.	Y	Fatty Alcohol Task Force	42372002
Cattananch, P.; Riach, C.	870.5100	1992	Fatty Alcohol Blend Mouse Lymphoma Mutation Assay: Lab Project Number: 751985: 8715. Unpublished study prepared by Inveresk Research International. 55 p.	Y	Fatty Alcohol Task Force	42372003

TOXICOLOGICAL AND METABOLISM STUDIES

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Wilson, J.; Hazelden, K.	870.3700	1992	Teratogenicity Study in Rats: Fatty Alcohol Blend (FAB): Lab Project Number: 490327: 7821. Unpublished study prepared by Inveresk Research International. 72 p.	Y	**Fatty Alcohol Task Force**	**42609301**

2. **Formulated (end use product):**

N-TAC:

Short Term Summary of Mammalian Toxicity:

SPECIES	TEST	EPA Guideline Number	TEST MATERIAL	RESULT	MRID#
Rat	Acute Oral	870.1100	N-TAC	>5000 mg/kg	49218303
Rat	Acute Dermal	870.1200	N-TAC	>2000 mg/kg	49218304
Rat	Acute inhalation	8870.1300	N-TAC	>2.09 mg/l	49218305
Rabbit	Primary Eye Irritation	870.2400	N-TAC	Extremely Irritating	49218306
Rabbit	Primary skin Irritation	870.2500	N-TAC	Slightly irritating	49218307
Mice	Dermal Sensitization	870.2600	N-TAC	Contact dermal sensitizer at concentrations >25%	49218308

References:

Author	EPA GUIDELINE NUMBER	YEAR	TITLE	OWNER	MRID#
Lowe, Carolyn	870.1100	2013	Acute Oral	Fair Products, Inc.	49218303
Lowe, Carolyn	870.1200	2013	Acute Dermal	Fair Products, Inc.	49218304
Lowe, Carolyn	8870.1300	2013	Acute inhalation	Fair Products, Inc.	49218305
Lowe, Carolyn	870.2400	2013	Primary Eye Irritation	Fair Products, Inc.	49218306
Lowe, Carolyn	870.2500	2013	Primary skin Irritation	Fair Products, Inc.	49218307
Lowe, Carolyn	870.2600	2013	Dermal Sensitization	Fair Products, Inc.	49218308

Titles

1. N-TAC: Acute Oral Toxicity Up and Down Procedure in Rats – Limit Test; Product Safety Labs, Laboratory Study Number 36692; August 20, 2013; 14 pp.

2. N-TAC: Acute Dermal Toxicity Study in Rats- Limit Test; Product Safety Labs; Laboratory Study Number 36693, August 20, 2013; 14pp.

3. N-TAC: Acute Inhalation Toxicity Study in Rats- Limit Test; Product Safety Labs; Laboratory Study Number 36694; August 20, 2013; 21pp.

4. N-TAC: Primary Eye Irritation Study in Rabbit; Product Safety Labs; Laboratory Study Number 36695, August 20, 2013; 17pp.

5. N-TAC: Primary Skin Irritation Study in Rabbit; Product Safety Labs; Laboratory Study Number 36696; August 21, 2013; 14 pp.

6. N-TAC: Local Lymph Node Assay (LLNA) in Mice; Product Safety Labs; Laboratory Study number 36697; August 20, 2013; 24pp.

e. **Effects on soil organisms, crops, or livestock:**

This review concentrates on information available on n-fatty alcohols of "lower" chain lengths (6 to 16 carbons). Most research shows that the behavior of these compounds in *the environment is similar due to the manner in which the molecule is attacked and with* which it binds to soil. Soil microorganisms readily incorporate fatty alcohols into their nutrient assimilation cycles (Buning-Pfaue and Rehm, 1972). Birds, fish and mammals can ingest or digest these compounds or more complex compounds with fatty alcohol components without adverse effects (Noweck, 1987; Place and Roby, 1986; Obst, 1986; Prahl, Eglinton and Corner, 1985).

Effects on Terrestrial Vascular Plants (corn, onion, sorghum, wheat, carrot, cucumber, lettuce, radish, soybean and tomato).

Effects on Terrestrial Vascular Plants:

There were no phytotoxic abnormalties observed in any of the species from any of the treatments. Overall, emergence was excellent, however, onions and carrots were much slower emerging than the other species (non-treated controls included) . This resulted in no emergence data collected at 7 days after
treatment for these species . This effect was not treatment related. There was no detrimental effects from the fatty alcohol on seedling emergence or total fresh weight. Height of tomatoes and radishes, at 21 DAT, was reduced in the fatty alcohol treatment by 11 and 15%, respectively.

CONCLUSIONS

These data indicate that the fatty alcohol blend rate necessary to cause economically adverse effects on these species is greater than the maximum labeled use rate. These data coupled with the fact that the fatty alcohol blend is commercially applied to tobacco in a manner
which significantly reduces the likelihood of off- target movement indicates that this product poses little threat (to non-target plant species. These data indicate that a more elaborate multiple rate study (Tier 2) is not necessary to assess the potential impact of continued use of fatty alcohol blends in commercial tobacco production.

References

Author(s)	EPA Guideline Number	Year	Title	Data Protection Claimed	Owner	MRID#
Willard, T.	850.4200	1992	Study of the Effects of Fatty Alcohol Blend on Seed Germination and Seedling Emergence: A Tier I Terrestrial Non-Target Plant Hazard Evaluation: Lab Project Number. CSI-FATF-SFEI-92: FATF-9202: Unpublished study prepared by American Agricultural Services 142 p.	Y	Fatty Alcohol Task Force	42495101
Massey, L.	850.4200	1993	Study of the Effects of Fatty Alcohol Blend on Seed Germination and Seedling Emergence: A Tier I Terrestrial Non-Target Plant Hazard Evaluation: Amendment to MRID 42495101: Lab Project Number. CSI-FATF-SGEI-92: FATF-9202: Unpublished Study prepared by American Agricultural Services 6 p.	Y	Fatty Alcohol Task Force	42631901
Willard, T.	850.4150	1992	Study of the Effects of Fatty Alcohol Blend on Plant Vegetative Vigor: A Tier 2 Terrestrial Non-Target Plant Hazard Evaluation: Lab Project Number. FATF-9203: CSI-FATF-VV2-92: Unpublished study prepared by American Agricultural Services 126 p.	Y	Fatty Alcohol Task Force	42514701
Massey, L	850.4150	1993	Study of the Effects of Fatty Alcohol Blend on Plant Vegetative Vigor: A Tier 2 Terrestrial Non-Target Plant Hazard Evaluation: Amendment to MRID 42514701: Lab project number: CSI-FATF-VV2-92: FATF-9203. Unpublished study prepared by American Agricultural Services, Inc. 7 p.	Y	Fatty Alcohol Task Force	42631902

10. Safety information including MDSD Form:

MASCOL 80

O-TAC PLANT CONTACT AGENT

N-TAC (As Plant Contact Agent)

Reference Tab 3 & 5

11. Research information:

a. Literature Review on Fatty Alcohol Compunds; Lab Project Number FATF-9101; Compliance Services International; November 15, 1991; 60 pp.

b. Reregistration Eligibility Decision (RED) for Aliphatic Alcohols; US EPA Document EPA 738-R-07-004.

c. Aliphatic Alcohols: Human Health Chapter of Reregistration Eligibility decision (RED) cocument Reregistration Case Number 4004, June 30, 2006.

Reference Tab 3

12. A Petition Justification Statement:

Inclusion of a Synthetic on the National List 205.601(k) (2)

- **Explain why the synthetic substance is necessary for the production of an organic product ?**

- **Crop Sucker Control:**

The Fatty Alcohols being petitioned for use in organic crop productions, have beeen used on farms for several decades with a positive and effective use history, has an excellent record in the field, the environment, and human safety; with cultural benefits.

Proper crop use of these *Fatty Alcohols* reduces overall insect/pest pressures and chemical use, farm labor exposure, farm labor cost and energy. Through carefully timed applications as required, it reduces crop hand topping and suckering, this activity benefits the overall farm resources management, during the pre-and- post harvest peiords.

When used in conjuinction with traditional cultural practices, *Fatty Alcohols,* increases crop yield, quality and marketability and has been shown to increase gross yield by several hundreds pounds per acre, with a substandial income increase in crop value for the farmer!

Additionally, clean sucker and foliage control enables machine harvesting, once again increasing crop yield and quality, and providing major energy and labor savings. Following are a few benefits realized by the farmer when using *Fatty Alcohols:*

- **Yield increases amounting to 20-25 pounds per acre, per day.**
- **Pest/insect population reductions.**
- **Labor and chemical use reduction.**
- **Time/cost savings at critical pre-post–harvest handling.**
- **Increase crop quality and yields and gross income margins to the farmer.**

In summary, the proper use of *Fatty Alcohols* on crops, increases crop quality, yield, and value-added components, at substantial labor and energy reductions, which contributes significantly to the farm gross/net income of the family farm unit!

Reference Tab 7

13. Commerical Confidential Information Statement:

We are not declaring any *Confidental Business Information (CBI),* at this time!

REFERENCES:

Please Utilize the Reference List and References as indicated throughout this petition.

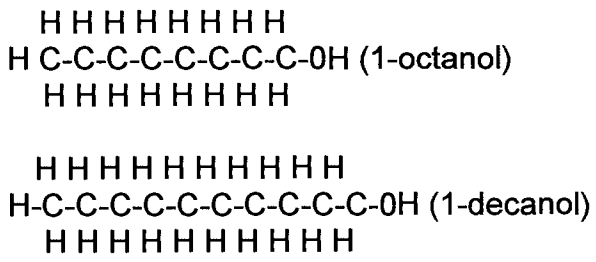
1. **List of Activities for which the substance will be Used:**

a. Sucker control on **organic crops**: 4-6% solution of the formulated product applied directed broadcast over the top of tobacco plants in the early button to early flower stage of growth when suckers, axillary buds are succulent tender, utilizing 50 gallons of spray solution per acre.

Mode of Action:

Upon contacting the axillary buds/suckers at the leaf axils, the solution containing the active substance quickly dissolves the thin undeveloped cuticle or waxy area and results in desiccation of the axillary bud/ sucker by rupturing cell walls and rapidly evaporating liquids.

Chemical Structure:



Industry Experts

OMRI Reviews & Industry Certifications

ICOF America Inc
9600 Colerain Ave, Suite 402, Cincinnati, OH 452451 Tel: 513-791-6813 Fax: 513-791-2767

May 8, 2014

Fair Products Inc.
806 Reedy Creek Rd
Cary, NC 27513

Dear Mr. Grainger and Mr. Harding:

We consider the MASCOL 80, produced from sustainable PKO, to be from a Natural Process, utilizing the Davy Methodology; and therefore is not considered a synthetic alcohol, in our industry!

The MASCOL 80 is utilized in the production of Natural Detergents and is in high demand throughout that industry, because it is derived from a natural process!

Thank you very much for your time.

Sincerely yours,

John Schnieder

ICOF America Inc
9600 Colerain Ave, Suite 402
Cincinnati, OH 45251

Renee Allen

From:	john.schnieder@icofgroup.com
Sent:	Thursday, March 14, 2013 3:59 PM
To:	Renee Allen
Subject:	RE: Request from Frank
Attachments:	RE: [Contact OMRI] Classification of fatty alcohol (2.98 KB); RE: [Contact OMRI] Classification of fatty alcohol (4.28 KB)

Renee,

See the comments from our technical group.

Yes this is funny and this was the same reply I got when I queried the US Agency for the classification of our alcohol as not natural. If this is the case then only the wax ester route of Lurgi will be classified as 'natural'. The Lurgi methyl ester route also employs methanol in the transesterification. The short chain alcohol is never produced from wax ester route so this means there are no natural short chain alcohols in the whole industry.

Please see the emails received on the definition of synthetic alcohol. By this definition, there will be no natural alcohols at all unless the Lurgi wax ester route is modified so that the hydrogenation plant can be run on short chain alcohol. We have tried this in Ecogreen but the HC content will be too high to meet the market requirement and it will be too costly to fractionate the C6-C10 alcohol. More so, the wax ester route does not allow change in feedstock as too much downtime will be employed to flush the system of the previous material. In short no company will produce short chain alcohol using the wax ester route. Therefore, where will they source natural short chian alcohol.

There definition is natural is different than other organizations.

Thanks,

John Schnieder

ICOF America Inc
9600 Colerain Ave, Suite 402
Cincinnati, OH 45251

Office: 513-245-7061
Cell: 513-746-7663
Fax: 513-791-2767

A member of the Musim Mas Group

From: Renee Allen [mailto:Renee@fairproductsinc.com]
Sent: Wednesday, March 13, 2013 3:16 PM
To: john.schnieder@icofgroup.com
Subject: Request from Frank
Importance: High

Hey John,

Frank asked me to tell you that we need an absolute argument from your chemists indicating that the alcohol is a non-synthetic alcohol.

If you have any questions, please call Frank.

Thank you,

Renee' Allen
FAIR PRODUCTS, INC
www.fairproductsinc.com
(919) 467-1599

Renee Allen

From: Lindsay Fernandez-Salvador <lindsayfs@omri.org>
Sent: Tuesday, October 30, 2012 12:21 PM
To: leng.gador@icofgroup.com
Subject: RE: [Contact OMRI] Classification of fatty alcohol

Hello,

Fatty acid alcohols are usually derived from vegetable oil via some sort of hydrolysis. Depending on the type of hydrolysis (i.e. chemical vs steam/pressure) we would consider it synthetic. Further, the fatty acid alcohols are usually fractionated in some way; we would want to see that process to make sure there were no synthetic reactions occurring there as well.

In short, not all fatty acid alcohols would be considered synthetic, but some would. OMRI would have to review the specific ingredients and manufacturing processes to be sure.

Regards,

Lindsay Fernandez-Salvador
Program Director
Organic Materials Review Institute
P.O. Box 11558
Eugene OR 97440-3758
Office (541)343-7600 x117
Fax (541)343-8971
www.omri.org

——Original Message——
From: Jean Schauerman
Sent: Monday, October 29, 2012 7:38 AM
To: Lindsay Fernandez-Salvador
Subject: FW: [Contact OMRI] Classification of fatty alcohol

Jean Schauerman
Administrative Specialist
Organic Materials Review Institute
P.O. Box 11558
Eugene OR 97440-3758
Office (541)343-7600 ext. 100
Fax (541)343-8971

www.omri.org
CONFIDENTIALITY NOTICE

This email, including any attachment, may contain information that is confidential for the use of the intended recipie only. Any review, reliance or distribution by others or forwarding without express permission is strictly prohibited. If you are not the intended recipient, please contact the sender and delete all copies. Information submitted to OMRI is considered confidential in accordance with the OMRI Policy Manual and Standards Manual Section 1.6.

-----Original Message-----
From: info@omri.org [mailto:info@omri.org] On Behalf Of
Sent: Monday, October 29, 2012 2:14 AM
To: info@omri.org
Subject: [Contact OMRI] Classification of fatty alcohol

Leng Gador sent a message using the contact form at http://www.omri.org/contact.

Please clarify why fatty alcohols derived fro,m vegetable oils are classified as synthetic.

Renee Allen

From: Lindsay Fernandez-Salvador <lindsayfs@omri.org>
Sent: Tuesday, October 30, 2012 6:57 PM
To: leng.gador@icofgroup.com
Subject: RE: [Contact OMRI] Classification of fatty alcohol

Hello,

The vegetable oil that is hydrolyzed by steam would be nonsnythetic. However, the esterification step to produce methyl esters would then render your particular substance as synthetic. This is because it is a synthetic reaction to produce a third, unique chemical. Your product would need to be reviewed by the NOSB for addition to the National List.

Regards,

Lindsay Fernandez-Salvador
Program Director
Organic Materials Review Institute
P.O. Box 11558
Eugene OR 97440-3758
Office (541)343-7600 x117
Fax (541)343-8971
www.omri.org

-----Original Message-----
From: leng.gador@icofgroup.com [mailto:leng.gador@icofgroup.com]
Sent: Tuesday, October 30, 2012 3:52 PM
To: Lindsay Fernandez-Salvador
Subject: Re: [Contact OMRI] Classification of fatty alcohol

Our fatty alcohols are produced from methyl esters. The methyl esters are produced by esterification of fatty acids. The fatty acids are produced by splitting the oil with steam. Are our fatty alcohols classified synthetic?

Sent from my iPhone

On Oct 31, 2012, at 12:20 AM, "Lindsay Fernandez-Salvador" <lindsayfs@omri.org> wrote:

Hello,

Fatty acid alcohols are usually derived from vegetable oil via some sort of hydrolysis. Depending on the type of hydrolysis (i.e. chemical vs steam/pressure) we would consider it synthetic. Further, the fatty acid alcohols are usually

fractionated in some way; we would want to see that process to make sure there were no synthetic reactions occurring there as well.

In short, not all fatty acid alcohols would be considered synthetic, but some would. OMRI would have to review the specific ingredients and manufacturing processes to be sure.

Regards,

Lindsay Fernandez-Salvador
Program Director
Organic Materials Review Institute
P.O. Box 11558
Eugene OR 97440-3758
Office (541)343-7600 x117
Fax (541)343-8971
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-----Original Message-----
From: Jean Schauerman
Sent: Monday, October 29, 2012 7:38 AM
To: Lindsay Fernandez-Salvador
Subject: FW: [Contact OMRI] Classification of fatty alcohol

Jean Schauerman
Administrative Specialist
Organic Materials Review Institute
P.O. Box 11558
Eugene OR 97440-3758
Office (541)343-7600 ext. 100
Fax (541)343-8971
www.omri.org

-----Original Message-----
From: info@omri.org [mailto:info@omri.org] On Behalf Of
Sent: Monday, October 29, 2012 2:14 AM
To: info@omri.org
Subject: [Contact OMRI] Classification of fatty alcohol

Leng Gador sent a message using the contact form at http://www.omri.org/contact.

Please clarify why fatty alcohols derived fro,m vegetable oils are classified as synthetic.

AgriSystems International™

The Organic Consultants

A Company of LVOG Inc.

125 West Seventh Street
Wind Gap, Pennsylvania 18091 USA

Telephone: 610 863-6700
Facsimile: 610 863-4622
Email : agrisys1@aol.com

August 31, 2012

Ms. Andria Schulze
Product Review Coordinator
Organic Materials Review Institute
2649 Willamette Street
Eugene, Oregon 9740-3134

Dear Ms. Schulze:

Please find herein and herewith attached our **Rebuttal To The OMRI Decision for the Natural Alcohol used in O-TAC Plant Contact Agent**, being submitted on behalf of my clients **Santa Fe Natural Tobacco Company (SFNTC) and Fair Products, Inc./South Atlantic Services , Inc.** , located in North Carolina .

AgriSystems International, are the *Organic Program Consultants* for these companies and the primary contact for this OMRI Application for O-TAC.

We are submitting our Rebuttal per your email letter dated August 3, 2012, whereas the OMRI Decision stated that the Natural Alcohol used in the O-TAC Product was a prohibited synthetic material and therefore the O-TAC Product is not approved for organic crop production , certified under the NOP ?

Please find herewith (FedEx) our check for $250.00 to cover the OMRI Rebuttal Fee, any questions, contact me.

OMRI Decision Rebuttal for O-TAC Natural Fatty Alcohol:

. We acknowledge the receipt of the OMRI Decision Letter and Email dated August 3, 2012; whereas OMRI declared the Natural Fatty Alcohol a prohibited synthetic, because of the methanol esterification and hydrogenation steps.

. We are rebutting this decision based upon the information contained in the *Independent Third Party Review* and other relevant documents, herewith attached; whereas, the (hydrogenation step) is actually a *Reductive Environmental Process Step* found in nature and therefore is a natural process step and not a synthetic hydrogenation step!

. It is our desire to have the OMRI Decision reversed and therefore recognize and permit the Natural Fatty Alcohol as naturally derived and not synthetic; and therefore approve the O-TAC Product for use on NOP organic crop production!

. Our formulation has not changed since our original product review submission to OMRI!

It has been our goal over the last forty (40) years to incorporate into our work and recognize - that one of the main tenants of organic agriculture , the community and industry is attempt to avoid wherever possible the use of synthetic compounds not found in nature and utilize all elements of a sustainable system.

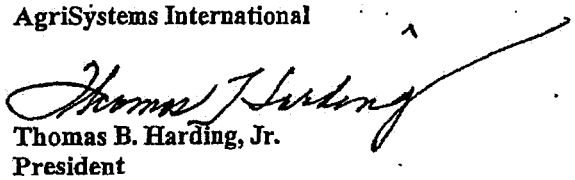
However, a balance of using modern knowledge and compounds found in nature is needed to prevent excessive crop loss and maintain a quality crop harvest. It is recognized in the strictest sense, all agriculture disturbs the natural ecosystem, our goal in organic farm production is to maintain reasonable yields, demonstrate excellent resource stewardship that truly builds a sustainable system . Therefore production tools, products using natural compounds are essential for the organic farmer today!

We therefore request your further review of all documents submitted to OMRI and that you recognize the O-TAC Product meets the Requirements of the National Organic Program (NOP).

Thank you very much for your consideration of our Rebuttal and I look forward to hearing from you soon.

Sincerely yours,

AgriSystems International



Thomas B. Harding, Jr.
President
Organic Program Consultants SFNTC

Building Sustainable Partnerships With Nature Through Organic Food and Agriculture

P.O. Box 11558, Eugene, Oregon 97440-3758
541.343.7600 • fax 541.343.
info@omr

August 3, 2012

Thomas Harding, Jr.
Fair Products, Inc.
125 W. Seventh Street
Wind Gap, PA 18091

Subject: OMRI Status Notification for O-TAC Plant Contact Agent® (fai-3376)

Dear Thomas,

The OMRI Review Panel has reviewed O-TAC Plant Contact Agent® (fai-3376) and determined that it is Prohibited for use in organic production because it does not comply with the *OMRI Policy and Standards Manual* which is based on the requirements of the USDA National Organic Program (NOP) Rule (7 CFR Part 205).

Specifically, the Review Panel determined that O-TAC Plant Contact Agent® is prohibited because the active ingredient is a synthetic material which does not appear on the National List at §205.601. As such it is not allowed for use in organic production.

You can petition the NOP to have the prohibited substance considered for use in organic production. For information on the petition procedure, see the NOP website. You may also choose to reformulate your product to remove any prohibited substances, and submit a new product application and fee to OMRI for review at any time.

Please be advised that the OMRI Listed® seal and wording can not be used for this product. Any unauthorized use of the OMRI Listed seal and name may result in legal action against the company that violates the OMRI Seal Use Policy. A list of prohibited products is periodically circulated to subscribing certifiers.

This letter serves as OMRI's final response regarding the status of this product. If you wish to rebut this decision, please refer to §5.2 of the *OMRI Policy and Standards Manual,* and ensure that the rebuttal is received within 30 days of the date of this notice. Please be advised that, in accordance with our policies, a notice of reformulation does not constitute a rebuttal.

Please contact me with any questions.

Sincerely,

Andria Schulze
Product Review Coordinator
(541)343-7600 x112
andrias@omri.org
PO Box 11558, Eugene, OR 97440-3758. Fax: (541) 343-8971

THE UNIVERSITY of WISCONSIN MADISON

August 30, 2012

Mr. Thomas B. Harding, Jr.
AgriSystems International
125 W. Seventh Street
Wind Gap, PA 18091

Re: Independent third-party review of O-TAC agent (AKA Mascol 80, fatty alcohol methyl esters)

This document outlines the production fatty alcohol methyl esters and the similarities with natural processing found in microbiological fermentation. The rationale is to show the chemical modifications, as outlined in the fatty alcohol methyl esters process, produce the same compounds as found in fermentation processes. Fermentation is considered by many agencies to be a natural process. Benefits of the fatty alcohol methyl esters process provide for more specific chemical specie, better yields, and with substantially less collateral waste as compared to fermentation.

In the strictest sense, any chemical modification could be considered synthetic. Even something as simple as leaving naturally occurring and extracted compounds exposed to air could produce oxides that would potentially change the function of the material. However, in this case, the reductive environment is more similar to processes found in nature than a true synthetic hydrogenation. One example is the instance of natural acidification through fermentation, for example, the production of an organic acid when another organic substrate is metabolized. These are chemical changes, yet, it is widely accepted that it is also a natural process. This results in one of the most simplest chemical modification reactions: the addition of ionic hydrogen (H+) to the organic acid (COO-) to produce the protonated form of the acid (COOH). Also, once these acids are produced, they are free to react with alcohols to form esters, thus producing many of the "fruity" favors we see with fermentation (wine, cheese, beer, etc). Another well-known product of fermentation is ethyl alcohol, as well as many other alcohols. Levels of ethanol produced by yeast can get as high as 20% as seen in some biofuel applications. Alcohol production in fermentation systems is used to shuttle and store electrons to extend as much as possible the oxidation requirements of the organism's metabolism.

The fatty alcohol methyl esters process outlined produce compounds that are found in nature and are also produced in large amounts within a fermentation process. However, fermentation may have low yields and thus the fatty alcohol methyl esters process employed uses modern chemistry to produce something that could be created by natural processes, but in a way that is more economical and potentially less impactful to the environment. It is also interesting to note in fermentation systems the lack of report relative to reduction of unsaturated double bonds on the fatty acids, which is in contrast to well known and well accepted synthetic position in the hydrogenation process used with margarine manufacture.

Department of Food Science
Babcock Hall University of Wisconsin–Madison 1605 Linden Drive Madison, Wisconsin 53706–1519
608/262–3046 Fax: 608/262–6872 http://www.wisc.edu/foodsci/

THE UNIVERSITY of WISCONSIN MADISON

There can be comparison of a fermentation process versus the fatty alcohol methyl esters process. Fermentation could be set up to produce free fatty acids from the plant-sourced triglycerides. Also, fermentation could also lower the oxygen content such to produce a very low oxidation-reduction potential, that is, favoring the reduction of oxygen containing compounds. This would promote the reduction of acid to the alcohol. Also, fermentation could produce methanol. The production of esters from acids and alcohols is very common in fermentation as well. The outlined fatty alcohol methyl esters process does not use fermentation, so the use of hydrogen provides for a reduced oxygen-limited environment. In biogas reactors (a specific type of fermentation), hydrogen is produced as well.

Fermentation systems have the benefit of bacterial enzymes that catalyze reactions. The benefit of using enzymes is that specific chemical modifications can be done at biological appropriate temperatures. The used of a catalyst in the fatty alcohol methyl esters process promotes the reduction of the acids, but does not get added or consumed into the chemical reaction. Just like fermentation uses moderate temperatures, the use of the catalyst in the fatty alcohol methyl esters process also allows lower temperatures to control better compounds produced. There is also only about 1 atmosphere of pressure used, just enough to help the efficiency, so again, mild conditions are employed when compared to other industries.

In conclusion, it is my opinion after reviewing the Mascol 80/fatty alcohol methyl esterification and reduction process flow, that this is more similar to a natural alcohol (green chemistry) process than a truly synthetic process.

Franco X. Milani

Franco X. Milani
Assistant Professor, Extension Food Manufacturing Specialist

Department of Food Science
University of Wisconsin-Madison
Madison, Wisconsin 53706
Tel: 608-8902640
Fax: 608-262-6872
Email: milani@wisc.edu

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James K Whitesell
Professor of Organic and Materials Chemistry
Tel: (858) 534-5870
Fax: (858) 534-0969
e-mail: jkw@ucsd.edu

University of California, San Diego
Department of Chemistry & Biochemistry
6100E Pacific Hall
9500 Gilman Drive, MC 0358
La Jolla, CA 92093-0358

November 15, 2011

Mr. Frank Grainger
Fair Products, Inc.
PO Box 386
Cary, NC 27512-0386

Dear Mr. Grainger:

I am responding to your request for an evaluation of the straight-chain alcohols that you use in formulating Fair O-Tac, a proprietary blend consisting of a mixture of eight- and ten-carbon straight-chain alcohols as active ingredients. I have examined the process used by Musim Mas to produce this mixture from naturally occurring triglycerides derived from natural sources. Musim Mas markets this mixture as MASCOL 80 and their process, known as the Davy processes and the alcohols produced using this technology should be considered as fully organic. Davy Technology acknowledges Musim Mas as a partner in this venture.

Briefly, the Davy process converts naturally occurring triglycerides (which are esters of glycerin) into methyl esters. These esters are then reduced with hydrogen and a catalyst to form the mixture of alcohols comprising MASCOL 80. The methanol introduced in the first stage us removed in the second (and recycled, that is, reused for the first stage). Nothing unnatural is introduced into the product alcohols during this process. All of the carbon, oxygen, and hydrogen present in the alcohols produced come from the starting, natural, triglycerides.

I should note that the production of fatty acid triglycerides by living systems produces mixtures that vary in composition not only from species to species (both plants and animals use these triglycerides for a variety of functions) but also vary with external conditions. For plants, these conditions include all of the normal growing variables including temperature, ambient light, etc. Thus, it is perfectly understandable that MASCOL 80 will vary in the precise percentage composition of the component alcohols from batch to batch. This variation should in no way altar the effect of Fair OTac as a contact sucker control agent for tobacco. The function of these alcohols in sucker control stems from a molecular structure with two parts: fat soluble (the hydrocarbon chain); and water soluble (the alcohol end of the chain). The ratio is relatively unimportant. Indeed, this variation in composition implies that the alcohols were derived from natural sources.

I hope that I have provided the clarification that you need. Please feel free to call on me in the future.

James K. Whitesell

ISO, GMP, RSPO, and Other Certifications

PT. MUSIM MAS

Head Office: Jl. K.L. Yos Sudarso Km. 7,8
Tanjung Mulia - Medan 20241
Sumatera Utara - Indonesia
Tel: (62-61) 6615511 - 6619866
Fax: (62-61) 6613060 - 6617386

Factory: Jl. Oleo, Kawasan Industri Medan II
Saentis - Percut Sei Tuan, Deli Serdang
Medan 20371 - Indonesia
Tel: (62-61) 6871123
Fax: (62-61) 6871152 - 6871153
Email: oleo@musimmas.com

Date: 15th January 2014
without prejudice

To Whom It May Concern:

Re: GMO Free Statement Letter

Based on our knowledge of the production methods and product formulation, fatty alcohol manufactured by PT. Musim Mas is free from GMO.

Certified by:
PT. Musim Mas

Eng BK
QA Manager

Approved by:

Wong FG
Sr. GM - Oleochemicals

CERTIFICATE
RSPO SCCS

CERTIFICATE CODE: CU-RSPO SCCS-816551

Based on an audit according to the regulations stated in the RSPO Supply Chain Certification Systems, version November 2011 and a signed contract, Control Union Certifications herewith certifies that the facility(s) listed below are found to be in compliance with the RSPO Supply Chain Certification Systems, version November 2011. This guarantees that the criteria for processing RSPO certified sustainable palm oil and palm kernel oil through one or more of the supply chain models as stated in the RSPO Supply Chain Certification Systems have been met.

Certificate holder information

Company Name:	**PT. Musim Mas - KIM 2**
RSPO member number:	
Company Address:	Jl. K.L. Yos Sudarso Km.7,8, Tanjung Mulia, Medan Deli, Medan, Sumatera Utara-20241, Indonesia
Contact manager*:	Mr. K.C Chia
Contact Email:	kcchia@musimmas.com
RSPO registered parent company of which the certificate holder is a subsidiary (If applicable):	
Company name:	**PT. Musim Mas**
RSPO member number:	**201411000000**

** Contact details of management representative responsible for overseeing the certification process*

Validity of certificate starts: **09/12/2012**
Validity of certificate ends: **08/12/2017**
Date of first RSPO certification: **09/12/2010**

Issued by Control Union Certifications.
Meeuwenlaan 4-6, P.O. Box 161, 8000 AD Zwolle, The Netherlands.
Tel: 0031 (0) 38 426 01 00.

Certifier: Markus Fertig
Date: 04/12/2012

Certificate no: C816551CU-RSPO SCCS-01.2012

Signature of certifier:
On behalf of the Managing Director.

Control Union Certifications is accredited for ISO/IEC Guide 65:1996
Approved by the RSPO for RSPO SCCS on 03/06/2010

Control Union Certifications
Member of Control Union World Group

RSPO
Roundtable on Sustainable Palm Oil

Annex 1 to Certificate – RSPO SCCS

CERTIFICATE CODE: CU-RSPO SCCS- 816551

Control Union Certifications has performed an inspection assigned by:

Company Name:	**PT. Musim Mas - KIM 2**
RSPO member number:	
Company Address:	Jl. K.L. Yos Sudarso Km.7,8, Tanjung Mulia, Medan Deli, Medan, Sumatera Utara-20241, Indonesia
Contact manager:	Mr. K.C Chia
Contact Email:	kcchia@musimmas.com
RSPO registered parent company of which the certificate holder is a subsidiary (If applicable):	
Company name:	**PT. Musim Mas**
RSPO member number:	**201411000000**

Certificate information

CU code:	Name of facility:	Location address:	Supply chain model *
REF 1	PT. Musim Mas KIM 2	Jalan Oleo, Kawasan Industria Medan 2, Saentis Percut, Sei Tuan Deli Serdang, 20371 MedanSumatera Utara, Indonesia	☒ IP, ☒ SG, ☒ MB

** Select applicable box(es)*

Summary report, including brief description of the scope of assessment
Purchase of certified Crude Palm Oil and Crude Palm Kernel Oil, Refine, Process, Fractionate and Sales of RSPO Certified palm oil (CPO) and Palm Kernel oil (CPKO) through Identity Preserved, Segregation and Mass Balance supply chain model and processing into certified CPOL, CPST, CPKOL, CPKST, RBDPO, RBDOL, Double Fractionate Olein, Palm Mid Fractionate, RBDST, Palm Mid Stearin, Double Fractionate Stearin, PFAD, RBDPKO and PKFAD, RBDPKOL, RBDPKST, Glycerine and Fatty Acids, Soap noodles, Finished Soap Bars, Amides, Esters, Fatty Alcohols and Methyl Esters.

This certificate including the annex remains the property of Control Union Certifications and can be withdrawn in case of terminations as mentioned in the licensee contract, or in case changes or deviations of the above mentioned data occur. The licensee is obliged to inform CUC immediately of any changes in the above mentioned data. Only an original and signed certificate is valid.

Authenticated by:

Certifier: Markus Fertig

Date: 04/12/2012
Certificate no: C816551CU-RSPO SCCS-01.2012

Signature of certifier:
On behalf of the Managing Director.

Control Union Certifications
Member of Control Union World Group

RSPO
Roundtable on Sustainable Palm Oil

בס"ד

KOSHER CERTIFICATE

KOSHER CERTIFICATION
Rabbi Don Yoel Levy
Kashruth Administrator

KC# 3281991 - 1
28 Adar I, 5774
February 28, 2014

P.T. MUSIM MAS (OLEOCHEMICAL DIVISION)
JL. OLEO, KAWASAN INDUSTRI MEDAN II
MEDAN 20001, NORTH SUMATRA (INDONESIA)
PHONE: 011-62-61-661-9866
FAX: 011-62-61-661-7386

The following products sold by PT. Musim Mas (Oleochemical Division) are certified Kosher with the listed restrictions.

Name	K-ID	Status		Restriction	Size
Mascol 80	BLV-BWSM	Pareve	Passover	Ⓚ P SYMBOL	

This certificate is VALID UNTIL February 28, 2015

Verify authenticity by entering K-ID at www.digitalkosher.com

Powered by: K-ID DIGITALKOSHER.COM

RABBI DON YOEL LEVY, Kashruth Administrator

391 Troy Avenue, Brooklyn, New York 11213 U.S.A. • Tel: 718 756-7500 Fax: 718-756-7503 • E-Mail: info@ok.org

Certificate MY05/0005

The management system of

PT Musim Mas

Jalan Oleo, Kawasan Industri Medan II
Saentis-Percut Sei Tuan
Deli Serdang – 20371, Medan
INDONESIA

has been assessed and certified as meeting the requirements of

GMP Codex Alimentarius

Recommended International Code of Practice
General Principles of Food Hygiene - CAC/RCP-1-1969, Rev. 4(2003)

For the following activities

Manufacturing of Oleochemicals Products such as Fatty Acids, Glycerine, Soap Noodles, Soap Bars, Amides, Esters, Fatty Alcohols and Methylesters

Further clarifications regarding the scope of this certificate and the applicability of GMP requirements may be obtained by consulting the organisation

This certificate is valid from 22 August 2011 until 21 August 2014 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 21 July 2014
Issue 5. Certified since 10 August 2005

Authorised by

SGS (Malaysia) Sdn Bhd, Systems & Services Certification
Unit 10-1, 10th Floor, Bangunan Malaysian RE, No. 17, Lorong Dungun
Damansara Heights, 50490 Kuala Lumpur, MALAYSIA
t 603 – 2095 9200 f 603 – 2093 8202 www.sgs.com

CERTIFICATE OF ACCREDITATION

LP-668-IDN

Date of issue : 23 November 2012

Date of expiry : 22 November 2016

Granted to

ANALYTICAL LABORATORY OF OLEOCHEMICALS AND SPECIALTY FATS PT. MUSIM MAS

at

Jl. Oleo Kawasan Industri Medan II Saentis, Percut, Sei Tuan Deli Serdang, Medan 20371

Which has shown its competence as

TESTING LABORATORY

by implementing consistently

SNI ISO/IEC 17025:2008 (ISO/IEC 17025:2005)
General requirements for the competence of testing and calibration laboratories

for the scope of accreditation as specified in the annex

KOMITE AKREDITASI NASIONAL

Prof. Dr. BAMBANG PRASETYA

CHAIRMAN

Certificate SG12/03970

The management system of

PT MUSIM MAS

KIM I: JL. Pulau Palu, Kawasan Industri Medan 1
Mabar, Medan 20252, Sumatera Utara
INDONESIA

has been assessed and certified as meeting the requirements of

ISO 14001:2004

For the following activities

The scope of registration appears on page 2 of this certificate.

This certificate is valid from 28 May 2012 until 27 May 2015 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 15 March 2015
Issue 1. Certified since 28 May 2012

This is a multi-site certification.
Additional site details are listed on the subsequent page.

Authorised by

SGS United Kingdom Ltd Systems & Services Certification
Rossmore Business Park Ellesmere Port Cheshire CH65 3EN UK
t +44 (0)151 350-6666 f +44 (0)151 350-6600 www.sgs.com

UKAS MANAGEMENT SYSTEMS
005

SGS EMS 04 0311 M2

PT MUSIM MAS

ISO 14001:2004

Issue 1

Detailed scope

- KIM I – Production, Storage & Delivery of CPKO & PKE.
- KIM II – Manufacturing of Oleochemicals (such as Fatty Acids, Glycerine, Soap Noodles, Soap Bars, Amides, Esters, Fatty Alcohols, Methyl Esters), Specialty Fats and Vegetable Oil Products.
- Belawan – Production of Refined Oils from CPO & CPKO, Storage & Delivery of Refined Oils & Oleochemicals.

Additional facilities

KIM II: JL. Oleo, Kawasan Industri Medan II, Saentis – Percut Sei Tuan, Deli Serdang Medan 20371 INDONESIA

JL. Pulau Nias Selatan, Kawasan Industri Medan II, Saentis – Percut Sei Tuan, Deli Serdang Medan 20371 INDONESIA

Belawan : JL. Sulawesi II, Kawasan Pelabuhan Ujung Baru Belawan Belawan I – Medan 20411 INDONESIA

UKAS MANAGEMENT SYSTEMS 005

Certificate MY12/00932

The management system of

PT MUSIM MAS

KIM 1: JL. Pulau Palu, Kawasan Industri Medan 1
Mabar, Medan 20252, Sumatera Utara
INDONESIA

has been assessed and certified as meeting the requirements of

OHSAS 18001:2007

Occupational Safety and Health Management Systems

For the following activities

The scope of registration appears on page 2 of this certificate.

Further clarifications regarding the scope of this certificate and the applicability of OHSAS 18001:2007 requirements may be obtained by consulting the organization

This certificate is valid from 28 May 2012 until 27 May 2015 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 15 March 2015
Issue 1. Certified since 28 May 2012

This is a multi-site certification
Additional site details are listed on the subsequent page

Authorised by

SGS (Malaysia) Sdn Bhd Systems & Services Certification
Unit 10-1, 10th Floor, Bangunan Malaysian RE, No. 17, Lorong Dungun
Damansara Heights, 50490 Kuala Lumpur, MALAYSIA
t 603 – 2095 9200 f 603 – 2093 8202 www.sgs.com

PT MUSIM MAS

OHSAS 18001:2007

Issue 1

Detailed scope

- KIM I – Production, Storage & Delivery of CPKO & PKE.
- KIM II – Manufacturing of Oleochemicals (such as Fatty Acids, Glycerine, Soap Noodles, Soap Bars, Amides, Esters, Fatty Alcohols, Methyl Esters), Specialty Fats and Vegetable Oil Products.
- Belawan – Production of Refined Oils from CPO & CPKO, Storage & Delivery of Refined Oils & Oleochemicals.

Further clarifications regarding the scope of this certificate and the applicability of OHSAS 18001:2007 requirements may be obtained by consulting the organization

Additional facilities

KIM II: Jl. Cleo, Kawasan Industri Medan II, Saentis – Percut Sei Tuan, Deli Serdang Medan 20371 INDONESIA

Jl. Pulau Nias Selatan, Kawasan Industri Medan II, Saentis – Percut Sei Tuan, Deli Serdang Medan 20371 INDONESIA

Belawan : Jl. Sulawesi II, Kawasan Pelabuhan Ujung Baru Belawan Belawan I – Medan 20411 INDONESIA

Certificate SG04/00044

The management system of

PT Musim Mas

Jalan Oleo, Kawasan Industri Medan II
Saentis-Percut Sei Tuan, Deli Serdang - 20371, Medan
INDONESIA

has been assessed and certified as meeting the requirements of

ISO 9001:2008

For the following activities

1) Manufacturing of Oleochemical Products such as Fatty Acids, Glycerine, Soap Noodles, Soap Bars, Amides, MCT & Alcohol Esters, Fatty Alcohols & Methylesters

2) Manufacturing of Specialty Fats and Vegetable Oil Products by one or more of the following process: Physical Refining, Fractionation, Neutralization, Hydrogenation, Blending, Texturing, Interesterification, Distillation, Spray Drying, Spray Cooling, Packaging & Storage

Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2008 requirements may be obtained by consulting the organisation

This certificate is valid from 19 July 2013 until 17 June 2016 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 17 May 2016
Issue 9, Certified since 18 June 2004

Authorised by

SGS United Kingdom Ltd Systems & Services Certification
Rossmore Business Park Ellesmere Port Cheshire CH65 3EN UK
t +44 (0)151 350-6666 f +44 (0)151 350-6600 www.sgs.com

SGS 9001-8 01 0311

EPA, FDA, EAFUS and State Authorities

SPEC. SHEETS, LABELS, & MSDS FORMS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES, AND
TOXIC SUBSTANCES

June 30, 2006

MEMORANDUM

SUBJECT: **Aliphatic Alcohols:** Human Health Chapter of the Reregistration Eligibility Decision (RED) Document. Reregistration Case Number 4004.

DP Barcode: 325712
PC Codes: 079029, 079038, 079059

Regulatory Action: Reregistration Action
Risk Assessment Type: Multiple chemical/no aggregate

FROM: Elissa Reaves, Ph.D., Toxicologist/Risk Assessor
Reregistration Branch 2 (RRB2)
Health Effects Division (7509P)

AND

Shanna Recore, Occupational/Residential Exposure
Yvonne Barnes, Product Chemistry
Reregistration Branch 2 (RRB2)
Health Effects Division (7509P)

Through: William Hazel, Ph.D., Branch Chief
Reregistration Branch 2 (RRB2)
Health Effects Division (7509P)

AND

Alan Nielsen, Senior Scientist
Reregistration Branch 2 (RRB2)
Health Effects Division (7509P)

TO: Tawanda Spears, Chemical Review Manager
Reregistration Branch 3
Special Review and Registration Division (7508P)

1. Executive Summary

This document represents the human health risk assessment chapter of the Reregistration Eligibility Decision (RED) document for the aliphatic alcohols, which include N-decanol, Cx-Cxx alcohols, and fatty alcohols. Aliphatic alcohols are contact sucker control agents used primarily on tobacco. There are no tolerances or tolerance exemptions established for residues of aliphatic alcohols on food.

It should also be noted that the one active product (EPA Reg. No. 53263-29) for the fatty alcohols has recently been voluntarily canceled (Anastasiou Memo, 6/7/06). Therefore, there are no supported products for the active ingredient use of the fatty alcohols. Based on the supported tobacco use, there are no residential uses for the aliphatic alcohols. In addition, the pesticidal uses of the aliphatic alcohols do not involve use on food and, therefore, **are not subject to the Food Quality Protection Act (1996).**

The available acute toxicity studies indicate the aliphatic alcohols are of low oral and dermal toxicity. Acute inhalation studies with the rat resulted in LD_{50} estimates above the limit concentration of 2 mg/L. Eye irritation studies, however, resulted in severe and sometimes non-reversible eye irritation. Dermal irritation studies revealed slight to moderate irritation in rabbits. The aliphatic alcohols generally did not produce sensitization in tests with guinea pigs.

A 90-day dermal rat study (fatty alcohol blend) resulted in irritation at lower concentrations and before the development of any marginal systemic effects. Slight changes in hematology, clinical chemistry, and organ weights were noted at the limit dose of 1000 mg/kg/day. Severe irritation including fissuring of the skin occurred in 40% of the animals at 100 mg/kg/day and in 80% of the animals at the limit dose. Available developmental toxicity studies (rat) via the inhalation (1-decanol) and oral (fatty alcohol blend) routes of exposure resulted in no adverse effects when examined at the maximum attainable vapor concentration (100 mg/m^3) and oral limit dose (1000 mg/kg/day) based on fetal and maternal parameters. Genotoxicity and mutagenicity studies available were negative and long-term rodent studies to inform the carcinogenic potential of the aliphatic alcohols are not available. However, as a class, the straight chain aliphatic alcohols are generally not carcinogenic. Neurotoxicity information is currently not available, however, there were no clinical signs in any of the acute, subchronic, or developmental toxicity studies to suggest the aliphatic alcohols elicit a neurotoxic effect. Currently there is insufficient hazard concern to warrant a dose-response evaluation or endpoint selection for quantitative risk estimates. Therefore, no acute or chronic endpoints have been identified.

An exposure assessment considers the different pathways (food, water, occupational, and residential) through which exposure to the aliphatic alcohols may occur. Oral exposure through food is not expected since the aliphatic alcohols have no food uses and there are no residential uses. Drinking water is not of concern due to: a) the high vapor pressure and likely volatilization in air; b) atmospheric degradation by reaction with photochemically produced hydroxyl radicals; c) lack of hazard for the oral route of

exposure; and d) lack of systemic endpoints based on the available studies. Acute and chronic dietary endpoints have not been selected. Therefore, based on the low hazard concern, lack of food uses, along with no quantitative toxicological endpoints, **a dietary (food and water) risk assessment is not required.**

Since a quantitative dermal endpoint was not identified, no quantitative post application dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) must be established. The REI should be based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational handler exposure of aliphatic alcohols-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use of Personal Protective Equipment (PPE). Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Based on the lack of food and residential uses and low hazard via the oral, dermal, and inhalation routes of exposure, **quantitative dietary (food and water) and occupational/residential exposure assessments have not been conducted.** Additionally, the aliphatic alcohols are 'non-food use' chemicals and are not subject to the amendments to the Federal Food, Drug, and Cosmetic Act (FFDCA) promulgated under the Food Quality Protection Act (FQPA) of 1996, and **an aggregate risk assessment is not required.**

2. Introduction

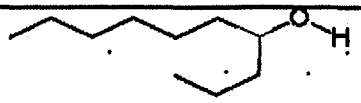
a. Scope of Risk Assessment

This risk assessment evaluates the aliphatic alcohols that are comprised of decanol, alcohols Cx-Cxx, and fatty alcohols. Because of the low hazard concern of the aliphatic alcohols, no toxicological endpoints have been selected for dietary or exposure risk assessment purposes.

b. Ingredient Profile

The review of the product chemistry for the aliphatic alcohols was not based on a single chemical or pc code but rather based on the collective nature of the aliphatic alcohols.

i. Structure and Nomenclature

Table 1 Nomenclature for Aliphatic Alcohols		
Chemical structure	 n-Decyl Alcohol	
Common name	Simple Aliphatic Alcohol: Ethanol	1-Decanol
Molecular formula	C_2H_5OH	CH3(CH2)9—OH
Molecular weight	46.068 g/mol	158.29 g/mol
IUPAC name (denotation)	InChI=1/C2H6O/c1-2-3/h3H,2H2,1H3	Not Reported
CAS name	Ethyl Alcohol	n-Decyl Alcohol
CAS number	64-17-5	112-30-1
PC Code	001501	079038

ii. Physical and Chemical Properties

Table 2. Physicochemical Properties Aliphatic Alcohols		
Parameter	Simple Aliphatic Alcohol Value/Reference	Aliphatic Alcohol : 1-Deconol Value/Reference
Melting point/range	-114.1 to -117 degrees Celsius Merck 12th Edition; MSDS	6.9 degrees Celsius MSDS
Vapor Density at 20 degrees Celsius	1.59 ChemFinder	4.5 MSDS
Water solubility	Fully miscible; >=10 g/100 mL at 23 °C Riddick, J.A. et al. (1996); ChemFinder	37 mg/L ; Insoluble; poor Barton, AFM (1984)
Solvent solubility at: 20 degrees Celsius	Organic solids of low molecular weight are usually soluble in ethanol. --Among ionic compounds, many mono-valent salts are at least somewhat soluble in ethanol, with salts of large, polarizable ions being more soluble than salts of smaller ions. -- Most salts of polyvalent ions are practically insoluble in ethanol. 1) Vaija, et al., *Appl. Biochem. Biotechnol.*, 7, 51, 1982. 2) J. M. Lee and J. Woodward, *Biotech. Bioeng.*, 25, 2441, 1983. 3) Encyclopedia	Not reported
Vapor pressure	40 mmHg at 19°C 44 mmHg at 20°C 59.3 mmHg at 25°C Daubert, TE & Danner, RP (1985); MSDS	0.00851 mmHg at 25°C Daubert, TE & Danner, RP (1989)
	15.9 (H^+ from OH group)	Not reported

Table 2. Physicochemical Properties Aliphatic Alcohols		
Parameter	Simple Aliphatic Alcohol Value/Reference	Aliphatic Alcohol : 1-Deconol Value/Reference
Dissociation constant, pK_a	Hansch, c et al. (1995)	
Octanol/water partition coefficient	Log K_{ow} Log P = -0.14 Hansch, c et al. (1995)	Log K_{ow} Log P = 3.79 Hansch, c et al. (1995)
UV/visible absorption spectrum	Data Gap	Data Gap

Refer to http://www.epa.gov/athens/research/regsupport/properties.html for further details relating to physical and chemical chemistry

c. Summary of Pesticidal Uses

All three chemicals that comprise the reregistration case for the aliphatic alcohols serve as plant regulators. N-Decanol, alcohols (Cx-Cxx), and fatty alcohols are formulated as liquids and are applied via the following methods: groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands.

d. Tolerances

i. Established Tolerances & Tolerance Exemptions

As the aliphatic alcohols are not registered for use on food crops, there are no tolerances established for residues on food. Similarly, there are currently no tolerance exemptions for the aliphatic alcohols.

3. Hazard Characterization and Assessment

The available toxicity database for the aliphatic alcohols consists of acute toxicity, irritation, and sensitization studies. In addition, there are developmental rat (oral and inhalation) toxicity studies and a 90-day rat (dermal) study. Mutagenicity studies available include the Ames, micronucleus, and gene mutation assays. Sources from the published literature are also included in this hazard assessment. The combination of the published literature and submitted toxicity studies are sufficient to assess the pesticidal nonfood uses of the aliphatic alcohols. Based on the low hazard concern via the oral, dermal, and inhalation routes of exposure, a qualitative hazard assessment is appropriate for the aliphatic alcohols.

1-Decanol has been found as a natural component in apples and oranges and has been reported in essential oils of ambrette seeds, almond flowers, citrus oils and fermented beverages (as cited in HSDB, 2005). 1-Decanol is also a permitted food additive for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the following FDA conditions: 1) the quantity added to food does not exceed the amount reasonably required to accomplish its intended physical, nutritive, or other technical effect in food, and 2) when intended for use in or on food it is of appropriate food grade and is prepared and handled as a food ingredient (21 CFR

172.515). There is currently no known mode of action for the aliphatic alcohols. There are currently no guideline metabolism studies in rats available for the aliphatic alcohols.

The acute toxicity studies available for all three of the aliphatic alcohols (PC Codes 079038, 079029, 079059) are listed in Table A1. The available acute toxicity studies indicate the aliphatic alcohols are of low oral and dermal toxicity (Toxicity Categories III and IV). Acute inhalation studies with the rat resulted in LD_{50} estimates above the limit concentration of 2 mg/L. However, eye irritation studies resulted in severe and sometimes non-reversible eye irritation (Toxicity Category I, II, and III). Dermal irritation studies revealed slight to moderate irritation in rabbits (Toxicity Category III and IV). The aliphatic alcohols generally did not produce sensitization in tests with guinea pigs.

Oral subchronic toxicity studies are not available for the aliphatic alcohols. However, a 90-day dermal toxicity study in the rat is available (MRID 43701201). Results of the dermal exposure to a fatty alcohol blend (56.7% decanol, 42.7% octanol) at 0, 100, 300, or 1000 mg/kg for 5 days/week for 13 weeks included erythema, edema, desquamation, eschar formation and exfoliation of all treated animals. The irritation occurred early (within two weeks of the application process) with irritation apparent in a dose-response fashion. Fissuring of the skin occurred in 40% of animals at 100 mg/kg/day while in 80% of animals at the limit dose of 1000 mg/kg/day. Decreased body weight was also observed at the limit dose (-19% M, -13% F). Slight changes in hematological parameters, clinical chemistry, and organ weight changes were apparent at the limit dose. No other gross or histopathological organ pathology was associated with the skin application of the fatty alcohol blend. The dermal irritation NOAEL was not established with an irritation LOAEL of 100 mg/kg based on severe irritation. The systemic NOAEL was 300 mg/kg/day with systemic LOAEL of 1000 mg/kg/day, based on hematological, clinical chemistry, and organ weight changes.

Developmental toxicity studies via the inhalation (1-decanol) and oral (fatty alcohol blend) routes of exposure resulted in no adverse effects based on fetal and maternal parameters. A developmental inhalation study exposed Sprague-Dawley rats (15) to 15 ppm (100 mg/m^3) 1-decanol for 7 hours per day on GD 1-19 (Nelson *et al.*, 1990a; Nelson *et al.*, 1990b). The concentration of 1-decanol selected was based on the highest concentration that could be generated as a vapor at an average daily chamber temperature of 70-80°F. No treatment-related effects were observed in pregnant females or fetuses including frequency of resorptions, fetal weights, or skeletal/visceral malformations. An oral developmental study exposed 25 female Sprague-Dawley rats/dose at 0, 125, 375, or 1000 mg/kg/day to a fatty alcohol blend (55% decanol; 40.7% octanol) on GD 6-16 (MRID 42609301). The maternal NOAEL was 375 mg/kg/day and LOAEL was 1000 mg/kg/day (limit dose), based on increased incidence of salivation (67%). No adverse effects were observed in the offspring. The developmental NOAEL was 1000 mg/kg/day (HDT) with no LOAEL being established.

Genotoxicity and mutagenicity studies available were negative for reverse gene mutations in *Salmonella typhimurium*, not mutagenic in 2 independent assays with/without

activation at levels ranging from 9.4 μg/ml to 37.5 μg/ml, and negative for micronucleus induction in bone marrow cells of male and female CD-1 mice harvested 24 or 48 hrs post-administration of 3 daily doses of 500, 1000, or 2000 mg/kg/day. There is currently no long-term rodent information regarding the carcinogenic potential for the aliphatic alcohols.

Neurotoxicity information is currently not available. However, there were no clinical signs in any of the acute, subchronic, or developmental toxicity studies to suggest the aliphatic alcohols elicit a neurotoxic effect.

4. Endpoint Selection

Based on the available data, there is no evidence to suggest that the aliphatic alcohols cause increased susceptibility in infants and children. Furthermore, based on the low hazard concern from the available studies, **no endpoints of toxicological concern have been identified for risk assessment purposes.**

5. Incident Report

Although a summary of the incident data for the aliphatic alcohols is currently not available for inclusion in this assessment, it should be noted that the aliphatic alcohols are scheduled to be reviewed. The Agency will consider the results of the incident review once the evaluation is available.

6. Exposure Assessment

a. Dietary Exposure (food and drinking water)

An exposure assessment considers the different pathways (food, water, occupational, and residential) through which exposure to the aliphatic alcohols may occur. Drinking water is not of concern due to: a) the high vapor pressure and likely volatilization in air; b) atmospheric degradation by reaction with photochemically produced hydroxyl radicals (HSDB, 2005); c) lack of hazard for the oral route of exposure; and d) lack of systemic endpoints based on the available studies. Acute and chronic dietary endpoints have not been selected. Therefore, based on the lack of food uses and the low hazard concern of the aliphatic alcohols along with no acute or chronic dietary endpoints being identified, **a dietary (food and water) risk assessment is not appropriate.**

b. Occupational and Residential Exposure

Aliphatic alcohols are contact sucker control agents used primarily on tobacco [N-decanol, alcohols (Cx-Cxx), fatty alcohols]. Currently there are no residential uses for the aliphatic alcohols. There is potential for exposure of occupational mixers, loaders, applicators, and post-application workers to aliphatic alcohol formulations. However, due to the low hazard concern of the aliphatic alcohols, no dermal, oral, or inhalation

endpoints of toxicological concern have been identified for the aliphatic alcohols. Therefore, an **occupational/residential exposure assessment is not required.**

N-Decanol, alcohols (Cx-Cxx), and fatty alcohols are formulated as liquids and are applied via the following methods: groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands.

Available dermal studies indicate that aliphatic alcohols are acutely irritating with any possible stress related changes systemically occurring at higher concentrations and over repeated dermal exposure. Mammals are, therefore, more sensitive to irritation than to any systemic effects and so dermal exposure should be avoided. Available inhalation toxicity studies indicate that aliphatic alcohols are of low toxicity via the inhalation route.

Due to the low hazard profile and lack of endpoint selection for the dermal route of exposure, no postapplication dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) must be established. The REI should be based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational uses of aliphatic alcohol-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use of Personal Protective Equipment (PPE). Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Table 3. Summary of Maximum Application Rates for Registered Aliphatic Alcohol Products

Chemical	Crop	Target	Formulation	Maximum Application Rate	Max # of applications	Application Equipment
N-Decanol	Tobacco	foliar	EC	21.5 lbs ai/acre for hand sprayer 18.9 lbs ai/acre for groundboom	2	groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands
Alcohols (Cx-Cxx)	Tobacco	foliar	Liquid (EC,SC)	21.7 lbs ai/acre	3	
Fatty Alcohols	Tobacco	foliar	EC	14.19 lbs ai/acre	2	

7. Cumulative Exposure

As the aliphatic alcohols are not registered for use on food crops, the requirements of FQPA are not applicable and a cumulative risk assessment is not appropriate.

8. Summary

1-Decanol has been found as a natural component in apples and oranges and has been reported in essential oils of ambrette seeds, almond flowers, citrus oils and fermented beverages. 1-Decanol is also a permitted food additive for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the FDA . Aliphatic alcohols are contact sucker control agents used primarily on tobacco [N-decanol, alcohols (Cx-Cxx), fatty alcohols]. Currently there are no residential uses for the aliphatic alcohols.

There is potential for exposure of occupational mixers, loaders, and applicators to aliphatic alcohol formulations. However, endpoint selection was not warranted based on the available toxicity data. Therefore, occupational handler risk assessments cannot be conducted and are not appropriate for the aliphatic alcohols.

Based on the hazard profile for dermal exposure to aliphatic alcohols, no post-application dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) must be established. The REI should be based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational uses of aliphatic alcohol-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use of PPE. Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Due to the toxicity profile of the aliphatic alcohols, toxicological endpoints of concern were not warranted for risk assessment purposes. **Quantitative dietary (food and water) and occupational/residential exposure assessments, therefore, have not been conducted.** Additionally, as the aliphatic alcohols are 'nonfood use' chemicals and are not subject to FQPA, **an aggregate risk assessment is not required.**

Appendix 1: Toxicological Profile Tables for the Aliphatic Alcohols

Table A1: Acute Toxicity Data for the Aliphatic Alcohols

Guideline No.	Study Type	PC Code	MRID	Results	Toxicity Category
870.1100 81-1	Acute oral [rat]	079029 Fatty Alcohols	00142279	85% fatty alcohols, LD50 = 29.3 mg/ml (95% CI of 26.5 to 32.5) (approximately 25 g/kg)	IV

Table A1: Acute Toxicity Data for the Aliphatic Alcohols					
870.1100 81-1	Acute oral [rat]	079038 1-Decanol	44460401	79.2% decanol No deaths at 2000 mg/kg LD50>2000mg/kg	III
870.1100 81-1	Acute oral [rat]	079038 1-Decanol	46004601	79% decanol No deaths at 2000 mg/kg LD50>2000 mg/kg	III
870.1100 81-1	Acute oral [rat]	079038 1-Decanol	45507901	37.98% decanol No deaths LD50>3000 mg/kg	III
870.1100 81-1	Acute oral [rat]	079038 1-Decanol	0060309 0064859	78.4% decanol, LD50 = 5000 mg/kg	IV
870.1200 81-2	Acute dermal [rat]	079038 1-Decanol	44460402	79.2% decanol No systemic clinical signs, no deaths, very slight erythema at 2000 and 4000 mg/kg LD50>4000 mg/kg	III
870.1200 81-2	Acute dermal [rat]	079038 1-Decanol	46004602	79% decanol No deaths, no systemic clinical signs, LD50> 2000 mg/kg	III
870.1200 81-2	Acute dermal [rat]	079038 1-Decanol	45507902	37.98% decanol No deaths, no clinical signs LD50>4000 mg/kg	III
870.1200 81-2	Acute dermal [rabbit]	079038 1-Decanol	0046993 0046994	78.4% decanol, LD50 = 5000 mg/kg	IV
870.1300 81-3	Acute inhalation [rat]	079038 1-Decanol	44460403	79.2% decanol (4 hr nose only) 1 male died Day 2 post-exposure, survivors recovered from 7 to 10 post-exposure LC50>5.07 mg/L.	IV
870.1300 81-3	Acute inhalation [rat]	079038 1-Decanol	46004603	79% decanol No deaths. LC50>3.35 mg/L	IV
870.1300 81-3	Acute inhalation [rat]	079038 1-Decanol	45517901	37.98% decanol (4 hr nose only) No deaths LC50>7.08 mg/L	IV
870.2400 81-4	Acute eye irritation [rabbit]	079038 1-Decanol	44460404 44578801	79.2% decanol Corneal opacity in all treated eye at 7 days. Conjunctive irritation until 7 and 14 days. Irreversible vascularisation in one eye until Day 21.	I

Table A1: Acute Toxicity Data for the Aliphatic Alcohols					
870.2400 81-4	Acute eye irritation [rabbit]	079038 1-Decanol	46004604	79% decanol Corneal opacity, irritation cleared by 6 days. Conjunctive irritation, redness, chemosis cleared by 6 days. Moderately irritating.	III
870.2400 81-4	Acute eye irritation [rabbit]	079038 1-Decanol	45517902	37.98% decanol Corneal involvement or irritation clearing in 7 days or less	III
870.2400 81-4	Acute eye irritation [rabbit]	079029 Fatty Alcohols	44340701	100% fatty alcohols, All 6 rabbits showed moderate to severe irritation. Opacity up to 7 days. Slight iritis with conjunctival redness to Day 6, slight chemosis to Day 7 and slight to severe discharge to Day 8.	II-III
870.2400 81-4	Acute eye irritation [rabbit]	079038 1-Decanol	--	78.4% decanol, irreversible corneal opacity in all 6 animals. Severe eye irritation.	I
870.2500. 81-5	Acute dermal irritation [rabbit]	079038 1-Decanol	44407601 44460405	79.2% decanol Primary irritation index 4.0. Moderate irritation.	III
870.2500. 81-5	Acute dermal irritation [rabbit]	079038 1-Decanol	46004605	79% decanol Primary irritation index 0.0	IV
870.2500. 81-5	Acute dermal irritation [rabbit]	079038 1-Decanol	45517903	37.98% decanol Primary irritation index 0.0. Non-irritant.	IV
870.2500. 81-5	Acute dermal irritation [rabbit]	079038 1-Decanol	--	PIS 2.04. Erythema, eschar formation and edema evident at 72 hrs. Mild irritant.	III
870.2600 81-6	Skin sensitization [guinea pig]	079029 Fatty Alcohols	43386201	Fatty alcohol blend C6-C12 (99%) All animals survived. No adverse effect on body weight. Not a dermal sensitizer	NA
870.2600 81-6	Skin sensitization [guinea pig]	079038 1-Decanol	44407602 44460406	79.2% decanol No change in body weight. 55% (11/20) sensitization rate.	NA

Table A1: Acute Toxicity Data for the Aliphatic Alcohols					
870.2600 81-6	Skin sensitization [guinea pig]	079038 1-Decanol	46004606	79% decanol Not a dermal sensitizer	NA
870.2600 81-6	Skin sensitization [guinea pig]	079038 1-Decanol	45507903	37.98% decanol Not a dermal sensitizer	NA

Table A2: Subchronic, Chronic, Developmental, Reproductive and Other Toxicity Profile on the Fatty Alcohols		
Guideline#/ Study Type	**MRID# (year)/ Classification /Doses**	**Results**
870.3250 82-3 90-Day dermal toxicity	43701201 (1995) Acceptable/Guideline 10 Sprague-Dawley rats/sex/dose of 0, 100, 300, or 1000 mg/kg for 5 days/week for 13 weeks	Fatty alcohol blend (56.7% decanol, 42.7% octanol) Primary adverse clinical signs included erythema, edema, desquamation, eschar formation and exfoliation of all treated animals. Irritation apparent within 2 weeks after dermal application. Fissuring of skin observed in 40% of animals in low dose while 80% of animals in high dose. High doses animals exhibited vocalization and hypersensitivity to touch. Body weight was reduced in high dose (-19% M, -13% F) animals. Marginally increased adrenal glands in high-dose animals, slightly reduced RBC counts, hematocrit, and increased WBC and platelet counts in high-dose animals. No gross or histological alterations other than severe irritation. **Dermal irritation NOAEL not established,** LOAEL 100 mg/kg based on severe irritation. **Systemic NOAEL 300 mg/kg/day,** LOAEL 1000 mg/kg/day (LTD), based on slight changes in hematological and clinical chemistry parameters, and decreased bodyweight.
Developmental Range Finding	42634201 (1991) Rats	Fatty Alcohol Blend: 96.6%. Dose levels tested: 125, 375, 750, and 1000 mg/kg/day. No treatment-related effects were seen in the dams or in the fetuses of dams given the highest dose. Based on this study, does level selected for the main study were: 0, 125, 375 or 1000 mg/kg/day.
870.3700a 83-3a Developmental Toxicity (rat)	42609301 (1992) Acceptable/Guideline 25 F Sprague-Dawley /dose at 0, 125, 375, 1000 mg/kg/day on GD 6-16	Fatty alcohol blend (55% decanol; 40.7% octanol) Maternal NOAEL 375 mg/kg/day Maternal LOAEL 1000 mg/kg/day, based on increased incidence of salivation (67%). Developmental NOAEL 1000 mg/kg/day Developmental LOAEL not established

Table A2: Subchronic, Chronic, Developmental, Reproductive and Other Toxicity Profile on the Fatty Alcohols		
Guideline#/ Study Type	**MRID# (year)/ Classification /Doses**	**Results**
Developmental Toxicity (rat)	Nelson et al., 1990a, 1990b 100 mg/m^3 (max vapor achievable) 15 F Sprague-Dawley/ 7 hrs/day on GD 1-19	Dams weighed daily for first week and weekly thereafter. Rats sacrificed on GD 20. No treatment related effects observed in pregnant females, frequency of resorptions, fetal weights, or skeletal/visceral malformations.
Gene Mutation 84-2 870.5100 (*Salmonella typhimurium*)	42372002 (1992) Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Negative for reverse gene mutations in *Salmonella typhimurium* TA 1535, TA 1537, TA 1538, TA98, and TA100 in presence or absence of S9 activation to 6 doses from 1.5 µg/plate to 500 µg/plate (2 independent trials). Cytotoxicity was apparent for all strains at 500 µg/plate +/- S9.
Gene Mutation 870.5300 84-2 (mouse lymphoma cells)	42372003 (1992) Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Not mutagenic in 2 independent assays with/without activation. Initial assay non-activated & S9 levels ranged from 9.4 µg/ml to 37.5 µg/ml; doses of 75 µg/ml severely cytotoxic. Confirmatory assay with 10-50 µg/ml –S9 and 30-70 µg/ml +S9 were evaluated with severe cytotoxicity observed at non-activated levels (60 µg/ml and at S9 activation 80 µg/ml).
Micronucleus 870.5395 84-2 (mouse)	42372001 (1992) Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Negative for micronucleus induction in bone marrow cells of Male and Female CD-1 mice harvested 24 or 48 hrs post-administration of 3 daily doses of 500, 1000, or 2000 mg/kg/day. No overt toxicity in any treated animal or target organ in any treatment group.

References:

Nelson BK, Brightwell WS, and Krieg EF Jr (1990a). Developmental toxicology of industrial alcohols: A summary of 13 alcohols administered by inhalation to rats. Toxicology and Industrial Health. Vol 6 (3/4): 373-387.

Nelson BK, Brightwell WS, Khan A, Krieg EF Jr, and Hoberman AM (1990b). Developmental toxicology assessment of 1-octanol, 1-nonanol, and 1-decanol administered by inhalation to rats. Journal of the American College of Toxicology. Vol 9(1): 93-97.

HSDB, 2005. Hazardous Substances Data Bank. National Library of Medicine. Search Term: 1-Decanol. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~fK9c0q:1

Reregistration Eligibility Decision for Aliphatic Alcohols

March 2007

United States
Environmental Protection
Agency

Prevention, Pesticides
and Toxic Substances
(7508P)

EPA 738-R-07-004

Reregistration Eligibility Decision for Aliphatic Alcohols

Reregistration Eligibility Decision (RED) for Aliphatic Alcohols

List D

Case No. 4004

Approved by: _____

Date: _____

Debra Edwards, PhD., Director
Special Review and Reregistration Division

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Glossary of Terms and Abbreviations

ai	Active Ingredient
CFR	Code of Federal Regulations
CSF	Confidential Statement of Formula
DCI	Data Call-In
EDWC	Estimated Drinking Water Concentration
EEC	Estimated Environmental Concentration
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FFDCA	Federal Food, Drug, and Cosmetic Act
FQPA	Food Quality Protection Act
GENEEC	Tier I Surface Water Computer Model (Estimated Aquatic Environmental Concentrations)
LC_{50}	Median Lethal Concentration. A statistically derived concentration of a substance that can be expected to cause death in 50% of test animals. It is usually expressed as the weight of substance per weight or volume of water, air or feed, e.g., mg/l, mg/kg or ppm.
LD_{50}	Median Lethal Dose. A statistically derived single dose that can be expected to cause death in 50% of the test animals when administered by the route indicated (oral, dermal, inhalation). It is expressed as a weight of substance per unit weight of animal, e.g., mg/kg.
LOC	Level of Concern
LOAEL	Lowest Observed Adverse Effect Level
mg/kg/day	Milligram Per Kilogram Per Day
mg/L	Milligrams Per Liter
MRID	Master Record Identification (number). EPA's system of recording and tracking studies submitted.
MUP	Manufacturing-Use Product
N/A	Not Applicable
NOAEL	No Observed Adverse Effect Level
OPP	EPA Office of Pesticide Programs
ppb	Parts Per Billion
PPE	Personal Protective Equipment
ppm	Parts per Million
RED	Reregistration Eligibility Decision
REI	Restricted Entry Interval
RQ	Risk Quotient
TGAI	Technical Grade Active Ingredient
UV	Ultraviolet
WPS	Worker Protection Standard

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Abstract

The Environmental Protection Agency (EPA or the Agency) has completed the human health and environmental risk assessments for the Aliphatic Alcohols case 4004 and is issuing its risk management decision. Currently, case 4004 consists of four active ingredients. Three of these active ingredients, 1-octanol, 1-decanol and a mixture of aliphatic alcohols described as "fatty alcohols," are used as plant growth regulators on tobacco. The fourth, 1-dodecanol (also known as lauryl alcohol), is registered as a Lepidopteran pheromone/sex attractant in pear and apple orchards.

A tolerance reassessment was performed in 2002 for the use of 1-dodecanol as a pheromone. In that assessment of potential human exposure and dietary risk, the Agency concluded, "the tolerance exemption for Lepidopteran pheromones has been reassessed and is in compliance with the FQPA ." Neither a handler nor post-application (reentry) occupational assessment has been conducted for any uses of aliphatic alcohols of case 4004, because no dermal, oral, or inhalation endpoints of toxicological concern have been identified.

The potential for ecological risk from the pheromone use and from the growth-regulator uses is considered in this document. The ecological risk assessment identifies no ecological risks of concern from the use of aliphatic alcohols.

The risk assessments, which are summarized below, are based on the review of the required target database supporting the use patterns of currently registered products. After considering the potential risks identified, EPA has determined that aliphatic alcohol-containing products are eligible for reregistration. That decision is discussed fully in this document.

I. Introduction

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was amended in 1988 to accelerate the reregistration of products with active ingredients registered prior to November 1, 1984. The amended Act calls for the development and submission of data to support the reregistration of an active ingredient, as well as a review of all submitted data by the U.S. Environmental Protection Agency (referred to as EPA or "the Agency"). Reregistration involves a thorough review of the scientific database underlying a pesticide's registration. The purpose of the Agency's review is to reassess the potential risks arising from the currently registered uses of the pesticide, to determine the need for additional data on health and environmental effects, and to determine whether or not the pesticide meets the "no unreasonable adverse effects" criterion of FIFRA.

This document summarizes EPA's human health and ecological risk assessments and reregistration eligibility decision (RED) for aliphatic alcohols. The document consists of six sections. Section I contains the regulatory framework for reregistration; Section II provides an overview of the chemical and a profile of its use and usage; Section III gives an overview of the human health and environmental effects risk assessments; Section IV presents the Agency's decision on reregistration eligibility and risk management; and Section V summarizes the label changes necessary to implement the risk mitigation measures outlined in Section IV. Finally, the Appendices list related information, supporting documents, and studies evaluated for the reregistration decision. The risk assessments for aliphatic alcohols and all other supporting documents are available in the Office of Pesticide Programs (OPP) public docket (http://www.regulations.gov) under docket number EPA-HQ-OPP-2007-0134.

II. Chemical Overview

A. Regulatory History

Reregistration case number 4004 consists of straight chain aliphatic alcohols with 6 to 16 carbon atoms in the chain, which has been abbreviated in previous documents as aliphatic alcohols (Cx-Cxx) or (C6-C16). Currently, case 4004 consists of four active ingredients. Three of these active ingredients are used as plant growth regulators on tobacco. These are described as fatty alcohol blend (PC code 079029), 1-octanol (079037) and 1-decanol (079038). The fatty alcohol blend under PC code 079029 is predominantly a mixture of 1-octanol and 1-decanol, although some labels list 0.5% 1-hexanol (C6) and 1.5 % dodecanol (C12) among the active ingredients. The single product listed under PC code 079037, although listed as 1-octanol, is also in fact a mixture of 1-octanol and 1-decanol. The earliest registered label for use of aliphatic alcohols for tobacco sucker control included in the Agency's Pesticide Product Label System (PPLS) was issued to Uniroyal in 1964.

The fourth active ingredient in case 4004, 1-dodecanol (PC code 001509), was first registered for use as a Lepidopteran pheromone/sex attractant in 1993. The potential human health risks from 1-dodecanol were reassessed in 2002 by the Agency's Biopesticides and Pollution Prevention Division (BPPD), as described in the document, *Tolerance Reassessment Decision Regarding Tolerance Exemption for the Biochemical Lepidopteran Pheromones. July*

26, 2002. This RED document describes the potential ecological effects of the use of 1-dodecanol.

Other aliphatic alcohols are not assessed in this document. The fatty alcohol product included under PC code 079059 is not being supported, and will be voluntarily cancelled. In April 1995, the Agency completed a Reregistration Eligibility Decision (RED) for case number 4003 (C1 - C5), which consists of aliphatic alcohols with only one to five carbons. The active ingredients addressed in that assessment included ethanol (PC code 001501), and isopropanol (PC code 047501).

B. Chemical Identification

The aliphatic alcohols are considered primary alcohols (i.e., the –OH group in the C-1 position). The aliphatic alcohols 1-octanol (PC code 079037) and 1-decanol (PC code 079038) are also known by many other common names, and the fatty alcohol blend (PC code 079029) is a generic term meaning that the compound is obtained by the hydrolysis of fatty acid esters. The registrations under the name fatty alcohol blend (PC code 079029) are considered a mixture of the linear, straight chain chemicals 1-octanol and 1-decanol. Tables 1 - 3 provide the chemical identification for 1-octanol, 1-decanol, and 1-dodecanol, respectively.

Table 1. Chemical Identification of 1-Octanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Octanol**
CAS Reg. No.	111-87-5
Other Names	Octyl alcohol; n-Octan-1-ol; n-Octanol; n-Octyl alcohol; Caprylic alcohol; Heptyl carbinol; Octanol; Alcohol C-8; Capryl alcohol; n-Heptyl carbinol; Octan-1-ol; Prim-n-octyl alcohol; Octanol-(1); Octyl alcohol, normal-primary; Primary octyl alcohol; Hydroxyoctane
Empirical Formula	$C_8H_{18}O$
Molecular Weight Number of Carbons	130.23 The number of carbons is 8
Chemical Structure	

Table 2. Chemical Identification of 1-Decanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Decanol**
CAS Reg. No.	112-30-1
Other Names	Decyl alcohol; n-Decan-1-ol; n-Decanol; n-Decyl alcohol; Alcohol C10; Capric alcohol; Caprinic alcohol; Decanol; Nonylcarbinol; Decylic Alcohol; Decan-1-ol; Decanol-(1); Decyl, n- alcohol 22; Primary decyl alcohol; Nonyl carbinol
Empirical Formula	$C_{10}H_{22}O$
Molecular Weight Number of Carbons	158.28 The number of carbons is 10

Type of Information	Information for this Chemical
Chemical Structure	

Table 3. Chemical Identification of 1-Dodecanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Dodecanol**
CAS Reg. No.	112-53-8
Other Names	Dodecyl alcohol; *n*-Dodecan-1-ol; *n*-Dodecyl alcohol; Alcohol C-12; Dodecanol-1; Lauric Alcohol; Laurinic alcohol; Lauryl alcohol; 1-Dodecyl alcohol; Duodecyl alcohol; *n*-Lauryl alcohol; *n*-Lauric alcohol, primary; Dodecanol; 1-Hydroxydodecane; Hydroxydodecane
Empirical Formula	$C_8H_{18}O$
Molecular Weight Number of Carbons	186.33 The number of carbons is 12
Chemical Structure	

The aliphatic alcohols 1-octanol and 1-decanol are applied as water-based sprays to burley, flue cured and dark tobacco by hand using a back pack sprayer, or to tobacco plants by a boom. The aliphatic alcohols are applied to tobacco at the button or early flower stage and act as chemical pinching agents to control sucker shoots. The aliphatic alcohols dissolve the layer of waxy cuticle on the plant, causing dehydration of the young sucker. Because these aliphatic alcohols are applied solely on tobacco, its use is limited to the tobacco growing states, mainly on the east coast (Connecticut, Pennsylvania, Virginia, North Carolina, South Carolina, Georgia, and Florida), but also in Kentucky and Tennessee. Between 1.5 and 2 million pounds of aliphatic alcohols are applied annually.

Recommended application rates range from approximately 8.5 lbs ai/acre up to approximately 21 lbs active ingredient/acre, at 1 to 3 applications per year. However, 1-octanol and 1-decanol have estimated volatilization half-lives of 3.5 and 1.0 minutes, respectively. Therefore, the amount of the aliphatic alcohol available for runoff or for chronic exposure to terrestrial animals is likely to be lower than the maximum label rates. As described below, the ecological risk assessment took this into account when estimating potential exposure.

The volatility of 1-dodecanol is essential to its use as a pheromone in apple and pear orchards. The pheromone is applied from polyethylene dispenser tubes hung throughout the orchard. The active ingredient, 1-dodecanol (lauryl alcohols; PC code 001509), disperses passively from the tube into the atmosphere over 3-4 months. Once dispersed from its dispensers, 1-dodecanol degrades quickly by photolysis in the air.

The aliphatic alcohols are used in, or can be naturally found in various food items. The Food and Drug Administration permits the use of aliphatic alcohols as a food additive, under certain conditions. The aliphatic alcohols have been found to be natural components of apples and oranges, and have been reported as a component of edible seeds, oils and fermented beverages.

III. Summary of Aliphatic Alcohols Risk Assessments

The purpose of this summary is to assist the reader by identifying the key features and findings of these risk assessments, and to help the reader better understand the conclusions reached in the assessments. The human health and ecological risk assessment documents, and supporting information listed in Appendix C were used to formulate the safety finding and regulatory decision for aliphatic alcohols.

While the following risk assessments and related addenda are not included in this document, they are available from the OPP Public Docket, docket number EPA-HQ-OPP-2007-0134, and may also be accessed through the website http://www.regulations.gov/. Hard copies of these documents may be found in the OPP public docket under this same docket number.

- *Tolerance Reassessment Decision Regarding Tolerance Exemption for the Biochemical Lepidopteran Pheromones. July 26, 2002;*
- Human Health Risk Assessment: *Aliphatic Alcohols: Human Health Chapter of the Reregistration Eligibility Decision (RED) Document. Reregistration Case Number 4004. June 30, 2006;*
- Ecological Risk Assessment: *Reregistration Eligibility Decision, Reregistration Case 4004: Aliphatic Alcohols C-8, C-10 and C-12. September 8, 2006.*
- *Aliphatic Alcohols (1-octanol; 1-decanol): Tier 2 Aquatic Exposure Model (PRZM and EXAMS) Estimates and Risk Characterization. November 28, 2006;*
- *Aliphatic Alcohols (1-octanol; 1-decanol): Addendum to PRZM and EXAMS refinement of environmental concentrations in surface water (DPBarcode D334066; 11/28/2006). Recalculation of EECs considering volatilization from soil as a dissipation route; Recalculation of Risk Quotients. December 11, 2006;*
- *Aliphatic Alcohols (1-octanol; 1-decanol) Addendum to Ecological Risk Assessment in Support of RED: Reconsideration of Ecological Toxicity Data Gaps in Light of Surface Water EEC Refinements. February 9, 2007.*

A. Human Health Risk Assessment

The Agency has conducted a risk assessment of the tobacco plant growth inhibitor use of the aliphatic alcohols. The Agency's screening level assessment was conducted using data submitted by the registrants and published in the open literature. A summary of the Agency's human health risk assessment is presented below. More detailed information associated with the risks posed by the tobacco plant growth inhibitor use of the aliphatic alcohols can be found in the human health risk assessment, *Aliphatic Alcohols: Human Health Chapter of the Reregistration Eligibility Decision (RED) Document. Reregistration Case Number 4004*, which is available in the public docket.

The potential human health risks from 1-dodecanol were assessed in 2002 by the Agency's Biopesticides and Pollution Prevention Division (BPPD), as described in the document, *Tolerance Reassessment Decision Regarding Tolerance Exemption for the Biochemical*

Lepidopteran Pheromones. July 26, 2002. The tolerance exemption for Lepidopteran pheromones, including 1-dodecanol, was determined to be in compliance with FQPA.

Toxicity Summary for Aliphatic Alcohols

The data base of submitted toxicity studies and published literature is sufficient to assess the uses of the aliphatic alcohols. The available toxicity data base for the aliphatic alcohols consists of acute toxicity, irritation, and sensitization studies. In addition, there are developmental rat (oral and inhalation) toxicity studies and a 90-day rat (dermal) study. The available mutagenicity studies include the Ames, micronucleus, and gene mutation assays.

Currently, there is no known mode of toxicological action for the aliphatic alcohols. Based on the low hazard concern via the oral, dermal, and inhalation routes of exposure, a quantitative risk assessment for the aliphatic alcohols is not appropriate. Therefore, the Agency conducted a qualitative assessment.

Toxicity Profile

Available acute toxicity studies indicate the aliphatic alcohols are of low oral and dermal toxicity. Acute inhalation studies with the rat resulted in estimates of the median lethal dose (LD_{50}) above the limit concentration of 2 mg/L. However, eye irritation studies resulted in severe and sometimes non-reversible eye irritation. Dermal irritation studies revealed slight to moderate irritation in rabbits, and the aliphatic alcohols generally did not produce sensitization in tests with guinea pigs.

There are few subchronic or chronic toxicity data available for the aliphatic alcohols; however, the available developmental toxicity studies revealed no adverse effects in fetal and maternal parameters. The available genotoxicity and mutagenicity studies were negative. There is currently no long-term rodent toxicity information regarding the carcinogenic potential for the aliphatic alcohols. While neurotoxicity information is currently not available, there were no clinical signs in any of the acute, subchronic, or developmental toxicity studies to suggest the aliphatic alcohols elicit a neurotoxic effect. Based on the available data, there is no evidence that warrants determining any dietary, oral, dermal, or inhalation endpoints to quantify sub-chronic or chronic toxicity.

Finally, there is no evidence to suggest that the aliphatic alcohols cause increased susceptibility in infants and children. Therefore, based on the results of the available studies, no endpoints of toxicological concern have been identified for human health risk assessment purposes. Table 4 summarizes the available toxicity data for the aliphatic alcohols.

Table 4. Acute Toxicity Data for the Aliphatic Alcohols

Guideline No.	Study Type	PC Code	MRID	Results	Toxicity Category
870.1100 81-1	Acute oral [rat]	079038 1-Decanol	44460401 46004601	LD_{50} > 2000 mg/kg (other studies report no deaths at 2000 mg/kg, one study showed LD_{50}	III

Guideline No.	Study Type	PC Code	MRID	Results	Toxicity Category
			45507901 0060309 0064859	=5000 mg/kg)	
870.1200 81-2	Acute dermal [rat]	079038 1-Decanol	44460402 46004602 45507902	LD_{50} reported as > 2000 mg/kg; (other studies reported LD_{50}> 4000 mg/kg and one study showed LD_{50} = 5000 mg/kg	III
870.1300 81-3	Acute inhalation [rat]	079038 1-Decanol	44460403 46004603 45517901	LD_{50}> 3.35 mg/L (other studies showed LD_{50}>5.07 mg/L and LD_{50}>7.08 mg/L)	IV
870.2400 81-4	Acute eye irritation [rabbit]	079038 1-Decanol	44460404 44578801 46004604 45517902	Most severe effect reported as corneal opacity in all treated eye at 7 days. Conjunctive irritation until 7 and 14 days. Irreversible vascularisation in one eye until day 21	I-III
870.2400 81-4	Acute eye irritation [rabbit]	079029 Fatty Alcohols	44340701	All 6 rabbits showed moderate to severe irritation. Opacity up to 7 days. Slight iritis with conjunctival redness to day 6, slight chemosis to day 7 and slight to severe discharge to day 8.	II-III
870.2500 81-5	Acute dermal irritation [rabbit]	079038 1-Decanol	44407601 44460405 46004605 45517903	In one study, erythema, eschar formation and edema was evident at 72 hrs. Test substance reported as mild irritant.	III-IV
870.2600 81-6	Skin sensitization [guinea pig]	079038 1-Decanol	44407602 44460406 46004606 45507903	Three studies reported 1-decanol is not a skin sensitizer.	NA
870.2600 81-6	Skin sensitization [guinea pig]	079029 Fatty Alcohols	43386201	All animals survived. No adverse effect on body weight. Not a dermal sensitizer.	NA

B. Environmental Risk Assessment

The Agency has conducted a screening-level risk assessment of the tobacco plant growth inhibitor and pheromone uses of the aliphatic alcohols. The Agency's screening level assessment was conducted using data submitted by the registrants in conjunction with acceptable

ecotoxicity data from the open literature. Anticipated exposure pathways to non-target species include oral exposure, and inhalation of aliphatic alcohol products.

A summary of the Agency's ecological risk assessment is presented below. More detailed information associated with the ecological risks posed by use of the aliphatic alcohols can be found in the environmental risk assessment, *Reregistration Eligibility Decision for the Aliphatic Alcohols*, dated September 8, 2006, which is available in the public docket.

1. Environmental Fate and Transport

Because environmental fate data are not available, physical and chemical properties for the aliphatic alcohols were estimated by Quantitative Structure-Activity Relationships (QSAR) using EPISuite v3.21 (Estimation Programs Interface for Windows (EPIWIN)). The estimated properties of 1-octanol, 1-decanol and 1-dodecanol differ somewhat, due to the different lengths (i.e. number of carbons) in their straight, saturated carbon chains. As suggested by their common names, 1-octanol has 8 carbons in its chain, 1-decanol has 10 carbons, and 1-dodecanol has 12 carbons.

In spite of these small differences, the expected behavior of these aliphatic alcohols in the environment is generally similar. The major route of dissipation in the field for these chemicals is likely to be volatilization. The volatility half-lives for 1-octanol and 1-decanol were estimated using the Dow Method described in the *Handbook of Chemical Property Estimation Methods* by Lyman, Reehl and Rosenblatt. The half-lives for volatility from soil for 1-octanol and 1-decanol were estimated to be 3.5 minutes and 1 minute, respectively. 1-dodecanol would likely volatilize even more quickly, but the half-life was not estimated, since volatility from pheromone traps is the known route of dissipation.

There is some uncertainty about the rate of volatility of 1-octanol and 1-decanol from plant surfaces, since aliphatic alcohols are hydrophobic and, therefore, have affinity for the waxy surfaces of plants. However, these volatility half-lives suggest that the aliphatic alcohols will not be available long to expose non-target terrestrial animals, nor to be transported to surface water bodies in runoff. Residues of 1-dodecanol are not expected on plants or in soil, since they are dispersed in the air from pheromone traps, and then degraded by photolysis. The ecological risk assessment concluded that except for terrestrial insects, which are the target for the pheromone use of 1-dodecanol, "environmental exposures resulting from this use are likely negligible." The risk assessment for this use was therefore qualitative.

Additional estimation of environmental fate parameters obtained from EPISuite provides a basic set of data to perform a screening-level environmental risk assessment. The model indicates that aliphatic alcohols have a moderate tendency to bind to soils. The portion of applied chemical that binds to the soil, rather than volatilizing, will be subject to biodegradation, with estimated half-lives for 1-octanol and 1-decanol of 2.3 days. The portion of applied chemical that does volatilize is estimated to degrade in the air by reaction with hydroxyl radicals with half-lives of about 10 hours.

As mentioned above, dissipation via volatilization will greatly reduce the amount of aliphatic alcohols reaching surface-water bodies, and aliphatic alcohols will volatilize from water as well as soil. However, the fraction that does reach surface water will not be degraded by hydrolysis. These alcohols have the potential to bioaccumulate in fish, but the rates of uptake, metabolism, and depuration, as well as the nature of metabolites, are not known. However, the magnitude of the bioconcentration factors (BCF) suggests a low potential to bioconcentrate.

EPISuite does not provide information on the rates of formation/decline of product, the nature and relative amounts of transformation products, and their distribution in soil/sediment-water-air. Therefore, the specific nature and persistence of potential biotransformation products (primary biodegradation) are not known. However, the ultimate biotransformation products of the aliphatic alcohols are water and carbon dioxide.

2. Ecological Risk Assessment

The Agency uses a pesticide's use profile, exposure data, and toxicity information to determine risk estimates to non-target terrestrial and aquatic organisms. Estimated environmental concentrations (EECs) are used to calculate risk quotients (RQs). EECs are based on the maximum application rate(s) which would potentially yield the greatest exposure. An RQ is derived by dividing the EEC by a single estimate of toxicity. The Agency then compares an RQ to its Level of Concern (LOC) to determine if exposure to the aliphatic alcohols could potentially pose a risk to non-target organisms (RQs that exceed the LOC indicate potential risk). Table 5 outlines LOCs, and the Agency's corresponding risk presumptions.

Table 5. Agency Level of Concerns and Risk Presumptions

Risk Presumption	LOC Terrestrial Animals	LOC Aquatic Animals	LOC Plants
Acute Risk – there is a potential for acute risk	0.5	0.5	1
Acute Endangered Species – endangered species may be adversely affected	0.1	0.05	1
Chronic Risk – there is potential for chronic risk	1	1	N/A

a. Exposure to Aquatic Organisms

The Agency ran a number of exposure modeling simulations to derive expected environmental concentrations of aliphatic alcohols in surface water. The Agency first ran the Tier I GENEEC model, which resulted in exceedences of the endangered species level of concern (LOC) for freshwater fish and estuarine/marine invertebrates for some application scenarios. However, these simulations did not consider the volatilization of aliphatic alcohols from soil, and each thereby overestimated potential exposure.

Although GENEEC is not designed to consider volatility from soil directly, the Agency used an indirect method to consider volatility with the GENEEC model and to refine the aquatic exposure assessment. As described above, the volatility half-lives for the aliphatic alcohols were

estimated using the Dow Method described in the *Handbook of Chemical Property Estimation Methods* (Lyman, et al., 1982). The half-lives for volatility from soil for 1-octanol and 1-decanol were estimated to be 3.5 minutes and 1 minute, respectively. Such short volatility half-lives mean that little pesticide will remain by the time a runoff event occurred, unless rainfall began immediately after application.

To simulate this scenario using GENEEC, the Agency determined the amount of 1-octanol or 1-decanol that would remain in the field 3 to 4 minutes after application at the maximum rates allowed on the label. GENEEC was then run in the standard fashion, but with this "effective application rate." Even though this was done using estimated volatility half-lives on the order of a couple of minutes, the resulting EECs are still considered upper-bound. GENEEC does not simulate a rainfall event until two days after application; if rainfall does not occur until two days after actual application of 1-octanol or 1-decanol, there could be very little product remaining to be subject to transport in runoff. For this reason, the simulations considered only a single application, although aliphatic alcohols can be used more than once within a single growing season.

b. Toxicity to Aquatic Organisms

Registrant-submitted data and open literature studies suggest that the aliphatic alcohols are "slightly" to "moderately" toxic to freshwater fish. Although the data base is not complete for all compounds in the aliphatic alcohol registration case, there are adequate data to assess the acute risk to freshwater fish. Although there are no registrant-submitted acute toxicity data available for estuarine/marine fish, data from the open literature provided the information to assess the acute risks of aliphatic alcohols to these organisms. The relevant study from the open literature indicates that 1-octanol is "slightly" toxic, and 1-decanol is "moderately" toxic to estuarine/marine fish.

No chronic toxicity guideline studies exist for any of the aliphatic alcohols. However, chronic data for freshwater fish from the open literature on 1-octanol provide an endpoint which the Agency used to calculate RQs. Chronic toxicity data for aquatic invertebrates on the aliphatic alcohols were also drawn from the open literature. The Agency used a chronic no observed adverse effect concentration (NOAEC) of 1 mg/L for reproductive effects for 1-octanol. The Agency notes that chronic toxicity data on 1-decanol for aquatic invertebrates would reduce the uncertainty posed by the lack of these data. A summary of all toxicity endpoints is presented below in Table 6.

Table 6. Toxicity Reference Values Used to Calculate RQs for Aliphatic Alcohols

Taxonomic Group	Assessment Endpoint	1-Octanol	1-Decanol
		Species/ Toxicity Endpoint	Species/ Toxicity Endpoint
Freshwater Fish	Survival	Fathead minnow Acute LC_{50} = 12.2 mg/L	Fathead minnow Acute LC_{50} = 2.3 mg/L
	Reproduction, Growth	Fathead minnow NOAEC = 0.75 mg/L	No data available

Taxonomic Group	Assessment Endpoint	1-Octanol	1-Decanol
		Species/ Toxicity Endpoint	Species/ Toxicity Endpoint
Freshwater Invertebrates	Survival	Water flea Acute EC_{50} = 4.16 mg/L	Water flea Acute EC_{50} = 6.5 mg/L
	Reproduction, Growth	Water flea Chronic NOAEC = 1 mg/L	No data available
Estuarine/marine Fish	Survival	Bleak LC_{50} = 15 mg/L	Bleak LC_{50} = 7.2 mg/L
	Reproduction, Growth	No data available	No data available
Estuarine/marine Invertebrates	Survival	Harpacticoid copepod LC_{50} = 58 mg/L	Harpacticoid copepod LC_{50} = 4 mg/L
	Reproduction, Growth	No data available	No data available
Aquatic Plants	Survival, Growth	*Scenedesmus subspicatus* EC_{50} = 6.5 mg/L; EC_{10} = 2.8 mg/L	No data available

LC_{50} - Median Lethal Concentration, statistically derived single concentration that can be expected to cause death in 50% of the test animals; EC_{50} - Median Effect Concentration, statistically derived single concentration that can be expected to cause an adverse effect in 50% of the test animals or plants; EC_{10} - statistically derived single concentration that can be expected to cause an adverse effect in 10% of the test animals or plants; NOAEC - no observed adverse effect concentration.

c. Risk to Aquatic Organisms

Based on the refined surface water EECs and the available ecotoxicity data for 1-octanol and 1-decanol, RQs for aquatic animals do not exceed acute LOCs. In addition, although chronic toxicity data are available for 1-octanol, but not 1-decanol, aliphatic alcohols do not appear to pose a chronic risk to freshwater aquatic animals. No chronic toxicity data are available for estuarine/marine fish and invertebrates. In spite of these data gaps, the Agency does not anticipate chronic risk to estuarine marine fish and invertebrates. As described above, little 1-octanol or 1-decanol would likely be available for transport in runoff if a significant rain event did not occur within a few hours of application. Estimated RQs for 1-decanol and 1-octanol are summarized in Tables 7 – 10 below.

Table 7. Acute and Chronic RQs for Freshwater Fish

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50} = 2300 NOAEC – nd	0.02	13	nd
1-Octanol	4.4, 1 application	140	LC_{50} = 12200 NOAEC = 750	0.01	29	<1

Table 8. Acute and Chronic RQs for Estuarine/Marine Fish

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	60-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	LC_{50} = 7200 NOAEC – nd	<0.01	13	nd
1-Octanol	4.4, 1 application	140	LC_{50} = 15000 NOAEC – nd	<0.01	29	nd

Table 9. Acute and Chronic RQs for Freshwater Invertebrates

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	21-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	EC_{50} = 6500 NOAEC – nd	<0.01	29	nd
1-Octanol	4.4, 1 application	140	EC_{50} = 4160 NOAEC = 1000	0.03	70	<1

Table 10. Acute and Chronic RQs for Estuarine/Marine Invertebrates

Chemical	Effective Application Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ	21-Max Average EEC (µg/L)	Chronic RQ
1-Decanol	1.95, 1 application	57	EC_{50} = 4000 NOAEC – nd	0.01	29	nd
1-Octanol	4.4, 1 application	140	EC_{50} = 58000 NOAEC – nd	<0.01	70	nd

nd = no data

Aquatic plant toxicity data from open literature were only available for 1-octanol. Based on these data, the acute RQs for aquatic plants do not exceed the Agency's acute and endangered species LOCs (both 1.0) (Table 11). However, there is some uncertainty in this risk conclusion, given that the NOAEC for 1-octanol is unknown, and no aquatic phytotoxicity data are available for 1-decanol. The NOAEC is used to calculate an RQ to evaluate potential risk to endangered species. Because the NOAEC was not established, the EC_{10} for 1-octanol was used. Since the LOC for endangered aquatic plants is 1.0, and the RQ derived using the EC_{10} is 0.05, the NOAEC would have to be at least 20 times lower than the EC_{10} for the Agency to have an endangered species concern for aquatic plants.

Based on the analysis of the volatility of the aliphatic alcohols, aquatic exposures resulting from the labeled use of 1-decanol and 1-octanol are unlikely to reach concentrations that exceed the Agency's LOC. As a result, the value of additional aquatic plant studies for the aliphatic alcohols is low.

Table 11. Risk to Aquatic Plants

Chemical	Rate (lbs a.i./acre)	Peak EEC (µg/L)	Toxicity Value (µg/L)	Acute RQ
1-Octanol	4.4, 1 application	140	EC_{50} = 6500 EC_{10} = 2800	0.02 0.05
1-Decanol	1.95, 1 application	57	No data	--

d. Exposure, Toxicity and Risk to Terrestrial Organisms

Birds

Available toxicity data indicate that the aliphatic alcohols are categorized as "practically non-toxic" to birds on acute oral and dietary bases. Acute risks to birds were not quantified, because no discreet median lethal doses or concentrations were established in the acute oral and dietary studies. An acute dietary study from the open literature reported a dietary LC_{50} for bantam chickens of 201,000 ppm (100% 1-decanol). This level is more than 20 times greater than the highest predicted dietary exposure level (~10,000 ppm). Therefore, the Agency concludes that the aliphatic alcohols do not pose an acute risk to birds.

No avian chronic toxicity studies were available for any of the aliphatic alcohols and, therefore, the Agency cannot directly assess the potential chronic risk to avian species. However, since 1) the aliphatic alcohols are not acutely toxic to birds at doses many times higher than expected exposure, 2) the volatility of the aliphatic alcohols makes chronic exposure unlikely, with EECs dropping more than an order of magnitude within 30 minutes, 3) the aliphatic alcohols assessed are listed as food additives and are "Generally Recognized as Safe" (GRAS) by the U.S. Food and Drug Administration[1], and 4) a mammalian chronic toxicity study indicates the aliphatic alcohols are not chronically toxic to mammals, the Agency does not expect a chronic risk to birds, and will not require chronic avian toxicity studies at this time.

Mammals

Acute oral mammalian toxicity data indicate that the aliphatic alcohols are "practically non-toxic" to mammals on an acute oral basis. Four studies performed with laboratory rats did not result in LC_{50} endpoints with which RQs could be calculated. The Agency concludes that aliphatic alcohols do not pose an acute dietary risk to mammals.

In the single chronic mammalian developmental toxicity study, which used a 1-decanol/1-octanol blend, no chronic effects were observed in laboratory rats, even at the maximum tested dose of 957 mg/kg bw/day. It is unknown if the predicted exposures approach the level at which effects may occur since no LOAEC was identified in the chronic study. However, the Agency does not anticipate chronic risk to mammals, considering the volatility of the aliphatic alcohols, and the acceptance of these chemicals as food additives, as described above.

Terrestrial Insects

Available toxicity data indicate that aliphatic alcohols are "practically non-toxic" to honey bees (acute contact $LD_{50} > 25$ µg/bee). However, given that aliphatic alcohols can be used as Lepidopteran sex inhibitors, there is a potential for sublethal (e.g., reproductive) effects on non-target Lepidopterans, such as butterflies. This potential effect cannot be quantified at this time.

[1] http://vm.cfsan.fda.gov/~dms/eafus.html

Terrestrial Plants

Tier-I terrestrial plant seedling emergence study data suggest a fatty alcohol blend (1-decanol and 1-octanol) is not toxic to most plants at the maximum rate tested (18.03 lbs ai/A). An EC_{25} could not be established for tested species, although lesser effects were observed in cucumbers, carrots and tomatoes. Therefore, the Agency did not calculate RQs based on seedling emergence effects.

EC_{25} values and related no-effect levels were established for two (corn and cucumber) of 10 crop plants tested in a submitted vegetative vigor study. The Agency used these endpoints in the TerrPlant model to calculate RQs (Table 12). All were below the Agency's LOC of 1.

Table 12. Terrestrial Plant Vegetative Vigor RQs from Drift only for Terrestrial Plants*

Class of Terrestrial Plant	Monocot	Dicot
Non-endangered species	0.02	0.01
Endangered species	0.19	0.36
* Based on vegetative vigor monocot NOAEL = 1.12 lbs a.i./A, EC25 = 9.02 lbs a.i./A; dicot NOAEL = 0.58 lbs a.i./A, EC25 = 14.8 lbs a.i./A (MRIDs 42514701, 43379602)		

e. Adverse Ecological Incidents

There are currently no adverse ecological incidents listed in the Ecological Incident Information System (EIIS) that are associated with the aliphatic alcohols.

f. Endangered Species

Based upon the screening-level assessment conducted on aliphatic alcohols, the Agency has not definitively identified exceedences of endangered species LOCs for direct effects to non-target animals or plants. Acute RQs did not exceed endangered species LOCs for birds, mammals, terrestrial plants, freshwater fish and invertebrates, or estuarine/marine fish and invertebrates. Chronic data were not available for birds and estuarine/marine fish and invertebrates. As described above, the Agency believes that the volatility and low toxicity in available acute and chronic toxicity studies for mammals and freshwater animals suggest that chronic risk to birds and estuarine/marine animals is unlikely. However, because the toxicity data are not available, the Agency cannot completely preclude risk to listed birds and estuarine/marine animals at this time. Similarly, since a no-effect level was not determined for aquatic plants, the Agency cannot preclude direct effects on these organisms, although exposure is expected to be negligible.

The Agency considers a potential for not only direct effects, but also adverse indirect effects to listed species that rely on other affected organisms. Because direct effects to aquatic plants cannot be precluded, indirect effects to listed aquatic species which rely on aquatic plants can also not be dismissed. Similarly, indirect effects to terrestrial plants and animals cannot be precluded because of potential reproductive effects of aliphatic alcohols to some terrestrial insects.

Table 13. Potential Listed Species Risks Associated with Direct or Indirect Effects Due to Applications of Aliphatic Alcohols as Shoot Inhibitors on Tobacco.

Listed Taxon	Direct Effects		Indirect Effects to Endangered Species
	Acute	Chronic	
Terrestrial and semi-aquatic plants - monocots	No	N/A	Possible
Terrestrial and semi-aquatic plants - dicots	No	N/A	Possible
Birds	No	No data	Possible
Terrestrial-phase amphibians	No	No data	Possible
Reptiles	No	No data	Possible
Mammals	No	No	Possible
Aquatic non-vascular plants*	Insufficient data	N/A	N/A
Aquatic vascular plants	Insufficient data	N/A	N/A
Freshwater fish	No	No	Possible
Aquatic-phase amphibians	No	No	Possible
Freshwater crustaceans	No	No	Possible
Mollusks	No	N/A	Possible
Marine/estuarine fish	No	No data	Possible
Marine/estuarine crustaceans	No	No data	Possible

* At the present time, no aquatic non-vascular plants are included in Federal listings of threatened and endangered species. The taxonomic group is included here for the purposes of evaluating potential contributions to indirect effects to other taxa and as a record of exceedences should future listings of non-vascular aquatic plants warrant additional evaluation of Federal actions.

Further analysis regarding the overlap of individual species with each use site is required prior to determining the likelihood of potential impact to listed species. At the screening level, this analysis is accomplished using the Location of Crops and Threatened and Endangered Species (LOCATES) data base, which uses location information for listed species at the county level and compares it to agricultural census data for crop production at the same county level of resolution. The ecological risk assessment includes a complete listing of aquatic plants, birds, reptiles, terrestrial-phase amphibians, mammals, and terrestrial invertebrates associated with the States where the aliphatic alcohols are use as a plant growth regulator on tobacco.

IV. Risk Management, Reregistration, and Tolerance Reassessment Decision

A. Determination of Reregistration Eligibility

Section 4(g)(2)(A) of FIFRA calls for the Agency to determine, after submission of relevant data concerning an active ingredient, whether or not products containing the active ingredient are eligible for reregistration. The Agency has previously identified and required the submission of the generic (i.e., active ingredient-specific) data required to support reregistration of products containing aliphatic alcohols as an active ingredient. The Agency has completed its review of these generic data, and has determined that the data are sufficient to support reregistration of all products containing aliphatic alcohols (C6 – C16).

The Agency has completed its assessment of the human health and ecological risks associated with the use of pesticide products containing aliphatic alcohols (C6 – C16). The Agency has determined that aliphatic alcohol-containing products are eligible for reregistration provided that label amendments are made as outlined in Chapter V. Appendix A summarizes the

uses of aliphatic alcohols (C6 – C16) that are eligible for reregistration. Appendix B identifies the generic data requirements that the Agency reviewed as part of its determination of reregistration eligibility of aliphatic alcohols (C6 – C16), and lists the submitted studies that the Agency found acceptable.

The Agency has identified eye-irritation concerns that warrant specific label language concerning personal protective equipment (PPE) and the length of restricted-entry intervals after application for tobacco uses of the aliphatic alcohols (C6 – C16). If all changes outlined in this document are incorporated into the product labels, the eye-irritation concerns will have been mitigated. Should a registrant fail to implement any of the reregistration requirements identified in this document, the Agency may take regulatory action to address these concerns.

B. Public Comment Period

Because the risks associated with the use of aliphatic alcohols were low and did not warrant mitigation measures, a Phase 3 public comment period on the aliphatic alcohols risk assessments was not conducted. However, a 60-day public comment period will be conducted after the RED is issued, and will be announced in the Federal Register. Comments may be submitted under Docket number EPA-HQ-OPP-2007-0134 at http://www.regulations.gov/. The RED document and technical supporting documents for aliphatic alcohols are also available to the public under docket identification (ID) number EPA-HQ-OPP-2007-0134. In addition, the aliphatic alcohols RED document may be downloaded or viewed through the Agency's website at http://www.epa.gov/pesticides/reregistration/status.htm.

C. Regulatory Position

1. Regulatory Rationale

The Agency has determined that aliphatic alcohols-containing products are eligible for reregistration provided that specified label amendments are made. The following is a summary of the rationale for managing risks associated with the use of aliphatic alcohols.

a. Human Health Risk Management

There are no human health risk concerns for the aliphatic alcohols with the exception of eye irritation for 1-decanol. 1-decanol, which is a component of all active tobacco use formulations of the aliphatic alcohols (C6 – C16), is an acute toxicity category I eye irritant and, therefore, pursuant to the Worker Protection Standards (WPS), products with agricultural uses must require a 48 hour REI and the following PPE for early entry: coveralls, chemical-resistant gloves made of any water proof material, shoes plus socks, and protective eyewear.

b. Ecological Risk Management

The risk assessment identified no exposure scenarios with aliphatic alcohols that pose ecological risks of concern to the Agency, including direct effects on endangered species. Thus,

no mitigation measures to address ecological risks are necessary for the reregistration of aliphatic alcohols.

Moreover, because of the low risks associated with the use of aliphatic alcohols, as summarized in this document, the Agency concludes that spray drift mitigation is not needed as part of the reregistration eligibility determination.

2. Endocrine Disruptor Effects

Following recommendations of its Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC), EPA determined that there was a scientific basis for including, as part of the program, the androgen and thyroid hormone systems, in addition to the estrogen hormone system. EPA also adopted EDSTAC's recommendation that EPA include evaluations of potential effects in wildlife. For pesticides, EPA will use FIFRA and, to the extent that effects in wildlife may help determine whether a substance may have an effect in humans, FFDCA authority to require the wildlife evaluations. As the science develops and resources allow, screening of additional hormone systems may be added to the Endocrine Disruptor Screening Program (EDSP).

When the appropriate screening and/or testing protocols being considered under the EDSP have been developed, individual pesticides may be subject to additional screening and/or testing. However, in the available toxicity studies for the aliphatic alcohols, there was no evidence of endocrine disruption.

3. Endangered Species

The Endangered Species Act required federal agencies to ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat. The Agency has developed the Endangered Species Protection Program to identify pesticides whose use may cause adverse impacts on federally listed endangered and threatened species, and to implement mitigation measures that address these impacts. To assess the potential of registered pesticide uses that may affect any particular species, EPA puts basic toxicity and exposure data developed for the REDs into context for individual listed species and considers ecological parameters, pesticide use information, the geographic relationship between specific pesticide uses and species locations and biological requirements and behavioral aspects of the particular species. When conducted, these analyses take into consideration any regulatory changes recommended in this RED being implemented at that time. A determination that there is a likelihood of potential effects to a listed species may result in limitations on the use of the pesticide, other measures to mitigate any potential effects, and/or consultations with the Fish and Wildlife Service or National Marine Fisheries Service, as necessary. If the Agency determines use of aliphatic alcohols "may affect" listed species or their designated critical habitat, EPA will employ the provisions in the Services regulations (50 CFR Part 402).

The ecological assessment that EPA conducted for this RED does not, in itself, constitute a determination as to whether specific species or critical habitat may be harmed by the pesticide. Rather, this assessment serves as a screen to determine the need for any species specific

assessment that will evaluate whether exposure may be at levels that could cause harm to specific listed species and their critical habitat. That assessment refines the screening-level assessment to take into account the geographic area of pesticide use in relation to the listed species, the habits and habitat requirements of the listed species, etc. If the Agency's specific assessments for aliphatic alcohols result in the need to modify use of the pesticide, any geographically specific changes to the pesticide's registration will be implemented through the process described in the Agency's Federal Register Notice (54 FR 27984) regarding implementation of the Endangered Species Protection Program.

The Agency has reviewed data and other information for the aliphatic alcohols (C6 – C16) and concludes that this plant growth regulator does not pose a risk of direct acute effects to most species listed under the Endangered Species Act, because EPA's screening-level assessment shows 'no effect' on listed species or their critical habitat (RQ values were below the level of concern for endangered species). There is some uncertainty regarding acute risk to aquatic plants, however. Although the volatility of 1-octanol and 1-decanol suggests that exposure to aquatic plants would be negligible, a no-observed-adverse-effect-level could not be established and, therefore, indirect effects to listed aquatic animals which depend on aquatic plants could not be precluded. Similarly, the Agency believes that the volatility and low toxicity in available acute and chronic toxicity studies for mammals and freshwater animals suggest that chronic risk to birds and estuarine/marine animals is unlikely. However, because the toxicity data are not available, the Agency cannot completely preclude risk to listed birds and estuarine/marine animals at this time.

D. Labeling Requirements

In order to be eligible for reregistration, various use and safety information will be included in the labeling of all end-use products containing aliphatic alcohols. For the specific labeling statements, refer to Section V of this RED document.

V. What Registrants Need to Do

The Agency has determined that aliphatic alcohols (C6 – C16)-containing products are eligible for reregistration provided that the required label amendments are made. The Agency intends to issue Data Call-In (DCIs) Notices requiring product-specific data. Generally, registrants will have 90 days from receipt of a DCI to complete and submit response forms or request time extension and/or waiver requests with a full written justification. For product-specific data, the registrant will have eight months to submit data. Below are the label amendments that the Agency intends to require for aliphatic alcohols to be eligible for reregistration.

A. Manufacturing Use Products

1. Additional Generic Data Requirements

The generic data base supporting the reregistration of aliphatic alcohols for currently registered uses has been reviewed and determined to be substantially complete. However, a few data gaps remain, and these are listed below.

Product Chemistry

830.7050	UV/VIS Spectrum for Pure Active Ingredient (PAI)
830.7950	Vapor Pressure

2. Labeling for Manufacturing-Use Products

To ensure compliance with FIFRA, manufacturing-use product (MUP) labeling should be revised to comply with all current EPA regulations, PR Notices, and applicable policies. The MUP labeling should bear the labeling contained in Table 14.

B. End-Use Products

1. Additional Product-Specific Data Requirements

Section 4(g)(2)(B) of FIFRA calls for the Agency to obtain any needed product-specific data regarding the pesticide after a determination of eligibility has been made. The Registrant must review previous data submissions to ensure that they meet current EPA acceptance criteria and if not, commit to conduct new studies. If a registrant believes that previously submitted data meet current testing standards, then the study MRID numbers should be cited according to the instructions in the Requirement Status and Registrants Response Form provided for each product. The Agency intends to issue a separate product-specific data call-in (PDCI), outlining specific data requirements. For any questions regarding the PDCI, please contact Karen Jones at 703-308-8047.

2. Labeling for End-Use Products

To be eligible for reregistration, labeling changes are necessary to implement measures outlined in Section IV above. Specific language to incorporate these changes is specified in Table 15. Generally, conditions for the distribution and sale of products bearing old labels/labeling will be established when the label changes are approved. However, specific existing stocks time frames will be established case-by-case, depending on the number of products involved, the number of label changes, and other factors.

C. Labeling Changes Summary Table

In order to be eligible for reregistration, amend all product labels to comply with the following table. Table 14 describes how language on the labels should be amended.

Table 14: **Labeling Changes Summary Table for 1-Octanol, 1-Decanol and Fatty Alcohols**

Description	1-Octanol, 1-Decanol and Fatty Alcohols : Required Labeling Language	Placement on Label
	Manufacturing-Use Products	
Required on all MUPs	"Only for formulation into a growth regulator for tobacco sucker control."	Directions for Use
One of these statements may be added to a label to allow reformulation of the product for a specific use or all additional uses supported by a formulator or user group.	"This product may be used to formulate products for specific use(s) not listed on the MP label if the formulator, user group, or grower has complied with U.S. EPA submission requirements regarding support of such use(s)." "This product may be used to formulate products for any additional use(s) not listed on the MP label if the formulator, user group, or grower has complied with U.S. EPA submission requirements regarding support of such use(s)."	Directions for Use
Environmental Hazards Statements Required by the RED and Agency Label Policies	"Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollution Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of the EPA."	Directions for Use

End-Use Products Intended for Occupational Use (WPS and non-WPS)		
Handler PPE Requirements[1] for (insert type of formulation) Note: Separate sections should be used for each formulation type (i.e. liquids, powders, granulars, etc…) unless the required handler PPE is identical for all formulation types.	"Personal Protective Equipment (PPE) Mixers, loaders, applicators, and other handlers must wear: > Long-sleeved shirt and long pants and, > Shoes plus socks"	Precautionary Statements: Hazards to Humans and Domestic Animals
User Safety Requirements	"Follow manufacturer's instructions for cleaning/maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry." "Discard clothing and other absorbent material that have been drenched or heavily contaminated with the product's concentrate. Do not reuse them."	Precautionary Statements: Hazards to Humans and Domestic Animals immediately following the PPE requirements
User Safety Recommendations	"USER SAFETY RECOMMENDATIONS" "Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet." "Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing." "Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing."	Precautionary Statements under: Hazards to Humans and Domestic Animals immediately following Engineering Controls (Must be placed in a

		box.)
Environmental Hazards Statement	"ENVIRONMENTAL HAZARDS" Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning of equipment or disposal of wastes."	Precautionary Statements under Environmental Hazards
Restricted-Entry Interval for products with WPS uses	"Do not enter or allow worker entry into treated areas during the restricted entry interval (REI) of 48 hours."	Directions for Use, Agricultural Use Requirements Box
Early Entry Personal Protective Equipment for products with WPS uses	"PPE required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as soil or water, is: > coveralls, > shoes plus socks, > chemical-resistant gloves made of any waterproof material, > protective eyewear."	Directions for Use, Agricultural Use Requirements Box
General Application Restrictions for products with WPS or non-WPS uses on the label	"Do not apply this product in a way that will contact workers or other persons, either directly or through drift." "Only protected handlers may be in the area during application."	Place in the Direction for Use.

[1] PPE that is established on the basis of Acute Toxicity of the end-use product must be compared to the active ingredient PPE in this document. In the case of multiple active ingredients, the more protective PPE must be placed on the product labeling. For guidance on which PPE is considered more protective, see PR Notice 93-7.

Appendix A

Fatty Alcohols – a review of their natural synthesis and environmental distribution

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For SDA and ERASM

November, 2005

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Executive Summary

The published and grey literature on the environmental occurrence, fate and behaviour of fatty alcohols has been reviewed. The principal focus has been on the natural production, which occurs in all living organisms from bacteria to man, and the profiles and concentrations of these compounds in water, soils and sediments. Their relatively non-polar nature means they are principally associated with solid phases (*e.g.* sediments) rather than dissolved in water. The major production mechanism is from the reduction of fatty acids, through aldehyde intermediates, to fatty alcohols and in many organisms to esters with fatty acids to form waxes. These waxes are used for a variety of purposed from the prevention of desiccation in the terrestrial environment to energy reserves in the marine environment. They are ubiquitous and occur in most environments around the world including the deep ocean and in sediment cores.

Due to the nature of the synthetic pathway using acetyl-CoA, most fatty alcohols are of an even chain length. Terrestrial plants utilise fatty alcohols as waxy coating and these compounds are dominated by long chain moieties with chain lengths from C_{22} to C_{32}; in contrast marine organisms synthesise smaller compounds with peak chain lengths of C_{14} to C_{16}. Bacteria also produce fatty alcohols but these can also be odd chain lengths and contain branches. This aspect of their occurrence enables them to be used as biomarkers for organic matter sources.

As well as their natural production and occurrence, fatty alcohols are also utilised in detergent formulations principally as polyethoxylates. The analytical method used to measure the concentration of the ethoxylates involves direct derivatisation with a pyridinium complex and quantification *via* LC-MS. This technique will detect free fatty alcohols as well as the ethoxylates but will not detect any of the bound alcohols such as the waxes. To detect this group, a saponification step is required. This second method in combination with the LC method will detect all of the ethoxylates and may be considered a good measure of the total fatty alcohols present in the system.

The concentration of individual fatty alcohols in the environment ranges from low values in old deep cores and the open ocean floor (undetectable to 12 $ng.g^{-1}$ DW for C_{16}) to high values near natural sources and especially in suspended particulate matter

(2.7 mg $.g^{-1}$ DW for C_{16}); this is almost a factor of 10^6 difference in their concentrations. The short chain compounds are more readily degradable than the longer chain compounds and in many cases are removed first as a food source for bacteria. The longer chain compound may also degrade to short chain compounds with time but, in general, the $>C_{20}$ class of alcohols are better preserved in sediments than the $<C_{20}$ class.

The different compound profiles for each source has made them suitable as biomarkers and the use of multivariate statistical methods can clearly distinguish compounds from each potential source as well as sites. Principal Component Analysis (PCA) is particularly useful in this regard. Signature analysis using Partial Least Squares (PLS) analysis is successful when the marine / terrestrial sources are used to discriminate samples, however, due to the commonality of commons present in detergent formulations and the natural environmental alcohols, source partitioning on the basis of compounds alone is not as successful. When ascribing proportions to such sources, a different approach such as stable isotopes may be more appropriate.

Key issues and directions for further study which have arisen from this review include the lack of context information presented when anthropogenic alcohols are quantified; no corresponding measure of total (including wax bound) alcohols is made and this may serve as a useful indicator of the relative importance of each source. Further information is needed on the rates at which free alcohols may be derived from bound sources or fatty acid precursors both in sewage treatment plants and in the environment as a whole. These aspects will have repercussions on the toxicity and ecotoxicity of alcohols in the environment, an aspect that was not included in this review.

Chapter 1. Definitions *(This chapter aims to introduce the family of compounds, how they are referred to, the likely structures that will be found and their chemistry from an environmental point of view).*

Names and structures

Fatty alcohol is a generic term for a range of aliphatic hydrocarbons containing a hydroxyl group, usually in the terminal position. The accepted definition of fatty alcohols states that they are naturally derived from plant or animal oils and fats and used in pharmaceutical, detergent or plastic industries (*e.g.* Dorland's Illustrated Medical Dictionary). It is possible to find the hydroxyl (–OH) group in other positions within the aliphatic chain although these secondary or tertiary alcohols are not discussed to any great extent in this treatise.

The generic structure of fatty alcohols or n-alkanols can be seen in Figure 1.1 and specific examples in Figure 1.2. The value of the *n* component is variable and is discussed below.

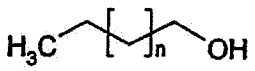

Figure 1.1 Generic structure of a fatty alcohol – the total number of carbons needs to be greater than 8 – 10 to be a "fatty" alcohol; shorter chain compounds have an appreciable water solubility.

The range of chain lengths for these n-alcohols can be from 8 to values in excess of 32 carbons. With such a wide range of chain lengths, the chemical properties and, consequently, environmental behaviour vary considerably. As well as these straight chain moieties, a range of branched chain compounds are also naturally produced by micro-organisms in the environment. The major positions for the methyl branches are on the carbons at the opposite end of the molecule to the terminal –OH. If the methyl branch is one in from the end of the molecule (ω-1) it is termed an *iso* fatty alcohol; if it is two in from the end (ω-2) it is called an *anteiso* fatty alcohol. Examples of these branches can be seen in Figure 1.2.

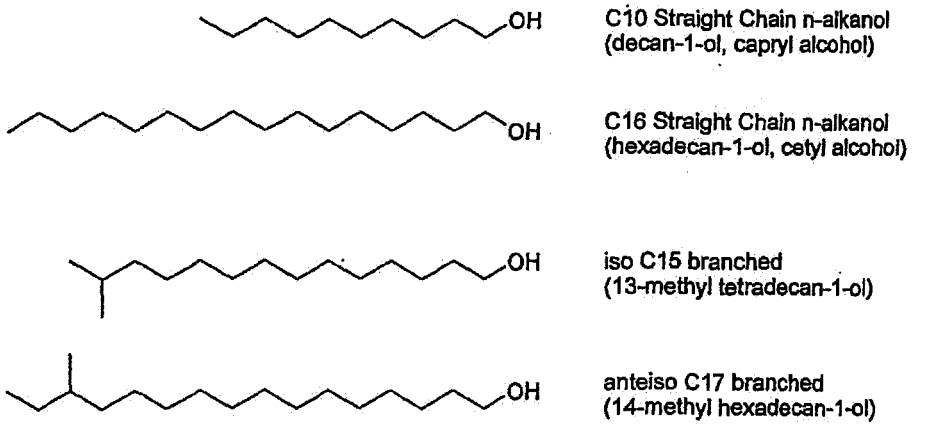

Figure 1.2 Example fatty alcohol structures. The majority found in nature are of the straight chain type with smaller amounts of the branched chain compounds also being present.

Most fatty alcohols are saturated in that they have no double bonds present in their structure. However, there are a limited number of mono-unsaturated compounds that can be found in nature. The two most common compounds are phytol (3,7,11,15 – tetramethyl-2-hexadecen-1-ol), an isoprene (Chikaraishi *et al.*, 2005) derived from the side chain of chlorophyll (Figure 1.3) and a straight chain C_{20} alcohol with a double bond in the ω9 position counted from the terminal carbon (eicos-11-en-1-ol, Figure 1.4, (Kattner *et al.*, 2003).

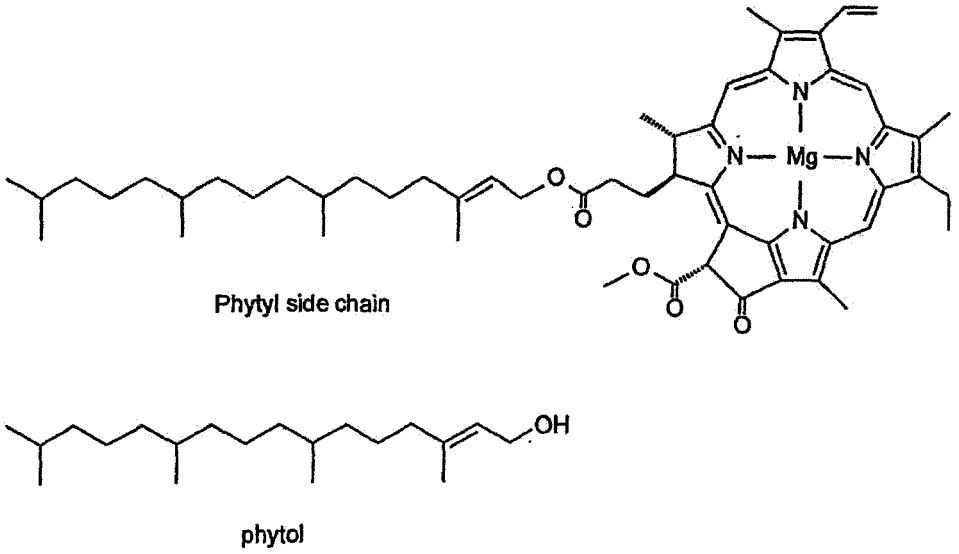

Figure 1.3 The chlorophyll a molecule with the phytyl side chain labelled. Cleavage of this chain at the COO- group produces free phytol in the environment.

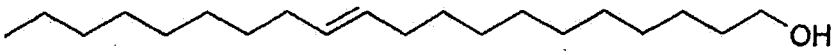

Figure 1.4 Eicos-11-en-1-ol or 20:1 fatty alcohol, one of the most frequently measured straight chain mono-unsaturated alcohol in the environment.

There have been occasional reports of polyunsaturated fatty alcohols but these are relatively rare (*e.g.* Ju and Harvey, 2004) and are confined to di-unsaturates such as 18:2. There is a group of isoprenoid lipids which may be found in bacteria which are essentially repeating isoprene subunits strung together and terminated by a hydroxyl group (Perry *et al.*, 2002). These compounds are also uncommon in environmental analyses and are not reported to any great extent.

Fatty alcohols together with many other groups of compounds have both systematic and trivial or common names. This trivial name is based on the length of the alkyl chain and the root is common between aliphatic hydrocarbons and fatty acids. These names together with the systematic name and carbon number are shown in Table 1.1.

Physico-Chemical Properties

Solubility vs. chain length

One of the key factors in determining the environmental behaviour of any compound is its water solubility; this will determine the partitioning between solid and solution phases. Compounds with low water solubility will be preferentially adsorbed to particulate matter, either settled or suspended in water. These compounds will also partition into the lipid phase of organisms and have higher bioconcentration factors. The available physico-chemical properties for the fatty alcohol series from C_4 to C_{30} are summarised in Table 1.1. These data are drawn from many sources but principally from the Beilstein Chemical Database (Elsevier MDL). The density and melting points in the summary data (Table 1.1) have a degree of uncertainty about them as some compounds, especially the longer chain and odd carbon number moieties, are less well studied. The density data are not available for all compounds.

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MONOGRAPH

Literature Review on Fatty Alcohol Compounds

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DATA REQUIREMENTS
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I. ABSTRACT

The scientific data bases available by on-line access to the Dialog Information Services were searched for information on fatty alcohols and their behavior in the environment. The data reviewed and presented here support many of the basic assumptions of fatty acid metabolism and straight-chain carbon compound breakdown. Fatty alcohols have been investigated as biomarkers, because they are associated with virtually every life form. Different species have different ranges of chain-length alcohols, and are variously able to transform these products into shorter or longer-chain fatty acids, ketone, glycols or other compounds which are natural components of living organisms.

The fate and metabolism of straight-chain fatty alcohols is explained by basic biochemical principals. The compounds of interest in tobacco sucker control are short chain fatty alcohols, primarily C_9 and C_{10} normal alcohols, with small amounts of C_8 and C_{12} normal alcohols. Many of the articles reviewed dealt with chain lengths above and below this number, or with iso- or antesio-chains; some investigations on fatty alcohol detergents have valuable information, but dealt with fatty alcohol ethoxylates.

While no reviewed information addresses the classical requirements of the EPA guidelines for environmental fate testing, there does appear to be some information available which allows the prediction of the behavior of n-fatty alcohols of C_6 to C_{12} chain length. Basic breakdown in all systems is by 2-carbon oxidation, followed by mineralization or use of the components in fatty acid synthesis pathways.

II. INTRODUCTION

As requested by the EPA in Dr. Allan S. Abramson's letter to Harley D. Hathaway of Cochran Corporation (August 21, 1991), a literature search was conducted to address the environmental fate aspects of the FIFRA Section N Guidelines for Pesticide Registration. A search of on-line data through Dialog Information Services was conducted on September 8, 1991. The "science and technical files" of Dialog were searched (120 files). No effort was made to limit this search by alcohol chain length or nature. There were 11,456 citations available on fatty alcohol compounds. In order to develop a reasonable list of citations, terms related to environmental fate were used to narrow down the number of "hits" on the data system. A print-out of 677 citations was the result of this search process; many of the citations had abstracts included. Particularly relevant articles, which were available in the English language, were obtained for review.

Where abstracts presented relevant information, but the article was either not directly related to our investigation or was published in a language other than English, appropriate excerpts of the abstract were noted in a bibliography. Full copies of articles were reviewed and built into the bibliography on fatty alcohols. Lastly, articles which were described or cited by authors whose publications are reviewed here (secondary references) were included in the bibliography as possible further source documents. Time did not allow the procurement of secondary references. It is important to include these publications in our list, since much of the research on fatty alcohols was elementary in that the predictability of the behavior of the compound is based on early biochemical discoveries related to the metabolism and global recycling of organic carbon compounds. All references found to be relevant (abstracts, reviewed articles and secondary references) are included in the appendix of this document.

The body of this document is arranged by guideline number, in accordance with the data requirements this monograph was intended to address. As might be expected, no publications approached fatty alcohol fate in a typical FIFRA-guideline testing manner. The findings of various authors do corroborate one another and can lead to a basic understanding of the behavior of normal (or straight chain saturated) fatty alcohols.

III. GENERAL INFORMATION

Mixtures of C_8 and C_{10} fatty alcohols are used in the "desuckering" of tobacco. The "technical product" consists of a distillation cut within the range of alcohols which (1) show significant activity for the use intended and (2) are not phytotoxic to mature tobacco foliage. The "formulated products" and the technical product usually include small amounts of C_6 and C_{12} alcohols, and the end use product includes the addition of polyoxyethylene (20) sorbitan mono-oleate (SMO). Fatty alcohols are applied as emulsions and in tobacco act as plant growth regulators by desiccating small axillary growth. They are not translocated but instead destroy the tissue at the point of contact (Wheeler, Seltman and Motten, 1991).

Fatty alcohols for use in tobacco sucker control are from natural and synthetic sources. The process of manufacture or isolation of the chain lengths of interest is by one of two means: hydrogenation of natural raw materials, such as coconut oils or palm kernel oils or the Zigler alcohol process which uses petrochemical feedstocks. The fatty alcohols synthesized by the Zigler processes are structurally similar to natural fatty alcohols (Noweck, 1987). These processes are the most appropriate for providing the basic ingredients of sucker control agents due to their production of materials which are high in purity and due to the range of chain-lengths obtained.

In the following discussions, several synonyms for primary alcohols will be used interchangeably. These are: n-fatty alcohols, 1-xxxxol (where xxxx is the description of the chain length), straight-chain alcohols, [normal] aliphatic alcohols and saturated alcohols. For ease in identification of the nomenclature which relates to various chain lengths, see Table 1.

This review concentrates on information available on n-fatty alcohols of "lower" chain lengths (6 to 16 carbons). Most research shows that the behavior of these compounds in ***the environment is similar due to the manner in which the molecule is attacked and with*** which it binds to soil. Soil microorganisms readily incorporate fatty alcohols into their nutrient assimilation cycles (Buning-Pfaue and Rehm, 1972). Birds, fish and mammals can ingest or digest these compounds or more complex compounds with fatty alcohol components without adverse effects (Noweck, 1987; Place and Roby, 1986; Obst, 1986; Prahl, Eglinton and Corner, 1985).

Some very valuable information comes from studies conducted on biodegradable detergents which are based on fatty alcohol. These studies followed the fate of the ring compounds as well as the fate of the straight-chain alcohols and used radiolabeled tracers to identify those components. The findings confirm the assumptions that basic 2-carbon oxidation and fatty alcohol assimilation or mineralization is rapid and complete, without the formation of exotic metabolites.

IV. SECTION N GUIDELINES, 160-5: CHEMICAL IDENTITY

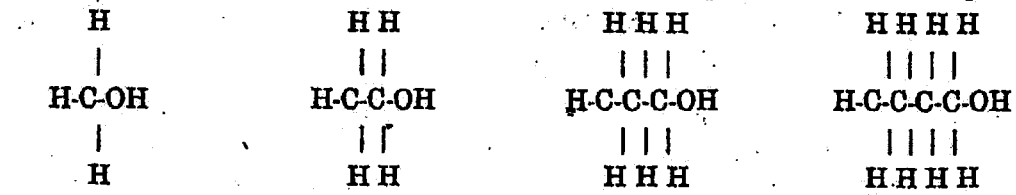
Fatty alcohols are aliphatic alcohols with chain lengths between C6 and C_{22}; alcohols with a chain length above C_{22} are referred to as "wax alcohols". Coconut ("natural") alcohols produce very few impurity peaks and contain less than 0.1% n-tridecanol and varying amounts of n-alkanes. Zigler alcohols are primary, straight chain alcohols with an even carbon number. Gas chromatography shows up to 1.0% impurities, consisting of numerous even-numbered, isomeric fatty alcohols (Noweck, 1987).

The compounds used in tobacco sucker control predominantly contain C_8 (1-octanol) and C_{10} (1-decanol), which are considered the effective ingredients in sucker control. The presence of C_6 and C_{12} are partly due to artifact and partly due to their contribution to the desiccation properties of the product. Saturated fatty alcohols up to 1-dodecanol (C_{12}) are clear, colorless liquids with a lower specific gravity than water. The lower members of the series have a characteristic odor. Boiling points and melting points increase uniformly with chain length. There are no gaseous alcohols. Sinniah (1983) reports a melting point value for 1-decanol which is significantly different from that reported by Noweck (-26.6° vs. 7°C, respectively). The influence of the polarizing hydroxyl group diminishes with chain length; thus hexanol and even octanol show some water solubility, but decanol is immiscible with water. Fatty alcohols are soluble in common organic solvents such as petroleum ether, lower alcohols, and diethyl ether (Noweck, 1987).

Available details on the production, properties and nomenclature of fatty alcohols are given in Tables 1, 2, 3 and 4 and in Figure 1. Approximately 60% of the fatty alcohols produced are based on petrochemicals. Price fluctuation in raw materials (natural versus petrochemical) could affect the future distribution of the use of these two raw materials. Fatty alcohols and their derivatives are used in synthetics, surfactants, oil additives and cosmetics (Noweck, 1987), as well as in the uses being supported by this review.

In Chemistry for Agriculture and Ecology, the author makes the following presentation regarding *general organic chemistry:*

> In spite of the large number of known organic compounds, it is not necessary to examine the properties and reactions of each compound individually. Instead, organic compounds can be classified into a few *homologous series* of closely related compounds with similar properties and reactions. For example, the series of compounds



> is a homologous series of *alcohols*, each containing the hydroxyl (OH) *functional group* attached to a hydrocarbon chain of varying length. As we shall see in chapter 12, hydrocarbon chains tend to be chemically inert [emphasis added] and, therefore, the chemical properties of alcohols depend mainly upon the hydroxyl functional group. Consequently, we can establish generalizations about the properties of alcohols by studying a few representative members of the series. (Hay, 1981)

Hay notes further that the length of the chain has a small effect on the chemical properties of the compound, but can have a large effect on the physical properties of the compound, such as melting point, boiling point and solubility (as we see in the information from Noweck, 1987). The high temperatures for changes of state and the high water solubilities of C_1-C_5 alcohols are due to the formation of strong hydrogen bonds between hydroxyl groups of the molecules and water molecules. However, as the hydrocarbon chain becomes longer, its hydrophobic properties dominate. This dominance is generally reported to occur at a chain length of 10 carbons.

Alcohols are very weak acids. For their ionization, K_a values vary from 10^{-13} to 10^{-18}, depending upon the length of the carbon chain. Primary alcohols are oxidized by strong oxidizing agents, such as potassium dichromate or potassium permanganate, and yield first aldehydes and subsequently carboxylic acids. Alcohols react with carboxylic acids to give esters; for example, ethanol reacts with acetic acid to give ethyl acetate. Alcohols may also be "condensed to form carbohydrates or other more complex molecules. Primary alcohols are very basic building blocks of organic molecules, and without biological processes or extreme conditions not found in the environment, n-fatty alcohols would be expected to be generally inert.

V. SECTION N GUIDELINES, 161-1: HYDROLYSIS

Hydrolysis studies reported in the literature are based on studies which utilize more complex compounds than normal saturated fatty alcohols. Lindstedt (1990) reported that fatty alcohol esters hydrolyze and produce normal human metabolites. The fate or action of hydrolysis on the chain itself was not discussed in the abstract which was reviewed; contents of the abstract suggested that the information was not directly relevant to the range and character of alcohols in which we have an interest.

In studies by Hosotani, Ohkochi and Inui (1988), there was no apparent interference from hydrolysis when the photoassimilation of fatty alcohols was studied in *Euglena gracilis Z.* Experiments were run in both light and dark conditions; in studies using sucrose as the nutrient source, hydrolysis of sucrose was reported to have interfered. No such mention was made for the studies conducted with fatty alcohols as a carbon source. *Euglena* cultures were maintained for up to 14 days.

The properties of fatty alcohol as displayed by the available literature suggest that hydrolysis is not a major degradation pathway for n-aliphatic alcohols. The behavior of lower chain (C_2 to C_8) alcohols in water-based formulations and their use as solvents in so many arenas suggest that decomposition by hydrolytic means is not a factor. The influence of the polarizing hydroxyl group, which in turn influences miscibility, diminishes with chain length (Noweck, 1987). The use of octanol in the FIFRA guideline study which determines an "octanol/water partition coefficient" is also a statement toward the stability of octanol under sterile solution conditions.

VI. SECTION N GUIDELINES, 161-2: PHOTODEGRADATION - WATER

No specific studies on the photodegradation of fatty alcohols in water were discovered in this literature search. Some conclusions can be drawn from the conditions reported in other types of investigations.

Peltzer and Gagosian (undated) compared concentrations of fatty alcohols in air and rain-water samples in order to test the efficiency of their sampling and analytical methods. Their interest was in the analysis of fatty alcohols and their use as biomarkers. No report of interference due to breakdown in water was given in the abstract reviewed here.

The single study found that specifically dealt with hydrolysis assessed breakdown by titration, with the experimentation being conducted on fatty alcohol esters (Brown, 1983). Since specific breakdown products were not identified, and the parameters of the test were far from those of "natural" conditions, the study provided no additional data specific to n-fatty alcohols.

The fact that marine and riverine surface sediments and oceanic surface samples contain fatty alcohols and acids which reflect the nature of life or organic carbon sources they contain (Sargent, et. al., 1983; Romankevich et. al., 1982; Garrett, 1964) also supports the thesis that these compounds do not degrade readily by photolysis.

The information above suggests that photodegradation of n-fatty alcohols in water is minimal and is not a major pathway for compound degradation.

VII. SECTION N GUIDELINES, 161-3: PHOTODEGRADATION - SOIL

As with the literature citations on photolysis in water, no studies were found which specifically dealt with this aspect of fatty alcohol behavior. Many researchers have undertaken to utilize fatty alcohols as biomarkers in identifying the origin of ancient sediments and in identifying the airborne sources of carbon compounds (Sargent et. al. (1983); Simoneit (1989); Simoneit and Mazurek (1982); Currie and Johns (1989); Venkatesan and Kaplan (undated); Sever and Parker (1969)). These researchers have found that the distribution of fatty alcohols and fatty acids in the samples collected are in many cases representative of the distribution of life forms which created the sediment or particulate matter dispersed throughout the associated environment. These similar "fingerprints" suggest that these compounds are relatively stable when not being cycled through a living organism. The presence of fatty alcohols in sedimentary rocks and in uncontaminated soils (Hoering (1969); Ambles (1991)) further supports this thesis.

The findings reported above on use of fatty alcohols as biomarkers or as origin-markers suggest that degradation in soil would not be expected in the absence of microbiological activity and photolysis in soil is not a major degradation pathway.

VIII. Section N Guidelines, 162-1: Aerobic Soil Metabolism

Several investigators have worked with isolated soil organisms to determine the ability of such organisms to degrade fatty alcohol or to use it as a food source. In experiments by Buning-Pfaue and Rehm (1972), *Pseudomonas aeruginosa* was able to produce fermentation products based on the use of decanol as a sole source of nutrients. His findings suggested that soil microorganisms of this type readily incorporate fatty alcohols into their nutrient assimilation cycles.

The commercial production of detergents and biosurfactants has lead to research on fermentation which includes experimentation with organisms isolated from the soil. Bacteria, yeast and fungi grown on basic carbon sources can synthesize fatty acids, glycerides, phospholipids, lipopeptides and antibiotics. Singer and Finnerty (1990) report that biosurfactants produced by microorganisms are generally considered to represent a mechanism for the solubilization or emulsification of water-insoluble substrates to facilitate transport by cells. Their investigation describes the identification of a biosurfactant-producing bacterium and the general physiology of biosurfactant synthesis. The organism studied is *Rhodococcus species* H13-A, which was isolated from soil after several passages on hexadecane (C_{16}) enrichment medium.

In general, biological assimilation of primary alkanes and alcohols would be expected to be similar. Of interest in the Singer and Finnerty work is their experiments to determine the growth rate of the isolated soil organism on various carbon sources. Among the compounds they investigated were straight chain alkanes. Extracellular glycolipid synthesis by *Rhodococcus* occurred when the carbon source was decane (C_{10} through C_{18}). Other studies were referenced which reported glycolipid synthesis by actinomycete during growth on alkanes.

Ambles, et. al, 1991, noted that soil lipids include a great number of neutral or acid components (including fatty alcohols). These he classed as "simple lipids"; the unknown, barely soluble fraction was reported as complex lipids or the "polar fraction" of the soil lipid components. Ambles observed that the experimental work of others (and his work) "suggested that the soil polar fraction may correspond to a polar matrix (a biopolymer) which can 'react' with simple lipids, [with] the process of incorporation of simple lipids being reversible in biologically active soils."

In his work, Ambles compared the simple lipids in the soil to breakdown products of the "polar fraction". Even carbon number, straight chain fatty alcohols were found in soils from the two locations he tested. His work showed that the distribution of simple lipids was fairly similar to the products derived from the breakdown of the polar fraction and that his initial premise may be valid. This work provides evidence that microbially active soil has an existing metabolic pathway for the immediate incorporation of short-chain fatty alcohols such as those used in tobacco sucker control. Since components of

the formulation are already naturally present in the soil, microbial metabolism may be expected to proceed rapidly, with the use of C_8 and C_{10} normal alcohols as a food source.

Fatty alcohol based detergents and surfactants have been shown to degrade thoroughly and completely in the environment (Steber, et. al, 1988; Richterich et. al, 1985). Steber reported generally that this group of detergents showed a very rapid and complete biodegradation under both aerobic and anaerobic conditions with respect to primary breakdown and ultimate degradability (mineralization and assimilation). Richterich reported a biodegradability (the German BiAs reduction test) of 93% to 98% for a C_{12}/C_{18} based fatty alcohol detergent.

The straight chain fatty alcohol sulfates (detergents), whether derived from natural alcohols, natural fats or oils, or from ethylene by Zigler-type processes, are generally considered to be completely biodegradable (Speel, 1963).

The relationship of the above articles to the degradation of fatty alcohol will be discussed further in Section IX (Anaerobic Aquatic Metabolism); investigations with [1-^{14}C]-stearyl alcohol ethoxylate and EO-labeled compound further identify the specific behavior of the alkyl portion of that compound. Two Italian language articles were not translated which could support further the microbial breakdown of aliphatic alcohols (Sabastiani et. al, 1971). Work by Langley (1970), which investigated the properties of monolayer films in connection with their proposed use as evaporation control agents, is also reported in the next section. The work reported in that section reinforces the assumption that metabolism of fatty alcohols in soil is rapid and complete and without the formation of exotic metabolites.

IX. SECTION N GUIDELINES, 162-3: ANAEROBIC AQUATIC METABOLISM

The aerobic and anaerobic degradation of fatty alcohol-derived detergents has been well reported in published literature. Since some of these studies follow the fate of the fatty alcohol moiety, they are valuable to our understanding of the aquatic metabolism of these compounds. Fatty alcohols are generally accepted as biodegradable under both aerobic and anaerobic conditions (Steber, et. al, 1988) and will be used as a carbon source by the microorganisms which occupy those respective environments. The pathway of incorporation and the assimilated products may vary based on many environmental factors, but all assimilated products will be typical compounds found in the fatty acid synthesis process which is basically "common" to all life forms.

The articles reviewed below give credence to the statement made above. They also provide some evidence of the possible end points which would be typical in a classical FIFRA guideline study on aerobic or anaerobic aquatic metabolism.

Hosotani, et. al (1988) conducted a series of investigations in the aquatic protozoan, *Euglena gracilis* Z. The assimilation of fatty alcohols and other carbon sources by *Euglena gracilis* Z. was investigated by studying the growth of the organism and its photoassimilation of these compounds. *E. gracilis* Z and its streptomycin-bleached mutant from established stock cultures were exposed to growth media containing 0.2% fatty alcohols (carbon chain lengths of 1 to 20).

E. gracilis growth varied depending upon the chain length of the alcohols included in the culture medium. 1-dodecanol (C_{12}), 1-tridecanol (C_{13}), and 1-tetradecanol (C_{14}) supported considerable growth under illumination. Assimilation of dodecanol and tetradecanol for growth strictly depended upon light. The fatty alcohols C_8-C_{11} inhibited growth, while methanol and the alcohols C_{15}-C_{20} did not support growth. The growth pattern of *E. gracilis* on fatty alcohol is shown in Figure 2.

The mechanism of photoassimilation of C_{14}-alcohol (myristyl alcohol) was strictly light dependent; however, DCMU, an inhibitor of photosynthetic electron transfer, did not inhibit growth completely. With the bleached mutant *Euglena*, a long lag-phase extending more than 10 days occurred before growth started under illumination, and the final cell yield was about half that observed with wild-type cells. Growth on myristyl alcohol was almost saturated at light intensities of 600-1000 lx in comparison to autotrophic growth which increased with light intensities to at least 2000 lx.

The reason for variance in growth rates from one compound to another was not clear. The alcohols with chain lengths of 5 to 11 carbons inhibited photoautotrophic growth completely, and killed the cells. Other varieties of *Euglena gracilis* have been reported to grow on these middle carbon-chain-length alcohols.

The results of the photoassimilation experiments show that photosynthetic energy is not completely necessary for the photoassimilation of the alcohol. Shading of *Euglena* grow-

ing on myristyl alcohol may have caused the accumulation of paramylon and lowered synthesis of amino acids and protein which are essential for the cell growth. The bleached mutant has been shown to adapt to myristyl alcohol medium after several transfers and an increase in $(NH_4)_2SO_4$ concentration. The mutant may induce an ability to synthesize amino acids from myristyl alcohols by this adaptation.

Steber and Wierich, in two publications (1983 and 1985), discuss the biodegradation of fatty alcohol ethoxylates. their work is particularly relevant to our interests here due to the labeling of both the alkyl chain and the ethoxylate in separate but parallel experiments. The [1-^{14}C] stearyl alcohol + 7 EO had a specific activity of 19.2 mCi/g; the radiochemical purity was 98%. Only the results of the experimentation conducted on the labeled alkyl compound is discussed here.

In the first publication (1983), the simulation tests used a model plant which was a miniature continuous flow activated sludge unit constructed according to Swisher. The die-away tests were discontinuous tests analogous to the OECD Screening Test and were performed in shake flasks modified to a closed system. In the simulated plant study, after a working-in period of approximately two weeks the plant was fed for about one week with synthetic sewage containing one of the radiolabeled surfactants. As expected, the carbon in the 1-position of the alkyl-labeled compound was mineralized to $^{14}CO_2$ to a greater extent than the EO-moiety of the analogous ^{14}C-EO surfactant. Mineralization rates were 50 to 60% after 2 to 3 days of ^{14}C-feeding, with a slightly increasing tendency. The radioactivity of the effluent from the alkyl-labeled surfactant only amounted to about 6% (undegraded). When results were adjusted for recovery (93.8%), it was reported that 99% of the fatty alcohol ethoxylates present in the influent incurred microbial attack within 3 hours retention time in the model plant.

The lipid fraction of the sludge from the [1-^{14}C] alkyl ethoxylate experiment had a considerably higher radioactivity than sludge from the ring labeled experiment. This was explained as a consequence of microbial degradation of the alkyl-chain via β-oxidation according to general biochemical pathways, resulting in the production of acetyl units, which represent the elementary precursors for fatty acid biosynthesis.

The relatively high surfactant content in the sludge may result from the comparatively low water solubility of stearyl alcohol + 7 EO. Additionally, the hydrophilic EO-chain of ***alcohol ethoxylates exhibits a slower biodegradation rate than the hydrophobic part of*** the surfactant molecule. The faster biodegradation of the alkyl chain is clearly shown by the fact that the intermediates of the [1-^{14}C] stearyl alcohol ethoxylate biodegradation found in the effluent consisted largely of higher EO-numbered acidic polyethylene glycols which obviously must contain a small ^{14}C labeled moiety. In addition, it is evident that these polyethylene glycol carboxylates can only arise if degradation of the alkyl chain starts at the terminal methyl group. This is in accordance with conclusions drawn by other authors.

The alkyl chain of the fatty alcohol ethoxylate exhibited an ultimate biodegradation of about 75%. The actual extent of degradation may exceed this value for two reasons: (1) the steady state mineralization rate was higher than the balanced value of total $^{14}CO_2$-evolution and (2) an undervaluation results from the ^{14}C-labeling position in connection

with the degradation mechanism. The biodegradation begins at the terminal methyl of the alkyl chain, so that in this case, the alkyl carbon in position 1 represents the last carbon being transformed.

From these studies it was concluded that the biodegradation of stearyl alcohol + 7 EO formed no recalcitrant metabolites and would be expected to completely biodegrade under primary sewage treatment, as well as by self-purification processes in surface waters. These findings relate to both aerobic and anaerobic metabolic pathways.

A second study by these authors was published in 1985. Here, Steber and Wierich report that there are two distinct primary degradation mechanisms acting simultaneously in the microbial biocenoses of fatty alcohol ethoxylates: intramolecular scission of the surfactant as well as ω- and β-oxidation of the alkyl chain. In this report, a picture of the microbial pathways that bring about ultimate biodegradation of fatty alcohol ethoxylates in the environment were made. Studies were again conducted in a model continuous flow activated sludge plant similar to that described by the OECD Confirmatory Test.

A fast degradation of the fatty alcohol moiety of the surfactant occurs, beginning with terminal methyl group and slowing down before the radiolabeled C-1 is reached. The terminal oxidation of the alkyl chain (ω-oxidation) and subsequent stepwise removal of C_2 units by β-oxidation is presented as the fatty alcohol chain metabolic process. The resulting products represent the elementary precursors of fatty acid biosynthesis.

In addition to the above work, Speel reports that sodium lauryl sulfate (C_{12}) disappears from water in less than 3 days. The studies with fatty alcohol detergents have generally demonstrated "complete biodegradeability" in three days or less.

Work by other authors has shown that straight-chain alcohols may be a preferred carbon source, or at minimum microorganisms require little conditioning to utilize normal fatty alcohols as a carbon source. Langley (1970) conducted experiments on hexadecanol (C_{16}) and octadecanol (C_{18}) in conjunction with research on the control of water loss from soil in the arid southwest. In conjunction with these efforts, this project was designed to meet two goals: (1) to investigate the behavior of hexadecanol and octadecanol in microbial systems, including the detection, identification and behavior of any intermediate or end products formed as a result of biological transformation; and (2) to correlate the behavior *of long-chain fatty alcohols with studies of lower molecular weight alcohols.*

Three primary analytical techniques were employed to obtain direct and specific measurements of the rate and extent of degradation of hexadecanol and octadecanol by adapted microorganisms: gas chromatography, total organic carbon analysis and recorded oxygen uptake. A settled sewage supernatant was used as the source of microbial organisms which were adapted to the alcohol substrate. Low chain length alcohols (3 and 5 carbon) were used to condition the system and demonstrate its capability to adapt to soluble alcohols as a carbon source. The higher chain alcohols were insoluble in water but formed a film on the water surface. Due to this filming tendency, 1-hexadecanol and 1-octadecanol were tested in a static environment to avoid loss of the compound on flask walls.

1-butanol and 1-pentanol were removed from the solutions within 4 to 6 hours of their introduction. When isopentanol was also present, there appeared to be a selectivity of response which favored the straight chain alcohols. The total organic carbon removal during this phase of experimentation approached first order microbial response with half-lives as short as 2 hours. Similar responses were evoked when cultures were exposed to isobutanol, 1-butanol and 1-pentanol; response to straight chain alcohols was virtually non-selective and the removal of isobutanol was essentially stopped until the straight chain alcohols were removed or converted.

Considerable operational difficulty was experienced in attempts to conduct growth and utilization trials on the higher chain alcohols. Given sufficient time in contact with the adapted microbial species, complete disappearance of 1-hexadecanol and 1-octadecanol as an identifiable molecular species did occur. Experimental difficulties precluded the establishment of an exact half-life, but degradation appeared to be fairly complete within 7 to 10 days. Where these substrates were added in granular, slow release forms, so that disappearance was also slowed, no significant soluble organic accumulation occurred. Where substrate was added in dissolved form (a hexane solution), microbial growth was rapid and there was evidence of soluble organic accumulation above the level of controls. Efforts to extract and identify the organics were unsuccessful, partly due to the presence of hexane as a complicating factor (some adaptation of the microorganisms to hexane may have occurred).

The complications of studying these compounds in both the field and laboratory were discussed. The fact that solvents such as hexane or isopropanol must be used to disperse the compounds in an aquatic system and the ubiquitous presence of carbon make qualification and identification of breakdown products extremely difficult.

In work with fatty alcohols as biomarkers, Simoneit and Mazurek (1982) reported that absolute concentration of the homologs of $< C_{20}$ in aerosol samples were not accurate although quantitative comparisons could be made. They speculated that the presence of shorter chain fatty alcohols were equal to or greater than the concentration of fatty alcohols which are $> C_{20}$. The quantitative comparisons made by Simoniet and Mazurek which include data on chain lengths of 10-35 carbons which are shown in Figure 3. These authors propose that the concentration of $< C_{20}$ fatty alcohols is relatively high in dispersed aerosols, and that the origin of these products is microbial activity resulting primarily from the breakdown of plant waxes.

In a living aquatic system, be it aerobic or anaerobic, fatty alcohol breakdown is rapid and complete. Papers reviewed here suggest that the aquatic half-life of shorter-chain fatty alcohols may be a matter of hours, and is likely to be less than 3 to 7 days. Because these types of compounds are a preferred carbon source, they will be rapidly bioassimilated or mineralized to CO_2.

X. SECTION N GUIDELINES, 163-1: LEACHING, ADSORPTION AND DESORPTION

Some of the papers reviewed and the chemical and physical properties of n-alipatic alcohols suggest that these compounds are not mobile in soils. One publication was found which provides data on the movement of n-fatty alcohols in soil. Unfortunately a full copy of this article was not available within the time period for this report's preparation. However, the abstract does provide the following summary information: hydrogen bonding was the primary attraction between the fatty alcohol compound and Wyoming bentonite clay. Binding was rapid and strong, with virtually no lateral or vertical movement detected. Fatty alcohols tendency to bind to soil and stay in place, and the film-forming properties of fatty alcohols of chain length C_{16} and above, are the specific properties which lead to the investigation of these compounds as evaporation inhibitors in soils where water use is critical.

The discovery of fatty alcohols in sedimentary rocks (Hoering, 1969) suggests that movement is limited once the substrate involved is no longer bioactive. Microbial biosynthesis or mineralization may result in the formation of fatty acids or other natural products as well as carbon dioxide. The movement of these compounds may vary; however, they are natural constituents of the soil and are likely to be thoroughly involved in the carbon cycling process.

Again, no FIFRA-guideline type studies are available for the leaching, adsorptive and desorptive properties of C_6 to C_{12} alcohols, but the information presented above, and the general properties of these compounds as described by Hay (1981) suggest that this range of fatty alcohol compounds will not be mobile in the soil.

XI. SECTION N GUIDELINES, 164-1: TERRESTRIAL FIELD DISSIPATION

No articles were discovered which dealt with the dissipation half-life of fatty alcohols in soil. Because these compounds are ubiquitous and constantly cycled through organisms and bioactive soil and water, one would expect that the exposure of soil to fatty alcohol from its use on tobacco would elicit no changes in the metabolic cycles therein. Brengle's (1965) thesis on the behavior of fatty alcohols in soil supports this postulation.

In a later publication, Brengle (1969) conducted field tests of the ability of hexadecanol and octadecanol to inhibit soil moisture loss. Octadecanol was broadcast at 0, 300, 600 or 900 pounds per acre each May for three years. Fatty alcohol, at the rates used in this study, did not retard soil water loss enough to warrant use in a fallow system. The treated area did maintain a protective vegetation cover. Apparently, even these extremely high rates did not affect the productivity of the soil over the three year test period.

The dissipation of fatty alcohols from soils would be expected to follow first order kinetics, with half-lives varying based on the level of microbial activity in the soil. Since most agricultural soils are quite bioactive, and receive fatty alcohols in the form of plant waxes on a regular basis, the dissipation of C_6 through C_{12} n-alcohols can be predicted to be quite rapid. Use rates for tobacco sucker control are several orders of magnitude below those used by Brengle. Brengle used longer chain compounds; however, since oxidation occurs carbon-by-carbon, the shorter chain compounds would be degraded more rapidly, if they are not simply assimilated for use in the fatty acid synthesis pathway.

Several studies in plants dealing with the synthetic pathways used in the production of plant waxes and wax esters give some information on the level of low-chain length fatty alcohols which may be deposited in agricultural soils. That data is not included in the section but is reviewed in the attached bibliography (see: Moreau and Huang, 1979; Wilkinson, 1973; and Wilkinson, 1974). These studies also suggest that the variability of background fatty alcohols in soil will be great, depending upon the specific environmental factors relating to plant growth, nutrition and soil metabolism.

XII. SECTION N GUIDELINES, 165-4: BIOACCUMULATION IN FISH

Fatty alcohols and wax esters are abundant in nature. The fact that one source of the fatty alcohols used in tobacco sucker control agents is plant material is the strongest evidence of their occurrence. Bioaccumulation would not be expected since these compounds are constantly cycled through the carbon pool. Several articles reviewed support this hypothesis.

Wax esters are an abundant source of energy in the marine environment (Place and Roby, 1986). Hydrolysis of wax esters produces fatty alcohols which then are oxidized to or assimilated into fatty acids. Cycling of fatty alcohols begins at the "base" of the food chain. Annelids, crustacea and single celled organisms all assimilate fatty alcohols and acids and are important in affecting the flux of lipids through food chains (Bradshaw, et. al, 1990 and 1990a; Hosotani, et al, 1988).

Obst (1986) reported that the feces of wax-fed birds (Wilson's storm petrel) contain fatty alcohol and fatty acid, again the products of wax hydrolysis. Fish feeding on zooplankton readily digest fatty acids of C_{18} to C_{20} chain length; higher chain lengths are excreted in the feces. The same pattern would be expected for fatty alcohols, except that they are likely to be converted to fatty acids or synthesized into more complex molecules.

In further studies on fish, Cowey and Sargent (1977) followed the distribution and fate of fatty alcohols which resulted from wax ester hydrolysis. These authors reported that fatty alcohols were oxidized to the corresponding acid and thereafter follow pathways of fatty acid metabolism. Some species were reported to have the ability to convert short chain acids into longer chain polyunsaturated acids that have full essential fatty acid activity. This finding would suggest that pathways exist for the rapid assimilation of fatty alcohols.

Similar findings are reported in other types of organisms. Komnick and Bauerfeind (1991) reported that dragonfly larvae hydrolyze wax esters and absorb both the fatty acid and fatty alcohol moieties. These moieties are then used in the synthesis of triglycerides and wax esters. No accumulation of lipid droplets occurred after ingestion of free fatty alcohol alone. Again supporting the rapid assimilation of this class of compounds.

Straight-chain fatty alcohols are considered "building blocks" in fatty acid synthesis and other carbon cycling pathways (Hay, 1981). The existence of these pathways provides for mechanisms which prevent bioaccumulation from occurring. Hence, bioaccumulation in fish, a result of the use of fatty alcohols in tobacco sucker control, definitely would not be expected to occur.

XIII. CONCLUSIONS

Guideline Number 160-5, Chemical Identity: Normal fatty alcohols are considered chemically "inert" and are precursors to fatty acids. Their production and manufacture yields a relatively pure product mixture, depending upon the "cut" desired. The C_6-C_{12} alcohols used in tobacco sucker control agents would be expected to contain no unusual or high levels of impurities.

Guideline Number 161-1, Hydrolysis: Hydrolysis is not a major pathway of degradation for C_6-C_{12} alcohols.

Guideline Number 161-2, Photodegradation in Water: Photolysis of C_6-C_{12} n-alcohols in water would not be expected to occur.

Guideline Number 161-3, Photodegradation in Soil: Photolysis of C_6-C_{12} n-alcohols in soil would not be expected to occur.

Guideline Number 162-1, Aerobic Soil Metabolism: Aerobic soil metabolism is the major degradation pathway for C_6-C_{12} n-alcohols. Breakdown or assimilation by microbial organisms is rapid and complete. Half-lives may be as short as a matter of hours, and would not be expected to exceed 3 to 5 days.

Guideline Number 162-3, Anaerobic Aquatic Metabolism: Anaerobic aquatic metabolism is similar to other microbial metabolism pathways for C_6-C_{12} n-alcohols. End products may differ due to individual organism output, but products will be natural components of the aquatic system. Breakdown or assimilation by microbial organisms is rapid and complete. Half-lives may be as short as a matter of hours, and would not be expected to exceed one day.

Guideline Number 163-1, Leaching/Adsorption/Desorption: C_6-C_{12} fatty alcohols strongly adsorb to soil and would not be expected to move through the soil column. Desorption is expected to be minimal.

Guideline Number 164-1, Terrestrial Field Dissipation: Dissipation of C_6-C_{12} fatty alcohols under field rates and conditions is rapid and complete. Half-lives as short as a ***matter of hours could be possible. Half-lives would not be expected to exceed 3 to 5 days.***

Guideline Number 165-4, Bioaccumulation in Fish: C_6-C_{12} fatty alcohols will not bioaccumulate in fish.

XIV. RAW DATA ARCHIVING

The final copy of this report will be archived in the Quality Assurance files of Compliance Services International. The references collected will be retained or returned to the sponsor and will be made available for further review if that is the desire of the sponsor or regulatory agencies.

XV. CERTIFICATION

The data presented in this report are true and accurate to the best of my knowledge and were taken from peer-reviewed, published articles. Hypotheses presented on the behavior of specific compounds are logical extensions of the information reviewed to date.

Signed: _____ Date: _____

XVI. TABLES

Table 1. PHYSICAL PROPERTIES OF FATTY ALCOHOL

IUPAC Name	Common Name	CAS registry No.	Molecular formula	M_1	Hydroxyl Number	mp, °C	bp, °C (p.kPa)	Density, g/cm^3 (t, °C)	Refractive index (t, °C)
1-Hexanol	caproic alcohol	111-27-3	$C_6H_{14}O$	102.2	548	-52	157	0.819(20)	1.4181(20)
1-Heptanol	cnanthic alcohol	111-70-6	$C_7H_{16}O$	116.2	482	-30	176	0.822(20)	1.4242(20)
1-Octanol	caprylic alcohol	111-87-5	$C_8H_{18}O$	130.2	430	-16	195	0.825(20)	1.4296(20)
1-Nonanol	pelargonic alcohol	143-08-8	$C_9H_{20}O$	144.3	388	-4	213	0.828(20)	1.4338(20)
1-Decanol	capric alcohol	112-30-1	$C_{10}H_{22}O$	158.3	354	7	230	0.829(20)	1.4371(20)
1-Undecanol		112-42-5	$C_{11}H_{24}O$	172.3	326	16	245	0.830(20)	1.4402(20)
1-Dodecanol	lauryl alcohol	112-53-8	$C_{12}H_{26}O$	186.3	300	23	260	0.822(40)	1.4428(20)
1-Tridecanol		112-70-9	$C_{13}H_{28}O$	200.4	280	30	276		
1-Tetradecabol	myristyl alcohol	112-72-1	$C_{14}H_{30}O$	214.4	261	38	172(2.67)	0.823(40)	1.4358(50)
1-Pentadecanol		629-76-5	$C_{15}H_{32}O$	228.4	245	44			1.4408(50)
1-Hexadecanol	cetyl alcohol	36653-82-4	$C_{16}H_{34}O$	242.5	230	49	194(2.67)	0.812(60)	1.4392(60)
1-Heptadecanol	margaryl alcohol	1454-85-9	$C_{17}H_{36}O$	256.5	218	54			
1-Octadecanol	stearyl alcohol	112-92-5	$C_{18}H_{38}O$	207.5	207	58	214(2.67)	0.815(60)	1.4388(60)
1-Nonadecanol		1454-84-8	$C_{19}H_{40}O$	284.5	196	62			1.4328(70)
1-Eicosanol	arachidyl alcohol	629-96-9	$C_{20}H_{42}O$	298.6	187	64	215(1.33)	0.806(70)	
1-Heneicosanol		15594-90-8	$C_{21}H_{44}O$	312.6	179	68			
1-Docosanol	behenyl alcohol	661-19-8	$C_{22}H_{46}O$	326.6	171	71	2411.33	0.807(80)	

Table 2. PRODUCTION PROCESS USED IN FATTY ALCOHOL MANUFACTURE

Name of Process	Raw Material	Predominent Brief Description	Chain Lengths
Hydrolysis of Wax Esters	Sperm Oil	Oil is heated with concentrated sodium hydroxide at about 300°C	C_{16}-C_{20}
Reduction of Wax Esters with Sodium	Sperm Oil	Molten Sodium is dispensed in an inert solvent and then carefully dried ester and alcohol are added. When the reaction is complete, the alkoxides are split by stirring in water, and the alcohols are washed and distilled	Unsaturated especoleyl alcohol
Hydrogenation of Natural Raw Materials (Proctor & Gamble)(Henkel)	Coconut or Palm Kernel Oil Palm Oil, Soybean oil, tallow Rapeseed oil	Impurties removed in a cleaning stage. Refined Triglycerides are hydrolyzed to yield fatty acids or trans-esterified with lower alcohols to yield fatty acid esters. Hydrogenation is by suspension, gas-phase or tricle-bed.	C_6-C_{18} C_{16} - C_{18} C_{20}-C_{22}
Ziegler Alcohol Process - Alfol (Vista)	Petrochemical feedstocks	Hydrogenation, ethylation, growth reaction, oxidation, hydrolysis, fractionation.	C_2-C_{26}
Ziegler Alcohol Process - Epal (Ethyl Corp)	Petrochemical feedstocks	As above, but growth reaction is limited.	C_6-C_{20}
Oxo Process (hydroformulation)	Petrochemical feedstocks	Reaction of olefins with an H_2-CO gas mixture in their presence of suitable catalyts.	n-butanol and 2-ethylhexanol
Hydrogenation of Fatty Acids	Oxidized Paraffinic Hydrocarbons	Mixture of parafins is oxidized above 100°C in the presence of manganese catalyts.	Linear, primary alcohols with many by products C_{10}-C_{20}
Bashkirov Oxidation	Parafins	Oxidation in the presence of boric acid at 160°C	Secondary alcohols
Other Processes	X-Olefins	Reaction with hydroperoxides in the presence of transition metal catalyts.	Isobutanol, C_{30}-C_{50}

Table 3. ALCOHOLS TESTED AGAINST THE AQUATIC STAGES OF MOSQUITOS

Alcohol	No. of Carbons	Physical Characteristics	Solubility in Water	Molecular Weight	Melting Point
1-decanol	C10	Liquid	Insoluble	158.3	-26.6°C
1-decanol	C10	Liquid	Insoluble	172.3	15.2°C
1-dodecanol	C12	Liquid	Insoluble	186.3	23.0°C
1-Tetradecanol	C14	Solid Wax	Insoluble	214.3	39.0°C
1-hexadecanol	C16	Solid Wax	Insoluble	242.2	49.0°C

Table 4. PROPERTIES OF SOME STRAIGHT-CHAIN ALCOHOLS

Name	Formula	Molecular Weight	m.p. °C	b.p. °C	Water solubility (g 100 ml^{-1})
Methanol	CH_3OH	32	-94	65	*
Ethanol	C_2H_5OH	46	-117	70	*
1-propanol	C_3H_7OH	60	-127	97	*
1-butanol	C_4H_9OH	74	-90	117	8•0
1-pentanol	$C_5H_{11}OH$	88	-79	137	2•2
1-hexanol	$C_6H_{13}OH$	102	-47	158	0•6
1-heptanol	$C_7H_{15}OH$	116	-34	176	0•1
1-octanol	$C_8H_{17}OH$	130	-17	195	0•04
1-decanol	$C_{10}H_{21}OH$	158	7	229	0•004

*Soluble in all proportions of water to alcohol.

XVII. FIGURES

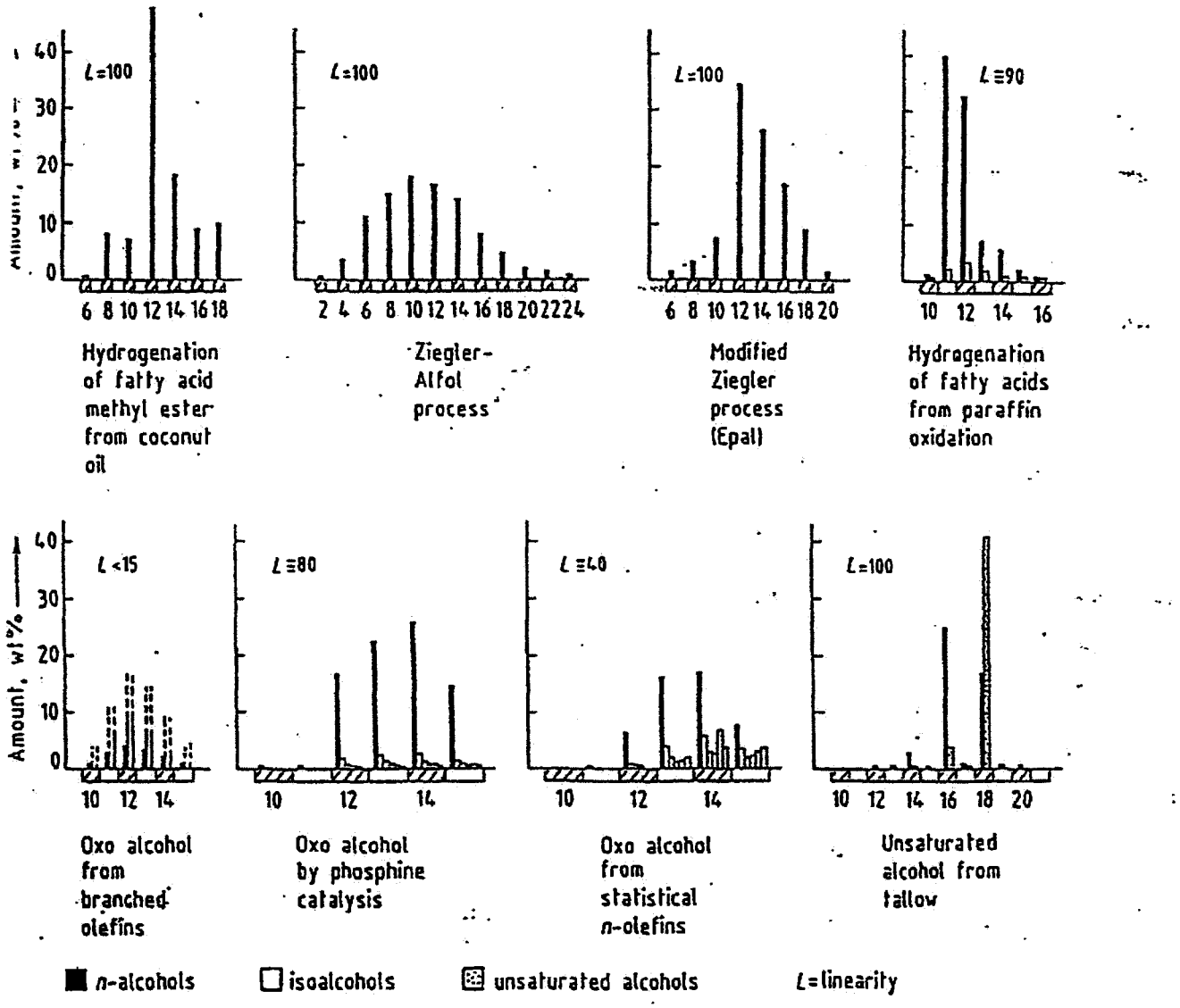
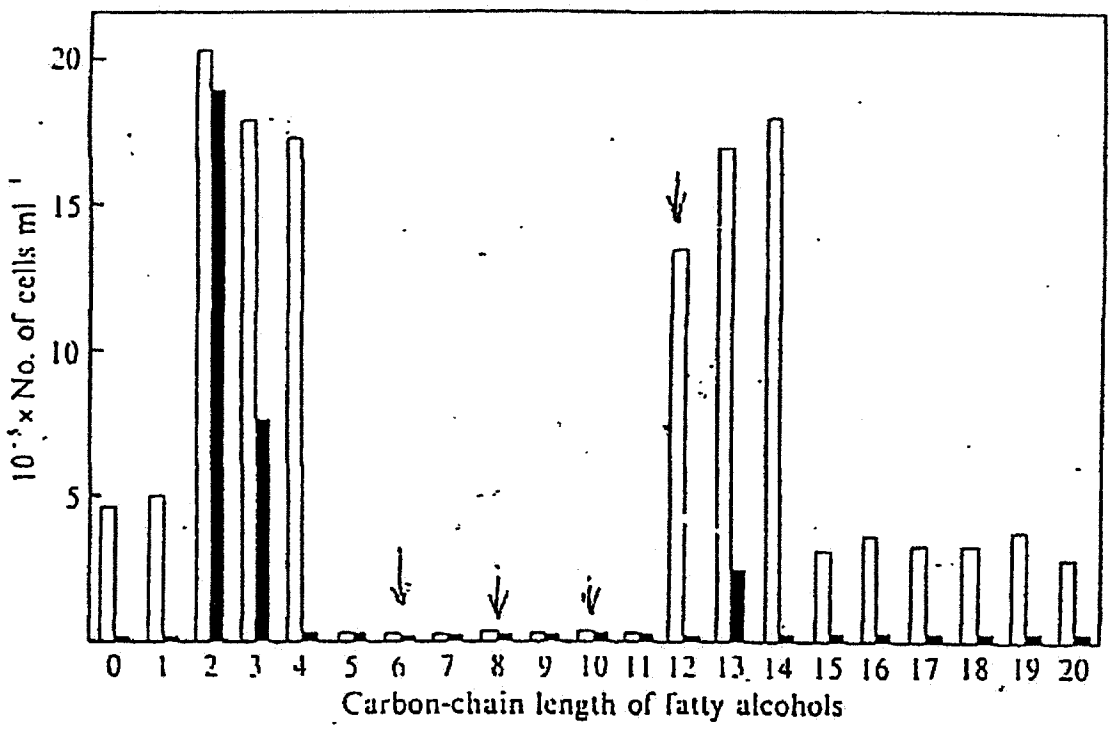


Figure 1. Typical fatty alcohol compositions obtained by different processes



Photoautotrophically grown cells are transferred to culture media containing individual fatty alcohol and cultivated for 14d with or without illumination. Initial cell number was 0.9×10^{-1}. Open and closed bars represent growth of Euglina with and without illumination respectively. A carbon chain length of 0 indicates photoautotrophic growth.

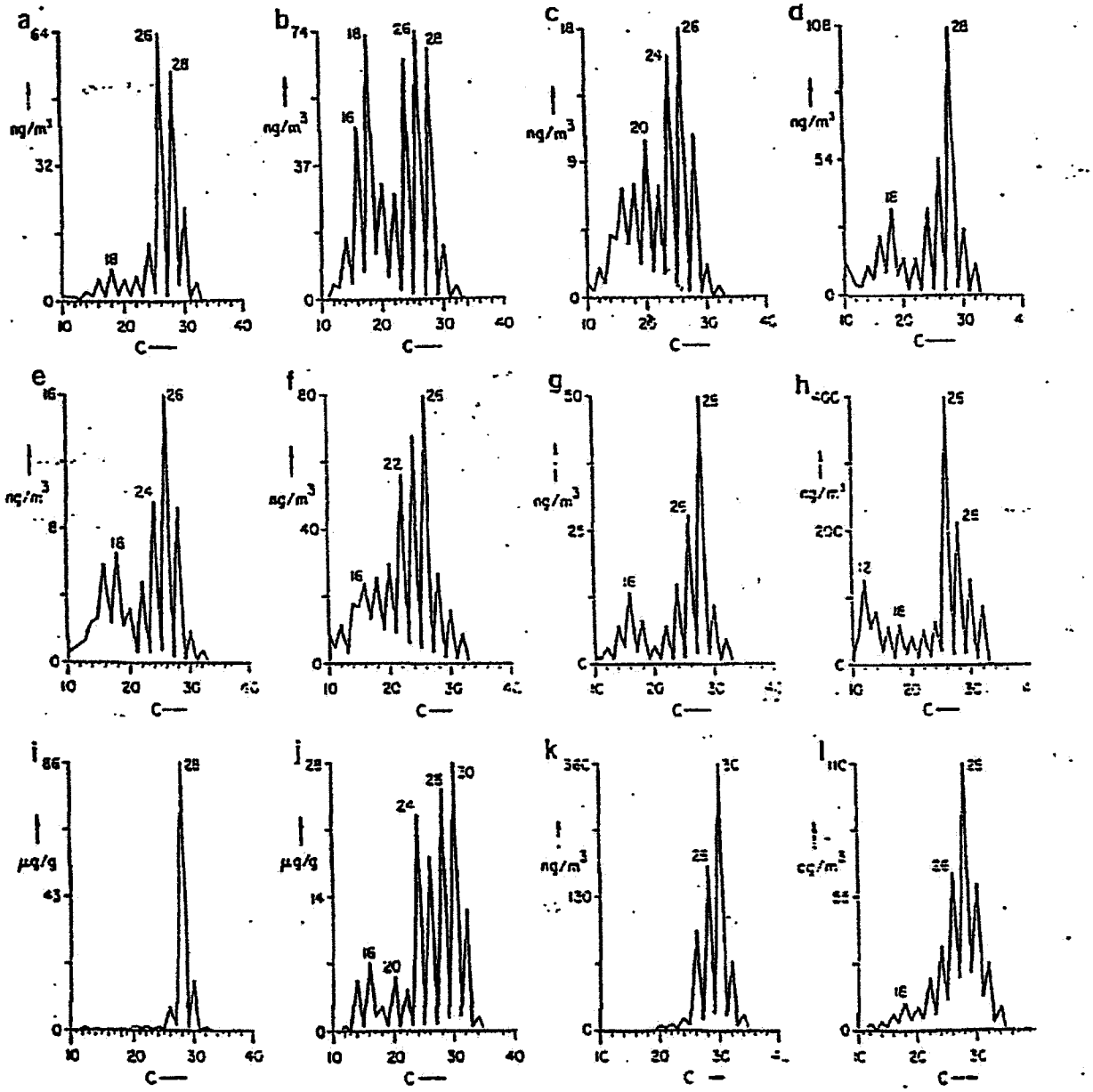


Fig. 3. Distribution diagrams for the *n*-fatty alcohols: (a) Battle Creek Meadow Ranch (sample 6); (b) Sugarpine Point State Park, night, summer (sample 1); (c) Sierra Ski Ranch (sample 5); (d) Sugarpine Point State Park, winter (sample 3); (e) D and D Ranch, summer (sample 8); (f) Corvallis, forest (sample 14); (g) Canoga Park, Santa Ana conditions (sample 16); (h) Pasadena (sample 17); (i) Composited grass, wax (sample 20); (j) Composited conifers, wax sample 21); (k) Harmattan aerosol, Jos, Nigeria (Cox *et al.*, 1982); (l) Atlantic Ocean, DC 4 (Simoneit, 1977a).

XVIII. ANNOTATED BIBLIOGRAPHY

Abstracts only	(-)
Article reviewed	(✓*)
Referenced by author and referenced information is presented	(*)

✓*Ambles, A., J. C. Jacquesy, P. Jambu, et al. 1991. Polar lipid fraction in soil - a kerogen-like matter. Organic Geochemistry 17(3):341-349.

"Soil lipids include a great number of neutral or acid components (hydrocarbons, esters, ketones, fatty alcohols and acids) which can be easily studied ("simple lipids") and an unknown, barely soluble, fraction called "polar fraction" or "complex lipids"."

In reviewing the work of others, conducted to identify the relationship of simple lipids to complex lipids in soils, Ambles observed that the experimental results "suggested that the soil polar fraction may correspond to a polar matrix (a biopolymer) which can "react" with simple lipids, the process of incorporation of simple lipids being reversible in biologically-active soils."

Ambles selected two hydromorphic soils from the western part of France for his studies. He compared the simple lipids in the soil to the breakdown products of the "polar fraction". The *n*-alkanes displayed a relatively regular distribution ranging from C_{16} to C_{36}. In further extraction processes, primarily even-carbon number, straight chain alkanols (maximum chain length C_{22}) were found in both soils. His work also showed that the distribution of simple lipids was similar to the products derived from the breakdown of the polar fraction of the soil, suggesting that his initial premise may be valid, and that the polar fraction of the soil is a "sink" for the fatty alcohols and lipids introduced into the soil from plant fractions and microbial activity.

*Aubertin, G.M., G. W. Gorsline. 1964. Effect of fatty alcohol on evaporation and transpiration. Agron. J56:50-52.

*Barras, D. R., & B. A. Stone. 1969. Carbohydrate composition and metabolism in Euglena. In The Biology of Euglena, Vol. 2, pp. 149-191. Edited by D. E. Buetow. NY:Academic Press.

Bradshaw, S. A., S. C. M. O'Hara, E. D. S. Corner, et al. 1990. Changes in lipids during simulated herbivorous feeding by the marine crustacean *Neomysis integer*. Journal of the Marine Biological Association of the United Kingdom. 70(1):225-244.

The results of these investigations indicate that crustaceans such as that tested here would have a profound effect on fatty acid and alcohol fractions in material that passes though the pelagic food chain; feeding activity of these organisms may determine certain aspects of the sedimentary lipid distributions.

Bradshaw, S. A., S. C. M. O'Hara, E. D. S. Corner. 1990. Dietary lipid changes during herbivory and coprophagy by the marine invertebrate *Nereis diversicolor*. Journal of the Marine Biological Association of the United Kingdom. 70(4):771-788.

Herbivorous and particularly coprophagous feeding by the annelid worm, *Nereis diversicolor* leads to relatively high abundances of "bacterial" odd carbon-number normal and branched chain fatty acids and these organisms are important in affecting the flux of lipids through marine food chains.

Brengle, K. G. 1965. The behavior of fatty alcohol applied to soils. Dissertation, Michigan State University (reported in Dissertation Abstracts International, 26(2):615.

Fatty alcohol absorption by Wyoming ventonite was studied by x-ray diffraction, differential thermal analysis, infra-red absorption and angle of wetting. Hydrogen bonding was assumed to be the primary attraction between fatty alcohol and ventonite. Fatty alcohols were found to be active in reducing water movement in soil at extremely high rates (see Brengle, 1969). This research was conducted with a special interest in fatty alcohols as evaporation control agents. Vertical and lateral movement of fatty alcohol in the soil was practically non-existent. the lack of lateral movement suggests that compressed monofilms are not formed at the air-water interface in the soil.

*Brengle, K. G., H. O. Mann. 1969. Effect of fatty alcohol on change in soil water during the summer fallow period. Journal of Soil and Water Conservation. 24(1):25-26.

Hexadecanol and octadecanol were used in an experiment assessing the capability of these compounds to inhibit soil moisture loss. Octadecanol was broadcast at 0, 300, 600 or 900 pounds per acre each May for three years. Fatty alcohol, at the rates used in this study, did not retard soil water loss enough to warrant use in a fallow system. The treated area did maintain a protective vegetation cover.

*Broddin, G. W. Cautreels & D. van Cauwenberghe. 1980. On the aliphatic and polyaromatic hydrocarbon levels in urban and background aerosols from Belgium and the Netherlands. Atmospheric Environment 14:895-910.

✓*Brown, H. 1983. The stability of esters to hydrolysis. Cosmetics and Toiletries. 98(12):56-58.

Six fatty alcohol esters were selected for hydrolysis studies: C_{12-15} alcohols benzoate, isopropyl myristate, isopropyl palmitate, lauryl lactate, dioctyl adipate and isononyl isononate. Lauryl lactate was included since it hydrolyzes readily and would be a good comparison standard reference. The hydrolysis methodology utilized 95% ethanol solutions and pH levels of 2, 3, and 12. Ten percent ester solutions were prepared and subjected to 3 hour reflux and oven storage (47°C for 30 days). Hydrolysis was measured by titration. The method utilized for alkaline hydrolysis was inadequate and no results were obtained. Under acid conditions, laurel lactate had the greatest degree of hydrolysis at both 3 hour reflux and 30 day storage intervals. While the behavior of the ester is determined in these studies, no specific data is provided on the alcohols or their stability in this system.

Buning-Pfaue, H., H. J. Rehm. 1972. Production of aldehyde from "batch" fermentation by *Pseudomonas aeruginosa* growing on decanol. Arch. Mikrobiol. 86(3):231-40.

A *Pseudomonas* species was able to produce fermentation products based on the use of decanol as a sole source of nutrients. This suggests that soil microorganisms readily incorporate fatty alcohols into their nutrient assimilation cycles.

*Cook, K. A. 1979. Degradation of non-ionic surfactant Dobanol 45-7 by activated sludge. Water Res. 13:259-266.

Cowey, C. B., J. R. Sargent. 1977. Lipid nutrition in fish. Comparative Biochemistry and Physiology B: Comparative Biochemistry. 57(4):269-274.

Currie, B. R., R. B. Johns. 1989. An organic geochemical analysis of terrestrial biomarkers in a transect of the Great Barrier Reef Lagoon, Queensland, Australia. Australian Journal of Marine and Freshwater Research. 40(3):275-284.

Fatty alcohols, as well as certain other compounds are being used as "biomarkers" to determine the deposition and source of marine sediments. Fatty alcohols are deposited not only from terrestrial sources but also from planktonic sources and thus are not well correlated with distance-from-land.

Fatty alcohols resulting from wax ester hydrolysis are oxidized to the corresponding acid and thereafter follow pathways of fatty acid metabolism. Some species have the ability to convert short chain acids into longer chain polyunsaturated acids that have full essential fatty acid activity.

*Finnerty, W. R. & M. E. Singer. 1984. A microbial biosurfactant - physiology, biochemistry and applications. Dev. Ind. Microbiol 25:31-40.

Garrett, W. D. 1964. The organic chemical composition of the ocean surface. Naval Research Laboratory (Washington) Report No. NRL-6201. NTIS No. AD-610 396.

The major water-insoluble organic constituents of the sea are fatty esters, free fatty acids, fatty alcohols and hydrocarbons. The distribution of the various fatty acids and alcohols varies according to the meteorological and oceanographic conditions prevalent at a particular location. The high molecular weight and less-water soluble fatty alcohols are the most surface active (likely to be found absorbed to the surface) while the more water soluble (less surface active) compounds are excluded from the surface by competition with these compounds.

*Gentner, W. A. 1966. The influence of EPTC on external foliage wax deposition. Weeds 14:27-31.

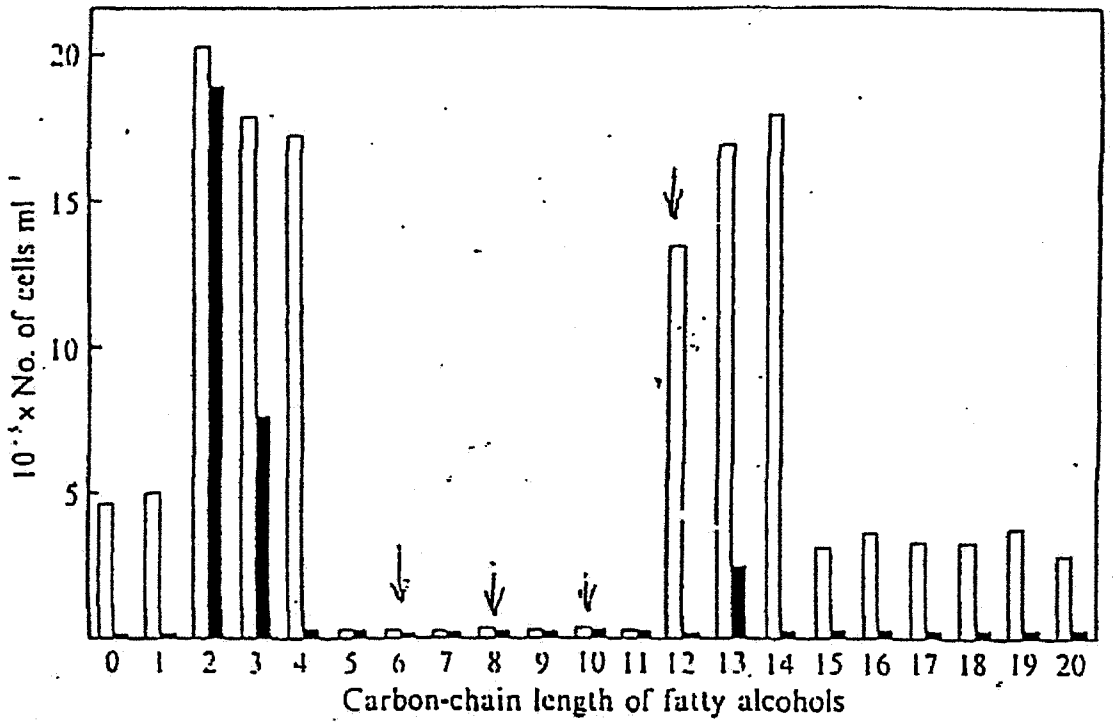
Gerhold, R. M. & G. W. Malaney. 1966. Structural Determinants in the Oxidation of Aliphatic Compounds by Activated Sludge. Journal Water Pollution Cont. Fed. 38(4):562-79.

✓*Hosotani, K., T. Ohkochi, H. Inui, et al. 1988. Photoassimilation of fatty acids, fatty alcohols and sugars by *Euglena gracilis* Z. Journal of General Microbiology. 134(1):61-66.

The assimilation of fatty alcohols and other carbon sources by *Euglena gracilis* Z. was investigated by studying the growth of the organism and its photoassimilation of these compounds. This investigation demonstrates the effect of light on the growth of *Euglena* and compares the mechanisms of their photoassimilation.

E. gracilis Z and its streptomycin-bleached mutant from established stock cultures were exposed to growth media containing 0.2% fatty alcohols (carbon chain lengths of 1 to 20). Cell numbers were determined by hemacytometer counts. Where investigation included the use of 1-tetradecanol (myristyl alcohol), extraction was by chloroform, with determination by gas-liquid chromatography.

E. gracilis growth varied depending upon the chain length of the alcohols included in the culture medium. Ethanol was the best carbon source in both light and dark. Propanol, butanol, 1-dodecanol, 1-tridecanol, and 1-tertadecanol also supported considerable growth under illumination. Assimilation of butanol, dodecanol and tetradecanol for growth strictly depended upon light. The fatty alcohols C_5-C_{11} inhibited growth, while methanol and the alcohols C_{15}-C_{20} did not support growth.



Photoautotrophically grown cells are transferred to culture media containing individual fatty alcohol and cultivated for 14d with or without illumination. Initial cell number was 0.9×10^{-1}. Open and closed bars represent growth of Euglina with and without illumination respectively. A carbon chain length of 0 indicates photoautotrophic growth.

The results of the photoassimilation experiments show that photosynthetic energy is not completely necessary for the photoassimilation of the alcohol. The blue light receptor may take part in the photoassimilation of myristyl alcohol; photosynthesis also appears to have some relation to photoassimilation since the occurrence of photosynthesis during the soldering caused a higher cell yield.

✓*Hoering, T. C. 1969. Fatty alcohols in sedimentary rocks. Yearbook of the Carnegie Institute of Washington. 67:202-203.

". . . Mild thermal treatment of unextracted recent sediment produced a good yield of the normal alkanes n-$C_{22}H_{46}$ and n-$C_{24}H_{50}$ and that under the same conditions recent sediment will reduce fatty alcohol to an alkane. These considerations suggest that fatty alcohols in the form of wax esters may be present in sedimentary rocks. Plant waxes are esters of fatty acids and fatty alcohols . . . where [carbon chain lengths] typically run from 12 to 30." [plus two for the initial and terminal carbons] . . . Fatty alcohols, presumably present in the form of wax esters, make a small but significant contribution to the inventory of normal alkyl groups found in sedimentary rocks."

*Ichikawa, Y., Y. Kitamoto & N. Hosoi. 1978. Degradation of polyethylene glycol ethers by a Pseudomonad isolated from activated sludge. J. Ferm. Techanol. 56:403-409.

*Ioneda, T. 1984. Lips of Actinomycetes: Their structure and biosynthesis In Biological, Biochemical and Biomedical Aspects of Actinomycetes. Ed. by L. Ortiz-Ortiz, L. F. Bojalil and Y. Yakoleff. Acad. Press. NY pp. 239-49.

*Jambu, P., G. Coulibaly, P. Bilong et al. 1983. Influence of lipids on physical properties of soil. Studies About Humus Humas & Planta. VIII 1:46-50.

*Kolattukudy, P.E. 1968. Tests whether a head to head condensation mechanism occurs in the biosynthesis of n-hentriacontaine, the paraffin of spinach and pea leaves. Plant Physiol. 43:1466-1470.

*Kolattukudy, P.E. & T. J. Liu. 1970. Direct evidence for biosynthetic relationships among hydrocarbons, secondary alcohols and kitones in *Brassica oleracea*. Biochem. Biophys. Res. Commun. 41:1369-1374.

Komnick, H., R. Bauerfeind. 1991. Intestinal absorption of defined lipids by the larval dragonfly *Aeshna cyanea* (Insecta, Odonata) - wax esters and fatty alcohols. Journal of Insect Physiology. 37(3):179*f*.

Dragonfly larvae hydrolyse wax esters and absorb both the fatty acid and fatty alcohol moieties. These components are then used in the synthesis of triglycerides and wax ester. No accumulation of lipid droplets occurs after ingestion of free fatty alcohol alone. Wax ester is a natural constituent of the larval cuticle of this species.

✓*Langley, W. D. Intermediate products in the bacterial decomposition of hexadecanol and octadecanol. Technical Report # TR-29; W70-09829; OWRR-A-012-TEX(1). Texas A&M University Water Resources Institute. NTIS Accession #PB-194-237.

In the arid climate of the southwest, control of water loss by the use of monolayer films was investigated. In conjunction with these efforts, this project was designed to meet two goals: (1) to investigate the behavior of hexadecanol and octadecanol in microbial systems, including the detection, identification and behavior of any intermediate or end products formed as a result of biological transformation; and (2) to correlate the behavior of long-chain fatty alcohols with studies of lower molecular weight alcohols.

Three primary analytical techniques were employed to obtain direct and specific measure of the rate and extent of degradation of hexadecanol and octadecanol by adapted microorganisms: gas chromatography, total organic carbon analysis and recorded oxygen uptake. A settled sewage supernatant was used as the source of microbial organisms

which were adapted to the alcohol substrate. Low chain length alcohols (3 and 5 carbon) were used to condition the system and demonstrate its capability to adapt to soluble alcohols as a carbon source. The higher chain alcohols were insoluble in water but formed a film on the water surface. Due to this filming tendency, 1-hexadecanol and 1-octadecanol were tested in a static environment to avoid loss of the compound on flask walls.

1-butanol and 1-pentanol were removed from the solutions within 4 to 6 hours of their introduction. When isopentanol was also present, there appeared to be a selectivity of response which favored the straight chain alcohols. The total organic carbon removal during this phase of experimentation approached first order microbial response with half-lives as short as 2 hours. Similar responses were evoked when cultures were exposed to isobutanol, 1-butanol and 1-pentanol; response to straight chain alcohols was virtually non-selective and the removal of isobutanol was essentially stopped until the straight chain alcohols were removed or converted.

Considerable operational difficulty was experienced in attempts to conduct growth and utilization trials on the higher chain alcohols. Given sufficient time in contact with the adapted microbial species, complete disappearance of 1-hexadecanol and 1-octadecanol as an identifiable molecular species will occur. Experimental difficulties precluded the establishment of an exact half-life, but degradation appeared to be fairly complete within 7 to 10 days. Where these substrates were added in granular, slow release forms, so that disappearance was also slowed, no significant soluble organic accumulation occurred. Where substrate was added in dissolved form (a hexane solution), microbial growth was rapid and there was evidence of soluble organic accumulation above the level of controls. Efforts to extract and identify the organs were unsuccessful, partly due to the presence of hexane as a complicating factor (some adaptation to hexane may have occurred).

The complications of studying these compounds in both the field and laboratory were discussed. The fact that solvents such as hexane or isopropanol must be used to disperse the compounds in a aquatic system and the ubiquitous presence of carbon make qualification and identification of breakdown products extremely difficult.

*Larson, R.J. & L.M. Games. 1981. Biodegradation of linear alcohol ethoxylates in natural TRANSLATED BY The British Library Document Supply Center. Boston Spa, Wetherby, West Yorkshire LS23 7BQ, United Kingdom. BLDSC 5828.4 (M-52051).

Lindstedt, M., S. Allenmark, R. A. Thompson and L. Edebo. 1990. Antimicrobial activity of betaine esters quaternary ammonium amphiphiles which spontaneously hydrolyze into non-toxic components. Antimicrobial Agents and Chemotherapy. 34(10):1949-1954.

*Lorenzen, G.A. and W. W. Meinke. 1968. A feasibility study on the utilization of monomolecular films for mosquito abatement. Mosquito News 28:230-232.

*Mann, H. Biological effects of fatty alcohols on freshwater animals. Internationale Revue der Gesamten Hydrobiologie. 56:599-607. TRANSLATED BY The British Library Document Supply Center. Boston Spa, Wetherby, West Yorkshire LS23 7BQ, United Kingdom. BLDSC 5828.4 (M-52051).

*Miller, S. and Q.D. Maddock. 1970. Ovicidal effect of selected compounds on the eggs of Anopheles albimanus. Journal of Economic Entomology. 63:1151-1154.

Moreau, R. A., A. H. C. Huang. 1979. Oxidation of fatty alcohol in the cotyledons of jojoba seedlings. Archives of Biochemistry and Biophysics. 194(2):422-430.

During the germination of jojoba (*Simmondsia chinensis*) seeds, fatty alcohols are formed from the hydrolysis of stored wax esters. The cotyledon extract has the ability to convert fatty alcohols to fatty aldehydes in the presence of molecular

O_2 and subsequently to fatty acids when NAD+ is added. The whole fatty alcohol oxidation system is capable of oxidizing monosaturated fatty alcohols which are the physiological substrates in jojoba cotyledons.

Noweck, K., H. Ridder. 1987. Fatty alcohols. In Ullman's Encyclopedia of Industrial Chemistry, 5th ed. A10(4): 277-296. VCH Publishers Inc., New York.

Fatty alcohols are aliphatic alcohols with chain lengths between C_6 and C_{22}. They are predominantly straight-chain and monohydric, and can be saturated or have one or more double bonds. Alcohols with a chain length above C_{22} are referred to as wax alcohols. The character of fatty alcohols is determined by the manufacturing process and the raw materials used. Natural products, such as fats, oils and waxes, and the Ziegler alcohol process give straight-chain, primary, even-numbered alcohols. Other types of dimerization and oxidation processes give branched chain or secondary alcohols of various characteristics.

"Natural fatty alcohols" are derived from renewable resources such as fats, oils and waxes of plant or animal origin. "Synthetic fatty alcohols" are produced from petrochemicals such as olefins and paraffins. Up until 1930, the manufacture of fatty alcohols was based almost exclusively on the splitting of sperm oil. The invention of high-pressure hydrogenation was developed at that time and allowed the use of new raw materials. In 1985, the world nameplate production capacity of fatty alcohols was estimated at 1.3×10^6 t/a, of which about 60% was based on petrochemicals. Fatty alcohols and their derivatives are used in synthetics, surfactants, oil additives and cosmetics and have many specialty uses, such as sucker control agents in tobacco.

Physical Properties: Saturated fatty alcohols up to dodecanol (12 carbons) are clear, colorless liquids with a lower specific density than water. The lower members of the series have a characteristic odor. The physical properties of straight-chain, primary alcohols are summarized in the table below.

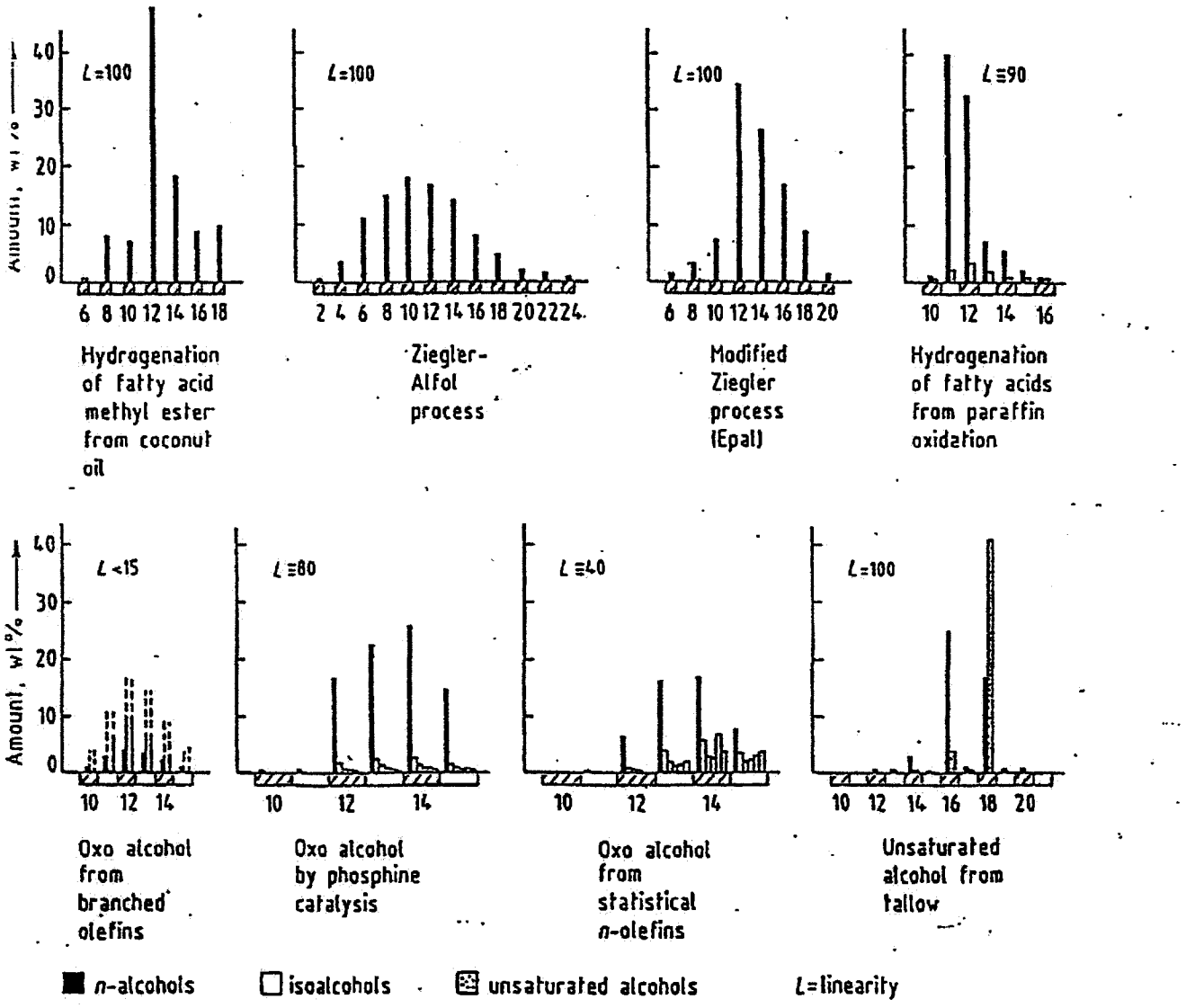


Figure 1. Typical fatty alcohol compositions obtained by different processes

Boiling points and melting points increase uniformly with chain length. The influence of the polarizing hydroxyl group diminishes with increasing chain length; thus hexanol and even octanol show some water solubility, but decanol and the higher fatty alcohols can be considered as immiscible with water. Common organic solvents such as petroleum ether, lower alcohols and diethyl ether are suitable for fatty alcohols.

Under normal conditions, fatty alcohols are resistant to oxidation. However, they can be converted into aldehydes or carboxylic acids using strong oxidants or by catalytic oxidation with air or oxygen.

Production Processes: Several processes are available for the production of fatty alcohols. The base material and the technique used determine the type and length of the carbon chain in the final product. The type of process, base material and the end products produces are outlined below:

PRODUCTION PROCESS USED IN FATTY ALCOHOL MANUFACTURE			
Name of Process	Raw Material	Predominent Brief Description	Chain Lengths
Hydrolysis of Wax Esters	Sperm Oil	Oil is heated with concentrated sodium hydroxide at about 300°C	C_{16}-C_{20}
Reduction of Wax Esters with Sodium	Sperm Oil	Molten Sodium is dispensed in an inert solvent and then carefully dried ester and alcohol are added. When the reaction is complete, the alkoxides are split by stirring in water, and the alcohols are washed and distilled	Unsaturated especoleyl alcohol
Hydrogenation of Natural Raw Materials (Proctor & Gamble)(Henkel)	Coconut or Palm Kernel Oil Palm Oil, Soybean oil, tallow Rapeseed oil	Impurties removed in a cleaning stage. Refined Triglycerides are hydrolyzed to yield fatty acids or trans-esterified with lower alcohols to yield fatty acid esters. Hydrogenation is by suspension, gas-phase or tricle-bed.	C_6-C_{18} C_{16} - C_{18} C_{20}-C_{22}
Ziegler Alcohol Process - Alfol (Vista)	Petrochemical feedstocks	Hydrogenation, ethylation, growth reaction, oxidation, hydrolysis, fractionation.	C_2-C_{26}
Ziegler Alcohol Process - Epal (Ethyl Corp)	Petrochemical feedstocks	As above, but growth reaction is limited.	C_6-C_{20}
Oxo Process (hydroformulation)	Petrochemical feedstocks	Reaction of olefins with an H_2-CO gas mixture in their presence of suitable catalyts.	n-butanol and 2-ethylhexanol
Hydrogenation of Fatty Acids	Oxidized Paraffinic Hydrocarbons	Mixture of parafins is oxidized above 100°C in the presence of manganese catalyts.	Linear, primary alcohols with many by products C_{10}-C_{20}
Bashkirov Oxidation	Parafins	Oxidation in the presence of boric acid at 160°C	Secondary alcohols
Other Processes	X-Olefins	Reaction with hydroperoxides in the presence of transition metal catalyts..	Isobutanol, C_{30}-C_{50}

Table 1. PHYSICAL PROPERTIES OF FATTY ALCOHOLS

Table 1. PHYSICAL PROPERTIES OF FATTY ALCOHOL									
IUPAC Name	Common Name	CAS registry No.	Molecular formula	M_1	Hydroxyl Number	mp, °C	bp, °C (p.kPa)	Density, g/cm^3 (t, °C)	Refractive index (t, °C)
1-Hexanol	caproic alcohol	111-27-3	$C_6H_{14}0$	102.2	548	-52	157	0.819(20)	1.4181(20)
1-Heptanol	cnanthic alcohol	111-70-6	$C_7H_{16}0$	116.2	482	-30	176	0.822(20)	1.4242(20)
1-Octanol	caprylic alcohol	111-87-5	$C_8H_{18}0$	130.2	430	-16	195	0.825(20)	1.4296(20)
1-Nonanol	pelargonic alcohol	143-08-8	$C_9H_{20}0$	144.3	388	-4	213	0.828(20)	1.4338(20)
1-Decanol	capric alcohol	112-30-1	$C_{10}H_{22}0$	158.3	354	7	230	0.829(20)	1.4371(20)
1-Undecanol		112-42-5	$C_{11}H_{24}0$	172.3	326	16	245	0.830(20)	1.4402(20)
1-Dodecanol	lauryl alcohol	112-53-8	$C_{12}H_{26}0$	186.3	300	23	260	0.822(40)	1.4428(20)
1-Tridecanol		112-70-9	$C_{13}H_{28}0$	200.4	280	30	276		
1-Tetradecabol	myristyl alcohol	112-72-1	$C_{14}H_{30}0$	214.4	261	38	172(2.67)	0.823(40)	1.4358(50)
1-Pentadecanol		629-76-5	$C_{15}H_{32}0$	228.4	245	44			1.4408(50)
1-Hexadecanol	cetyl alcohol	36653-82-4	$C_{16}H_{34}0$	242.5	230	49	194(2.67)	0.812(60)	1.4392(60)
1-Heptadecanol	margaryl alcohol	1454-85-9	$C_{17}H_{36}0$	256.5	218	54			
1-Octadecanol	stearyl alcohol	112-92-5	$C_{18}H_{38}0$	207.5	207	58	214(2.67)	0.815(60)	1.4388(60)
1-Nonadecanol		1454-84-8	$C_{19}H_{40}0$	284.5	196	62			1.4328(70)
1-Eicosanol	arachidyl alcohol	629-96-9	$C_{20}H_{42}0$	298.6	187	64	215(1.33)	0.806(70)	
1-Heneicosanol		15594-90-8	$C_{21}H_{44}0$	312.6	179	68			
1-Docosanol	behenyl alcohol	661-19-8	$C_{22}H_{46}0$	326.6	171	71	2411.33	0.807(80)	

Uses: Fatty alcohols are mainly used as intermediates. Surfactants account for 70-75% of fatty alcohol production. The most important groups of surfactants are alkyl polyglycol ethers, alkyl sulfates and alkyl polyglycol ether sulfates. On a much smaller volume, fatty alcohols are used in cosmetic creams, lotions and industrial emulsions.

Analytical Methods: Analytical methods for quality control purposes are defined by DIN [101], ASTM [102] and the Deutsche Gesellschaft für Fettwissenschaft (DGF) [103]. the parameters measured typically include (where appropriate of the compound under production): composition (by gas chromatography), hydrocarbon content, color, refractive index, density, viscosity, solidification point, boiling range, flash point, ignition temperature, hydroxyl number, carbonyl number, peroxide number, iodine number, acid number, saponification number and water content. The sources of fatty alcohols used for tobacco desuckering include those produced from coconut and other natural oils and those produced from petroleums compounds by the Ziegler Process. Coconut alcohols produce very few impurity peaks and contain less that 0.1% n-tridecanol and varying amounts of n-alkanes. Ziegler alcohols are primary, straight chain alcohols with an even carbon number. Gas chromatography shows up to 1.0% impurities, consisting of numerous even-numbered, isomeric fatty alcohols.

*Neufahrt, A., K. Lötzsch & D. Gantz. 1982. Biodegradability of ^{14}C-labeled ethoxylated fatty alcohols. Tenside Detergents 19:264-268.

*Nooi, J.R., M.C. Testa & S. Willemse. 1970. Biodegradation mechanisms of fatty alcohol non-ionics. Tenside Detergents. 7:61-65.

*Olsen, S.R., F. S. Watanabe, F. E. Clark Et al. 1964. Effect of hexadecanol on evaporation of water from soil. Soil Sci. 97:13-18.

Obst, B. S. 1986. 1986. Wax digestion in Wilson's storm petrel *Oceanites oceanicus*. Wilson Bulletin. 98(2):189-195.

Wax esters are an abundant source of energy in the marine environment. Hydrolysis of the wax ester produces fatty alcohols which are then oxidized to or assimilated into fatty acids.

*Patterson, S.J., C.C. Scott & K.R.E. Tucker. 1970. Nonionic detergent degradation. III. Initial mechanism of the degradation. J. Am. Oil Chem. Soc. 47:37-41.

Peltzer, E. T., R. B. Gagosian. Sampling and quantitation of lipids in aerosols from the remote marine atmosphere. Anal. Chim. Acta. 198:125-144.

Air and rain samples were collected to demonstrate the efficiency of an analytical method for five classes of naturally occurring lipids, one of which was fatty alcohols of C13 to C36 chain length.

Place, A. R., D. D. Roby. 1986. Assimilation and deposition of dietary fatty alcohols in Leach's storm petrel *Oceanodroma leucorhoa*. Journal of Experimental Zoology. 240(2):149-162.

Shading of *Euglena* growing on yield alcohol may have caused the accumulation of paramylon and lowered synthesis of amino acids and protein which are essential for the cell growth. The bleached mutant has been shown to adapt to myristyl alcohol medium after several transfers and an increase in $(NH_4)_{Solution}$ concentration. The mutant may induce an ability to synthesize amino acids from myristyl alcohols by this adaptation.

Prahl, F. G., G. Eglinton, E. D. S. Corner, et al. 1985. Fecal lipids released by fish feeding on zooplankton. Journal of the Marine Biological Association of the United Kingdom. 65(2):547-560.

Fatty acid (and therefore fatty alcohol?) moieties of C18-C20 virtually eliminated in digestion; higher chain lengths were enriched in the feces.

The feces of wax-fed (hexadecyl oleate) birds contain fatty alcohol and fatty acid, the products of wax hydrolysis.

*Ristau, E. & F. Wagner. 1983. Formation of novel anionic trehalose tetraesters from Rhodococcus erythropolis under growth limiting conditions. Biotechnol. Lett 5:95-100.

Romankevich, Ye. A., M. G. Bystrova, I. A. Nemirovskaya, et al. 1982. Composition of lipids of benthic sediments. Viniti. No volume number given. Pages 100-107.

A study was made of the upper layer (0-5 cm) of benthic sediments from a river system shelf. The lipids in the organic matter of the sediments fluctuated from 1.5 to 10.7%, averaging 3.5%, with fatty alcohols being one of the 7 lipid components. This article is in Russian and has not been translated.

Richterich, K., P. Gode, W. Guhl. 1985. Ecological evaluation of a new non-ionic anti-foaming agent. Fette Seifen Anstrichmittel. 87(10) 421-424.

The product discussed is a mixture of C12/C18 fatty alcohol with 10 EO butyl ether. In Germany, specific tests are required for biodegradability ("BiAs" reduction). For this product, the BiAs reduction was between 93 and 98%; a better degree than the minimum regulatory requirement of 80%. Closed bottle tests and a simulation of sewer plant/riverine environments demonstrated rapid biodegradation (time values are not given in abstract. The article is in German and has not been translated.)

Sabastiani, A., Simonetti, A. D., Borgioli, A., et. al. 1971. Behavior of synthetic detergents in soil. III. Soft detergents, microorganisms and soil. Nuovi Ann Ig Microbiol. 22(4):229-242.

This article is in Italian, with no abstract. Lack of other information may require this to be ordered and translated.

Sargent, J. R., C. C. E. Hopkins, J. V. Seiring, et al. 1983. Partial characterization of organic material in surface sediments from Balsfjorden, Northern Norway, in relation to its origin and nutritional value for sediment ingesting animals. Marine Biology (Berlin). 76(1):87-94.

Basin surface sediments were characterized to assess the nature and origin of the organic material present and its potential nutritive value for sediment ingesting animals. Fatty alcohols accounted for 30% of the non-saponifiable lipids and phytol alcohols accounted for 40% of the fatty alcohols. Small amounts of very long-chain fatty alcohols characteristic of terrestrial plants were present, but long-chain monounsaturated fatty alcohols characteristic of marine zooplankton were essentially absent.

No fatty alcohols n-chain-lengths of less than 13 carbons were detected in this experiment. It is possible that the extraction process volatilized the n-fatty alcohols with lower chain lengths (the shortest chain alcohol detected had a melting point near the temperature used in the extraction process and lower chain length compounds would be expected to be more volatile than longer straight-chain alcohols). The percentages of n-fatty alcohols recovered are presented below:

Table 5. Percentages of total epicuticular fatty alcohols within classes on burley tobacco leaves grown under different temperature and light regimes

C_n	18° Short	18° Long	28° Short	28° Long	35° Long	Field	S_x
13	0.0	0.0	0.1	0.0	0.3	0.0	0.07
15	0.6	0.4	1.1	0.8	3.4	2.1	0.42
19	0.9	0.0	1.4	5.2	0.0	0.0	0.40
21	0.7	0.3	1.5	3.8	0.0	0.6	0.15
23	3.2	0.5	3.4	2.2	0.0	0.7	0.54
25	3.6	0.0	6.5	7.6	0.0	0.7	0.96
27	17.8	0.0	1.9	3.8	0.0	0.1	2.22
14	2.0	0.0	2.6	3.4	1.2	0.2	0.10
16	0.5	13.6	6.1	1.0	13.9	11.5	0.80
18	9.2	4.5	11.5	16.6	5.5	5.9	0.58
20	3.3	1.6	2.2	1.2	1.2	4.9	0.91
22	2.4	0.4	2.8	3.8	0.2	6.5	1.50
24	0.0	0.6	1.4	3.7	7.9	1.6	0.53
26	9.3	0.7	8.5	4.5	2.3	0.9	0.32
28	4.1	0.0	1.1	2.0	0.0	0.2	0.42

Fatty alcohol contents exhibited differences in response among leaves grown under differing photoperiods and temperatures. Since epicuticular fatty acid and fatty alcohol class totals were altered by the effects of the environment on genetically uniform leaves, the possibility arose of a random synthesis within a single subclass as opposed to the synthesis of a single product as a major unit within each subclass.

Tobacco epicuticular alkane quality is influenced by photoperiod, temperature and leaf age. Fatty acids are precursors to alkanes in peas and spinach and to primary alcohols in broccoli. Also, alkanes can be converted to secondary alcohols and ketones in broccoli. The quantity of each of these constituents in leaf epicuticular wax appears to depend upon the plant species and the environment during leaf development. In this experiment, generally, long photoperiod and cool temperature were associated with highest long-aliphatic carbon chain production on a leaf area basis. Quantity of the individual alkane, fatty acid and fatty alcohol elasses present under the different growth conditions varied in relation to the leaf metabolic status and not leaf size.

chöberl, P., E. Kunkel & K. Espeter. 1981. (No title provided; cited by Steber (1983)). Tenside Detergents. 18:64.

*Schöberl, P. 1982. Mikrobieller Abbau eines Kokosfettalkohol-ethoxylates durch *Acinetobacter lwoffi*, Stamm ML. Tenside Detergents 19:329-3339.

*Schnitzer, M., C.A. Hindle, M. Meglic. 1986. Supercritical gas extraction of alkanes and alkanoic acids from soils and humic materials. Soil Science Soc. Am. J50:913-919.

✓*Sever, J., P. L. Parker. 1969. Fatty alcohols normal and isoprenoid in sediments. Science (Washington). 164(388-3):1052-1054.

Normal long-chain fatty alcohols were identified in marine sediments and evaluated as indicators of sediment age. Both normal and isoprenoid alcohols were found in recent and ancient sediments. Sediments from three different recent and three different ancient sediments were analyzed by gas chromatography. Ancient sediments were: Miocene age, from an outcrop in the Philippine Islands; Eocene, from Green River (Colorado) Shale; and Upper Cretaceous, from an outcrop near Austin, Texas. Recent sediments were: Baffin Bay, a hypersaline arm of Laguna Madre off Corpus Christi, Texas; Gulf of Mexico, off Port Aransas, Texas; and San Nicholas Basin, off the coast of Southern California.

Recent sediments, even where terrestrial run-off is minimal, contain normal saturated alcohols with 12 to 26 carbons. Alcohols with both even and odd numbers of carbon atoms were present. In addition, normal, monomethyl and isoprenoid long-chain hydrocarbons, alcohols and fatty acids were present. The amounts of alcohols found in recent sediments were from one order of magnitude less to the same order of magnitude as the concentrations of fatty acids.

SEVER TABLE: Concentration
(Parts of alcohol per million parts of dry sediment)
of the Normal Alcohols in Sediments

ALCOHOL	BAFFIN BAY	GULF OF MEXICO	SAN NICHOLAS BASIN	MIOCENE AGE	EOCENE AGE	UPPER CRETACEOUS
n-dodecanol	1.00	-	-	-	-	-
n-tetradecanol	1.40	0.36	3.00	1.75	3.20	1.30
n-hexadecanol	0.99	1.08	2.20	0.14	0.50	1.10

Analytical confirmation was conducted to assure that the extraction procedure did not create any artifacts. Fatty alcohols in sediments probably have their origin in the marine life of the areas studied. Baffin Bay, where C_{12} alcohol was detected, normally receives very little fresh water and is often twice as saline as normal sea water. Such restricted run-off would probably not transport enough terrestrial organic matter to account for the uniform concentrations of alcohols observed in the Bay sediments. The author did not speculate as to which marine organisms were involved in the formation of organic compounds studied here, although he

proposed that bacteria may be involved. Isoprenoid alcohols which were detected suggested that these products were side chains of chlorophyll and possibly were partially decayed deposits of plant material.

*Shadiakhy, A., H. Stage. 1981. Influence of double bonds and branchings on vapor pressure as well as the volatility relations of fatty acids, fatty acid esters, fatty alcohol mixtures or mixtures of the corresponding carbohydrates. Fette Seifen Anstrichmittel. 83(11):431.

This article is in German and is apparently presented only as a meeting abstract. There are no references. It may be interesting to pursue if no other information on volatility is discovered.

✓*Singer, M. E. V., W. R. Finnerty. 1990. Physiology of biosurfactant synthesis by *Rhodococcus* species H13-A. Canadian Journal of Microbiology. 36(11):741-745.

The commercial production of biosurfactants from microbial activity is of interest. Biosurfactants are surface-active agents produced by bacteria, yeasts, and fungi and include such products as fatty acids, glycerides, phospholipids, lipopeptides and antibiotics. Biosurfactants produced by microorganisms are generally considered to represent a mechanism for the solubilization or emulsification of water-insoluble substrates to facilitate transport by the cells.

This investigation describes the identification of a biosurfactant-producing bacterium and the general physiology of biosurfactant synthesis in *Rhodococcus* species H13-A. *Rhodococcus* species H13-A was isolated from soil after several passages on hexadecane enrichment medium. Extracellular glycolipid synthesis by *Rhodococcus* species H13-A occurred following growth on decane through octadecane as sole sources of carbon and energy. The highest levels of glycolipid results from growth on dodecane, tridecane and tetradecane. No evidence was obtained of cell lysis. The synthesis and release of glycolipid into the growth medium are linked to nitrogen limitation.

Other studies were referenced which have investigated this process in other organisms. Other surface-active glycolipids are synthesized by actinomycetes during growth on alkanes, including trehalose mycolates by *Arthrobacter paraffineus*.

✓*Sinniah, B. 1983. Insecticidal effect of aliphatic alcohols against aquatic stages of *Aedes* mosquitoes. Transactions of the Royal Society of Tropical Medicine and Hygiene. 77(1):35-38.

Long chain fatty alcohols (C_{12}-C_{20}) can be applied to water so that a monomolecular layer is formed on the surface. Earlier research showed that a surface layer of lauryl alcohol (C_{12} alcohol) kills all larval stages of *Culex quinquefasciatus*. The aim of the current study was to investigate the effectiveness of some aliphatic alcohols as insecticides against the aquatic stages of *Aedes aegypti* (L.) and *Aedes scutellaris* (Walker).

The article also presents some information on the properties of the compounds investigated. Compounds of interest and their properties given are listed below:

ALCOHOLS TESTED AGAINST THE AQUATIC STAGES OF MOSQUITOS					
ALCOHOL	NO. OF CARBONS	PHYSICAL CHARACTERISTICS	SOLUBILITY IN WATER	MODECULAR WEIGHT	MELTING POINT
1-decanol	C10	Liquid	Insoluble	158.3	-26.6°C
1-decanol	C10	Liquid	Insoluble	172.3	15.2°C
1-dodecanol	C12	Liquid	Insoluble	186.3	23.0°C
1-tetradecanol	C14	Solid Wax	Insoluble	214.3	39.0°C
1-hexadecanol	C16	Solid Wax	Insoluble	242.2	49.0°C

The alcohols tested ranged from chain lengths of C_2-C_{18}, but there were no straight chain alcohols tested below the chain length of decanol. Compounds were tested at concentrations equivalent to 1, 2, 4, 8, 10, 20, 40, 80, 100 and 200 liters/hectare, at test temperatures of 25 to 27 degrees C. Larvae, pupae and eggs were tested. Results are shown below:

24-hour LD_{50} and LD_{90} (%) for various alcohols tested against eggs, first, third and fourth instar larvae and pupae of *Ae. aegypti* and *Ae. scutellaris*

Alcohol Tested	Egg or Larval state	Lethal dose in litres/hectare			
		Ae. aegypti		*Ae. scutellaris*	
		LD^{50}	LD^{90}	LD^{50}	LD^{90}
1-decanol	Egg	3	5	3	5
	L1	3	5	3	4
	L3-L4	3	6	3	6
	pupae	2	3	2	3
1-undecanol	Egg	4	6	4	6
	L1	3	5	3	5
	L3-L4	4	6	3	6
	pupae	4	5	4	5
1-dodecanol	Egg	4	7	4	7
	L1	4	6	4	6
	L3-L4	4	7	4	7
	pupae	3	6	4	6
1-tetradecanol	Egg	20	4	21	42
	L1	285	312	280	315
	L3-L4	285	352	309	335
	pupae	59	86	62	92
1-hexadecanol	Egg	37	54	40	59
	L1	312	396	296	385
	L3-L4	356	436	321	409
	pupae	86	132	91	140

In control trials, the solvent (hexane) showed no harmful effect on the larvae. Trials with more than 10% mortality in the control were not used in the determination of an LC_{50}. This author reports work by Miller and Maddock (1970) which tested a number of alcohols and found only one that was effective (cinnamyl alcohol). Most of the alcohols tested were of lower carbon chain length, and they tend to evaporate before they have a chance to cause damage to the tissues of mosquitoes. Very long chains were ineffective except at very high dosages. In separate studies also reported here, Lorenzen and Meinke (1968) found that larvae fed 1-hexadecanol did not die. It was speculated that mortality was induced by the breakdown of cuticular lipids. thus as with most oils, the surface-active properties may be responsible for the ovicidal activities of these compounds.

Simoneit, B.R.T. 1977. Organic matter in eolian dusts over the Atlantic Ocean. Mar. Chem. 5:443-464.

Simoneit, B. R. 1989. Organic matter of the troposphere V: Application of molecular marker analysis to biogenic emissions into the troposphere for source reconciliations. Journal of Atmospheric Chemistry. 8(3):251.

Aerosols from rural and remote areas in the Western US, South America, Nigeria, and Australia were analyzed for "atmospheric detritus" content. All samples contained predominantly plant waxes. The loadings of hydrocarbons included fatty alcohols at 10 to 1650 ng/m^3. Higher molecular weight lipids contributed a major portion of the organic carbon in samples from remote and rural areas. They are therefore important indicators for regional biogenic sources in the global cycling of organic carbon.

✓*Simoneit, B.R.T. 1979. Biogenic lipids in eolian particulates collected over the ocean. In Proceedings: Carbonaceous Particles In the Atmosphere. (Ed. by T. Novakov), pp. 233-244. NSF-LBL

*Simoneit, B. R. T., M. A. Mazurek. 1982. Organic matter of the troposphere. II. Natural Background of biogenic lipid matter in aerosols over the rural western United States. Atmos. Environ. (England). 16(9):2-139-2159.

This research concluded that higher plant waxes were the predominant matural components in the lipid fractions ($>C_{15}$) of aerosols sampled over rural and oceanic regions. These compounds are important components in the global recycling of organic carbon. Volatile natural organic compounds have been identified and quantified in rural, oceanic and urban aerosols.

This study of aerosols from the Western United States was initiated for the threefold purpose of: (1) comparison of the area extremes; (2) characterization of the solvent soluble fractions; and (3) evaluation of relative organic aerosol contributions from natural biogenic emissions and anthropogenic sources. Aerosol samples were acquired from the rural and urban sites by filtration of the ambient air using a standard high volume air sampler fitted with a quartz fiber filter. Representative samples of vegetation were taken in various areas to provide a composite for *in situ* wax analysis. Analysis was by gas chromatography and GC/MS.

The concentration range for the total lipids (hydrocarbons, fatty acids, fatty alcohols, trace amounts of ketones, etc) was discovered to be from 90 to 3600 ng m^{-3} with the fatty alcohols and other polar lipids at a concentration of 200 to 2000 ng m^{-3}. The yield of lipid material for these samples represented up to 10% of the total organic carbon. The total fatty alcohol composition was indicative of derivation from

vascular plant waxes, especially forest and grassland types of plants. The saw-toothed distribution of the chain lengths (odd>even) compared directly with the n-alkane distributions in specific plant communities. The total fatty alcohol fractions included chain lengths of C_{10} to C_{33}, with the middle of this range predominating.

In this particular investigation, the C_1 to C_{20} homologs were largely lost due to evaporation (according to their boiling points) in the environment and/or in the experimental procedure, or were separated by distillation in the refining process. Absolute concentrations of the homologs $<C_{20}$ in these aerosol samples are not accurate, but qualitative comparisons can be made.

From the information above, the authors have concluded that the concentration of shorter chain fatty alcohols is equal to or greater than the concentration of fatty alcohols which are $>C_{20}$. Typical distribution of fatty alcohols which were quantifiable are shown below, and include data on chain lengths of 10 to 35 carbons.

The author speculates that the homologs $<C_{20}$ may be derived from microbial sources since they are not prevalent in fresh vascular plant waxes. The predominant alcohols in all samples were normal fatty alcohols with minor amounts of secondary alcohols and varying amounts of phytosterols. The dominance of C_{26} and C_{28} chain lengths in the aerosol samples compares in general with the distributions for grass wax. These data indicate that fatty alcohols from plant waxes preserve their characteristic fingerprint in aerosols and are a major fraction of the lipid material.

Procedural blanks were analyzed to assess the accuracy of the extraction and analytical procedures. Some contaminants were discovered and included minor amounts of n-fatty acids and residual phthalate esters, but no fatty alcohols.

✓*Solberg, Y. 1989. A literature review of the lipid constituents of higher fungi. New investigations of *Agaricales* species. International Journal of Mycology and Lichenology. 4(1/2):137-154.

The chemical contents of several higher fungi were studied. Extraction and concentration lead to isolation of fractions containing aliphatic and aromatic hydrocarbons, fatty alcohols and fatty acids. Fatty acids (and fatty alcohols?) were predominantly of C_{16} to C_{18} chain length. The details of findings by species tested are provided, with the discussion centering on fatty acids.

✓*Speel, H. C. 1963. Foam, pollution and biodegradability. Journal of the American Oil Chemist's Society. 40(7):4,12,13,15.

This article presents general information but no original research. The biodegradability of detergents is the topic matter, but their origin (alkyl benzene sulfonates vs. alkyl sulfates) determines their behavior. The straight chain fatty alcohol sulfates, whether derived from natural alcohols, natural fats or oils, or from ethylene by Ziegler-type processes, are generally considered to be completely biodegradable. Sodium lauryl sulfate (C_{12}), for example, disappears in less than 3 days (in water). The overall process was oxidative. In general, the lower molecular weight species of each detergent type produces more foam on agitation, but degrades more rapidly than the higher molecular weight species.

✓*Steber, J., P. Wierich. 1983. The environmental fate of detergent range fatty alcohol ethoxylates. Biodegradation studies with a 14C labelled model surfactant. Tenside Detergents. 20(4):183-187.

In order to solve several outstanding problems in the biodegradation of a model fatty alcohol ethoxylate (labelled separately in the alkyl as well as the EO chain) was elucidated in a continuous activated sludge system using simulation tests and die-away tests. Because the alkyl chain was labeled, some conclusions can be drawn about the fate of the stearyl alcohol side chain. The [1-^{14}C] stearyl alcohol = 7 EO had a specific activity of 19.2 mCi/g; the radiochemical purity was 98%. Only the results of the experimentation conducted on the labeled alkyl compound is discussed here.

The simulation tests used a model plant which was a miniature continuous flow activated sludge unit constructed according to Swisher. The die-away tests were discontinuous tests analogous to the OECD Screening Test and were performed in shake flasks modified to a closed system. In the simulated plant study, after a working-in period of approximately two weeks the plant was fed for about one week with synthetic sewage containing one of the radiolabeled surfactants. As expected, the carbon in the 1-position of the alkyl-labeled compound was mineralized to $^{14}CO_2$ to a greater extent than the EO-moiety of the analogous ^{14}C-EO surfactant. Mineralization rates were 50 to 60% after 2 to 3 days of ^{14}C-feeding, with a slightly increasing tendency. The radioactivity of the effluent from the alkyl-labeled surfactant only amounted to about 6% (undegraded). When results were adjusted for recovery (93.8%), it was reported that 99% of the fatty alcohol ehtoxylates present in the influent incurred microbial attack within 3 hours' retention time in the model plant.

Degradation of the [1-^{14}C] stearyl alcohol ethoxylate led to predominantly (90%) acidic metabolites. This fraction of degradation products was mainly composed of carboxylated polyethylene glycols. The neutral metabolites as well as the acidic biodegradation intermediates were reported as highly biodegradable. 25-30% of the sludge radioactivity accounted for undegraded residual surfactants. The main portion of sludge radioactivity (70%) corresponded to about 27% of the initial radioactivity and consisted of bacterial biomass. The lipid fraction of the sludge from the [1-^{14}C] alkyl ethoxylate experiment had a considerably higher radioactivity than sludge from the ring labeled experiment. This was explained as a consequence of microbial degradation of the alkyl-chain via β-oxidation according to general biochemical pathways, resulting in the production of acetyl units, which represent the elementary precursors for fatty acid biosynthesis.

The relatively high surfactant content in the sludge may result from the comparatively low water solubility of stearyl alcohol + 7 EO. Additionally, the hydrophilic EO-chain of alcohol ethoxylates exhibits a slower biodegradation rate than the hydrophobic part of the surfactant molecule. The faster biodegradation of the alkyl chain is clearly shown by the fact that the intermediates of the [1-^{14}C] stearyl alcohol ethoxylate biodegradation found in the effluent consisted largely of higher EO-numbered acidic polyethylene glycols which obviously must contain a small ^{14}C labeled moiety. In addition, it is evident that these polyethylene glycol carboxylates can only arise if degradation of the alkyl chain starts at the terminal methyl group. This is in accordance with conclusions drawn by other authors.

The alkyl chain of the fatty alcohol ethoxylate exhibited an ultimate biodegradation of about 75%. The actual extent of degradation may exceed this value for two reasons: (1) the steady state mineralization rate was higher than the balanced value of total $^{14}CO_2$-evolution and (2) an undervaluation results from the ^{14}C-labeling position in connection with the degradation mechanism. The biodegradation begins at the terminal

methyl of the alkyl chain, so that in this case, the alkyl carbon in position 1 represents the last carbon being transformed.

From these studies it was concluded that the biodegradation of stearyl alcohol + 7 EO formed no recalcitrant metabolites and would be expected to completely biodegrade under primary sewage treatment, as well as by self-purification processes in surface waters.

Steber, J., P. Gode, W. Guhl. 1988. Fatty alcohol sulfates: the ecological evaluation of a group of important detergent surfactants. Fett Wissenschaft Technologie. 90(1):32-38.

This group of alcohol detergents showed a very rapid and complete biodegradation with respect to primary breakdown and ultimate degradability (mineralization and assimilation). This was true under both aerobic and anaerobic conditions. The similarity of these processes to those for straight-chain fatty alcohol is not explained in the abstract for the article (the article is in German and has not been translated).

✓*Steber, J., P. Wierich. 1985. Metabolites and biodegradation pathways of fatty alcohol ethoxylates in microbial biocenoses of sewage plants. Applied and Environmental Microbiology. 49(3):530-537.

The results of Steber (1983) and subsequent experimentation are discussed and indicate that there is a faster degradation of the alkyl than the polyethylene glycol moiety and that there are two distinct primary degradation mechanisms acting simultaneously in the microbial biocenoses: intramolecular scission of the surfactant as well as ω- and β-oxidation of the alkyl chain. In this report, a picture of the microbial pathways that bring about ultimate biodegradation of fatty alcohol ethoxylates in the environment were made. Studies were conducted in a model continuous flow activated sludge plant similar to that described by the OECD Confirmatory Test.

Stearyl alcohol ethoxylate was labeled on the alcohol or EO portion of the molecule. The information presented here concentrates on the results obtained with the stearly-labeled compound. [1-^{14}C] stearyl alcohol-7 EO of 19.2 mCi/g specific activity and radiochemical purity of 98% was used. The OECD model sewage treatment plant had a 3 hour mean retention time. Radioactivity of the effluent from the alkyl-labeled model surfactant amounted to 9% of the initial activity. Only small amounts (1% of the initial level) of each compound could be attributed to intact parent surfactants. After degradation of the chain-labeled compound, largely acidic compounds were abstained.

A fast degradation of the fatty alcohol moiety of the surfactant, beginning with terminal methyl group and slowing down before the radiolabeled C-1 is reached. The terminal oxidation of the alkyl chain (ω-oxidation) and subsequent stepwise removal of C_2 units at a time by β-oxidation is presented as the fatty alcohol chain metabolic process. The resulting products represent the elementary precursors of fatty acid biosynthesis.

*Steffens, G. L., T.C. Tso & D.W. Spaulding. 1967. Fatty alcohol inhibition of tobacco axillary & terminal bud growth. J. Agr. Food Chem. 15:972-975.

*Stephens, U. 1958. Research and Experiments in Evaporation Reduction. Journal of American Water Works Association. 50:846-854.

*Stevenson, F.J. 1982. Humus Chemistry, Genesis, Composition Reactions. Wiley, New York.

*Still, G. G., D. G. Davis & G. L. Zander. 1970. Plant epicuticular lipids: alternation by herbicidal carbamates. Plant Physiol. 46:307-314.

*Suzuki, T., K. Tanaka, I. Matsuhara et al. 1969. Trehalose lipid and α-branched hydroxy fatty acid formed by bacteria grown on n-alkanes. Agric. Biol. Chem. 33:1619-1627.

Scharer, D.H., L. Kravetz & J.B. Carr. 1979. Biodegradation of non-ionic surfactants, p. 61-66. Proc. of the TAPPI Env. Conf. TAPPI, Atlanta.

Simoneit, B.R.T. 1978. The organic chemistry of Marine Sediments. In Chemical Oceanography, 2nd ed. (edited by J. P. Riley & R. Chester) Vol 7:233-311. Academic Press, New York.

*Tobin, R.S., F.I. Onuska, B.G. Brownlee et al. 1976. The application of an ether cleavage technique to a study of the biodegradation of a linear alcohol ethoxylate noniomic surfactant. Water Res. 10:529-535.

*Vashon, R.D. & B.S. Schwab. 1982. Mineralization of linear alcohol ethoxylates & linear ethoxy sulfates at trace concentrations in estuarine water. Environ. Sci. Technol. 16:433-436.

Venkatesan, M. I., I. R. Kaplan. The lipid geochemistry of Antartic marine sediments: Bransfield Straight. Marine Chemistry. 21(4):347-376.

In sections of sediment cores from the area titled, the resolvable lipid compound classes generally occur in the following order of abundance: n-fatty acids > n-alkanes > n-alcohols > sterols > PAH. The distribution of various lipid components indicate that they are principally from marine autochthonous sources, largely from diatoms and bacteria and to a lesser extent from dinoflagellates.

*Wilkinson, R.E. & M.J. Kasperbauer. 1972. (No title provided; cited by Wilkinson & Kasperbauer(19-80)). Phytochemistry. 11:2439.

*Wilkinson, R.E. & W.S. Hardcastle. 1970. EPTC effects on total leaflet fatty acids and hydrocarbons. Weed Sci. 18:125-128.

*Wilkinson, R.E. 1970. Sicklepod fatty acid response to photo period. Plant Physiol. 46:463-465.

*Wang, T.S.C. 1969. Soil organic matter as cause of increased soil productivity or otherwise phytotoxicity. Int. Rice Com. Newsletter 18(2):23-26.

Wilkinson, R. E., M. J. Kasperbauer. 1980. Effect of light and temperature on epicuticular fatty acid and fatty alcohol of tobacco *Nicotiana tabacum Cultivar Burley-21*. Phytochemistry (Oxford). 19(7):1379-1383.

*Wilkinson, R. E. 1974. Sicklepod surface wax response to photoperiod and S-(2,3-dichloroallyl)diisopropylthiocarbamate (diallate). Plant Physiology. 53(2): 269-275.

The influence of herbicides on the deposition of epicuticular waxes and the components of such waxes has been studied in several species. In a study on peas, diallate was found to inhibit wax synthesis quantitatively but did not qualitatively influence lipids except for the primary alcohols. The current investigation evaluates the wax deposition and its components in sicklepod leaf tissue in order to determine the influence of photoperiod and various diallate concentrations on epicuticular wax formation and content.

Total fatty alcohol content of sicklepod leaflet epicuticular waxes was significantly increased over the untreated control by 0.28 kg/ha diallate and significantly decreased by 1.12 kg/ha diallate. Between these two extremes, the intermediate application rates of diallate were not significantly different from the untreated control. This general pattern was repeated in all structural classes of fatty alcohols present in the epiculticular waxes of sicklepod leaflets with the exception of the antesio-fatty alcohols which were significantly decreased by all application rates of diallate.

Synthesis of fatty acids was shown to be greatly inhibited by diallate with the exception of four constituents ($C_{14:1}$, $C_{16:1}$, $C_{20:1}$ and C_{122}). Conversely, the synthesis of all fatty alcohols was stimulated by 0.14 and 0.28 kg/ha diallate with the exception of C_{A17} and C_{122}. These results suggest that the biochemical relationships between the various lipid classes is not completely elucidated. In addition, epicuticular fatty alcohol content was responsive to photoperiod in a different pattern from that of the fatty acids. The two patterns were not reciprocal. The influence of diallate on individual n-fatty alcohols which are in our range of interest is shown below.

Each value is the average of 20 determinations; five from each of 10-, 12-, 14-, 16-hr photoperiods.

Table IV. Influence of Diallate on the Individual Epicuticular Fatty Alcohol Constituents

	Diallate (kg/ha)				
	0	0.14	0.28	0.56	1.12
10	100	725	1071	207	
11	100	312	343	152	2
12	100	260	232	189	
13	100	683	238	190	1
14	100	270	215	59	
15	100	230	400	8	
16	100	113	275	46	10
18	100	167	230	64	16

Fatty alcohol content of the external wax of sickelpod leaflets demonstrated a different photoperiod response from that of the fatty acids. The total surface fatty alcohol content was minimal under 12-hour photoperiods and maximal under 16 hour photoperiods. Earlier experiments with thiocarbamate herbicides noted a reduction of cuticular waxes upon herbicide exposure. Sublethal application rates of EPTC were reported to stimulate total fatty acid synthesis and reduce alkane synthesis in the sicklepod. Fatty acids were converted to alkanes in pea or spinach and to alcohols in broccoli. The presumption that fatty acyl moieties produced by fatty acid synthetase serve as general intermediates to the various lipid classes found in plant cuticular waxes has gained credence. Plant cuticular waxes have been proposed as the end product of metabolism in the epidermis.

Wilkinson, R. E. 1973. Diallate and photoperiod influence on epicuticular fatty acid and fatty alcohol content. *Abstracts*, 1973 Meeting of the Weed Science Society of America (unnumbered).

In experiments with sicklepod, a common weed species, it was found that herbicide application and varying photoperiods could result in variations in plant fatty alcohol content. Fatty alcohol contents were highest under 10 hour photoperiods. Previous experiments showed that age and temperature could also induce variations.

✓*Wheeler, J. J., H. Seltman, A. G. Motten. 1991. The mode of action of fatty alcohols on leaf tissue. Journal of Plant Growth Regulation. 10(3):129-137.

Mixtures of C_8 and C_{10} fatty alcohols, which usually include small amounts of the C_6 and C_{12} alcohols, formulated with polyoxyethylene (20) sorbitan mono-oleate (SMO), are among the agents used in the control of axillary buds ("suckers") in the culture of tobacco. Fatty alcohols as emulsions are contact herbicides; they are not translocated, but instead destroy tissue at the point of contact. In these studies, the fatty alcohol emulsion was applied at label rates and it was found to pass through the cuticle without disrupting it. The plasma membranes of subtending cells were altered so that, in time, bud tissues were desiccated and growth of the sucker was controlled. Eight plant species/varieties were used in this investigation: *Nicotiana tabacum* L. and *Nicotiana tabacum* L. cv Xanthi (tobacco); *Nicotiana glauca* L.; *Ficus elastica* Roxb. ex Hornam.; *Taraxacum officinale* L.; *Lamium amplexicaule* L.; *Rosa sp.*; and *Elodea sp.*. The mode of action in each plant type was identical; the induction of desiccation apparently was dependent upon the time it took fatty alcohol to cross the leaf cuticle (thus the selective desiccation of axillary buds with incompletely developed cuticular surfaces).

Wertz, P. W., D. T. Downing. 1989. Integral lipids of human hair. Comparative Biochemistry and Physiology B: Comparative Biochemistry. 92(4):759-762.

A series of quaternary ammonium compounds that are esters of betaine and fatty alcohols with hydrocarbon chain lengths of 10 to 18 carbon atoms were tested with respect to antimicrobial activities and rates of hydrolysis. The hydrolysis products were normal human metabolites.
It has been demonstrated that hair contains lipids . . . including fatty alcohols at levels of trace to 0.2 mg/g.

The reason for variance in growth rates from one compound to another was not clear. The alcohols with chain lengths of 5 to 11 carbons inhibited photoautotrophic growth completely, and killed the cells. Other varieties of *Euglena gracilis* have been reported to grow on these middle carbon-chain-length alcohols.

There was a relationship between growth and the intracellular content of paramylon, the reserve polysaccharide of *Euglena*. In the presence of myristyl alcohol, when cells were shaded growth stopped, but alcohol was still assimilated and paramylon was increased in concentration to up to twice that of control light cells.

The mechanism of photoassimilation of C_{14}-alcohol (myristyl alcohol) was strictly light dependent; however, DCMU, an inhibitor of photosynthetic electron transfer, did not inhibit growth completely. With the bleached mutant *Euglena*, a long lag-phase extending more than 10 days occurred before growth started under illumination, and the final cell yield was about half that observed with wild-type cells. Growth on myristyl alcohol was almost saturated at light intensities of 600-1000 lx in comparison to autotrophic growth which increased with light intensities to at least 2000 lx.

Biosynthetic hypotheses suggest that short chain fatty-acid synthesis occurs with elongation of the aliphatic chain to long-carbon chains. Unsaturate, even-carbon numbered saturates, odd-carbon numbered saturates, and branched chain aliphatic units are derived from deaminated valine and isoleucine. Then, fatty acids are converted to alcohols and alkanes. Thus, the total variability of epicuticular wax quality and quantity reflects the activity of the individual enzymatic processes as they are affected by each environmental condition. These processes include but are not limited to: aliphatic carbon chain synthesis, desaturation, reduction and other modification, amino acid metabolism, and the multiplicity of factors influencing leaf growth.

COMPLIANCE SERVICES INTERNATIONAL

November 27, 1991

Ronald B. Ames
Uniroyal Chemical Company Inc.
World Headquarters
Benson Road
Middlebury, CT 06749

Dear Mr. Ames:

As you requested full copies of articles referenced in the Monograph report are enclosed (list is also attached). Bernalyn also requested that I include a copy of the report.

Sincerely,

Janece Perry

Janece Perry
Administrative Assistant

COMPLIANCE SERVICES INTERNATIONAL

November 1, 1991

Mr. Ronald B. Ames
Uniroyal Chemical Company Inc.
World Headquarters
Benson Road
Middlebury, CT 06749

Dear Ron:

Attached are the citations, with abstracts, we recovered in our environmental fate literature search. I have not sent you copies of the articles we ordered, but will do so if you want them.

Also enclosed is a printout from the teratology work we completed earlier in the project. Let me know if there is any further information you may need.

Sincerely,

Bernalyn

Bernalyn D. McGaughey
President

jp

FDA – GRAS - EAFUS

Support Documents

U. S. Food and Drug Administration
Center for Food Safety and Applied Nutrition
Office of Premarket Approval

EAFUS: A Food Additive Database

This is an informational database maintained by the U.S. Food and Drug Administration (FDA) Center for Food Safety and Applied Nutrition (CFSAN) under an ongoing program known as the Priority-based Assessment of Food Additives (PAFA). It contains administrative, chemical and toxicological information on over 2000 substances directly added to food, including substances regulated by the U.S. Food and Drug Administration (FDA) as direct, "secondary" direct, and color additives, and Generally Recognized As Safe (GRAS) and prior-sanctioned substances. In addition, the database contains only administrative and chemical information on less than 1000 such substances. The more than 3000 total substances together comprise an inventory often referred to as *"Everything" Added to Food in the United States* (EAFUS).

This list of substances contains ingredients added directly to food that FDA has either approved as food additives or listed or affirmed as GRAS. Nevertheless, it contains only a partial list of all food ingredients that may in fact be lawfully added to food, because under federal law some ingredients may be added to food under a GRAS determination made independently from the FDA. The list contains many, but not all, of the substances subject to independent GRAS determinations.

The list below is an alphabetical inventory representing only five of 196 fields in FDA/CFSAN's PAFA database. To obtain the entire database, including abstractions of over 7,000 toxicology studies performed on substances added to food as well as a search engine to locate desired information, order *Food Additives: Toxicology, Regulation, and Properties*, available in CD-ROM format from CRC Press.

Definitions of the labels that are found in the inventory are:

DOCTYPE

An indicator of the status of the toxicology information available for the chemical in PAFA (administrative and chemical information is available on all chemicals):

ASP

Fully up-to-date toxicology information available;

EAF

There is reported use of the chemical, it has not yet been assigned for toxicology literature search.

NEW

There is reported use of the chemical; the toxicology literature search is in progress.

NIL

Although listed as a food additive, there is no current reported use of the chemical, and, therefore, although toxicology information may be available in PAFA, it is not being updated;

NUL

There is no reported use of the chemical and there is no toxicology information available in PAFA;

BAN

The chemical was formerly approved as a food additive but is now banned; there may be some toxicology data available.

DOCNUM

PAFA database number of the *Food Additive Safety Profile* volume containing the printed source information concerning the chemical.

MAINTERM

Name of the chemical as recognized by CFSAN.

CAS RN OR OTHER CODE

Chemical Abstract Service (CAS) Registry Number for the chemical or a numerical code assigned by CFSAN to those substances that do not have a CAS Registry Number (888nnnnnn or 977nnnnnn-series).

REGNUM

Regulation numbers in Title 21 of the U.S. Code of Federal Regulations where the chemical appears.

To access the specific regulations listed below, type in the title number, **21**, and then the section and part numbers, e.g. **184** and **1330** at the Government Printing Office web site.

To search this list, use your browser's "find" feature. In most web browsers look under the **Edit** menu at the top of your browser window and click on **Find** (or use **CTRL-F**) to bring up the browser's "find" window. Type in the phrase you wish to search on, and your browser window should move to the next occurrence of that phrase on this web page.

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EVERYTHING ADDED TO FOOD IN THE UNITED STATES

DOC TYPE	DOC NUM	MAINTERM	CAS RN OR OTHER CODE	REGNUM
ASP	1620	ACACIA, GUM (ACACIA SENEGAL (L.) WILLD.)	009000-01-5	184.1330 169.179 172.230
ASP	2952	ACESULFAME POTASSIUM	055589-62-3	172.800
ASP	1	ACETAL	000105-57-7	172.515
ASP	2	ACETALDEHYDE	000075-07-0	182.60 177.2410
ASP	3	ACETALDEHYDE, BUTYL PHENETHYL ACETAL	064577-91-9	
EAF	2997	ACETALDEHYDE ETHYL CIS-3-HEXENYL ACETAL	028069-74-1	
ASP	4	ACETALDEHYDE PHENETHYL PROPYL ACETAL	007493-57-4	172.515
ASP	5	ACETANISOLE	000100-06-1	172.515
ASP	1609	ACETIC ACID	000064-19-7	131.136 172.814 184.1005 73.85 178.1010 176.300 131.144 133.123

ASP	295	DECANOIC ACID	000334-48-5	172.860 173.340 172.210 178.1010
ASP	296	1-DECANOL	000112-30-1	172.864 172.515
ASP	297	3-DECANOL	001565-81-7	
ASP	298	2-DECENAL	003913-71-1	172.515
ASP	299	4-DECENAL	030390-50-2	
NUL	2007	5-DECENOIC ACID	085392-03-6	
NUL	2008	6-DECENOIC ACID	085392-04-7	
EAF	2009	9-DECENOIC ACID	014436-32-9	
ASP	300	3-DECEN-2-ONE	010519-33-2	172.515
ASP	301	DECYL ACETATE	000112-17-4	172.515
ASP	302	DECYL BUTYRATE	005454-09-1	172.515
ASP	303	DECYL PROPIONATE	005454-19-3	172.515
EAF	2972	DEERTONGUE SOLID EXTRACT	068602-86-8	
ASP	304	DEHYDRATED BEETS	977010-48-2	73.40
ASP	305	DEHYDROACETIC ACID	000520-45-6	172.130 175.105
ASP	306	DEHYDRODIHYDROIONOL	057069-86-0	
ASP	307	DEHYDRODIHYDROIONONE	020483-36-7	
NUL	2974	DEHYDROMENTHOFUROLACTONE	075640-26-5	
NUL	2010	DESOXYCHOLIC ACID	000083-44-3	
EAF	2011	DEXTRANS (AVG M W LESS THAN 100,000)	009004-54-0	186.1275
ASP	2012	DEXTRIN	009004-53-9	184.1277
ASP	2013	DEXTROSE	000050-99-7	133.124 133.178 133.179 169.175 145.134 155.200 155.170 169.179 145.180 184.1857 73.85 101.9 145.3 146.3

ASP	2455	NUTMEG (MYRISTICA FRAGRANS HOUTT.)	977051-44-7	182.10 101.22
ASP	2456	NUTMEG, OIL (MYRISTICA FRAGRANS HOUTT.)	008008-45-5	182.20
ASP	2457	NUTMEG OLEORESIN	008007-12-3	182.20
EAF	2458	OAK CHIPS, WHITE, EXTRACT (QUERCUS ALBA L.)	977083-13-8	172.510
EAF	2459	OAK MOSS, ABSOLUTE (EVERNIA SPP.)	977059-15-6	172.510
EAF	2460	OAK WOOD, ENGLISH (QUERCUS ROBUR L.)	977089-90-9	172.510
NUL	2461	OAT GUM	073020-09-4	133.178 PART 135 133.179
ASP	1134	OCIMENE	013877-91-3	172.515
ASP	1135	9,12-OCTADECADIENOIC ACID (48%) AND 9,12,15-OCTADECATRIENOIC ACID	977043-76-7	
ASP	1136	OCTADECYLAMINE	000124-30-1	173.310
ASP	1137	2-TRANS-6-TRANS-OCTADIENAL	056767-18-1	
EAF	2463	TRANS,TRANS-2,4-OCTADIENAL	030361-28-5	
NIL	1138	OCTAFLUOROCYCLOBUTANE	000115-25-3	173.360
ASP	3012	OCTAHYDROCOUMARIN	004430-31-3	
ASP	1139	DELTA-OCTALACTONE	000698-76-0	
ASP	1140	GAMMA-OCTALACTONE	000104-50-7	172.515
ASP	1141	OCTANAL	000124-13-0	172.515
NIL	1142	OCTANAL DIMETHYL ACETAL	010022-28-3	172.515
NIL	1143	1,8-OCTANEDITHIOL	001191-62-4	
ASP	1144	OCTANOIC ACID	000124-07-2	172.860 186.1025 184.1025 173.340 172.210 178.1010 178.3130 173.315
ASP	1145	1-OCTANOL	000111-87-5	172.515 172.230 177.1200 175.105
ASP	1146	2-OCTANOL	000123-96-6	172.515
ASP	1147	3-OCTANOL	000589-98-0	172.515

[Code of Federal Regulations]
[Title 21, Volume 3]
[Revised as of April 1, 2011]
[CITE: 21CFR172.864]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION (CONTINUED)

PART 172 -- FOOD ADDITIVES PERMITTED FOR DIRECT ADDITION TO FOOD FOR HUMAN CONSUMPTION

Subpart I--Multipurpose Additives

Sec. 172.864 Synthetic fatty alcohols.

Synthetic fatty alcohols may be safely used in food and in the synthesis of food components in accordance with the following prescribed conditions:

(a) The food additive consists of any one of the following fatty alcohols:

(1) Hexyl, octyl, decyl, lauryl, myristyl, cetyl, and stearyl; manufactured by fractional distillation of alcohols obtained by a sequence of oxidation and hydrolysis of organo-aluminums generated by the controlled reaction of low molecular weight trialkylaluminum with purified ethylene (minimum 99 percent by volume C2H4), and utilizing the hydrocarbon solvent as defined in paragraph (b) of this section, such that:

(i) Hexyl, octyl, decyl, lauryl, and myristyl alcohols contain not less than 99 percent of total alcohols and not less than 96 percent of straight chain alcohols. Any nonalcoholic impurities are primarily paraffins.

(ii) Cetyl and stearyl alcohols contain not less than 98 percent of total alcohols and not less than 94 percent of straight chain alcohols. Any nonalcoholic impurities are primarily paraffins.

(iii) The synthetic fatty alcohols contain no more than 0.1 weight percent of total diols as determined by a method available upon request from the Commissioner of Food and Drugs.

(2) Hexyl, octyl, and decyl; manufactured by fractional distillation of alcohols obtained by a sequence of oxidation, hydrolysis, and catalytic hydrogenation (catalyst consists of copper, chromium, and nickel) of organo-aluminums generated by the controlled reaction of low molecular weight trialkylaluminum with purified ethylene (minimum 99 percent by volume C2H4), and utilizing an external coolant such that these alcohols meet the specifications prescribed in paragraph (a)(1) (i) and (iii) of this section.

(3) n-Octyl; manufactured by the hydrodimerization of 1,3-butadiene, followed by catalytic hydrogenation of the resulting dienol, and distillation to producen -octyl alcohol with a minimum purity of 99 percent. The analytical method forn -octyl alcohol entitled "Test Method [Normal-octanol]" dated October 2003, and printed by Kuraray Co., Ltd., is incorporated by reference. The Director of the Office of the Federal Register approves this incorporation by reference in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. You may obtain a copy from the Office of Food Additive Safety, 5100 Paint Branch Pkwy., College Park, MD 20740, or you may examine a copy at the Center for Food Safety and Applied

Nutrition's Library, Food and Drug Administration, 5100 Paint Branch Pkwy., College Park, MD 20740, or at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to*http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html* .

(b) The hydrocarbon solvent used in the process described in paragraph (a)(1) of this section is a mixture of liquid hydrocarbons essentially paraffinic in nature, derived from petroleum and refined to meet the specifications described in paragraph (b)(1) of this section when subjected to the procedures described in paragraph (b) (2) and (3) of this section.

(1) The hydrocarbon solvent meets the following specifications:

(i) Boiling-point range: 175 deg. C-275 deg. C.

(ii) Ultraviolet absorbance limits as follows:

Wavelength (millicrons)	**Maximum absorbance per centimeter optical path length**
280-289	0.15
290-299	.12
300-359	.05
360-400	.02

(2) Use ASTM method D86-82, "Standard Method for Distillation of Petroleum Products," which is incorporated by reference, to determine boiling point range. Copies of the material incorporated by reference may be obtained from the American Society for Testing Materials, 100 Barr Harbor Dr., West Conshohocken, Philadelphia, PA 19428-2959, or may be examined at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:*http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.*

(3) The analytical method for determining ultraviolet absorbance limits is as follows:

General Instructions

All glassware should be scrupulously cleaned to remove all organic matter such as oil, grease, detergent residues, etc. Examine all glassware, including stoppers and stopcocks, under ultraviolet light to detect any residual fluorescent contamination. As a precautionary measure, it is recommended practice to rinse all glassware with purified isooctane immediately before use. No grease is to be used on stopcocks or joints. Great care to avoid contamination of hydrocarbon solvent samples in handling and to assure absence of any extraneous material arising from inadequate packaging is essential. Because some of the polynuclear hydrocarbons sought in this test are very susceptible to photo-oxidation, the entire procedure is to be carried out under subdued light.

Apparatus

Chromatographic tube. 450 millimeters in length (packing section), inside diameter 19 millimeters +/-1 millimeter, equipped with a wad of clean Pyrex brand filtering wool (Corning Glass Works Catalog No. 3950 or equivalent). The tube shall contain a 250-milliliter reservoir and a 2-millimeter tetrafluoroethylene polymer stopcock at the opposite end. Overall length of the tube is 670 millimeters.

Stainless steel rod. 2 feet in length, 2 to 4 millimeters in diameter.

Vacuum oven. Similar to Labline No. 3610 but modified as follows: A copper tube one-fourth inch in diameter and 13 inches in length is bent to a right angle at the 4-inch point and plugged at the opposite end; eight copper tubes one-eighth inch in diameter and 5 inches in length are silver soldered in drilled holes (one-eighth inch in diameter) to the one-fourth-inch tube, one on each side at the 5-, 7.5-, 10- and 12.5-inch points; the one-eighth-inch copper tubes are bent to conform with the inner periphery of the oven.

Beakers. 250-milliliter and 500-milliliter capacity.

Graduated cylinders. 25-milliliter, 50-milliliter, and 150-milliliter capacity.

Tuberculin syringe. 1-milliliter capacity, with 3-inch, 22-gauge needle.

Volumetric flask. 5-milliliter capacity.

Spectrophotometric cells. Fused quartz ground glass stoppered cells, optical path length in the range of 1.000 centimeter +/-0.005 centimeter. With distilled water in the cells, determine any absorbance difference.

Spectrophotometer. Spectral range 250 millimicrons--400 millimicrons with spectral slit width of 2 millimicrons or less: under instrument operating conditions for these absorbance measurements, the spectrophotometer shall also meet the following performance requirements:

Absorbance repeatability, +/-0.01 at 0.4 absorbance.

Absorbance accuracy,[1]+/-0.05 at 0.4 absorbance.

Wavelength repeatability, +/-0.2 millimicron.

Wavelength accuracy, +/-1.0 millimicron.

Nitrogen cylinder. Water-pumped or equivalent purity nitrogen in cylinder equipped with regulator and valve to control flow at 5 p.s.i.g.

Reagents and Materials

Organic solvents. All solvents used throughout the procedure shall meet the specifications and tests described in this specification. The isooctane, benzene, hexane, and 1,2-dichloroethane designated in the list following this paragraph shall pass the following test:

To the specified quantity of solvent in a 250-milliliter beaker, add 1 milliliter of purified*n*- hexadecane and evaporate in the vacuum oven under a stream of nitrogen. Discontinue evaporation when not over 1 milliliter of residue remains. (To the residue from benzene add a 5-milliliter portion of purified isooctane, reevaporate, and repeat once to insure complete removal of benzene.)

Dissolve the 1 milliliter of hexadecane residue in isooctane and make to 5 milliliters volume. Determine the absorbance in the 1-centimeter path length cells compared to isooctane as reference. The absorbance of the solution of the solvent residue shall not exceed 0.02 per centimeter path length between 280 and 300 m[micro] and shall not exceed 0.01 per centimeter path length between 300 and 400 m[micro].

Isooctane (2,2,4-trimethylpentane). Use 10 milliliters for the test described in the preceding paragraph. If necessary, isooctane may be purified by passage through a column of activated silica gel (Grade 12, Davison Chemical Co., Baltimore, Md., or equivalent).

Benzene, spectro grade (Burdick and Jackson Laboratories, Inc., Muskegon, Mich., or equivalent). Use 80 milliliters for the test. If necessary, benzene may be purified by distillation or otherwise.

Hexane, spectro grade (Burdick and Jackson Laboratories, Inc., Muskegon, Mich., or equivalent). Use 650 milliliters for the test. If necessary, hexane may be purified by distillation or otherwise.

1,2-Dichloroethane, spectro grade (Matheson, Coleman, and Bell, East Rutherford, N.J., or equivalent). Use 20 milliliters for test. If necessary, 1,2-dichloroethane may be purified by distillation.

Eluting mixtures:

1.*10 percent 1,2-dichloroethane in hexane.* Pipet 100 milliliters of 1,2-dichloroethane into a 1-liter glass-stoppered volumetric flask and adjust to volume with hexane, with mixing.

2.*40 percent benzene in hexane.* Pipet 400 milliliters of benzene into a 1-liter glass-stoppered volumetric flask and adjust to volume with hexane, with mixing.

n-Hexadecane, 99 percent olefin-free. Dilute 1.0 milliliter of*n*- hexadecane to 5 milliliters with isooctane and determine the absorbance in a 1-centimeter cell compared to isooctane as reference between 280 m[micro]-400m[micro]. The absorbance per centimeter path length shall not exceed 0.00 in this range. If necessary,*n*- hexadecane may be purified by percolation through activated silica gel or by distillation.

Silica gel, 28-200 mesh (Grade 12, Davison Chemical Co., Baltimore, Md., or equivalent). Activate as follows: Weigh about 900 grams into a 1-gallon bottle, add 100 milliliters of de-ionized water, seal the bottle and shake and roll at intervals for 1 hour. Allow to equilibrate overnight in the sealed bottle. Activate the gel at 150 deg. C for 16 hours, in a 2-inch * 7-inch * 12-inch porcelain pan loosely covered with aluminum foil, cool in a dessicator, transfer to a bottle and seal.

Procedure

Determination of ultraviolet absorbance. Before proceeding with the analysis of a sample determine the absorbance in a 1-centimeter path cell for the reagent blank by carrying out the procedure without a sample. Record the absorbance in the wavelength range of 280 to 400 millimicrons. Typical reagent blank absorbance in this range should not exceed 0.04 in the 280 to 299 millimicron range, 0.02 in the 300 to 359 millimicron range, and 0.01 in the 360 to 400 millimicron range. If the characteristic benzene peaks in the 250 to 260 millimicron region are present, remove the benzene by the procedure described above under "Reagents and Materials," "Organic Solvents," and record absorbance again.

Transfer 50 grams of silica gel to the chromatographic tube for sample analysis. Raise and drop the column on a semisoft, clean surface for about 1 minute to settle the gel. Pour 100 milliliters of hexane into the column with the stopcock open and allow to drain to about one-half inch above the gel. Turn off the stopcock and allow the column to cool for 30 minutes. After cooling, vibrate the column to eliminate air and stir the top 1 to 2 inches with a small diameter stainless steel rod. Take care not to get the gel above the liquid and onto the sides of the column.

Weigh out 40 grams +/-0.1 gram of the hydrocarbon solvent sample into a 250-milliliter beaker, add 50 milliliters of hexane, and pour the solution into the column. Rinse the beaker with 50 milliliters of hexane and add this to the column. Allow the hexane sample solution to elute into a 500-milliliter beaker until the solution is about one-half inch above the gel. Rinse the column three times with 50-milliliter portions of hexane. Allow each hexane rinse to separately elute to about one-half inch above the gel. Replace the eluate beaker (discard the hexane eluate) with a 250-milliliter beaker. Add two separate 25-milliliter portions of 10 percent 1,2-dichloroethane and allow each to separately elute as before. Finally, add 150 milliliters of 10 percent 1,2-dichloroethane for a total of 200 milliliters. When the final 10 percent 1,2-dichloroethane fraction is about one-half inch above the top of the gel bed, replace the receiving beaker (discard the 1,2-dichloroethane eluate) with a 250-milliliter beaker containing 1 milliliter of hexadecane. Adjust the elution rate to 2 to 3 milliliters per minute, add two 25-milliliter portions of 40 percent benzene and allow each to separately elute as before to within about one-half inch of the gel bed. Finally, add 150 milliliters of 40 percent benzene for a total of 200 milliliters. Evaporate the benzene in the oven with vacuum and sufficient nitrogen flow to just ripple the top of the benzene solution. When the benzene is removed (as determined by a constant volume of hexadecane) add 5 milliliters of isooctane and evaporate. Repeat once to insure complete removal of benzene. Remove the beaker and cover with aluminum foil (previously rinsed with hexane) until cool.

Quantitatively transfer the hexadecane residue to a 5-milliliter volumetric flask and dilute to volume with isooctane. Determine the absorbance of the solution in 1-centimeter path length cells between 280 and 400 millimicrons using isooctane as a reference. Correct the absorbance values for any absorbance derived from reagents as determined by carrying out the procedure without a sample. If the corrected absorbance does not exceed the limits prescribed in paragraph (b)(1)(ii) of this section, the sample meets the ultraviolet absorbance specifications for hydrocarbon solvent.

(c) Synthetic fatty alcohols may be used as follows:

(1) As substitutes for the corresponding naturally derived fatty alcohols permitted in food by existing regulations in this part or part 173 of this chapter provided that the use is in compliance with any prescribed limitations.

(2) As substitutes for the corresponding naturally derived fatty alcohols used as intermediates in the synthesis of food additives and other substances permitted in food.

[1]As determined by using potassium chromate for reference standard and described in National Bureau of Standards Circular 484, Spectrophotometry, U.S. Department of Commerce, (1949). The accuracy is to be determined by comparison with the standard values at 290, 345, and 400 millimicrons. Circular 484 is incorporated by reference. Copies are available from the Center for Food Safety and Applied Nutrition (HFS-200), Food and Drug Administration, 5100 Paint Branch Pkwy., College Park, MD 20740, or available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202-741-6030, or go to:*http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html*.

[42 FR 14491, Mar. 15, 1977, as amended at 47 FR 11837, Mar. 19, 1982; 49 FR 10105, Mar. 19, 1984; 54 FR 24897, June 12, 1989; 70 FR 72908, Dec. 8, 2005]

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U.S. Food & Drug Administration

CFR - Code of Federal Regulations Title 21

[Code of Federal Regulations]
[Title 21, Volume 3]
[Revised as of April 1, 2011]
[CITE: 21CFR172.840]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION (CONTINUED)

PART 172 -- FOOD ADDITIVES PERMITTED FOR DIRECT ADDITION TO FOOD FOR HUMAN CONSUMPTION

Subpart I--Multipurpose Additives

Sec. 172.840 Polysorbate 80.

The food additive polysorbate 80 (polyoxyethylene (20) sorbitan monooleate), which is a mixture of polyoxyethylene ethers of mixed partial oleic acid esters of sorbitol anhydrides and related compounds, may be safely used in food in accordance with the following prescribed conditions:

(a) The food additive is manufactured by reacting oleic acid (usually containing associated fatty acids) with sorbitol to yield a product with a maximum acid number of 7.5 and a maximum water content of 0.5 percent, which is then reacted with ethylene oxide.

(b) The food additive meets the following specifications:

Saponification number 45-55.

Acid number 0-2.

Hydroxyl number 65-80.

Oxyethylene content 65 percent-69.5 percent.

(c) The additive is used or intended for use as follows:

(1) An emulsifier in ice cream, frozen custard, ice milk, fruit sherbet, and nonstandardized frozen desserts, when used alone or in combination with polysorbate 65 whereby the maximum amount of the additives, alone or in combination, does not exceed 0.1 percent of the finished frozen dessert.

(2) In yeast-defoamer formulations whereby the maximum amount of the additive does not exceed 4 percent of the finished yeast defoamer and the maximum amount of the additive in the yeast from such use does not exceed 4 parts per million.

(3) As a solubilizing and dispersing agent in pickles and pickle products, whereby the maximum amount of the additive does not exceed 500 parts per million.

(4) As a solubilizing and dispersing agent in:

(i) Vitamin-mineral preparations containing calcium caseinate in the absence of fat-soluble vitamins, whereby the maximum intake of polysorbate 80 shall not exceed 175 milligrams from the recommended daily dose of the preparations.

(ii) Fat-soluble vitamins in vitamin and vitamin-mineral preparations containing no calcium caseinate, whereby the maximum intake of polysorbate 80 shall not exceed 300 milligrams from the recommended daily dose of the preparations.

(iii) In vitamin-mineral preparations containing both calcium caseinate and fat-soluble vitamins, whereby the maximum intake of polysorbate 80 shall not exceed 475 milligrams from the recommended daily dose of the preparations.

(5) As a surfactant in the production of coarse crystal sodium chloride whereby the maximum amount of the additive in the finished sodium chloride does not exceed 10 parts per million.

(6) In special dietary foods, as an emulsifier for edible fats and oils, with directions for use which provide for the ingestion of not more than 360 milligrams of polysorbate 80 per day.

(7) As a solubilizing and dispersing agent for dill oil in canned spiced green beans, not to exceed 30 parts per million.

(8) As an emulsifier, alone or in combination with polysorbate 60, in shortenings and edible oils intended for use in foods as follows, when standards of identity established under section 401 of the act do not preclude such use:

(i) It is used alone in an amount not to exceed 1 percent of the weight of the finished shortening or oil.

(ii) It is used with polysorbate 60 in any combination providing no more than 1 percent of polysorbate 80 and no more than 1 percent of polysorbate 60, provided that the total combination does not exceed 1 percent of the finished shortening or oil.

(iii) The 1-percent limitation specified in paragraph (c)(8) (i) and (ii) of this section may be exceeded in premix concentrates of shortening or edible oil if the labeling complies with the requirements of paragraph (d) of this section.

(9) As an emulsifier in whipped edible oil topping with or without one or a combination of the following:

(i) Sorbitan monostearate;

(ii) Polysorbate 60;

(iii) Polysorbate 65;

whereby the maximum amount of the additive or additives used does not exceed 0.4 percent of the weight of the finished whipped edible oil topping.

(10) It is used as a wetting agent in scald water for poultry defeathering, followed by potable water rinse. The concentration of the additive in the scald water does not exceed 0.0175 percent.

(11) As a dispersing agent in gelatin desserts and in gelatin dessert mixes, whereby the amount of the additive does not exceed 0.082 percent on a dry-weight basis.

(12) As an adjuvant added to herbicide use and plant-growth regulator use dilutions by a grower or applicator prior to application of such dilutions to the growing crop. Residues resulting from such use are exempt from the requirement of a tolerance. When so used or intended for use, the additive shall be exempt from the requirements of paragraph (d)(1) of this section.

(13) As a defoaming agent in the preparation of the creaming mixture for cottage cheese and lowfat cottage cheese, as identified in 133.128 and 133.131 of this chapter, respectively, whereby the amount of the additive does not exceed .008 percent by weight of the finished

products.

(14) As a surfactant and wetting agent for natural and artificial colors for use in barbecue sauce where the level of the additive does not exceed 0.005 percent by weight of the barbecue sauce.

(d) To assure safe use of the additive, in addition to the other information required by the Act:

(1) The label of the additive and any intermediate premixes shall bear:

(i) The name of the additive.

(ii) A statement of the concentration or strength of the additive in any intermediate premixes.

(2) The label or labeling shall bear adequate directions to provide a final product that complies with the limitations prescribed in paragraph (c) of this section.

[42 FR 14491, Mar. 15, 1977, as amended at 43 FR 2871, Jan. 20, 1978; 45 FR 58835, Sept. 5, 1980; 46 FR 8466, Jan. 27, 1981]

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Specification Sheet and MSDS Forms

Fatty Alcohols

MUSIM MAS

MASCOL 80 For : P & G

Octyl Decyl Alcohol

Spec No. : AL800-02

Property	Spec	Test Method
Chain Distribution (wt%):		**GC**
C6	1.0 max	
C8	39.0 - 47.0	
C10	51.0 - 59.0	
C12	1.0 max	
Total Alcohol	99.0 min	
Chemical Property		
Acid Value, mg KOH/g	0.10 max	AOCS Te-2a-64; DIN 53 402
Saponification Value, mg KOH/g	0.5 max	AOCS Tl-1a-64; DIN 53 401
Iodine Value, g/100g	0.1 max	AOCS Cd 1b-87; DGF C-V 11b
Hydroxyl Value, mg KOH/g	380 - 393	Derived from chain distribution
Hydrocarbon, wt%	0.50 max	GC
Moisture, wt%	0.10 max	Karl Fisher; DIN 51 777/T1
Carbonyl of Value, ppm CO	50 max	MM TN-AM-ALF06
Physical Property		
Color (APHA)	10 max	AOCS Ea 9-65; DIN ISO 6271
Appearance	Clear, no extraneous matter	-
Odor	Bland and free from uncharacteristic odors; Typical of previous acceptable receipts	-

CAS No. : 68603-15-6

EINECS No. : 271-642-9

Contact address:
Inter-Continental Oils and Fats Pte Ltd
150 Beach Road #16-01 Gateway West Singapore 187920
Tel No. : +65 6353 6563 Email: mktg.fatty-alcohol@icof.com.sg

Issuance date: 1 Apr 2011
Revision No.: 1.00

PT. MUSIM MAS

Fatty Alcohol, Methyl Esters and Derivatives

SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE AND THE COMPANY

Product Identification

Product Name	: Octyl Decyl Alcohol
Trade Name	: MASCOL 80
Other Identifier	: Alcohols C6-C12, 1-Octanol+1-Decanol.
Recommended Use	: Cosmetic base product for industrial purpose. General chemicals, as they are used in many ways in the chemicals industry.

Company Identification

Manufacturer Name	: PT Musim Mas
Address	: Jl. Oleo, Kawasan Industri Medan II, Saentis - Percut Sei Tuan, Deli Serdang Medan 20371 - Indonesia
Telephone Number	: 62-61-6871123
Fax Number	: 62-61-6871152 / 6871153
Email Address	: *oleo@musimmas.com*
Emergency Telephone Number	: +62-8116054139

2. HAZARD IDENTIFICATION

GHS Classification

Physical Hazard	: Not classified as hazardous substance
Health Hazard	: Serious eye damage / eye irritation, Category 2
Environmental Hazard	: Not classified as hazardous substance

GHS Label Element

Hazard Symbol :

Signal Word	: Warning
Hazard Statement	: H319 Causes Serious eye irritation
Precautionary Statement	: P264 Wash hands thoroughly after handling. P280 Wear protective gloves/protective clothing/eye protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+P313 If eye irritation persists: Get medical advice/attention.
Other Hazard	: No information available

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Substance

Chemical Name	: Alcohols,C6-C12
Synonym	: Octyl Decyl alcohol.
CAS No	: 68603-15-6
EINECS No	: 271-642-9
Ingredients or impurities that contribute to hazard	: This product doesn't have impurities that contribute to the hazard classification.

4. FIRST AID MEASURES

Eye Contact	: Rinse cautiously with water for several minutes, Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists, get medical advice/attention.
Skin Contact	: Gently wash with plenty of soap and water.
Ingestion	: Call a POISON CENTER or doctor/physician if you feel unwell.
Inhalation	: Remove victim to fresh air and keep at rest in a position comfortable for breathing.

Most important symptomps/effects,accute and delayed
: No information available

Indication of immediate medical attention and special treatment needed
: No information available

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media	: Powder, alcohol resistant foam, carbon dioxide.
Unsuitable Extinguishing Media	: No information available
Specific hazards arising from the substances or mixture	: Combustible material, vapours are heavier than air and may spread along floors. Forms explosive mixtures with air on intense heating. Development of hazardous combustion gases or vapours possible in the event of fire.
Special Protective equipment for fire-fighters	: Use safety goggles in combination with dust mask, and other protection as appropriate to situation
Special Protective action for fire-fighters :	: Keep away from source of ignition and use appropriate extinguishing media. Fight fire from upwind position if possible.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	: Use safety goggles and protective gloves. Large spills : Remove person to safety. Ensure adequate ventilation.
Environmental precautions	: Avoid release to the environment.
Methods and materials for containment and cleaning up	: Small spills : Absorb spills with sand, inert absorbent, waste cloth or sawdust. Then wipe up remainder in waste cloth. Large spills : Dike spills and dispose of in safe area.

7. HANDLING AND STORAGE

Precautions for safe Handling	: Use an adequate ventilation. Wash thoroughly after handling. Used personal protective equipment as required.
Conditions for safe storage including any incompatibilities	: Store container tightly closed in well-ventilate place. Do not store together with oxidizing agents. Keep away from source of ignitions.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Appropriate Engineering Controls	: Facilities storing or utilizing this materials should be equipped with an eyewash facilities and safety shower

Individual Protection Measures, such as personal protective equipment

Eye/Face Protection	: Tightly seal safety glasses.
Skin Protection	: Wear suitable protective clothing and glove (butyl rubber, nitrile rubber).
Respiratory Protection	: If technical suction or ventilation measures are not possible or are insufficient, protective breathing apparatus must be worn.
Thermal Hazards	: Not applicable
Environmental Exposure Controls	: Do not empty into drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

Basic Information	
Appearance	
Physical State	: Liquid
Colour	: Colourless
Odour	: Fishy alcohol
Odour threshold	: No information available
pH	: No information available
Melting Point/freezing point	: -11°C
Initial Boiling point and boiling range	: 204 - 238°C @ 1 atm
Flash point	: 96°C PMCC
Evaporation Rate	: No information available
Flammability (solid,gas)	: No information available
Upper/lower flammability or explosive limits	: No information available
Vapour pressure	: 0.058mmHg (7.7 Pa) at 24°C
Vapour density	: No information available
Relative density	: 0.818 g/cm³ @ 30°C
Solubility	: Water solubility : < 500 mg/L at 25°C Solvent solubility : Soluble in general organic solvent
Partition coefficient :n-octanol/water	: log Pow : 3.5 - 4.7
Auto-ignition temperature	: Approx 260°C
Decomposition temperature	: No information available
Viscosity	: 8 mPa.s (30°C)
Explosive properties	: No information available
Oxidizing properties	: No information available
Other Information	: No information available

10. STABILITY AND REACTIVITY

Reactivity	: Stable in general
Chemical stability	: Stable in general
Possibility of hazardous reactions	: No information available
Conditions to avoid	: Do not expose to extreme heat or flame
Incompatible materials	: Strong oxidizing agents
Hazardous decomposition products	: Carbon Monoxide Complete combustion forms carbon dioxide and water. Partial combustion also forms carbon monoxide, soot, aldehydes and ketones

[redacted]

11. TOXICOLOGICAL INFORMATION

Acute toxicity	: Oral : Rat, LD50 > 5000 mg/kg Dermal: Rabbit, LD50 2000 mg/kg Inhalation: No information Available
Skin corrosion/irritation	: Rabbit, slight irritating
Serious eye damage/irritation	: Rabbit, irritating
Respiratory or skin sensitization	: Negative
Mutagenicity	: Negative
Carcinogenicity	: Negative
Reproductive toxicity	: Negative
STOT-single exposure	: No information available
STOT-repeated exposure	: No information available
Aspiration Hazard	: No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity	: LC50 Species : Pimephales promelas Dose : 2.3 mg/L Exposure time : 96 h EC50 Species : N. Spinipes Dose : 3.1mg/L Exposure time : 96 h
Persistence and Degradability	: Readily biodegradable
Bioaccumulative potential	: Octanol-water partition coefficient : log Pow: 3.15-4.57
Mobility in soil	: No information available
Result of the PBT and vPvB assessment	: No information available
Other adverse effects	: Additional ecological information : Do not allow to run into surface waters, wastewater or soil.

13. DISPOSAL CONSIDERATIONS

Disposal methods	: Dispose of content/container to an approved waste disposal plant. Dispose only in accordance with local, state and federal regulations. Do not dispose via sinks, drains or into the immediate environment.

[redacted]

14. TRANSPORT INFORMATION

Land Transport (US-DOT)	: Not classified
Land Transport (ADR/RID)	: Not classified
Sea Transport (IMDG Code)	: Not classified
Air Transport (IATA)	: Not classified
Inland waterways Transport (ADN)	: Not classified

Transport in Bulk (Annex II of MARPOL 73/78 and the IBC code)

Product Name	: Alcohols(C8-C11), primary, linear and essential linear.
Ship Type	: 2
Pollution category	: Y

15. Regulatory Information

Inventories List

AICS (Australia)	: Listed
DSL (Canada)	: Listed
NDSL (Canada)	: No
IECSC (China)	: Listed
EINECS (EU)	: 271-642-9
ENCS (Japan)	: Listed
ECL (Korea)	: Listed
NZIoC (New Zealand)	: Listed
PICCS (Philippines)	: Listed
TSCA (USA)	: Listed
Chemical Safety assessment	: No information available.

16. OTHER INFORMATION

Document No.	: SDS-FAQ-11
Revision No.	: 2.00
Issue date	: 18-Jul-14

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PT. MUSIM MAS

Fatty Alcohol, Methyl Esters and Derivatives

SAFETY DATA SHEET

1. IDENTIFICATION OF THE SUBSTANCE AND THE COMPANY

Product Identification

Product Name	: Octyl Decyl Alcohol
Trade Name	: MASCOL 80
Other Identifier	: Alcohols C8+C10, 1-Octanol+1-Decanol.
Recommended Use	: Cosmetic base product for industrial purpose. General chemicals, as they are used in many ways in the chemicals industry.

Company Identification

Manufacturer Name	: PT Musim Mas
Address	: Jl. Oleo, Kawasan Industri Medan II, Saentis - Percut Sei Tuan, Deli Serdang Medan 20371 - Indonesia
Telephone Number	: 62-61-6871123
Fax Number	: 62-61-6871152 / 6871153
Email Address	: *oleo@musimmas.com*
Emergency Telephone Number	: +62-8116054139

2. HAZARD IDENTIFICATION

GHS Classification

Physical Hazard	: Not classified as hazardous substance
Health Hazard	: Serious eye damage / eye irritation, Category 2
Environmental Hazard	: Not classified as hazardous substance

GHS Label Element

Hazard Symbol :

Signal Word	: Warning
Hazard Statement	: H319 Causes Serious eye irritation
Precautionary Statement	: P264 Wash hands thoroughly after handling. P280 Wear protective gloves/protective clothing/eye protection. P305+P351+P338 IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. P337+P313 If eye irritation persists: Get medical advice/attention.
Other Hazard	: No information available

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Mixture

Chemical Name	CAS Number	Wt %
1- Octanol	111-87-5	40 - 65
1- Decanol	112-30-1	35 - 60

Ingredients or impurities that contribute to hazard : This product doesn't have impurities that contribute to the hazard classification.

4. FIRST AID MEASURES

Eye Contact : Rinse cautiously with water for several minutes, Remove contact lenses, if present and easy to do. Continue rinsing.
If eye irritation persists, get medical advice/attention.

Skin Contact : Gently wash with plenty of soap and water.

Ingestion : Call a POISON CENTER or doctor/physician if you feel unwell.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing.

Most important symptomps/effects,accute and delayed
: No information available

Indication of immediate medical attention and special treatment needed
: No information available

5. FIRE-FIGHTING MEASURES

Suitable Extinguishing Media : Powder, alcohol resistant foam, carbon dioxide.

Unsuitable Extinguishing Media : No information available

Specific hazards arising from the substances or mixture : Combustible material, vapours are heavier than air and may spread along floors. Forms explosive mixtures with air on intense heating. Development of hazardous combustion gases or vapours possible in the event of fire.

Special Protective equipment for fire-fighters : Use safety goggles in combination with dust mask, and other protection as appropriate to situation

Special Protective action for fire-fighters : : Keep away from source of ignition and use appropriate extinguishing media. Fight fire from upwind position if possible.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	: Use safety goggles and protective gloves. Large spills : Remove person to safety. Ensure adequate ventilation.
Environmental precautions	: Avoid release to the environment.
Methods and materials for containment and cleaning up	: Small spills : Absorb spills with sand, inert absorbent, waste cloth or sawdust. Then wipe up remainder in waste cloth. Large spills : Dike spills and dispose of in safe area.

7. HANDLING AND STORAGE

Precautions for safe Handling	: Use an adequate ventilation. Wash thoroughly after handling. Used personal protective equipment as required.
Conditions for safe storage including any incompatibilities	: Store container tightly closed in well-ventilate place. Do not store together with oxidizing agents. Keep away from source of ignitions.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Appropriate Engineering Controls	: Facilities storing or utilizing this materials should be equipped with an eyewash facilities and safety shower

Individual Protection Measures, such as personal protective equipment

Eye/Face Protection	: Tightly seal safety glasses.
Skin Protection	: Wear suitable protective clothing and glove (butyl rubber, nitrile rubber).
Respiratory Protection	: If technical suction or ventilation measures are not possible or are insufficient, protective breathing apparatus must be worn.
Thermal Hazards	: Not applicable
Environmental Exposure Controls	: Do not empty into drains.

[redacted]

14. TRANSPORT INFORMATION

Land Transport (US-DOT) : Not classified
Land Transport (ADR/RID) : Not classified
Sea Transport (IMDG Code) : Not classified
Air Transport (IATA) : Not classified
Inland waterways Transport (ADN) : Not classified
Transport in Bulk (Annex II of MARPOL 73/78 and the IBC code)
Product Name : Alcohols(C8-C11), primary, linear and essential linear.
Ship Type : 2
Pollution category : Y

15. Regulatory Information

Inventories List

AICS (Australia)	: Listed
DSL (Canada)	: Listed
NDSL (Canada)	: No
IECSC (China)	: Listed
EINECS (EU)	: Listed
ENCS (Japan)	: Listed
ECL (Korea)	: Listed
NZIoC (New Zealand)	: Listed
PICCS (Philippines)	: Listed
TSCA (USA)	: Listed
Chemical Safety assessment	: No information available.

16. OTHER INFORMATION

Document No.	: SDS-FAQ-12
Revision No.	: 2.00
Issue date	: 18-Jul-14

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EPA Registered Products Containing

Fatty Alcohols

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Mr. Roland L. Cargill
Fair Products, Inc
PO Box 38626 Davis Drive
Cary, NC 27512

FEB 10 2014

Subject: Product name: O-TAC Plant Contact Agent
Reg. Number 51873-18
Amendment Dated 9/11/13
New product chemistry and acute toxicology studies replace those previously cited on data matrix
Decision Number: 483318

Dear Registrant:

The amendment referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act as amended is acceptable under 3(c) (5).

The new product chemistry and acute toxicology studies submitted are acceptable and will be placed on file. The revised label reflects the new acute toxicology studies and is acceptable

If you have questions concerning this letter, please contact Banza Djapao at 703-305-7269, or via email at djapao.banza@epa.gov, or myself at 703-308-9443.

Sincerely,

Tony Kish
Product Manager, Team 22
Fungicide Branch
Registration Division (7504P)

FIRST AID

If In Eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye • Call a poison control center or doctor for treatment advice.
If On Skin or Clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If Swallowed	• Call a poison control center or doctor for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person.
If Inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. • Call a poison control center or doctor for treatment advice.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

Have the container or label with you when calling a poison control center or doctor or going for treatment. For emergency information pertaining to the product and contact with eyes call (919)-467-8352, Monday through Friday 9AM to 5PM EST. After 5PM call your Poison Control Center or Call the National Poison Control Hotline at 1-800-222-1222 for additional information.

PRECAUTIONARY STATEMENTS
Hazards to Humans and Domestic Animals
DANGER

Corrosive. Causes irreversible eye damage. Wear protective eyewear (goggles, face shield, or safety glasses). Harmful if absorbed through skin. Avoid contact with skin or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using toilet. Remove and wash contaminated clothing before reuse. Avoid contact with skin, eyes or clothing. Wear long-sleeved shirt and long pants, socks, shoes, and gloves (such as or made out of any waterproof material, selection category A).

Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

PERSONAL PROTECTIVE EQUIPMENT (PPE)
Some materials that are chemical-resistant to this product are made of barrier laminate, butyl rubber, nitrile rubber, neoprene rubber, polyvinyl chloride, or viton. If you want more options, follow the instructions for **CATEGORY C** on an EPA chemical resistance category selection chart.

MIXERS, LOADERS, APPLICATORS AND OTHER HANDLERS MUST WEAR:

- Goggles or faceshield
- Coveralls over short-sleeved shirt and short pants
- Chemical resistant footwear plus socks, and
- Chemical resistant gloves

USER SAFETY REQUIREMENTS
Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the Restricted Entry Interval (REI) of 24 hours.

PPE required for early entry into treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water, is:

- Coveralls
- Chemical resistant gloves
- Shoes plus socks
- Protective eyewear

USER SAFETY RECOMMENDATIONS
Users should:

- Wash hands before eating, drinking, chewing gum, using tobacco or using toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Users should remove PPE immediately after handling this product. Wash outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS
Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning equipment or disposal of waste.

STORAGE AND DISPOSAL
Do not contaminate water, food or feed by storage and disposal.

1. **PESTICIDE STORAGE** -Do not stack over 2 pallets high. Store original containers in cool dry place away from food, water and feed.
2. **PESTICIDE DISPOSAL** -Pesticide wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility
3. **CONTAINER DISPOSAL** -Non-refillable containers. Do not reuse or refill this container. **For container sizes of 5 gallons or less**, triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and draining for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay of of smoke.

For container sizes greater than 5 gallons, triple rinse as follows: empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat the procedure two more times. Then offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay of of smoke.

O-TAC
PLANT CONTACT AGENT®

CONTACT TOBACCO SUCKER CONTROL AGENT

KEEP OUT OF REACH OF CHILDREN

DANGER - PELIGRO

PRECAUCION AL USUARIO: Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle. (If you do not understand the label, find someone to explain it to you in detail)

READ ENTIRE LABEL CAREFULLY BEFORE USING THIS PRODUCT

ACTIVE INGREDIENTS: (% by weight)

Octanol (C_8)	36.2%
Decanol (C_{10})	48.2%
Related Compounds (Dodecanol (C_{12})	0.3%
OTHER INGREDIENTS	15.3%
TOTAL	100%

This product contains 2.57 lb. octanol, 3.41 lb. decanol and 0.02 lb. do decanol per gallon. If not used in accordance with directions, plant injury, excessive residues, or other undesirable results may occur.

Sold by:
Fair Products, Inc., USA
Agri-Specialties Division
Post Office Box 386
Cary, North Carolina 27512
Telephone: (919) 467-8352

MADE IN U.S.A.
EPA REG. NO. 51873-18
EPA EST. NO. 45671-NC-01
02102014V-2014P

NET CONTENTS:
275 GALLONS
1040.9 LITERS

DIRECTIONS FOR USE
It is a violation of federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or persons, either directly or indirectly through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

O-TAC PLANT CONTACT AGENT is a carefully balanced combination of active ingredients and wetting agents to be used for the control of sucker growth on Burley, Flue-Cured, Dark Fired, Maryland and Cigar tobacco. The concentrated product is diluted with water to form a creamy emulsion, which is applied as a coarse spray. The emulsion is effective only when it comes in direct contact with suckers; therefore, the material is applied so that maximum contact is made with the suckers.

WHEN TO APPLY:
O-TAC PLANT CONTACT AGENT can be applied before or after topping. Best results are usually obtained by spraying the tobacco with O-TAC PLANT CONTACT AGENT before topping in the early to late button stage and then topping the tobacco immediately followed by additional applications of O-TAC PLANT CONTACT AGENT starting and spaced 3 to 5 days apart. If you top the tobacco before spraying, remove any suckers over one inch in length as you top and apply O-TAC PLANT CONTACT AGENT after topping. Because O-TAC PLANT CONTACT AGENT is a contact type agent, it is necessary to straighten any plants that are leaning so that the emulsion flows down the stalk evenly and contacts each sucker.

O-TAC PLANT CONTACT AGENT usually can be applied anytime during the day, but not to wilted plants. For best results, it is recommended that you wait until the dew dries before spraying. Do not spray after the leaves begin to close in the evening. Because the underside of the leaves may be injured by contact with O-TAC PLANT CONTACT AGENT, do not apply when the wind is high enough to turn the top leaves over. Do not apply during the rain or when plants are wet. If however, it rains after O-TAC PLANT CONTACT AGENT has been on the plants for over an hour, you should not have to apply O-TAC PLANT CONTACT AGENT again. Do not apply during periods of high heat or if plants are wilted.

HOW MUCH O-TAC PLANT CONTACT AGENT TO APPLY:
For each tobacco type listed use the lower rate and apply to untopped plants in the button stage when plant tissue is tender, then top immediately. Use the higher rate for the first application when plants are more mature and for the second application 3 to 5 days later followed by additional applications 3 to 5 days apart as needed.

Flue-Cured: For power sprayer - use 2 gallons (7.57 liters) in 48 gallons (182 liters) of water, for a total spray solution of 50 gallons (189 liters) – 4% solution; or 2.5 gallons (9.4 liters) in 47.5 gallons (180 liters) of water for a total spray solution of 50 gallons (189 liters) – 5% solution.

For hand sprayer - use 5 ounces (148 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (4% solution), or 6 ounces (177 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (5% solution).

NOTE: *In the event of an extended season, later applications of 2.5 gallons (9.4 liters) O-TAC PLANT CONTACT AGENT in 47.5 gallons (180 liters) water (5% concentration) may be made.*

Burley: For power sprayer - use 1.75 to 2 gallons (6.62-7.57 liters) in water to make a total of 50 gallons (189 liters) of spray solution (3.5 to 4% solution).

Dark Fired: For hand sprayer - use 6 to 8 ounces (177-237 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (4.5 - 6% solution).

Cigar: Use 4 to 5 ounces (118-148 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray solution to apply with a hand sprayer (3 - 4 % solution).

Maryland: Use 4 to 4.5 ounces (118-133 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray solution to apply with a hand sprayer (3 to 3.5% solution).

When applied by hand using 2/3 to 1 ounce (20 - 30 milliliters) of spray solution per plant, 1 gallon (3.785 liters) of diluted O-TAC PLANT CONTACT AGENT will treat 128-190 plants.

If a power sprayer is used, 50 gallons (189 liters) of diluted product should be applied per acre of tobacco.

HOW TO APPLY:
The diluted emulsion is most easily prepared by adding the required amount of O-TAC PLANT CONTACT AGENT to your spray tank and then adding the water. In order to obtain the best results, it is important that the water be added to the O-TAC PLANT CONTACT AGENT rather than the O-TAC PLANT CONTACT AGENT to the water to enhance mixing and reduce floating.

If you use a hand-held or backpack sprayer, the diluted solution must be applied at a rate of 2/3 to 1 ounce (20-30 milliliters) per plant (or enough to insure rundown to the bottom of the plant). A coarse spray is recommended, directed downward at the top of the stalk from 6-8 inches above the top leaves, very little tank pressure is required, and in no case should more than 20 pounds be used.

When applied with power equipment, three nozzles per row must be used (TG full cone tips, or larger, are satisfactory). One TG-5 nozzle should be directed downward over the center of the row and two TG-3s should be positioned approximately 11 inches on either side directed at or slightly above the top of the stalk. The diluted O-TAC PLANT CONTACT AGENT must be applied to the tobacco as a coarse spray from a height of 12 to 16 inches above the top of the stalk. It is recommended that boom pressure be kept at 20 lbs. By using the recommended spray tips, spraying at approximately 20 lbs. pressure, and operating a tractor speed of 2.5 to 3 mph, you will apply approximately 50 gallons of diluted solution per acre of tobacco.

HOW OFTEN TO APPLY:
Usually one application of O-TAC PLANT CONTACT AGENT will give good control of both primary and secondary suckers and produce excellent leaf quality. However, in most cases additional treatments of O-TAC PLANT CONTACT AGENT are recommended 3 to 5 days apart to allow time for uneven crops to become uniform.

NOTES:

1. Mix well prior to use and, if allowed to stand during the use, mix again before applying since the diluted emulsion may separate on standing.
2. Do not use on Burley tobacco during periods of high heat and high humidity.
3. Usage according to the directions outlined has resulted in adequate sucker control with very little or no leaf injury. Application not in accordance with the directions may lead to injury of leaves or improper sucker control.
4. Make sure spray equipment is clean before using.
5. Do not mix with other pesticides, fertilizers, surfactants or any other materials as plant damage or death may result.

WARRANTY STATEMENT: To the extent permitted by applicable law, Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Material Safety Data Sheet

fair products, inc.

O-TAC PLANT CONTACT AGENT

Version: 1.2 Revision Date: 09/07/2012 Print Date: 09/07/2012

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	O-TAC PLANT CONTACT AGENT
Product Use Description:	Plant Growth Regulator
EPA Registration Number	51873-18
Company:	Fair Products, Inc. P.O. Box 386 Cary, NC 27512 United States of America Telephone: (US) 919-467-1599
Emergency Telephone:	Chemtrec: (24 hours) 800-424-9300
Prepared by:	Fair Products, Inc.

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

WARNING!

Form: liquid Color: light yellow Odor: Characteristic Fatty Alcohol Odor

Hazard Summary	Risk of serious damage to eyes. Irritating to respiratory system and skin. Irritating to mucous membrane. May cause allergic skin reaction.

Potential Health Effects

Primary Routes of Entry	Skin contact Eye contact Inhalation
Aggravated Medical Condition	Respiratory disorders Skin disorders

Target Organs	Eyes Respiratory system Skin
Inhalation	Irritating to respiratory system.
Skin	Irritating to skin. May cause allergic skin reaction.
Eyes	Risk of serious damage to eyes.
Ingestion	Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Chronic Exposure	May cause respiratory system effects. Lung damage. Repeated or prolonged skin contact may cause allergic reactions with susceptible persons.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous components

Component / CAS-No.	Weight percent
Octanol/111-87-5	36.2%
Decanol/112-30-1	48.2%
Polyoxyethylene sorbitan monooleate/9005-65-6	15.3%
Related compounds (dodecanol C-12)/112-53-8	0.3%

SECTION 4. FIRST AID MEASURES

First aid procedures

Inhalation	If breathed in, move person to fresh air. Give oxygen or artificial respiration if needed. Obtain medical attention.
Skin contact	If on clothes, remove clothes. Wash off immediately with plenty of water for at least 15 minutes. If skin irritation occurs, seek medical advice/ attention. Wash contaminated clothing in hot water and detergent before reuse. Destroy contaminated shoes.
Eye contact	In case of eye contact, remove contact lens and rinse immediately with plenty of water, also under

	the eyelids, for at least 15 minutes. If symptoms persist, call a physician.
Ingestion	DO NOT induce vomiting. Give small amounts of water to drink. Call a physician or poison control center immediately. Never give anything by mouth to an unconscious person.

SECTION 5. FIREFIGHTING MEASURES

Flammable properties

Flash Point	>200 °F

Fire fighting

Extinguishing media	Water spray, CO_2, dry chemical or foam.
Fire fighting procedures	Assure self-contained breathing apparatus is worn. Stay upwind.
Further information	Keep away from fire, sparks and heated surfaces. Use water spray to cool unopened containers. Prevent fire extinguishing water from contaminating surface water or the ground water system.

Protective equipment and precautions for firefighters

Special protective equipment	Body covering protective clothing, full "turn-out" for firefighters gear. Self-contained breathing apparatus

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Evacuate personnel to safe areas. Wear suitable protective clothing, long-sleeve shirt and long pants, chemical resistant gloves, such as barrier laminate or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton. Wear shoes plus socks, protective eyewear such as goggles, safety glasses or face shield. Avoid contact with skin and eyes. Ventilate the area.
Environmental precautions:	Toxic to aquatic life. Do not allow uncontrolled discharge of product into

	the environment. Do not flush into surface water or sanitary sewer system.
Methods for containment/ Methods for cleaning up:	Soak up spills with an inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Shovel into suitable container for disposal. Prevent runoff from entering waterways. Assure protective clothing is worn.
Disposal:	Dispose of in accordance with Local, State and Federal Regulations.

SECTION 7. HANDING AND STORAGE

Handling procedures:	Handle and open container with care. Protect from contamination. Use only in well-ventilated areas. Avoid inhalation, ingestion and contact with skin and eyes. Wear suitable protective clothing, gloves and eye/face protection. Wash thoroughly after handling. Keep container closed when not in use.
Storage:	
Requirements for storage areas and containers	Keep only in the original container. Keep container tightly closed in a cool, dry and well-ventilated area. Store away from direct heat sources. Keep away from foodstuff.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

Contains no substance with occupational exposure limit values.

Engineering measures	Use mechanical ventilation for general area control. Ensure that extracted air cannot be returned to the workplace through the ventilation system. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protective equipment

Eye protection	Tightly fitting protective eyewear, such as goggles, safety glasses or face shield.
Hand protection	Chemical resistant protective gloves, such as barrier laminate, or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton.
Skin and body protection	Long-sleeve shirt and long pants or coveralls. Shoes plus socks. Remove and wash contaminated clothing before re-use. Discard contaminated shoes.
Respiratory protection	In case of insufficient ventilation, wear a suitable "NIOSH approved organic mist respirator.
Hygiene measures:	Handle in accordance with good industrial hygiene and safety practices. Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Avoid prolonged inhalation of mists. Ensure adequate ventilation. Wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet. Remove and wash contaminated clothing before re-use.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form:	liquid
Color:	yellow liquid
Odor:	Characteristic fatty alcohol odor

Safety Data

Flash point:	>200°F
pH	7 – 8
Density:	0.85 gms/cc

SECTION 10. STABILITY AND REACTIVITY

Materials to avoid	Remarks: None known.
Hazardous decomposition	Note: Carbon monoxide, carbon dioxide and unburned hydrocarbons.
Hazardous reactions:	Hazardous polymerization does not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

Acute Oral Toxicity:	LD_{50} 28 gms/kg (Rat)
Acute Inhalation Toxicity:	TLV 5mg/m^3 (Rat)
Acute Dermal Toxicity:	LD_{50} 2gm/kg (Rat)
Skin Irritation:	Causes moderate skin irritation (Rabbit)
Eye Irritation:	Causes severe eye irritation (Rabbit)
Sensitization:	Not a sensitizer (Guinea Pig)

Toxicological Assessment

CMR Effects:	Carcinogenicity: negative Mutagenicity: negative Teratogencity: negative Reproductive Toxicity: negative

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity Effects

Toxicity to fish:	96 hours LC_{50} Rainbow trout: 20.4 ppm
	96 hours LC_{50} Bluegill: 9.96 ppm
Toxicity to Daphnia and other aquatic invertebrates:	48 hour LC_{50} to Daphnia magna (water flea): 8.24 mg/l
Toxicity to birds:	Acute oral LD_{50} to Mallard Ducks: >4640 mg/kg/bw
	Eight Day Dietary LC_{50} to: Bobwhite Quail - >10,000 ppm Mallard Ducks - >10,000 ppm
Toxicity of honey bees:	48 hour contact LD_{50} >25 µg/bee

Elimination Information (persistence and degradability)

Biodegradability:	Readily biodegradable

SECTION 13. DISPOSAL CONSIDERATION

Further information:

Dispose of waste material in compliance with all federal, state and local regulations.

Pesticide wastes are toxic.
Do not contaminate ponds, waterways or ditches with chemical or used container.

SECTION 14. TRANSPORT INFORMATION

DOT
Not dangerous goods

TDG
Not dangerous goods

IATA
Not dangerous goods

IMDG
Not dangerous goods

RID
Not dangerous goods

SECTION 15: REGULATORY INFORMATION

Sara 311/312 Hazards:	Chronic Health Hazard Acute health Hazard
California Prop. 65 components:	This product does not contain any chemicals known to the State of California to cause cancer, birth defects or any other reproductive harm.

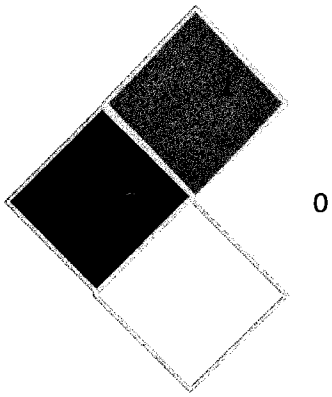
The components of this product are reported in the following inventories:

REACH	Not in compliance with the inventory.
US.TSCA	All substances in this product are exempt from TSCA as this product is registered under FIFRA (Federal Insecticide Fungicide Rodenticide Act).

DSL	This product is registered under the Pest Control Products Act and is therefore exempt from WHMIS supplier labeling and MSDS requirements. Please read entire MSDS and product label for safety precaution.
AICS	Not in compliance with the inventory
NZIoC	Not in compliance with the inventory
ENCS	Not in compliance with the inventory
KECI	Not in compliance with the inventory
PICCS	Not in compliance with the inventory
IECSC	Not in compliance with the inventory

SECTION 16. OTHER INFORMATION

HMIS Classification:	Health hazard: 3 Flammability: 1 Reactivity: 0
NFPA Classification:	Health hazard: 3 Fire hazard: 1 Reactivity hazard: 0



This information in this Material Safety Data Sheet is correct to the best of our knowledge and information at the date of its publication. The information provided is designed only as a guidance document for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Mr. Roland L. Cargill
Fair Products, Inc
PO Box 38626 Davis Drive
Cary, NC 27512

FEB 10 2014

Subject: Product name: N-TAC
Reg. Number 51873-20
Amendment Dated 9/11/13
New product chemistry and acute toxicology studies replace those previously cited on data matrix
Decision Number: 483319

Dear Registrant:

The amendment referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act as amended is acceptable under 3(c) (5).

The new product chemistry and acute toxicology studies submitted are acceptable and will be placed on file. The revised label reflects the new acute toxicology studies and is acceptable

If you have questions concerning this letter, please contact Banza Djapao at 703-305-7269, or via email at djapao.banza@epa.gov, or myself at 703-308-9443.

Sincerely,

Tony Kish
Product Manager, Team 22
Fungicide Branch
Registration Division (7504P)

FIRST AID

If In Eyes	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
If On Skin or Clothing	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If Swallowed	• Call a poison control center or doctor for treatment advice. • Have person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by the poison control center or doctor. • Do not give anything by mouth to an unconscious person
If Inhaled	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably by mouth-to-mouth, if possible. • Call a poison control center or doctor for treatment advice.

NOTE TO PHYSICIAN: Probable mucosal damage may contraindicate the use of gastric lavage.

Have the container or label with you when calling a poison control center or doctor or going for treatment. For emergency information pertaining to the product and contact with eyes call (919)-467-8352, Monday through Friday 9AM to 5PM EST. After 5PM call your Poison Control Center or Call the National Poison Control Hotline at 1-800-222-1222 for additional information.

PRECAUTIONARY STATEMENTS
Hazards to Humans and Domestic Animals

DANGER
Corrosive. Causes irreversible eye damage. Wear protective eyewear (goggles, face shield, or safety glasses). Harmful if absorbed through skin. Avoid contact with skin or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using toilet. Remove and wash contaminated clothing before reuse. Avoid contact with skin, eyes or clothing. Wear long-sleeved shirt and long pants, socks, shoes, and gloves (such as or made out of any waterproof material, selection category A).

Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals

PERSONAL PROTECTIVE EQUIPMENT (PPE)
Some materials that are chemical-resistant to this product are made of barrier laminate, butyl rubber, nitrile rubber, neoprene rubber, polyvinyl chloride, or viton. If you want more options, follow the instructions for CATEGORY C on an EPA chemical resistance category selection chart.

MIXERS, LOADERS, APPLICATORS AND OTHER HANDLERS MUST WEAR:
- Goggles or faceshield
- Coveralls over short-sleeved shirt and short pants
- Chemical resistant footwear plus socks, and
- Chemical resistant gloves

USER SAFETY REQUIREMENTS
Discard clothing and other absorbent materials that have been drenched or heavily contaminated with this product's concentrate. Do not reuse them. Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables exist, use detergent and hot water. Keep and wash PPE separately from other laundry.

AGRICULTURAL USE REQUIREMENTS
Use this product only in accordance with its labeling and the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about personal protective equipment (PPE), and restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard.

Do not enter or allow worker entry into treated areas during the Restricted Entry Interval (REI) of 24 hours.

PPE required for early entry into treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water is:

- Coveralls
- Chemical resistant gloves
- Shoes plus socks
- Protective eyewear

USER SAFETY RECOMMENDATIONS
Users should:
- Wash hands before eating, drinking, chewing gum, using tobacco or using toilet.
- Remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Users should remove PPE immediately after handling this product. Wash outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

ENVIRONMENTAL HAZARDS
Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water by cleaning equipment or disposal of waste.

STORAGE AND DISPOSAL
Do not contaminate water, food or feed by storage and disposal.

1. PESTICIDE STORAGE - Do not stack over 2 pallets high. Store original containers in cool dry place away from food, water and feed.

2. PESTICIDE DISPOSAL - Pesticide wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

3. CONTAINER DISPOSAL – Non-refillable containers. Do not reuse or refill this container. **For container sizes of 5 gallons or less**, triple rinse as follows: Empty the remaining contents into application equipment or a mix tank and draining for 10 seconds after the flow begins to drip. Fill the container ¼ full with water and recap. Shake for 10 seconds. Pour rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Drain for 10 seconds after the flow begins to drip. Repeat this procedure two more times. Then offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

For container sizes greater than 5 gallons, triple rinse as follows: empty the remaining contents into application equipment or a mix tank. Fill the container ¼ full with water. Replace and tighten closures. Tip container on its side and roll it back and forth, ensuring at least one complete revolution, for 30 seconds. Stand the container on its end and tip it back and forth several times. Turn the container over onto its other end and tip it back and forth several times. Empty the rinsate into application equipment or a mix tank or store rinsate for later use or disposal. Repeat the procedure two more times. Then offer for recycling if available, or puncture and dispose of in a sanitary landfill, or by incineration, or if allowed by state and local authorities, by burning. If burned, stay out of smoke.

KEEP OUT OF REACH OF CHILDREN

DANGER - PELIGRO
PRECAUCION AL USUARIO:
Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.
(If you do not understand the label, find someone to explain it to you in detail)

READ ENTIRE LABEL CAREFULLY BEFORE USING THIS PRODUCT.

ACTIVE INGREDIENTS: (% by weight)

Octanol (C8)	36.2%
Decanol (C10)	48.2%
Related Compounds (dodecanol C12)	0.3%
OTHER INGREDIENTS:	15.3%
TOTAL	100%

This product contains 2.57 lb. octanol 3.41 lb. decanol and 0.02 lb. dodecanol per gallon. If not used in accordance with directions, plant injury, excessive residues, or other undesirable results may occur.

Sold by:

Fair Products, Inc., USA
Agri-Specialties Division
Post Office Box 386
Cary, North Carolina 27512
Telephone: (919) 467-8352

MADE IN U.S.A.
EPA REG. NO. 51873-20
EPA EST. NO. 45671-NC-01
021202014V-2014P

NET CONTENTS:
275 GALLONS
1040.9 LITERS

DIRECTIONS FOR USE
It is a violation of federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a way that will contact workers or persons, either directly or indirectly through drift. Only protected handlers may be in the area during application. For any requirements specific to your State or Tribe, consult the agency responsible for pesticide regulation.

N-TAC is a carefully balanced combination of active ingredients and wetting agents to be used for the control of sucker growth on Burley, Flue-Cured, Dark Fired, Maryland and Cigar tobacco. The concentrated product is diluted with water to form a creamy emulsion, which is applied as a coarse spray. The emulsion is effective only when it comes in direct contact with suckers; therefore, the material is applied so that maximum contact is made with the suckers.

WHEN TO APPLY:
N-TAC can be applied before or after topping. Best results are usually obtained by spraying the tobacco with N-TAC before topping in the early to late button stage and then topping the tobacco immediately followed by additional applications of N-TAC starting and spaced 3 to 5 days apart. If you top the tobacco before spraying, remove any suckers over one inch in length as you top and apply N-TAC after topping. Because N-TAC is a contact type agent, it is necessary to straighten any plants that are leaning so that the emulsion flows down the stalk evenly and contacts each sucker.

N-TAC usually can be applied anytime during the day, but not to wilted plants. For best results, it is recommended that you wait until the dew dries before spraying. Do not spray after the leaves begin to close in the evening. Because the underside of the leaves may be injured by contact with N-TAC, do not apply when the wind is high enough to turn the top leaves over. Do not apply during the rain or when plants are wet. If however, it rains after N-TAC has been on the plants for over an hour, you should not have to apply N-TAC again. Do not apply during periods of high heat or if plants are wilted.

HOW MUCH N-TAC TO APPLY:
For each tobacco type listed use the lower rate and apply to untopped plants in the button stage when plant tissue is tender, then top immediately. Use the higher rate for the first application when plants are more mature and for the second application 3 to 5 days later followed by additional applications 3 to 5 days apart as needed.

FLUE-CURED: For power sprayer - use 2 gallons (7.57 liters) in 48 gallons (182 liters) of water, for a total spray solution of 50 gallons (189 liters) –4% solution; or 2.5 gallons (9.4 liters) in 47.5 gallons (180 liters) of water for a total spray solution of 50 gallons (189 liters) – 5% solution.

For hand sprayer - use 5 ounces (148 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (4% solution), or 6 ounces (177 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (5% solution).

NOTE: In the event of an extended season, later applications of 2.5 gallons (9.4 liters) N-TAC in 47.5 gallons (180 liters) water (5% concentration) may be made.

BURLEY: For power sprayer - use 1.75 to 2 gallons (6.62-7.57 liters) in water to make a total of 50 gallons (189 liters) of spray solution (3.5 to 4% solution).

DARK FIRED: For hand sprayer, use 6 to 8 ounces (177-237 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray (4.5 - 6% solution).

CIGAR: Use 4 to 5 ounces (118-148 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray solution to apply with a hand sprayer (3 – 4 % solution).

MARYLAND: Use 4 to 4.5 ounces (118-133 milliliters) in water to make a total of 1 gallon (3.785 liters) of spray solution to apply with a hand sprayer (3 to 3.5% solution).

When applied by hand using 2/3 to 1 ounce (20 - 30 milliliters) of spray solution per plant, 1 gallon (3.785 liters) of diluted N-TAC will treat 128-190 plants.

If a power sprayer is used, 50 gallons (189 liters) of diluted product should be applied per acre of tobacco.

HOW TO APPLY:
The diluted emulsion is most easily prepared by adding the required amount of N-TAC to your spray tank and then adding the water. In order to obtain the best results, it is important that the water be added to the N-TAC rather than the N-TAC to the water to enhance mixing and reduce floating.

If you use a hand-held or backpack sprayer, the diluted solution must be applied at a rate of 2/3 to 1 ounce (20-30 milliliters) per plant (or enough to insure rundown to the bottom of the plant). A coarse spray is recommended, directed downward at the top of the stalk from 6-8 inches above the top leaves, very little tank pressure is required, and in no case should more than 20 pounds be used.

When applied with power equipment, three nozzles per row must be used (TG full cone tips, or larger, are satisfactory). One TG-5 nozzle should be directed downward over the center of the row and two TG-3s should be positioned approximately 11 inches on either side directed at or slightly above the top of the stalk. The diluted N-TAC must be applied to the tobacco as a coarse spray from a height of 12 to 16 inches above the top of the stalk. It is recommended that boom pressure be kept at 20 lbs. By using the recommended spray tips, spraying at approximately 20 lbs. pressure, and operating a tractor speed of 2.5 to 3 mph, you will apply approximately 50 gallons of diluted solution per acre of tobacco.

HOW OFTEN TO APPLY:
Usually one application of N-TAC will give good control of both primary and secondary suckers and produce excellent leaf quality. However, in most cases additional treatments of N-TAC are recommended 3 to 5 days apart to allow time for uneven crops to become uniform.

NOTES:
1. Mix well prior to use and, if allowed to stand during the use, mix again before applying since the diluted emulsion may separate on standing.
2. Do not use on Burley tobacco during periods of high heat and high humidity.
3. Usage according to the directions outlined has resulted in adequate sucker control with very little or no leaf injury. Application not in accordance with the directions may lead to injury of leaves or improper sucker control.
4. Make sure spray equipment is clean before using.
5. Do not mix with other pesticides, fertilizers, surfactants or any other materials as plant damage or death may result.

WARRANTY STATEMENT: To the extent permitted by applicable law, Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these conditions.

Material Safety Data Sheet

fair products, inc.

N-TAC

Version: 1.2 Revision Date: 09/07/2012 Print Date: 09/07/2012

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	N-TAC Tobacco Sucker Control
Product Use Description:	Plant Growth Regulator
EPA Registration Number	51873-XX
Company:	Fair Products, Inc. P.O. Box 386 Cary, NC 27512 United States of America Telephone: (US) 919-467-1599
Emergency Telephone:	Chemtrec: (24 hours) 800-424-9300
Prepared by:	Fair Products, Inc.

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

WARNING!

Form: liquid Color: light yellow Odor: Characteristic Fatty Alcohol Odor

Hazard Summary	Risk of serious damage to eyes. Irritating to respiratory system and skin. Irritating to mucous membrane. May cause allergic skin reaction.

Potential Health Effects

Primary Routes of Entry	Skin contact Eye contact Inhalation
Aggravated Medical Condition	Respiratory disorders Skin disorders

Target Organs	Eyes Respiratory system Skin
Inhalation	Irritating to respiratory system.
Skin	Irritating to skin. May cause allergic skin reaction.
Eyes	Risk of serious damage to eyes.
Ingestion	Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Chronic Exposure	May cause respiratory system effects. Lung damage. Repeated or prolonged skin contact may cause allergic reactions with susceptible persons.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous components

Component / CAS-No.	Weight percent
Octanol/111-87-5	36.2%
Decanol/112-30-1	48.2%
Polyoxyethylene sorbitan monooleate/9005-65-6	15.3%
Related compounds (dodecanol C-12)/112-53-8	0.3%

SECTION 4. FIRST AID MEASURES

First aid procedures

Inhalation	If breathed in, move person to fresh air. Give oxygen or artificial respiration if needed. Obtain medical attention.
Skin contact	If on clothes, remove clothes. Wash off immediately with plenty of water for at least 15 minutes. If skin irritation occurs, seek medical advice/ attention. Wash contaminated clothing in hot water and detergent before reuse. Destroy contaminated shoes.
Eye contact	In case of eye contact, remove contact lens and

	rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. If symptoms persist, call a physician.
Ingestion	DO NOT induce vomiting. Give small amounts of water to drink. Call a physician or poison control center immediately. Never give anything by mouth to an unconscious person.

SECTION 5. FIREFIGHTING MEASURES

Flammable properties

Flash Point	>200 °F

Fire fighting

Extinguishing media	Water spray, CO_2, dry chemical or foam.
Fire fighting procedures	Assure self-contained breathing apparatus is worn. Stay upwind.
Further information	Keep away from fire, sparks and heated surfaces. Use water spray to cool unopened containers. Prevent fire extinguishing water from contaminating surface water or the ground water system.

Protective equipment and precautions for firefighters

Special protective equipment	Body covering protective clothing, full "turn-out" for firefighters gear. Self-contained breathing apparatus

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Evacuate personnel to safe areas. Wear suitable protective clothing, long-sleeve shirt and long pants, chemical resistant gloves, such as barrier laminate or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton. Wear shoes plus socks, protective eyewear such as goggles, safety glasses or face shield. Avoid contact with skin and eyes. Ventilate the area.
Environmental precautions:	Toxic to aquatic life.

	Do not allow uncontrolled discharge of product into the environment. Do not flush into surface water or sanitary sewer system.
Methods for containment/ Methods for cleaning up:	Soak up spills with an inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Shovel into suitable container for disposal. Prevent runoff from entering waterways. Assure protective clothing is worn.
Disposal:	Dispose of in accordance with Local, State and Federal Regulations.

SECTION 7. HANDING AND STORAGE

Handling procedures:	Handle and open container with care. Protect from contamination. Use only in well-ventilated areas. Avoid inhalation, ingestion and contact with skin and eyes. Wear suitable protective clothing, gloves and eye/face protection. Wash thoroughly after handling. Keep container closed when not in use.
Storage:	
Requirements for storage areas and containers	Keep only in the original container. Keep container tightly closed in a cool, dry and well-ventilated area. Store away from direct heat sources. Keep away from foodstuff.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

Contains no substance with occupational exposure limit values.

Engineering measures	Use mechanical ventilation for general area control. Ensure that extracted air cannot be returned to the workplace through the ventilation system. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protective equipment

Eye protection	Tightly fitting protective eyewear, such as goggles, safety glasses or face shield.
Hand protection	Chemical resistant protective gloves, such as barrier laminate, or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton.
Skin and body protection	Long-sleeve shirt and long pants or coveralls. Shoes plus socks. Remove and wash contaminated clothing before re-use. Discard contaminated shoes.
Respiratory protection	In case of insufficient ventilation, wear a suitable "NIOSH approved organic mist respirator.
Hygiene measures:	Handle in accordance with good industrial hygiene and safety practices. Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Avoid prolonged inhalation of mists. Ensure adequate ventilation. Wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet. Remove and wash contaminated clothing before re-use.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form:	liquid
Color:	yellow liquid
Odor:	Characteristic fatty alcohol odor

Safety Data

Flash point:	>200°F
pH	7 – 8
Density:	0.85 gms/cc

SECTION 10. STABILITY AND REACTIVITY

Materials to avoid	Remarks: None known.
Hazardous decomposition	Note: Carbon monoxide, carbon dioxide and unburned hydrocarbons.
Hazardous reactions:	Hazardous polymerization does not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

Acute Oral Toxicity:	LD_{50} 28 gms/kg (Rat)
Acute Inhalation Toxicity:	TLV 5mg/m^3 (Rat)
Acute Dermal Toxicity:	LD_{50} 2gm/kg (Rat)
Skin Irritation:	Causes moderate skin irritation (Rabbit)
Eye Irritation:	Causes severe eye irritation (Rabbit)
Sensitization:	Not a sensitizer (Guinea Pig)

Toxicological Assessment

CMR Effects:	Carcinogenicity:	negative
	Mutagenicity:	negative
	Teratogenicity:	negative
	Reproductive Toxicity:	negative

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity Effects

Toxicity to fish:	96 hours LC_{50} Rainbow trout: 20.4 ppm
	96 hours LC_{50} Bluegill: 9.96 ppm
Toxicity to Daphnia and other aquatic invertebrates:	48 hour LC_{50} to Daphnia magna (water flea): 8.24 mg/l
Toxicity to birds:	Acute oral LD_{50} to Mallard Ducks: >4640 mg/kg/bw
	Eight Day Dietary LC_{50} to: Bobwhite Quail - >10,000 ppm Mallard Ducks - >10,000 ppm

Toxicity of honey bees:	48 hour contact LD_{50} >25 µg/bee

Elimination Information (persistence and degradability)

Biodegradability:	Readily biodegradable

SECTION 13. DISPOSAL CONSIDERATION

Further information:

Dispose of waste material in compliance with all federal, state and local regulations.

Pesticide wastes are toxic.
Do not contaminate ponds, waterways or ditches with chemical or used container.

SECTION 14. TRANSPORT INFORMATION

DOT
Not dangerous goods

TDG
Not dangerous goods

IATA
Not dangerous goods

IMDG
Not dangerous goods

RID
Not dangerous goods

SECTION 15: REGULATORY INFORMATION

Sara 311/312 Hazards:	Chronic Health Hazard Acute health Hazard
California Prop. 65 components:	This product does not contain any chemicals known to the State of California to cause cancer, birth defects or any other reproductive harm.

The components of this product are reported in the following inventories:

REACH	Not in compliance with the inventory.
US.TSCA	All substances in this product are exempt from

	TSCA as this product is registered under FIFRA (Federal Insecticide Fungicide Rodenticide Act).
DSL	This product is registered under the Pest Control Products Act and is therefore exempt from WHMIS supplier labeling and MSDS requirements. Please read entire MSDS and product label for safety precaution.
AICS	Not in compliance with the inventory
NZIoC	Not in compliance with the inventory
ENCS	Not in compliance with the inventory
KECI	Not in compliance with the inventory
PICCS	Not in compliance with the inventory
IECSC	Not in compliance with the inventory

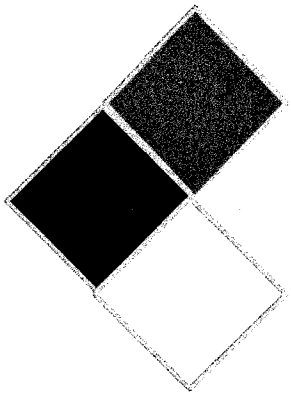
SECTION 16. OTHER INFORMATION

HMIS Classification:

Health hazard: 3
Flammability: 1
Reactivity: 0

NFPA Classification:

Health hazard: 3
Fire hazard: 1
Reactivity hazard: 0



This information in this Material Safety Data Sheet is correct to the best of our knowledge and information at the date of its publication. The information provided is designed only as a guidance document for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification.

Department of Agriculture
STATE OF HAWAII

Pesticides Branch
1428 S. King Street
Honolulu, HI 96814-2512

CODE: 8938.1
FOR OFFICIAL USE ONLY

APPLICATION FOR LICENSE OF PESTICIDES AND NON-CHEMICAL PEST CONTROL DEVICES

1. Firm Name: Fair Products, Inc.

2. Mailing Address: P.O. Box 386 | City: Cary | State: NC | Zip Code: 27512

3. Name of Person Responsible for License: Renee' Allen | Title: renee@fairproductsinc.com | Telephone Number: 919-467-1599

Fax Number: 919-467-9142 | E-mail Address:

4. Principal Hawaii Distributor: LBD Coffee LLC | Address: 6200-B Kawaihau Road | Zip Code: Kapaa, HI 96746

5. Brand Name (Exactly as shown on label): Fair 85 Contact Tobacco Sucker Control Agent | EPA Registration Number: 51873-7

Confidential Statement of Formula (EPA Form No. 8570-4) [X] Is attached [ ] Being submitted by basic registrant

Non-Chemical Pest Control Device Supporting Data Package: [ ] Is attached [ ] Being submitted by manufacturer

Firm Name on Label (if differs from Item 1):

6. Type of Pesticide (Check each applicable item) [ ] Non-Chemical Pest Control Device

[ ] Insecticide [ ] Fungicide [ ] Herbicide [ ] Rodenticide [ ] Nematicide [ ] Algicide [ ] Germicide [X] Other

7. Type of Formulation

[ ] Dust [ ] Wettable Powder [ ] Pressurized Product [ ] Granular [X] Emulsifiable Liquid [ ] Bait [ ] Other

8. Type of Containers and Sizes: 5-Gallon Pails

9. Signature of Authorized Representative: Frank Grainger | Type or Print Name: Frank Grainger | Date: 4/19/13

(For State Use Only) License Period 2013-2015

CERTIFICATE OF LICENSE

When signed under authority of the Chairperson, Board of Agriculture, this certifies that the pesticide / device named above is duly licensed, license fee paid therefore and its sale in Hawaii authorized for the license period referred to, pursuant to provisions of the Hawaii Pesticide Law (Chapter 149A, Hawaii Revised Statutes) and the Administrative Rules, Chapter 66, Pesticides, Title 4, Department of Agriculture.

06/03/13
Date Issued

P10293 04/23/13
Receipt No.

Neil Reimer
Administrator, Division of Plant Industry

SEE BACK FOR INFORMATION ON FEES, LABELING AND PROCEDURES

Form P-2
Revised 1/29/09

****
*FOR YOUR RECORDS *
NOT TO BE RETURNED
THIS IS NOT A BILL
****

NORTH CAROLINA DEPARTMENT OF AGRICULTURE
PESTICIDE SECTION
STEVE TROXLER, COMMISSIONER

PESTICIDE REGISTRATION CERTIFICATION

THIS CERTIFIES THAT THE BRANDS OR GRADES OF PESTICIDE(S) LISTED BELOW HAVE BEEN DULY REGISTERED, AND THEIR SALES IN NORTH CAROLINA AUTHORIZED FOR THE CALENDAR YEAR INDICATED, ACCORDING TO THE NORTH CAROLINA PESTICIDE LAW OF 1971, ARTICLE 52 OF CHAPTER 143 OF THE GENERAL STATUTES.

SUBMITTED FOR: 000001231
FAIR PRODUCTS INC
RENEE ALLEN
PO BOX 386
CARY NC 27515

SUBMITTED BY: 000001231
FAIR PRODUCTS INC
RENEE ALLEN
PO BOX 386
CARY NC 27515

PHONE: (919)467-1599

EPA REG NO		BRAND NAME OF PESTICIDE (AS SHOWN ON LABEL)	NC ID	STATUS	REG FEE	ETF FEE	REG YEAR
051873-00002-	-	FAIR PLUS FOR THE PREVENTION OF GROWTH OF TOBACCO SUCKERS	19881729	RENEWAL	$150.00	$50.00	2015
051873-00005-	-	FAIR TAC CONTACT TOBACCO SUCKER CONTROL AGENT	20011991	RENEWAL	$150.00	$50.00	2015
051873-00006-	-	FST-7 CONTACT & SYSTEMIC TOBACCO SUCKER CONTROL AGENT	19881730	RENEWAL	$150.00	$50.00	2015
051873-00007-	-	FAIR 85 CONTACT TOBACCO SUCKER CONTROL AGENT	19881728	RENEWAL	$150.00	$50.00	2015
051873-00008-	-	DE-CUT TO CONTROL & RETARD PLANT GROWTH IN ACRES DIFFICULT TO MAINTAI	19881731	RENEWAL	$150.00	$25.00	2015
051873-00009-	-	FAIR 30 FOR THE PREVENTION OF GROWTH OF TOBACCO SUCKERS	19881732	RENEWAL	$150.00	$50.00	2015
051873-00017-	-	FAIR 80 SP FOR THE SYSTEMIC PREVENTION OF TOBACCO SUCKER GROWTH	19960990	RENEWAL	$150.00	$50.00	2015
051873-00018-	-	O-TAC PLANT CONTACT AGENT	20090689	RENEWAL	$150.00	$50.00	2015
051873-00018-	-	GREEN-TAC PLANT CONTACT AGENT	20121147	RENEWAL	$150.00	$25.00	2015
051873-00020-	-	N-TAC TOBACCO SUCKER CONTROL	20131328	RENEWAL	$150.00	$25.00	2015

MASCOL 80

Fatty Alcohol

Substances Physical Properties and Mode Of Action

. Natural Fatty Alcohols, are derived from natural sources generally isolated from any of a variety of natural occurring fats, oils, and waxes of either animal or vegetable origin, The most commonly used sources are coconut oil, palm oil, lard and tallow.

The alcohols are prepared by a transesterification of the fatty acids in the triglycerides found in natural oils and fats followed by a catalytic hydrogenolysis of the resulting esters. purification and fraction of the resulting alcohols is similar to the synthetically produced materials. All of the natural alcohols used here are PKO, sustainably sourced !

The Primary Mode of Action, upon contact of the natural fatty alcohols the axillary buds/suckers at the leaf axils, the solution containing the active substance quickly dissolves the thin underdeveloped cutile or waxy area and results in desiccation of the axillary bud/sucker by rupturing cell walls and rapidly evaporating liquids.

Reference additional information herewith.

History Of Natural Fatty Alcohols

Production and occurrence

Most fatty alcohols in nature are found as waxes which are esters with fatty acids and fatty alcohols.[1] They are produced by bacteria, plants and animals for purposes of buoyancy, as source of metabolic water and energy, biosonar lenses (marine mammals) and for thermal insulation in the form of waxes (in plants and insects).[3] Fatty alcohols were unavailable until the early 1900s. They were originally obtained by reduction of wax esters with sodium by the Bouveault–Blanc reduction process. In the 1930s catalytic hydrogenation was commercialized, which allowed the conversion of fatty acid esters, typically tallow, to the alcohols. In the 1940s and 1950s, petrochemicals became an important source of chemicals, and Karl Ziegler had discovered the polymerization of ethylene. These two developments opened the way to synthetic fatty alcohols.

From natural sources

The traditional and still important source of fatty alcohols are fatty acid esters. Wax esters were formerly extracted from sperm oil, obtained from whales. An alternative plant source is jojoba. Fatty acid triesters, known as triglycerides, are obtained from plant and animal sources. These triesters are subjected to transesterification to give methyl esters, which in turn are hydrogenated to the alcohols. Although tallow is predominantly C16-C18, the chain length from plant sources are more variable (C6-C24). Higher alcohols (C20–C22) can be obtained from rapeseed or mustard seed. Midcut alcohols (C12-C14) are obtained from coconut or palm oil.

From petrochemical sources

Fatty alcohols are also prepared from petrochemical sources. In the Ziegler process, ethylene is oligomerized using triethylaluminium followed by air oxidation. This process affords even-numbered alcohols:

$$Al(C_2H_5)_3 + 18\ C_2H_4 \rightarrow Al(C_{14}H_{29})_3$$

$$Al(C_{14}H_{29})_3 + 1.5\ O_2 + 1.5\ H_2O \rightarrow 3\ HOC_{14}H_{29} + 0.5\ Al_2O_3$$

Alternatively ethylene can be oligomerized to give mixtures of alkenes, which are subjected to hydroformylation, this process affording odd-numbered aldehyde, which is subsequently hydrogenated. For example, from 1-decene, hydroformylation gives the C11 alcohol:

$$C_8H_{17}CH{=}CH_2 + H_2 + CO \rightarrow C_8H_{17}CH_2CH_2CHO$$

$$C_8H_{17}CH_2CH_2CHO + H2 \rightarrow C_8H_{17}CH_2CH_2CH_2OH$$

In the Shell higher olefin process, the chain-length distribution in the initial mixture of alken

oligomers is adjusted so as to more closely match market demand. Shell does this by means of an intermediate metathesis reaction.[4] The resultant mixture is fractionated and hydroformylated/hydrogenated in a subsequent step.

Applications

Fatty alcohols are mainly used in the production of detergents and surfactants. They are components also of cosmetics, foods, and as industrial solvents. Due to their amphipathic nature, fatty alcohols behave as nonionic surfactants. They find use as emulsifiers, emollients and thickeners in cosmetics and food industry. About 50% of fatty alcohols used commercially are of natural origin, the remainder being synthetic.[1]

Nutrition

Very long chain fatty alcohols (VLCFA), obtained from plant waxes and beeswax have been reported to lower plasma cholesterol in humans. They can be found in unrefined cereal grains, beeswax, and many plant-derived foods. Reports suggest that 5–20 mg per day of mixed C24–C34 alcohols, including octacosanol and triacontanol, lower low-density lipoprotein (LDL) cholesterol by 21%–29% and raise high-density lipoprotein cholesterol by 8%–15%.[*citation needed*] Wax esters are hydrolyzed by a bile salt–dependent pancreaticcarboxyl esterase, releasing long chain alcohols and fatty acids that are absorbed In the gastrointestinal tract. Studies of fatty alcohol metabolism in fibroblasts suggest that very long chain fatty alcohols, fatty aldehydes, and fatty acids are reversibly inter-converted in a fatty alcohol cycle. The metabolism of these compounds is impaired in several inherited human peroxisomal disorders, including adrenoleukodystrophy and Sjögren-Larsson syndrome.[5]

Fatty alcohols, derived from natural fats and oils, are high molecular straight chain primary alcohols. They include lauryl (C12), Myristyl (C14), Cetyl (or palmityl: C16), stearyl (C18), Oleyl (C18, unsaturated), and Linoleyl (C18, polyunsaturated) alcohols. There are synthetic fatty alcohols equivalent physically and chemically to natural alcohols obtained from oleochemical sources such as coconut and palm kernel oil. Fatty alcohols are emulsifiers and emollients to make skin smoother and prevent moisture loss. Identical fatty esters are used to improve rub-out of formulas and to control viscosity and dispersion characteristics in cosmetics, personal care products and pharmaceutical ingredients. As chemical intermediates, the primary use of fatty alcohols are as raw material for the production of fatty sulfate salts and alcohol ethoxylates for foaming and cleaning purposes in the field of detergent industry. Chemical reactions of primary alcohols include esterifications, ethoxylation, sulfation, oxidation and many other reactions. Their derivatives and end use applications include;

- Nonionic surfactants (Ethoxylates and propoxylates)
- Anionic surfactants (Alkyl sulfates and alkyl ethoxy sulfates)
- Chemical intermediates and polymerization modifiers (Alkyl halides, Alkyl mercaptans)
- Quaternary ammonium compounds for detergent sanitisers, softner for textiles, phase transfer catalyst and biocides
- Antioxidants for plastics (Alkyl thiopropionates and alkyl phosphites)
- Lubricant additives (Metallic and thio alkylphosphates)
- Flavor and Fragrance (Aldehydes and ketones)
- PVC plasticizers (Dialkyl Phthalates, adipates and trimellitates)
- Coatings and inks (acrylate and methacrylate esters)
- Water treatment (acrylate and methacrylate esters)

Large amount of fatty alcohols are used as special solvents, fillers in plasticizer and insulating materials for the building industry. Fatty alcohols are used as ingredients in the industries of agricultural, foodstuff, metal processing, cosmetics, lube additive, pharmaceutical, rubber, textile, perfume and flavouring as well as synthetic detergent.

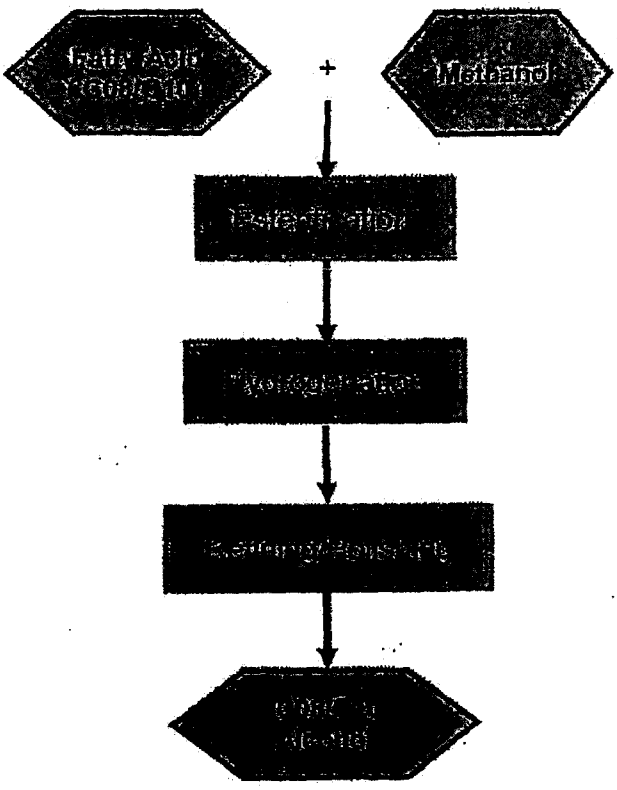
Manufacturing and Production Process

Fatty Alcohols

P.T. MUSIM MAS

Jl. Oleo. Kawasan Industri Medan II
Saentis - Percut Sei Tuan
Deli Serdang – 20371
Medan - Indonesia
Tel. : (62 - 61) 6871123
Fax. : (62 - 61) 6871152 / 6871153

Fatty Alcohol Process Flow



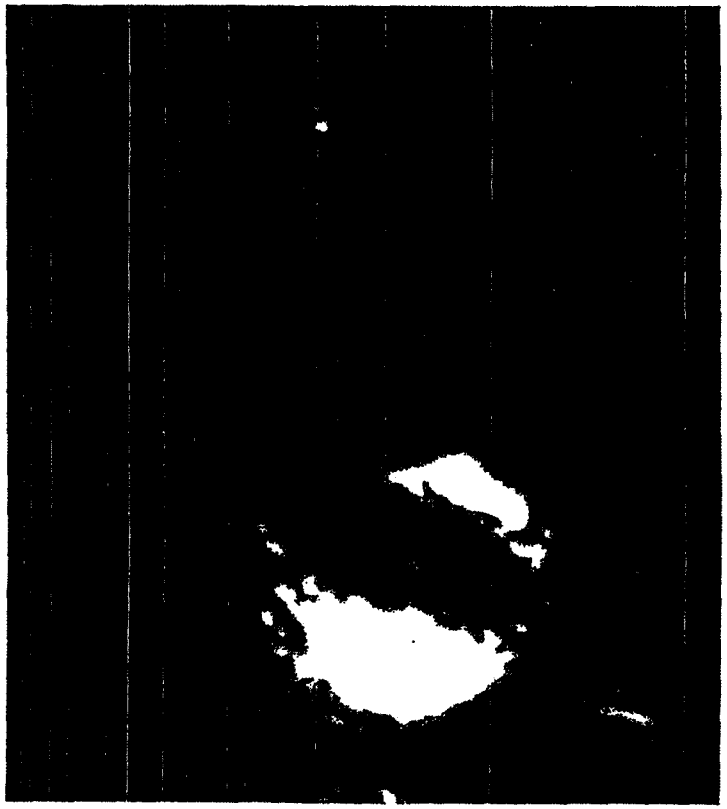
Prepared by:

Eng Bung Kiang
QA Manager

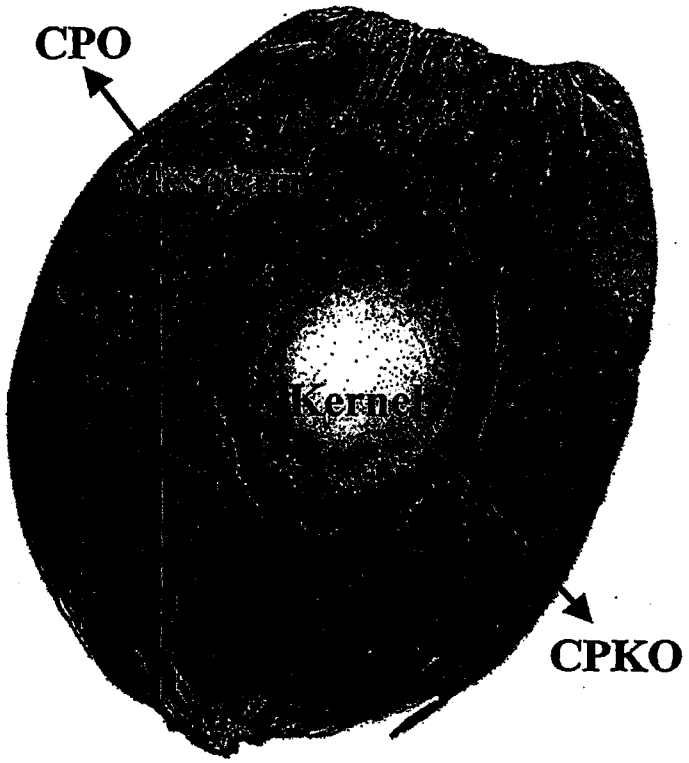
Oil Palm Plant

FFB (Fresh Fruit Bunch)

Oil Palm Fruilet



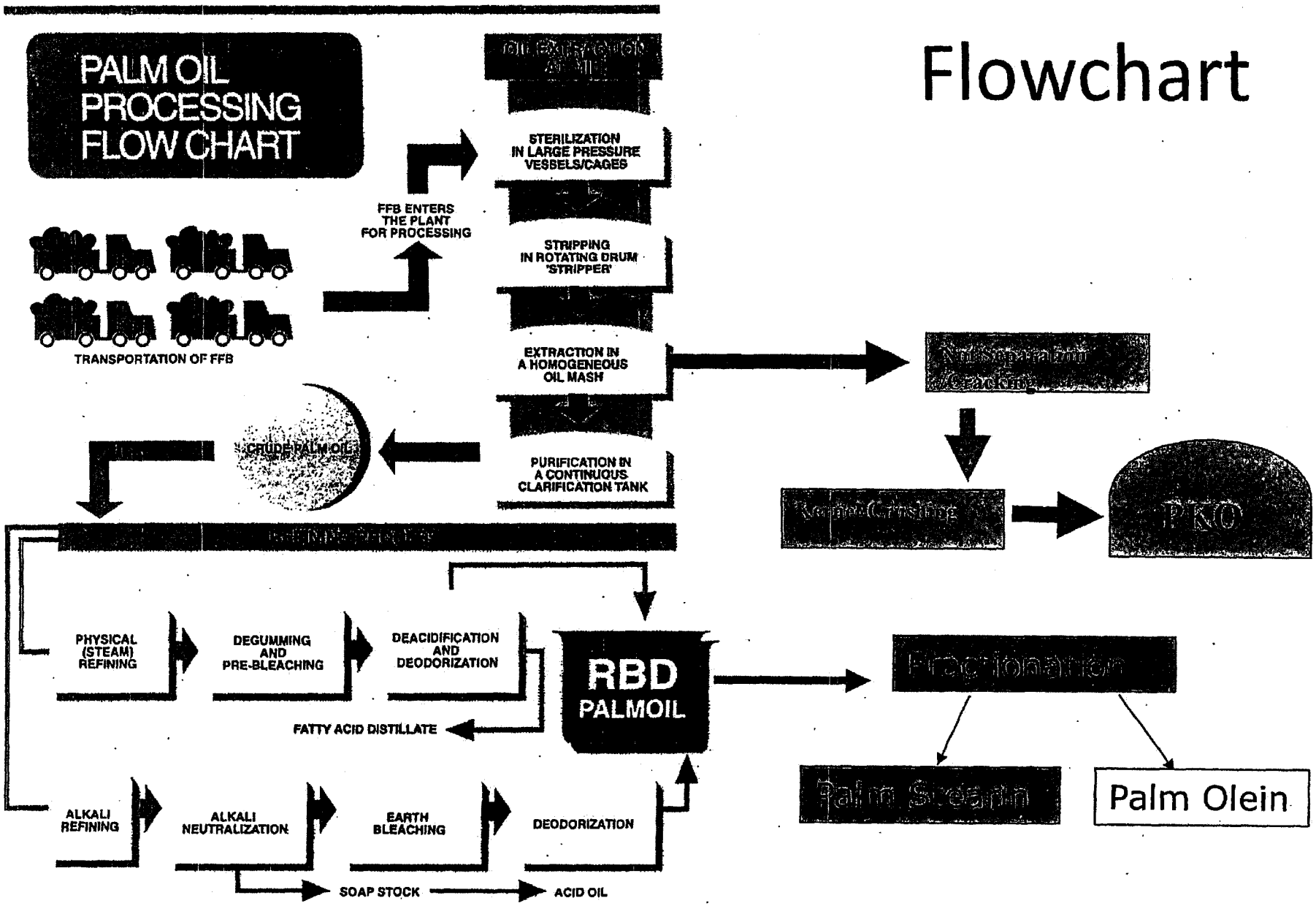
Whole



Cut into Half

Oil Palm – Field to Mill

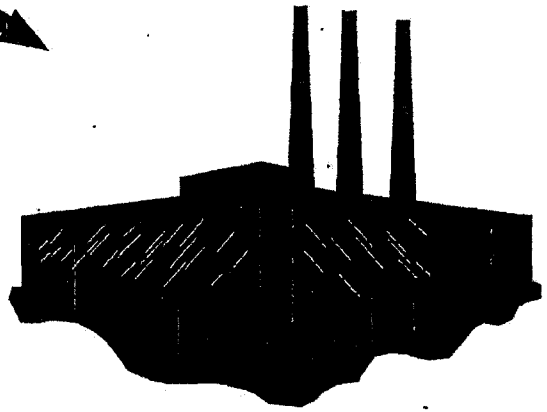
Flowchart


PALM OIL PROCESSING FLOW CHART
FFB ENTERS THE PLANT FOR PROCESSING
TRANSPORTATION OF FFB
STERILIZATION IN LARGE PRESSURE VESSELS/CAGES
STRIPPING IN ROTATING DRUM 'STRIPPER'
EXTRACTION IN A HOMOGENEOUS OIL MASH
PURIFICATION IN A CONTINUOUS CLARIFICATION TANK
CRUDE PALM OIL
PKO
PHYSICAL (STEAM) REFINING
DEGUMMING AND PRE-BLEACHING
DEACIDIFICATION AND DEODORIZATION
FATTY ACID DISTILLATE
RBD PALMOIL
Fractionation
Palm Stearin
Palm Olein
ALKALI REFINING
ALKALI NEUTRALIZATION
EARTH BLEACHING
DEODORIZATION
SOAP STOCK
ACID OIL

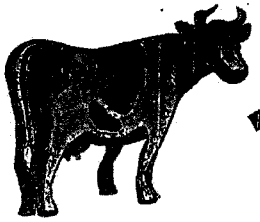
The Production of Oleochemicals

Vegetable oils :

palm, coconut, rapeseed, sunflower, etc.



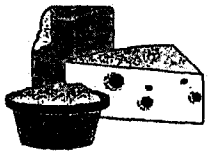
Oleochemical plant

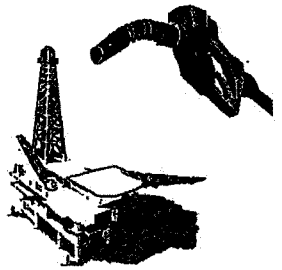


Animal fats and oils

Used in :

- Soap & detergents
- Chemical synthesis
- Food & Feed additives
- Cosmetics
- Pharmaceuticals
- Paints
- Textile products
- Polymer additives
- Rubber additives
- Paper additives
- Agrochemicals
- Fuel additives
- Lubricants
- Offshore chemicals

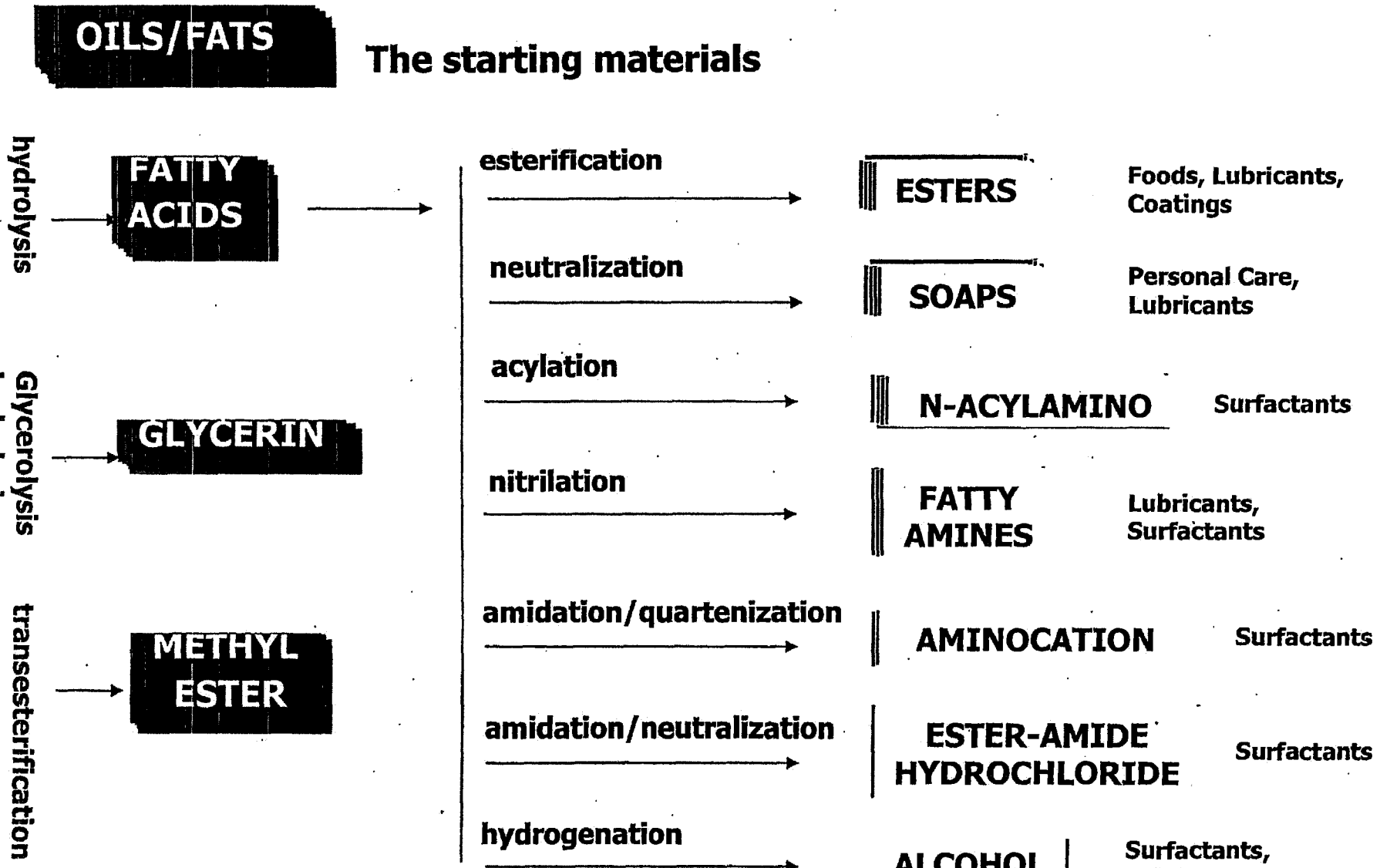




BASIC OILS & FATS FATTY ACIDS COMPOSITION

FATTY ACIDS		TALLOW	PALM OIL	PALM STEARIN	SOYA BEAN	RAPESEED (high C22:1)	CNO	PKO
CAPROIC	C6	-	-	-	-	-	1.3	Tr
CAPRYLIC	C8	-	-	-	-	-	5.8	3.6
CAPRIC	C10	-	-	-	-	-	6.5	3.5
LAURIC	C12	Tr	Tr	0.2	-	-	51.2	47.3
MYRISTIC	C14	3.5	1.1	1.4	-	Tr	17.6	16.4
PALMITIC	C16	27.4	44	55.7	11.3	2.8	8.5	8.1
STEARIC	C18:0	18.2	4.5	4.8	3.8	1.2	2.7	2.3
OLEIC	C18:1	40	39.2	31	22.3	16.2	6.5	16.2
LINOLIEC	C18:2	2.6	10.1	6.6	53.2	14.3	1.2	1.8
LINOLENIC	C18:3	Tr	0.4	Tr	4.3	9.5	-	-
ICOSANOIC	C20:0	-	-	-	2	7	Tr	-
ERUCIC	C22:1	-	-	-	-	45.4	-	-

Fatty Acid Derivatives



METHYL ESTERS The starting materials

hydrogenation → **ALCOHOLS** — Intermediates for Surfactants, Lubricants

Amidation → **ALKANOL AMIDES** — Foam booster, Foam stabilizer

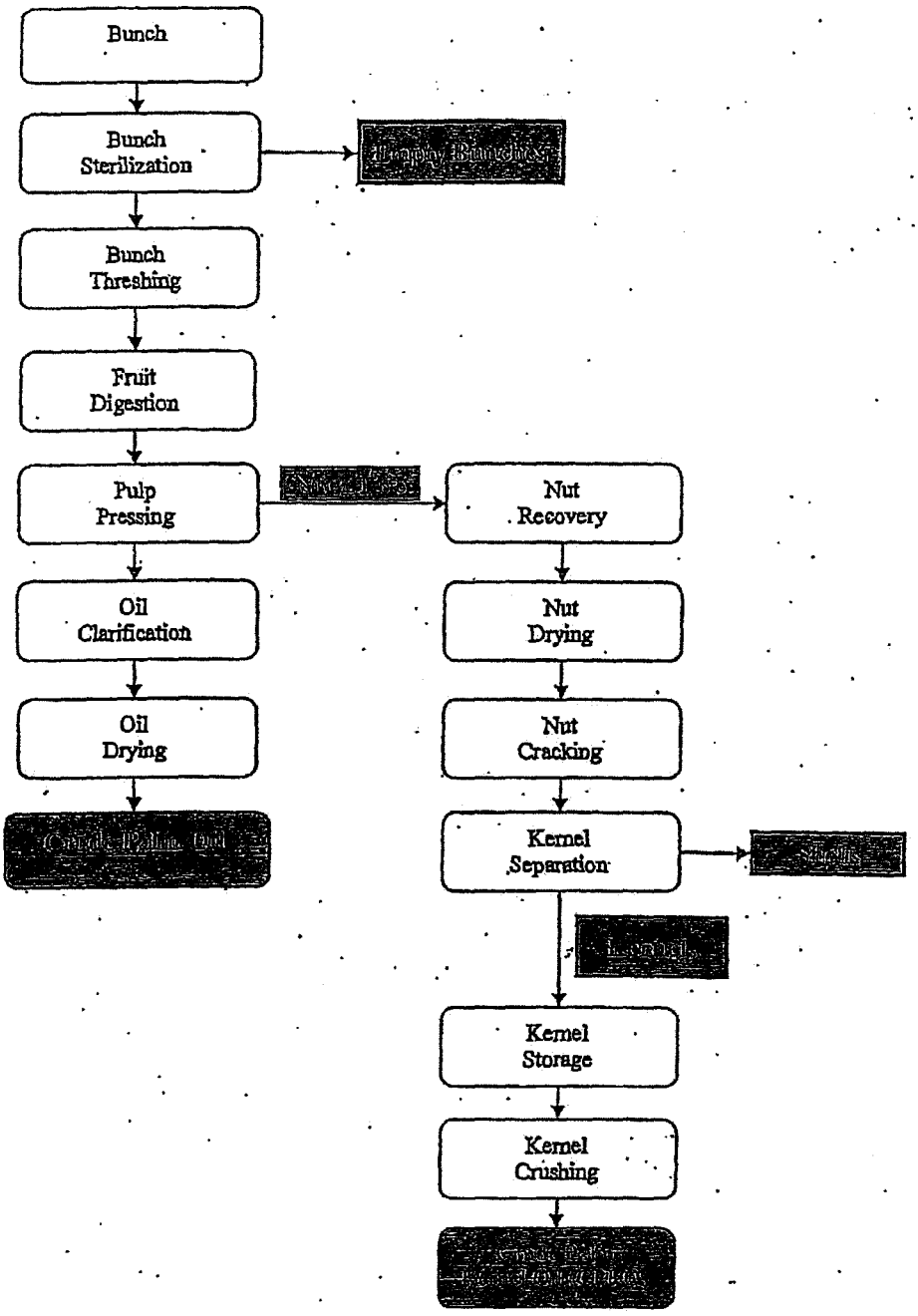
Sulfonation → **MES** — Detergents

FATTY ALCOHOLS

The starting materials

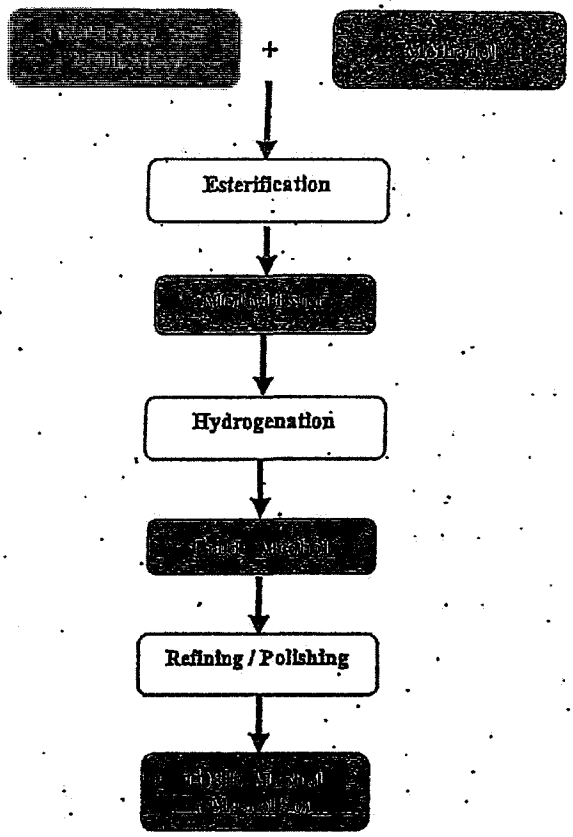
Acetalization →	Alylglucosides low irritation, provide lathering	Dish-washing detergents Shampoos Household detergents
Ethoxylation →	Nonionic Surfactants emulsification, detergency	Laundry & household detergents cosmetics
Sulfation →	Sulfonates, detergency	Detergents, Shampoos, Toothpaste
Phosphorylation →	Phosphates Low irritation	Cosmetics, body & facial cleaner
Dimerization →	Guerbet alcohols	Aroma chemicals
Amination →	Fatty Amines	Detergents, softeners, shampoos

Palm Kernel Oil Process Flow



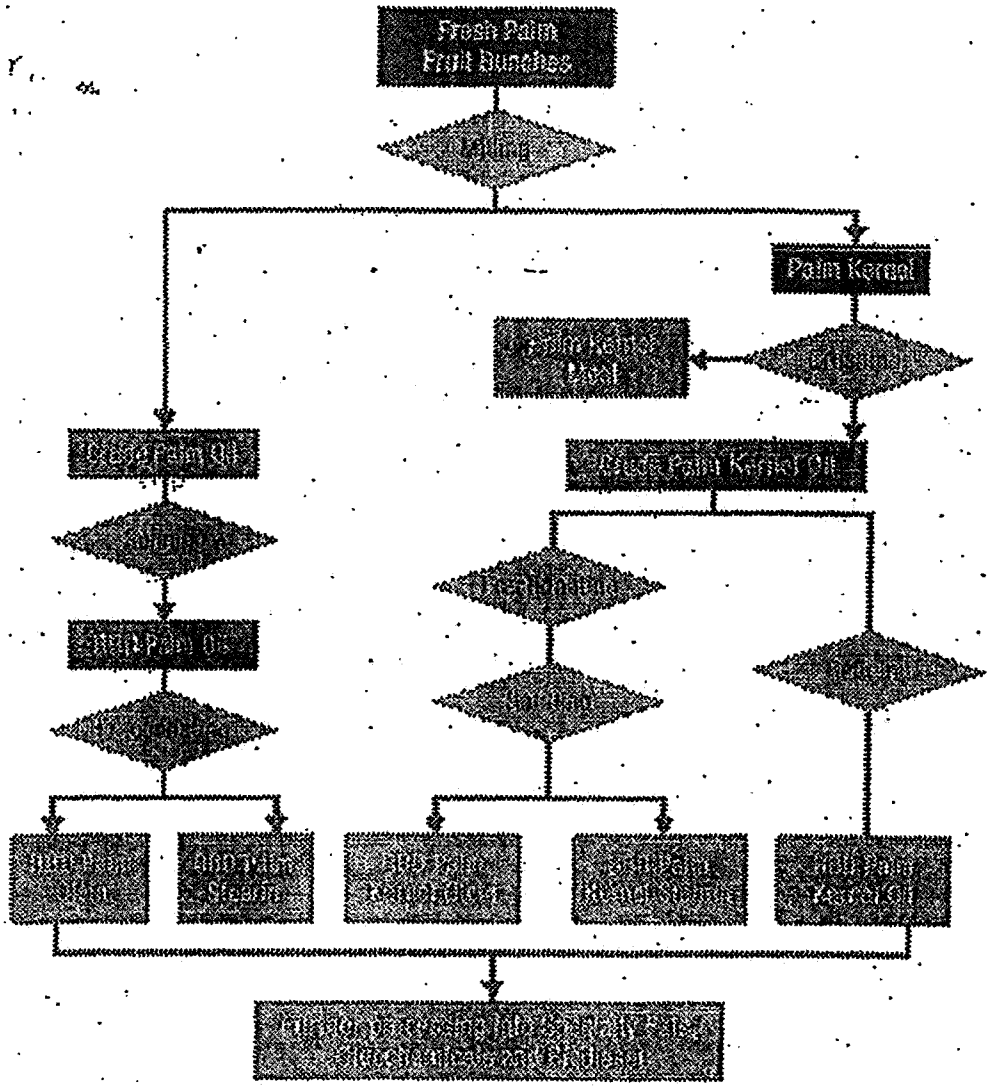
Fatty Alcohol Process Flow

Process Flow



Subj: Palm oil info
Date: 1/19/2009 12:11:27 PM Eastern Standard Time
From: john.schnieder@icofgroup.com
To: renee@fairproductsinc.com, agrisys1@aol.com
Sent from the Internet (Details)

Below is general information regarding the production of palm oil. Our palm oil, laurics and related products are widely used in many industries including food manufacturing, cosmetics and pharmaceutical industries.



a) Processing FFBs into crude palm oil and palm kernel

The process begins with the harvesting of fresh fruit bunches (FFBs) which are milled within 24 hours from harvesting. FFBs are first transferred to the palm oil mills for sterilisation by applying high-pressure steam, whereupon the palm fruits are enzyme deactivated and separated from the palm bunches.

After the steaming process, the palm fruitlets are crushed in a pressing machine to obtain crude palm oil and palm kernel. Waste and water is then cleared and separated from the CPO by means of a centrifuge. The cleared crude palm oil emerging from the centrifuge is then sent for refining while the palm kernel nut is sent for crushing. The empty fruit bunches and liquid waste arising from the process are used as fertiliser in the plantations.

b) Crushing palm kernel into crude palm kernel oil

The palm kernel nut is fractured causing the palm kernel within the shell to contract away from the shell. The shell is separated from the kernel through a clay bath where it is used as fuel in the boiler room or co-generation plant.

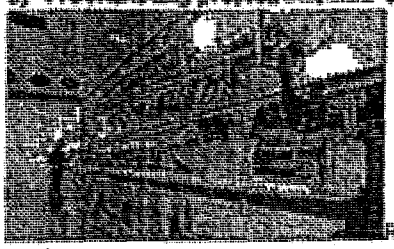
The palm kernel is further crushed to produce crude palm kernel oil and the remaining palm kernel meal is used as animal feed.

c) Refining process to obtain RBD palm oil and RBD palm kernel oil

To produce refined oil, crude palm oil and crude palm kernel oil is processed through three refining stages, namely degumming, bleaching and deodorising. In degumming, the gum and fatty acid in crude palm oil and crude palm kernel oil are separated together with other impurities such as trace minerals, copper and iron by the application of phosphoric acid.

In bleaching, the oil is mixed with bleaching earth (bentonite calcium) in a vacuum room to remove impurities and colour pigments in the palm oil. In deodorising, the odour and taste of the oil is removed when the oil is steamed at high temperatures between 240°C to 260°C and then cooled to room temperature.

d) Fractionating process into RBD stearin and RBD olein



RBD palm stearin and RBD palm olein are obtained by the fractionation of RBD palm oil; whereas RBD palm kernel stearin and RBD palm kernel olein are obtained by the fractionation of RBD palm kernel oil. Through a process known as crystallisation, RBD oil is cooled until crystals are formed.

The crystallized oil in the crystallizer is then filtered through a membrane to separate the liquid fraction i.e. olein from the solid fraction i.e. stearin. RBD palm olein is usually sold as cooking oil and may go through further fractionation.

Thanks,

John Schnieder

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Cincinnati, OH 45242

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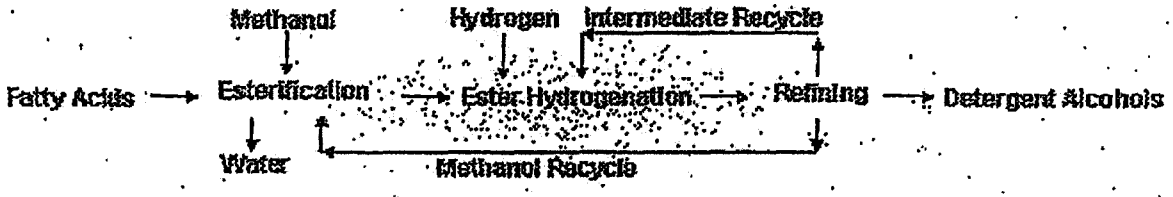
A member of the Musim Mas Group

Davy Process Technology

Natural Detergent Alcohols

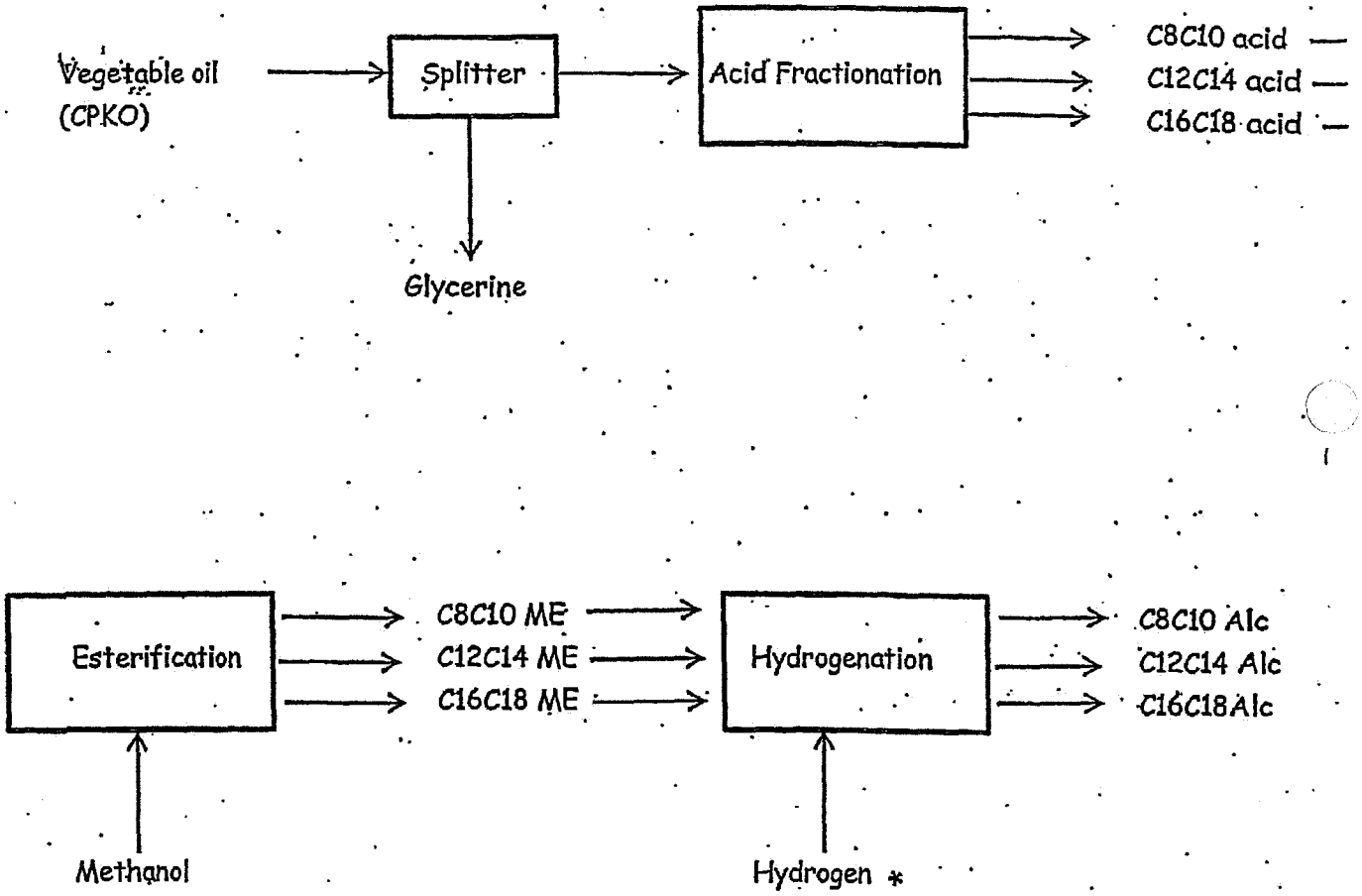
The Davy Process Technology Natural Detergent Alcohol process converts fatty acids to non-acidic intermediate methyl esters and hydrogenates these to alcohols. Methanol vapour passes counter current to the fatty acid ensuring almost complete conversion of the fatty acids to methyl esters. These are fed directly to a low pressure (40 bar) vapour phase hydrogenation process over a fixed bed of chrome free copper catalyst to produce a high purity crude mixed alcohol product stream. The product alcohol is then refined before being polished to convert any residual carbonyls (principally aldehydes) in the product to alcohols. The methanol consumed in the esterification is recovered in the hydrogenation step and recycled; so the methanol make-up is minimal. The C12-C14 product alcohols are removed as a liquid side-draw from near the top of the column and pumped to product polishing. The C16-C18 product alcohols are removed as a vapour side-draw from near the base of the column. The product polishing system converts any trace aldehydes in the product to alcohol.



This vapour phase process has been licensed around the world in 10 ester hydrogenation plants with a total installed capacity of 350,000 tonnes per year of alcohols. These plants have virtually no effluents; small by-product streams are recycled and consumed within the process so they have minimal environmental impact. Please contact us for further information.

Process Flow Chart

O-TAC Agent : Mascol 80. Fatty Alcohol Methyl Esters



*Note : Natural Reductive Environment

Mascol 80 Octyl Decyl Alcohol

The traditional and still important source of fatty alcohols are fatty acid esters. Fatty acid triesters, known as triglycerides, are obtained from plant and animal sources. Musim Mas uses renewable Palm Kernal Oil as the oil feed . These triesters are subjected to transesterification to give methyl esters, which in turn are hydrogenated to the alcohols. Shorter alcohols (C8-C10) are obtained from coconut oil and palm kernal oil.

Contaminants such as phosphatides, sterols or oxidation products and impurities such as seed particles, dirt and water are removed in a cleaning process. The refined triglycerides are then hydrolyzed to yield fatty esters. Refined free fatty acids esters are used for hydrogenation. Distilled fatty acids are predominantly used. Methanol reacts with the fatty acid in a countercurrent reactor. The methyl ester is subsequently distilled for purification

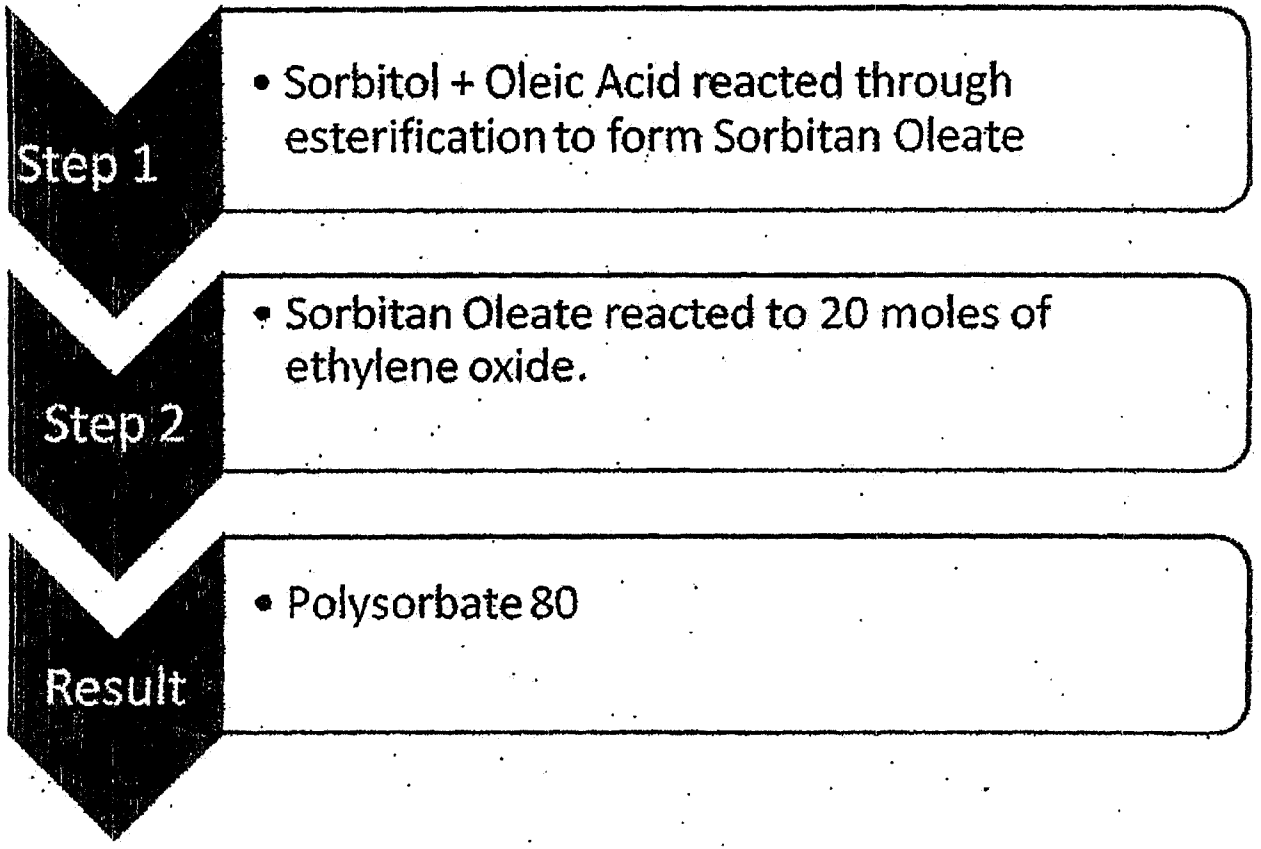
$$R'\text{-}CH_2\text{-}COOH + R''OH \longleftrightarrow R'\text{-}CH_2\text{-}COOR'' + H_2O$$

Fatty acid + **Methanol or Butanol** ⟷ **Methyl- or Buthylester**

Gas-Phase Hydrogenation

This process requires a vaporized substrate and is therefore particularly suitable for methyl esters. Characteristics of the process are an extremely large excess of recycle gas (approx. 600 mole of H2 per mole of ester), high gas velocities and the addition of methanol to aid evaporation. The product mixture is split into a gas and a liquid phase; the hydrogen is recycled, the methanol is stripped from the fatty alcohol and the fatty alcohol is purified by distillation

The Davy Process Technology Natural Detergent Alcohol process converts fatty acids to non-acidic intermediate methyl esters and hydrogenates these to alcohols. Methanol vapor passes counter current to the fatty acid ensuring almost complete conversion of the fatty acids to methyl esters. These are fed directly to a low pressure (40 bar) vapor phase hydrogenation process over a fixed bed of chrome free copper catalyst to produce a high purity crude mixed alcohol product stream. The product alcohol is then refined. The methanol consumed in the esterification is recovered in the hydrogenation step and recycled.

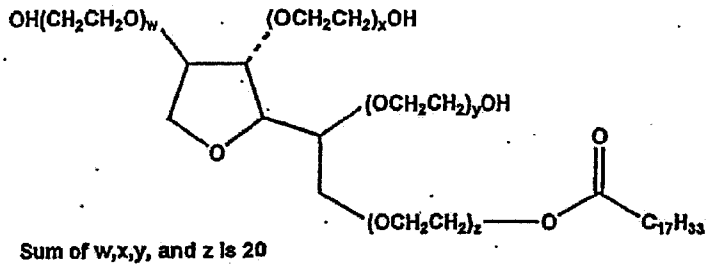

Step 1
• Sorbitol + Oleic Acid reacted through esterification to form Sorbitan Oleate
Step 2
• Sorbitan Oleate reacted to 20 moles of ethylene oxide.
Result
• Polysorbate 80

U.S. Pharmacopeia
The Standard of Quality™

USP Certificate

Polysorbate 80

LOT G0I359



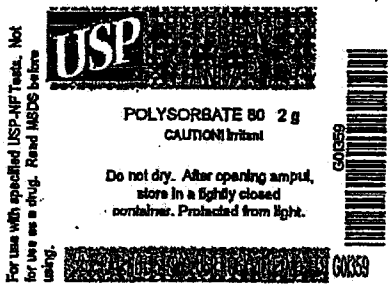
Sum of w,x,y, and z is 20

Molecular Formula
$C_{64}H_{124}O_{26}$

Molecular Weight
1309.67

CAS Number
9005-65-6

LABEL TEXT



USP certifies that the USP Reference Standards Committee, in accordance with their rules and procedures, determined that this USP Reference Standard lot is suitable to assess compliance with the monograph standards for which it is specified. The critical characteristics of this lot are usually determined independently in three or more laboratories, including USP, government, academic, and industrial collaborators.

QA Director

-2-

09-Apr-2010

Calculation Value

Unless otherwise stated on the Reference Standard label, a value of 100.0% should be used in USP or NF compendial applications for which the use of this Reference Standard is intended. Please refer to the specific Reference Standard label for further information.

Expiration

Current lots are identified in the Official USP Reference Standards catalog. In some cases, the previous lot may still be considered official. If so, it is identified in the column marked "Previous Lot/Valid Use Date." Ordinarily, the previous lot is carried in official status for about one year after the current lot enters distribution.

It is the responsibility of each user to determine that this lot is current when used. To ensure up-to-date information, USP publishes the Official USP Reference Standards Catalog, which contains official lot designations. This information is also available on the USP web site, at www.usp.org, as well as in the bimonthly subscription publication, *Pharmacopeial Forum*.

Instructions for Use

Follow the instructions in the appropriate USP or NF Monographs and General Requirements for Tests and Assays of the current *USP–NF*. In the event that instructions on the label of this lot differ from those found in the current *USP–NF*, those on the label supersede any instructions listed in Chapter <11>.

Non-Monograph Use

The suitability of this Reference Standard for use in non-compendial applications is solely the responsibility of the user.

[Code of Federal Regulations]
[Title 21, Volume 3]
[Revised as of April 1, 2011]
[CITE: 21CFR172.840]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION (CONTINUED)

PART 172 -- FOOD ADDITIVES PERMITTED FOR DIRECT ADDITION TO FOOD FOR HUMAN CONSUMPTION

Subpart I--Multipurpose Additives

Sec. 172.840 Polysorbate 80.

The food additive polysorbate 80 (polyoxyethylene (20) sorbitan monooleate), which is a mixture of polyoxyethylene ethers of mixed partial oleic acid esters of sorbitol anhydrides and related compounds, may be safely used in food in accordance with the following prescribed conditions:

(a) The food additive is manufactured by reacting oleic acid (usually containing associated fatty acids) with sorbitol to yield a product with a maximum acid number of 7.5 and a maximum water content of 0.5 percent, which is then reacted with ethylene oxide.

(b) The food additive meets the following specifications:

Saponification number 45-55.

Acid number 0-2.

Hydroxyl number 65-80.

Oxyethylene content 65 percent-69.5 percent.

(c) The additive is used or intended for use as follows:

(1) An emulsifier in ice cream, frozen custard, ice milk, fruit sherbet, and nonstandardized frozen desserts, when used alone or in combination with polysorbate 65 whereby the maximum amount of the additives, alone or in combination, does not exceed 0.1 percent of the finished frozen dessert.

(2) In yeast-defoamer formulations whereby the maximum amount of the additive does not exceed 4 percent of the finished yeast defoamer and the maximum amount of the additive in the yeast from such use does not exceed 4 parts per million.

(3) As a solubilizing and dispersing agent in pickles and pickle products, whereby the maximum amount of the additive does not exceed 500 parts per million.

(4) As a solubilizing and dispersing agent in:

(i) Vitamin-mineral preparations containing calcium caseinate in the absence of fat-soluble vitamins, whereby the maximum intake of polysorbate 80 shall not exceed 175 milligrams from the recommended daily dose of the preparations.

(ii) Fat-soluble vitamins in vitamin and vitamin-mineral preparations containing no calcium caseinate, whereby the maximum intake of polysorbate 80 shall not exceed 300 milligrams from the recommended daily dose of the preparations.

(iii) In vitamin-mineral preparations containing both calcium caseinate and fat-soluble vitamins, whereby the maximum intake of polysorbate 80 shall not exceed 475 milligrams from the recommended daily dose of the preparations.

(5) As a surfactant in the production of coarse crystal sodium chloride

whereby the maximum amount of the additive in the finished sodium chloride does not exceed 10 parts per million.

(6) In special dietary foods, as an emulsifier for edible fats and oils, with directions for use which provide for the ingestion of not more than 360 milligrams of polysorbate 80 per day.

(7) As a solubilizing and dispersing agent for dill oil in canned spiced green beans, not to exceed 30 parts per million.

(8) As an emulsifier, alone or in combination with polysorbate 60, in shortenings and edible oils intended for use in foods as follows, when standards of identity established under section 401 of the act do not preclude such use:

(i) It is used alone in an amount not to exceed 1 percent of the weight of the finished shortening or oil.

(ii) It is used with polysorbate 60 in any combination providing no more than 1 percent of polysorbate 80 and no more than 1 percent of polysorbate 60, provided that the total combination does not exceed 1 percent of the finished shortening or oil.

(iii) The 1-percent limitation specified in paragraph (c)(8) (i) and (ii) of this section may be exceeded in premix concentrates of shortening or edible oil if the labeling complies with the requirements of paragraph (d) of this section.

(9) As an emulsifier in whipped edible oil topping with or without one or a combination of the following:

(i) Sorbitan monostearate;

(ii) Polysorbate 60;

(iii) Polysorbate 65;

whereby the maximum amount of the additive or additives used does not exceed 0.4 percent of the weight of the finished whipped edible oil topping.

(10) It is used as a wetting agent in scald water for poultry defeathering, followed by potable water rinse. The concentration of the additive in the scald water does not exceed 0.0175 percent.

(11) As a dispersing agent in gelatin desserts and in gelatin dessert mixes, whereby the amount of the additive does not exceed 0.082 percent on a dry-weight basis.

(12) As an adjuvant added to herbicide use and plant-growth regulator use dilutions by a grower or applicator prior to application of such dilutions to the growing crop. Residues resulting from such use are exempt from the requirement of a tolerance. When so used or intended for use, the additive shall be exempt from the requirements of paragraph (d)(1) of this section.

(13) As a defoaming agent in the preparation of the creaming mixture for cottage cheese and lowfat cottage cheese, as identified in 133.128 and 133.131 of this chapter, respectively, whereby the amount of the additive does not exceed .008 percent by weight of the finished products.

(14) As a surfactant and wetting agent for natural and artificial colors for use in barbecue sauce where the level of the additive does not exceed 0.005 percent by weight of the barbecue sauce.

(d) To assure safe use of the additive, in addition to the other information required by the Act:

(1) The label of the additive and any intermediate premixes shall bear:

(i) The name of the additive.

(ii) A statement of the concentration or strength of the additive in any intermediate premixes.

(2) The label or labeling shall bear adequate directions to provide a final product that complies with the limitations prescribed in paragraph (c) of this section.

[42 FR 14491, Mar. 15, 1977, as amended at 43 FR 2871, Jan. 20, 1978.]

CCl_4; sp. gr. 1.05; HLB 10.5; pour pt. 33 C; acid no. 2 max.; sapon. no. 88-98; hyd. no. 44-60; flash pt. (CC) 149 C; Nonionic
Toxicology: TDLo (oral, rat) 635 g/kg; experimental reproductive effector; TSCA listed
Precaution: Wear safety glasses, lab coat, and dust respirator
Hazardous Decomp. Prods.: Heated to decomp., emits acrid smoke and irritating fumes
HMIS: Health 1, Flammability 1, Reactivity 0
Uses: Emulsifier, dispersant, stabilizer in foods, ice cream, frozen desserts, cakes, cake mixes/icings/fillings, whipped toppings, coffee whiteners; defoamer in processing foods
Regulatory: FDA 21CFR §73.1001, 172.838, 173.340, 175.300, 178.3400; Europe listed; UK approved; Canada DSL
Manuf./Distrib.: Fluka; Mosselman NV; Sigma
Trade Names: Avapol™ 65; Crillet 35; Durfax® 65; Glycosperse® TS-20 KFG; Kollen-S/3; Liposorb TS-20; Liposorb TS-20K; Lumisorb™ PSTS-20K; Sorbax PTS-20; T-Maz® 65K; Tween® 65
Trade Names Containing: Aldosperse® TS-20; Aldosperse® TS-20 FG; Aldosperse® TS-20 KFG; Aldosperse® TS-40; Aldosperse® TS-40 FG; Aldosperse® TS-40 KFG

Polysorbate 80
CAS 9005-65-6 (generic); 37200-49-0; 61790-86-1
FEMA 2917; INS433
Synonyms: PEG-20 sorbitan oleate; POE (20) sorbitan monooleate; Sorbi- macrogol oleate 300
Definition: Mixture of oleate esters of sorbitol and sorbitol anhydrides, with ≈ 20 moles EO
Properties: Amber visc. liq.; faint odor; bitter taste; nonionic; very sol. in water; sol. in alcohol, fixed oils, cottonseed oil, corn oil, ethyl acetate, methanol, toluene; insol. in min. oil; dens. 1.06-1.10; visc. 270-430 cSt; HLB 15.0; acid no. 2 max.; sapon. no. 45-55; hyd. no. 65-80; pH 5-7 (5% aq.)
Toxicology: LD50 (oral, mouse) 25 g/kg, (IP, rats) 6.3 ml/kg, (IV, rat) 179 mg/kg; mod. toxic by IV route; mildly toxic by ing.; eye irritant; questionable carcinogen; experimental tumorigen, reproductive effects; human mutagenic data; TSCA listed
Hazardous Decomp. Prods.: Heated to decomp., emits acrid smoke and irritating fumes
Uses: Diluent in food colorants; synthetic flavoring agent, emulsifier, solubilizer, dispersant, surfactant, wetting agent, stabilizer in foods; in defoamers for beet sugar, yeast processing; emulsifier in ice cream, edible fat/oils; solubilizer, dispersant in pickles, vitamin-mineral preps., gelatin dessert; surfactant in prod. of coarse cryst. NaCl; wetting agent in poultry scalds
Regulatory: FDA 21CFR §73.1, 73.1001, 172.515, 172.840, 172.842, 173.340, 175.105, 175.300, 176.180, 178.3400, 573.860; USDA 9CFR §318.7, 381.147 (limitation 1% alone, 1% total combined with polysorbate 60); FEMA GRAS; Europe listed; UK approved; FDA approved for buccals, intramuscular injectables, intravenous, parenterals, ophthalmics, orals, otics, rectals, topicals, vaginals; USP/NF, BP, EP compliance
Manuf./Distrib.: CarboMer; Chemacon GmbH; Croda Chem. Europe Ltd; Fluka; Mallinckrodt Baker; Mosselman NV; SAFC Specialties; Sigma; Spectrum Quality Prods.; Volgt Global Distrib.
Trade Names: Alkamuls® PSMO-20; Avapol™ 80; Avapol™ 80K; Canarcel TW 80; Crillet 4; Crillet 4 HP; Crillet 4 NF; Crillet 4 Super; Durfax® 80; Glycosperse® O-20 KFG; Lamesorb® SMO-20; Liposorb O-20; Liposorb O-20K; Lonzest® SMO-20; Lumisorb™ PSMO-20 FGK; Lumisorb™ PSMO-20K; Nissan Nonion OT-221; Sorbax PMO-20; T-Maz® 80; T-Maz® 80K; T-Maz® 80KLM; TO-10V; Tween® 80K; Tween® 80V Pharma
Trade Names Containing: AFC AS 920; Aldosperse® O-20; Aldosperse® O-20 KFG; Ice # 2; Monofreeze 80

Polysorbate 81
CAS 9005-65-6 (generic)
Synonyms: PEG-5 sorbitan oleate; POE (5) sorbitan monooleate
Definition: Mixture of oleate esters of sorbitol and sorbitol anhydrides, with ≈ 5 moles EO
Properties: Amber oily liquid; visc. 300-500 cs; hydroxyl value 134-150; sapon. value 96-104; acid value 2.2; HLB 10.0; Nonionic
Toxicology: TSCA listed
Uses: Emulsifier for bakery, confectionery, convenience foods; solubilizer for flavors, vitamin oils; visc. modifier, suspending agent for foods
Regulatory: FDA 21CFR §175.300
Trade Names: Crillet 41; Hetsorb O-5; Sorbax PMO-5; T-Maz® 81; Tween® 81

Polysorbate 85
CAS 9005-70-3 (generic)
Synonyms: PEG-20 sorbitan trioleate; POE (20) sorbit... macrogol trioleate 300
Definition: Mixture of oleate esters of sorbitol and sorbitol ≈ 20 moles ethylene oxide
Properties: HLB 11.0; Nonionic
Toxicology: Human skin irritant; TSCA listed
Uses: Solubilizer for flavors, vitamin oils; o/w emulsifier confectionery, convenience food applics.; wetting agent, blizer in foods
Regulatory: FDA 21CFR §175.300, 178.3400
Manuf./Distrib.: Aldrich; Fluka; Mosselman NV; Sigma; S Prods.
Trade Names: Alkamuls® PSTO-20; Crillet 45; Sorbax P 85

Polystyrene
CAS 9003-53-6; EINECS/ELINCS 202-851-5
UN 2211
Synonyms: Atactic polystyrene; Benzene, ethenyl-, hom... nylbenzene homopolymer; Polystyrene latex; Polystyren... rol; PS; Styrene polymer; Styrene, polymerized; Vinylber
Classification: Hydrocarbon polymer
Definition: High molecular weight thermoplastic resin produ... lcal polymerization of styrene; grades: crystal, impact, ex...
Empirical: $(C_8H_8)_x$
Formula: $(CH(C_6H_5)CH_2)_x$
Properties: Colorless to ylsh. glassy solid or soft colorless ...ing odor; sol. in alcohol; sl. sol. in water; m.w. 2500-250,0... kg/l; m.p. 86-91 C; soften. pt. 80-102 C; ref. index 1.59... MPa; tens. mod. 3900 MPa
Toxicology: TDLo (IV, rat, 2 wk intermittent) 200 mg/kg, (im... kg; severe eye irritant; may cause irritation to mucous m... be narcotic in high concs.; questionable carcinog... igen by implant; TSCA listed
Hazardous Decomp. Prods.: Heated to decomp., irritating fumes
Uses: Ion-exchange resin for purification of foods and ... (removes undesirable ions); purification of glycerin and er...
Regulatory: FDA 21CFR §175.105, 175.125, 175.300, 17... 177.1200, 177.1640, 177.2600, 178.1005
Manuf./Distrib.: A. Schulman; Acros Org.; Advanced Cher... Ampacet; Arkema; Ashland; BASF; BP Chemicals; Chevr... Plastics; Evonik Degussa GmbH; Fluka; GE Plastics; GE P... man; Lyondell; Monomer-Polymer & Dajac Labs; Nova ... Royce Intl.; Scott Bader; Sigma; Total Petrochemicals Bl... lake Plastics; Whyte Chems. Ltd
Trade Names: Dialon® SA20A; Dialon® SA21A; Dial... Dialon® UBK550; Dialon® UBK555; Dialon® WA30

Poly (styrene-co-butadiene). *See* Styrene/butadiene polym...
Polystyrene latex; Polystyrene resin; Polystyrol. *See* Poly...
Polysulfone resin
CAS 25135-51-3
Synonyms: PSU
Definition: Amorphous engineering thermoplastic with high r... alcohols and salt solns.; resist. to heat, oxidation, deterger... and smoke emission; self-extinguishing; good creep res... props.; dimensionally stable
Properties: Transparent hard rigid solid; sol. in aromatic ... ketones, chlorinated hydrocarbons; m.w. 30,000; dens. ... index 1.6330; tens. str. 70 N/mm²; tens. mod. 2.5 N/mm... (break)
Precaution: Combustible, but self-extinguishing
Uses: In membranes for liq. separations for food processing
Regulatory: FDA 21CFR §177.1655
Manuf./Distrib.: Acros Org.; Aldrich; BASF; CarboMer; GE P...
Trade Names Containing: Filmtec®; Filmtec® BW30-400; Fil... 2540; Filmtec® BW30-4014; Filmtec® BW30-40... 2514; Filmtec® SW30-2540; Filmtec® SW30-4040... 2521; Filmtec® TW30-2026; Filmtec® TW30-25... 2521; Filmtec® TW30-2540; Filmtec® TW30-4014; ... 4021; Filmtec® TW30-4040; Filmtec® TW30HP-254... TW30HP-4611; Filmtec® TW30HP-4641

Polyterpene resin. *See* Terpene resin
Polythene. *See* Polyethylene

TWEEN™ 80-NV-LQ-(AP)

Polyoxyethylene(20) Sorbitan Monooleate

Non-hazardous substance

Contains NJTSN 08306620-11474P

Precautions Handle in accordance with good industrial hygiene and safety practice.

Protective equipment For prolonged or repeated contact use protective gloves. Safety glasses with side-shields impervious clothing No personal respiratory protective equipment normally required.

First aid measures:
Eye contact In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. If eye irritation persists, consult a specialist.
Skin contact Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. If symptoms persist, call a physician.
Ingestion If symptoms persist, call a physician.
Inhalation If breathed in, move person into fresh air. If symptoms persist, call a physician.

Firefighting measures Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment. In the event of fire, wear self-contained breathing apparatus.

Spills and leaks Soak up with inert absorbent material. Sweep up and shovel into suitable containers for disposal. Contaminated surfaces will be extremely slippery.

Waste disposal methods Dispose of in accordance with local regulations.

Container Disposal Empty remaining contents. Empty containers should be taken to an approved waste handling site for recycling or disposal.

Storage Store in original container. Keep container tightly closed in a dry and well-ventilated place.

Flash point 148.9 °C

In case of emergency call CHEMTREC US: 1-800-424-9300, CHEMTREC WORLD: 1-703-527-3887.

All chemical substances in this product are listed on the TSCA Inventory.

Material Number:
SD47163/BULK

Batch No.:

Date of Manufacture: 10/14/2013

Made in: USA

	HMIS	NFPA
Health	0	0
Flammability	1	1
Reactivity	0	0

SD47163/BULK

CRODA

Croda Inc
300-A Columbus Circle Edison NJ 08837-3907 US Tel 1-732-417-0800 Fax 1-732-417-0804

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	TWEEN™ 80-NV-LQ-(AP)
Product number	:	SD47163
Product Use Description	:	Surfactant
Company	:	**Croda Inc.** **300-A Columbus Circle** **Edison, NJ 08837-3907**
Telephone	:	(732) 417-0800 (Mon.-Fri., 9:00 AM - 5:00 PM EST)
Telefax	:	(732) 417-0804
Emergency telephone	:	24 Hour Emergency Response Information CHEMTREC 1-800-424-9300 (toll free) 1-703-527-3887 (direct / international)

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

NON-HAZARDOUS SUBSTANCE

Potential Health Effects

Eyes	:	Not an irritant.
Skin	:	Not an irritant.
Ingestion	:	No toxic effects are expected following ingestion of this product.
Inhalation	:	No toxic effects are known to be associated with inhalation of this material.
Form	:	liquid
Color	:	yellow-orange
Odor	:	no data available

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Component	CAS-No.	Percent (%)
Alkoxylate	9005-65-6	90 - 100

SECTION 4. FIRST AID MEASURES

Eye contact	:	Immediately flush eye(s) with plenty of water. If eye irritation persists, consult a specialist.
Skin contact	:	Take off contaminated clothing and shoes immediately. Wash off with soap and

plenty of water. If symptoms persist, call a physician.

Ingestion	:	If large quantities of this material are swallowed, call a physician immediately.
Inhalation	:	If breathed in, move person into fresh air. If symptoms persist, call a physician.

SECTION 5. FIRE-FIGHTING MEASURES

Flash point	:	>148.9 °C (300.0 °F)open cup
Suitable extinguishing media	:	Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide. Use extinguishing measures that are appropriate to local circumstances and the surrounding environment.
Extinguishing media which shall not be used for safety reasons	:	High volume water jet
Specific hazards during fire fighting	:	Do not use a solid water stream as it may scatter and spread fire. Do not allow run-off from fire fighting to enter drains or water courses.
Special protective equipment for fire-fighters	:	In the event of fire, wear self-contained breathing apparatus.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions	:	Use personal protective equipment. Ensure adequate ventilation.
Methods for cleaning up	:	Soak up with inert absorbent material. Sweep up and shovel into suitable containers for disposal.

SECTION 7. HANDLING AND STORAGE

Handling	:	Handle in accordance with good industrial hygiene and safety practice.
Advice on protection against fire and explosion	:	Normal measures for preventive fire protection.
Requirements for storage areas and containers	:	Store in original container. Keep container tightly closed in a dry and well-ventilated place.
Other data	:	Stable under recommended storage conditions.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

no data available

Personal protective equipment

Eye protection	:	Safety glasses
Hand protection	:	For prolonged or repeated contact use protective gloves.
Skin and body protection	:	impervious clothing
Respiratory protection	:	No personal respiratory protective equipment normally required.
Hygiene measures	:	Handle in accordance with good industrial hygiene and safety practice.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Form	:	liquid
Color	:	yellow-orange
Odor	:	no data available
Odor Threshold	:	no data available
Flash point	:	>148.9 °C (300.0 °F)open cup
pH	:	6.5 - 7.5
pour point	:	approximately-20.56 °C (-5.01 °F)
Boiling point	:	> 100 °C (> 212 °F)
Vapor pressure	:	no data available
Density	:	no data available
Bulk density	:	no data available
Water solubility	:	no data available
Partition coefficient: n-octanol/water	:	no data available
Solubility in other solvents	:	Ethanol soluble Isopropanol soluble
Viscosity, dynamic	:	approximately425 mPa.s
Viscosity, kinematic	:	300 - 500 mm2/s at 25 °C (77 °F)

Values are not product specifications.

SECTION 10. STABILITY AND REACTIVITY

Stability	:	Stable under normal conditions.
Conditions to avoid	:	None known.
Materials to avoid	:	Strong oxidizing agents

Hazardous decomposition products	:	In case of fire hazardous decomposition products may be produced such as: Carbon oxides
Thermal decomposition	:	no data available

SECTION 11. TOXICOLOGICAL INFORMATION

Acute oral toxicity	:	LD50 rat Dose: 42,200 mg/kg	Low acute toxicity.
Acute dermal toxicity	:		no data available
Eye irritation	:	rabbit Method: Draize Test Result: No eye irritation	
Skin irritation	:	rabbit Method: Draize Test Result: No skin irritation	
Sensitization	:	Humans Result: Did not cause sensitization on laboratory animals. Method: Patch Test on humans.	
Further information	:		no data available

Carcinogenicity:

Not classifiable as a human carcinogen.

SECTION 12. ECOLOGICAL INFORMATION

Biodegradability	:	BOD28 32 % (OECD 301C)
	:	37 % (OECD 302B)
	:	static test 100 % (OECD static test method)
	:	(OECD 301C)

52 %

Toxicity to fish	:	static test LC50 Species: Oncorhynchus mykiss (rainbow trout) Dose: 471.00 mg/l Exposure time: 96 h Method: static test
Toxicity to daphnia and other aquatic invertebrates	:	LC50 Species: Mysidopsis bahia Dose: 165.00 mg/l Exposure time: 96 h
Toxicity to bacteria	:	IC0 Species: Pseudomonas putida Dose: > 10,000.00 mg/l
Additional ecological information	:	no data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal Method	:	Dispose of in accordance with local regulations.
Container Disposal	:	Empty remaining contents. Empty containers should be taken to an approved waste handling site for recycling or disposal.

SECTION 14. TRANSPORT INFORMATION

DOT	:	Not regulated for transport in accordance with DOT, TDG, IMDG, and IATA regulations.

SECTION 15. REGULATORY INFORMATION

Notification status

TSCA	:	All chemical substances in this product are listed on the TSCA Inventory.
DSL	:	All components of this product are on the Canadian DSL.
REACH	:	On the inventory, or in compliance with the inventory
AICS	:	On the inventory, or in compliance with the inventory
NZIoC	:	On the inventory, or in compliance with the inventory
IECSC	:	On the inventory, or in compliance with the inventory
ENCS	:	On the inventory, or in compliance with the inventory
KECI	:	On the inventory, or in compliance with the inventory
PICCS	:	On the inventory, or in compliance with the inventory

SARA 302	: SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.	
SARA 313	: SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.	
SARA 311/312 Hazards	: No SARA Hazards	
Pennsylvania Right To Know Ingredients	: Alkoxylate	9005-65-6
New Jersey Right To Know Ingredients	: Alkoxylate	9005-65-6
California Prop. 65 Ingredients	: WARNING! This product contains a chemical known in the State of California to cause cancer. WARNING: This product contains a chemical known in the State of California to cause birth defects or other reproductive harm.	
WHMIS Classification	: Non-controlled	

SECTION 16. OTHER INFORMATION

HMIS Classification	: Health Hazard:	0
	Flammability:	1
	Reactivity:	0

HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks and 4 representing significant hazard or risks. HMIS® is a registered trademark of the National Paint and Coatings Association.

NFPA	: Health Hazard:	0
	Fire:	1
	Reactivity:	0

This information is intended solely for the use of individuals trained in the particular hazard rating system. Additional information regarding the NFPA rating system is available from the National Fire Protection Agency at www.nfpa.org.

Further information

Prepared by : Product Safety and Regulatory Affairs Department
Croda Inc.
300-A Columbus Circle
Edison, NJ 08837-3907
(732) 417-0800

Print Date : 2013.12.20

Revision Date : 2013.11.14

OMRI Listed®

The following product is OMRI Listed. It may be used in certified organic production or food processing and handling according to the USDA National Organic Program Rule.

Product
TWEEN 80-NV-LQ-(AP)

Company
Croda Inc.
Rachel Lafferty
315 Cherry Lane
New Castle, DE 19720

Status	Category	Issue date
Allowed with Restrictions	NOP: Adjuvants – for pesticide use	12-Dec-2013

Product number	Class	Expiration date
crd-4521	Crop Management Tools and Production Aids	01-Mar-2016

Restrictions

EPA inert ingredients on EPA's List 4 may be used only with EPA registered pesticides or active ingredients considered "25b exempt" from FIFRA registration. List 3 inert ingredients may be used only in passive dispensers of EPA registered pheromones.

Peggy Miars
Executive Director

Product review is conducted according to the policies in the current *OMRI Policy Manual*[©] and based on the standards in the current *OMRI Standards Manual*[©]. To verify the current status of this or any OMRI Listed product, view the most current version of the *OMRI Products List*[©] at OMRI.org. OMRI listing is not equivalent to organic certification and is not a product endorsement. It cannot be construed as such. Final decisions on the acceptability of a product for use in a certified organic system are the responsibility of a USDA accredited certification agent. It is the operator's responsibility to properly use the product, including following any restrictions.

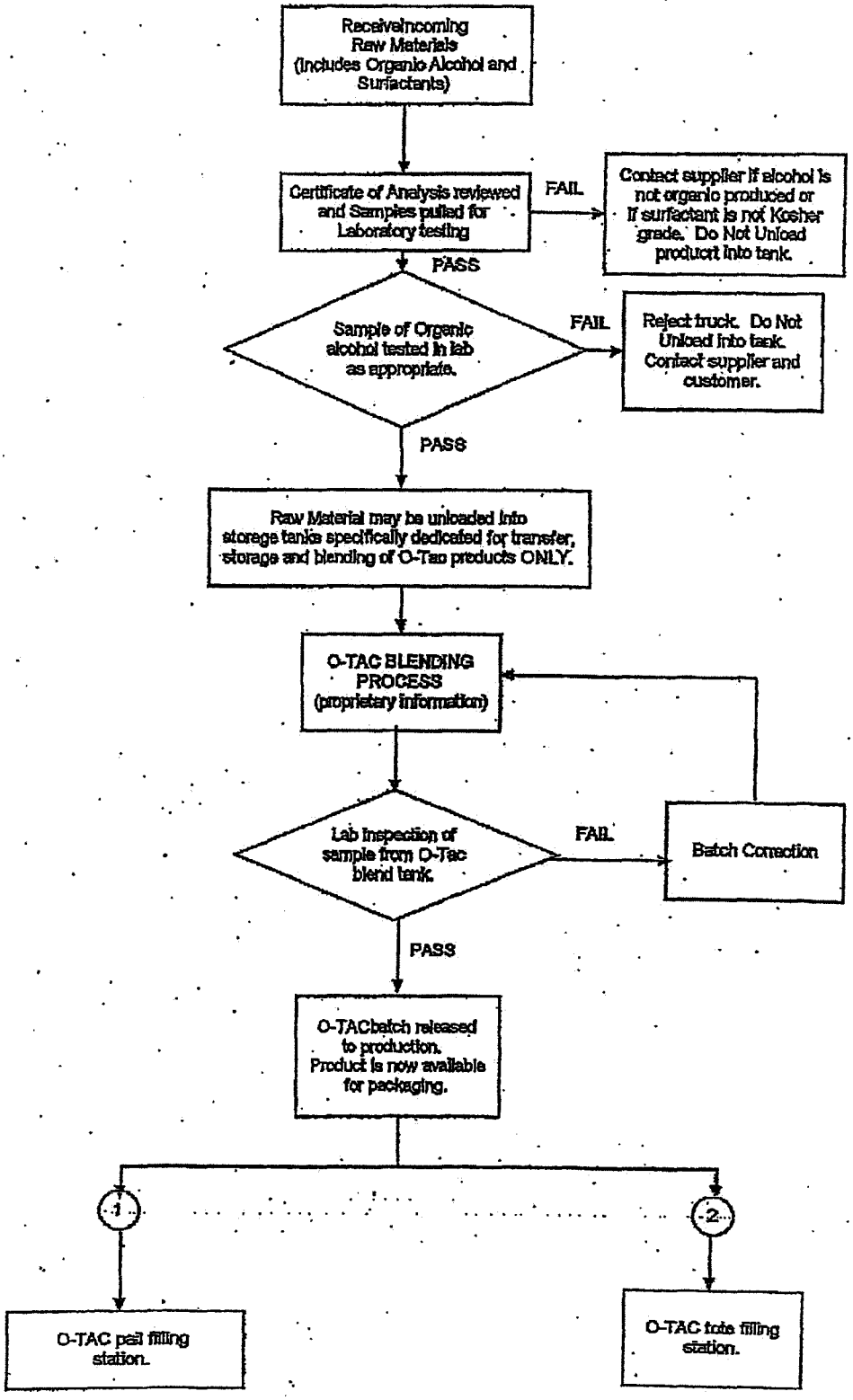
OMRI LISTED
For Organic Use

Organic Materials Review Institute
P.O. Box 11558, Eugene, OR 97440-3758, USA
541.343.7600 · fax 541.343.8971 · info@omri.org · www.omri.org

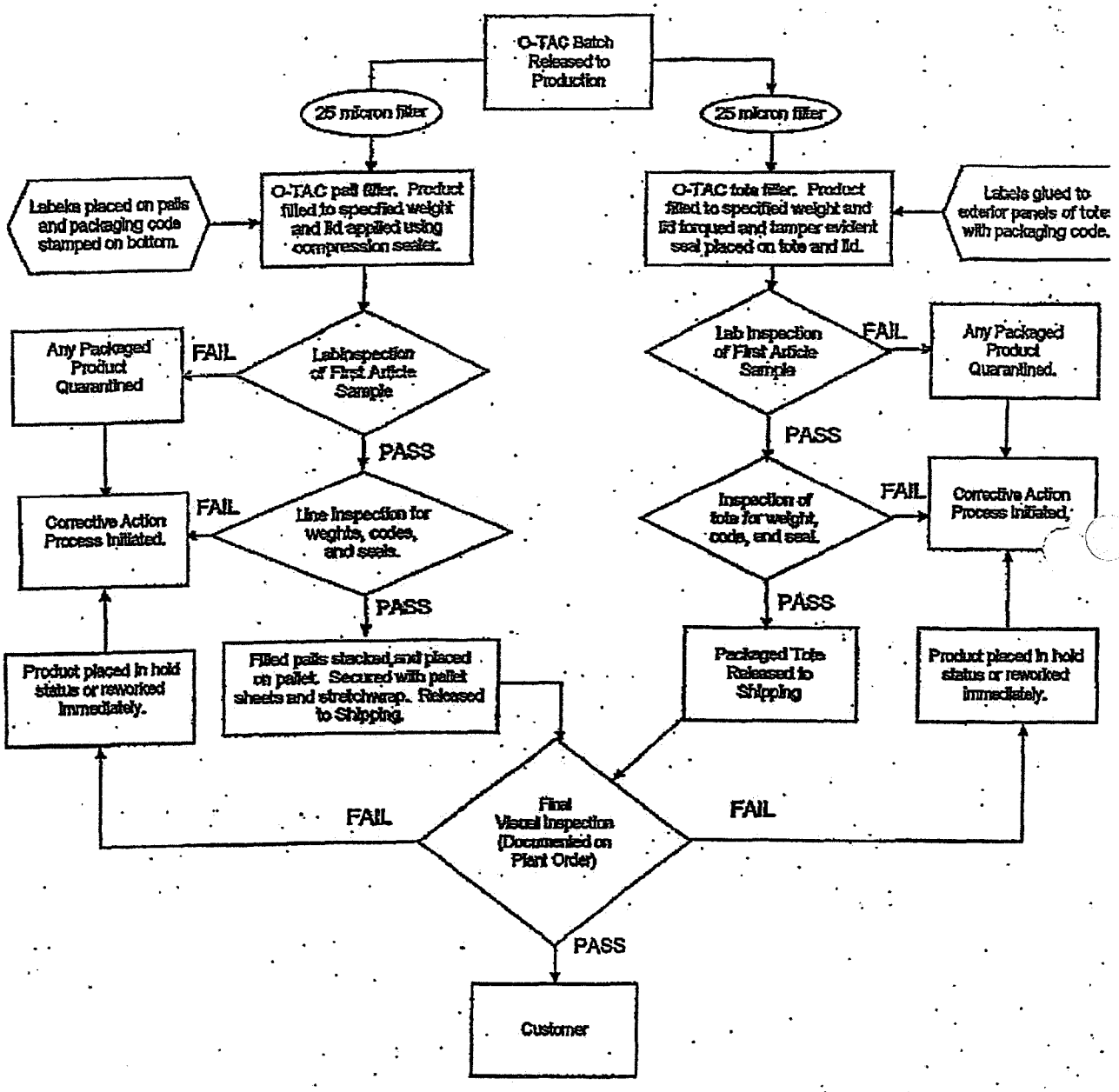
Fatty Alcohols and Surfactant Blending Products

O-TAC PLANT CONTACT AGENT and N-TAC

O-TAC BLENDING
Process Flow Chart



O-TAC PACKAGING
Process Flow Chart



NOTE: ALL TRANSFER LINES, PUMPS, AND HOSES USED IN THE BLENDING AND PACKAGING PROCESS OF O-TAC ARE SOLELY DEDICATED FOR THAT PURPOSE AND ARE CLEARLY MARKED THROUGHOUT TH PLANT AND PACKAGING AREAS.

eurofins | GeneScan

REPORT OF ANALYSIS

Customer: AgriSystems International
125 West 7th St.
Wind Gap, PA 18091
Attn: Thomas B Harding Jr.

Date Received: 06/11/12
Report Date: 06/13/12

‡Description: 0-TAC Finished 4/3/12
Lab Number: CF59747
Commodity: 0-TAC BN-01

Analysis	Result	Units	Analyzed
PCR Qualitative - CaMV 35S promoter	Negative	NA	06/13/12
PCR Qualitative - NOS terminator	Negative	NA	06/13/12
PCR Qualitative - FMV 34S promoter	Negative	NA	06/13/12

‡The results shown in this report relate solely to the item submitted for analysis.

ISO/IEC 17025

Testing Cert. 1940.01

Eurofins GeneScan

ES

Dr. Frank Spiegelhalter
Executive Vice President

Eurofins GeneScan Incorporated • 2315 N. Causeway Boulevard • Suite 200 • Metairie, LA 70001 USA
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Mr. Roland L. Cargill
Fair Products, Inc
PO Box 38626 Davis Drive
Cary, NC 27512

FEB 10 2014

Subject: Product name: O-TAC Plant Contact Agent
Reg. Number 51873-18
Amendment Dated 9/11/13
New product chemistry and acute toxicology studies replace those previously cited on data matrix
Decision Number: 483318

Dear Registrant:

The amendment referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act as amended is acceptable under 3(c) (5).

The new product chemistry and acute toxicology studies submitted are acceptable and will be placed on file. The revised label reflects the new acute toxicology studies and is acceptable

If you have questions concerning this letter, please contact Banza Djapao at 703-305-7269, or via email at djapao.banza@epa.gov, or myself at 703-308-9443.

Sincerely,

Tony Kish
Product Manager, Team 22
Fungicide Branch
Registration Division (7504P)

Material Safety Data Sheet

fair products, inc.

O-TAC PLANT CONTACT AGENT

Version: 1.2 Revision Date: 09/07/2012 Print Date: 09/07/2012

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	O-TAC PLANT CONTACT AGENT
Product Use Description:	Plant Growth Regulator
EPA Registration Number	51873-18
Company:	Fair Products, Inc. P.O. Box 386 Cary, NC 27512 United States of America Telephone: (US) 919-467-1599
Emergency Telephone:	Chemtrec: (24 hours) 800-424-9300
Prepared by:	Fair Products, Inc.

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

WARNING!

Form: liquid Color: light yellow Odor: Characteristic Fatty Alcohol Odor

Hazard Summary	Risk of serious damage to eyes. Irritating to respiratory system and skin. Irritating to mucous membrane. May cause allergic skin reaction.

Potential Health Effects

Primary Routes of Entry	Skin contact Eye contact Inhalation
Aggravated Medical Condition	Respiratory disorders Skin disorders

Target Organs	Eyes Respiratory system Skin
Inhalation	Irritating to respiratory system.
Skin	Irritating to skin. May cause allergic skin reaction.
Eyes	Risk of serious damage to eyes.
Ingestion	Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Chronic Exposure	May cause respiratory system effects. Lung damage. Repeated or prolonged skin contact may cause allergic reactions with susceptible persons.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous components

Component / CAS-No.	Weight percent
Octanol/111-87-5	36.2%
Decanol/112-30-1	48.2%
Polyoxyethylene sorbitan monooleate/9005-65-6	15.3%
Related compounds (dodecanol C-12)/112-53-8	0.3%

SECTION 4. FIRST AID MEASURES

First aid procedures

Inhalation	If breathed in, move person to fresh air. Give oxygen or artificial respiration if needed. Obtain medical attention.
Skin contact	If on clothes, remove clothes. Wash off immediately with plenty of water for at least 15 minutes. If skin irritation occurs, seek medical advice/ attention. Wash contaminated clothing in hot water and detergent before reuse. Destroy contaminated shoes.
Eye contact	In case of eye contact, remove contact lens and rinse immediately with plenty of water, also under

	the eyelids, for at least 15 minutes. If symptoms persist, call a physician.
Ingestion	DO NOT induce vomiting. Give small amounts of water to drink. Call a physician or poison control center immediately. Never give anything by mouth to an unconscious person.

SECTION 5. FIREFIGHTING MEASURES

Flammable properties

Flash Point	>200 °F

Fire fighting

Extinguishing media	Water spray, CO_2, dry chemical or foam.
Fire fighting procedures	Assure self-contained breathing apparatus is worn. Stay upwind.
Further information	Keep away from fire, sparks and heated surfaces. Use water spray to cool unopened containers. Prevent fire extinguishing water from contaminating surface water or the ground water system.

Protective equipment and precautions for firefighters

Special protective equipment	Body covering protective clothing, full "turn-out" for firefighters gear. Self-contained breathing apparatus

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Evacuate personnel to safe areas. Wear suitable protective clothing, long-sleeve shirt and long pants, chemical resistant gloves, such as barrier laminate or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton. Wear shoes plus socks, protective eyewear such as goggles, safety glasses or face shield. Avoid contact with skin and eyes. Ventilate the area.
Environmental precautions:	Toxic to aquatic life. Do not allow uncontrolled discharge of product into

	the environment. Do not flush into surface water or sanitary sewer system.
Methods for containment/ Methods for cleaning up:	Soak up spills with an inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Shovel into suitable container for disposal. Prevent runoff from entering waterways. Assure protective clothing is worn.
Disposal:	Dispose of in accordance with Local, State and Federal Regulations.

SECTION 7. HANDING AND STORAGE

Handling procedures:	Handle and open container with care. Protect from contamination. Use only in well-ventilated areas. Avoid inhalation, ingestion and contact with skin and eyes. Wear suitable protective clothing, gloves and eye/face protection. Wash thoroughly after handling. Keep container closed when not in use.
Storage:	
Requirements for storage areas and containers	Keep only in the original container. Keep container tightly closed in a cool, dry and well-ventilated area. Store away from direct heat sources. Keep away from foodstuff.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

Contains no substance with occupational exposure limit values.

Engineering measures	Use mechanical ventilation for general area control. Ensure that extracted air cannot be returned to the workplace through the ventilation system. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protective equipment

Eye protection	Tightly fitting protective eyewear, such as goggles, safety glasses or face shield.
Hand protection	Chemical resistant protective gloves, such as barrier laminate, or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton.
Skin and body protection	Long-sleeve shirt and long pants or coveralls. Shoes plus socks. Remove and wash contaminated clothing before re-use. Discard contaminated shoes.
Respiratory protection	In case of insufficient ventilation, wear a suitable "NIOSH approved organic mist respirator.
Hygiene measures:	Handle in accordance with good industrial hygiene and safety practices. Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Avoid prolonged inhalation of mists. Ensure adequate ventilation. Wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet. Remove and wash contaminated clothing before re-use.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form:	liquid
Color:	yellow liquid
Odor:	Characteristic fatty alcohol odor

Safety Data

Flash point:	>200°F
pH	7 – 8
Density:	0.85 gms/cc

SECTION 10. STABILITY AND REACTIVITY

Materials to avoid	Remarks: None known.
Hazardous decomposition	Note: Carbon monoxide, carbon dioxide and unburned hydrocarbons.
Hazardous reactions:	Hazardous polymerization does not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

Acute Oral Toxicity:	LD_{50} 28 gms/kg (Rat)
Acute Inhalation Toxicity:	TLV 5mg/m^3 (Rat)
Acute Dermal Toxicity:	LD_{50} 2gm/kg (Rat)
Skin Irritation:	Causes moderate skin irritation (Rabbit)
Eye Irritation:	Causes severe eye irritation (Rabbit)
Sensitization:	Not a sensitizer (Guinea Pig)

Toxicological Assessment

CMR Effects:	Carcinogenicity: negative Mutagenicity: negative Teratogencity: negative Reproductive Toxicity: negative

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity Effects

Toxicity to fish:	96 hours LC_{50} Rainbow trout: 20.4 ppm
	96 hours LC_{50} Bluegill: 9.96 ppm
Toxicity to Daphnia and other aquatic invertebrates:	48 hour LC_{50} to Daphnia magna (water flea): 8.24 mg/l
Toxicity to birds:	Acute oral LD_{50} to Mallard Ducks: >4640 mg/kg/bw
	Eight Day Dietary LC_{50} to: Bobwhite Quail - >10,000 ppm Mallard Ducks - >10,000 ppm
Toxicity of honey bees:	48 hour contact LD_{50} >25 µg/bee

Elimination Information (persistence and degradability)

Biodegradability:	Readily biodegradable

SECTION 13. DISPOSAL CONSIDERATION

Further information:

Dispose of waste material in compliance with all federal, state and local regulations.

Pesticide wastes are toxic.
Do not contaminate ponds, waterways or ditches with chemical or used container.

SECTION 14. TRANSPORT INFORMATION

DOT
Not dangerous goods

TDG
Not dangerous goods

IATA
Not dangerous goods

IMDG
Not dangerous goods

RID
Not dangerous goods

SECTION 15: REGULATORY INFORMATION

Sara 311/312 Hazards:	Chronic Health Hazard Acute health Hazard
California Prop. 65 components:	This product does not contain any chemicals known to the State of California to cause cancer, birth defects or any other reproductive harm.

The components of this product are reported in the following inventories:

REACH	Not in compliance with the inventory.
US.TSCA	All substances in this product are exempt from TSCA as this product is registered under FIFRA (Federal Insecticide Fungicide Rodenticide Act).

DSL	This product is registered under the Pest Control Products Act and is therefore exempt from WHMIS supplier labeling and MSDS requirements. Please read entire MSDS and product label for safety precaution.
AICS	Not in compliance with the inventory
NZIoC	Not in compliance with the inventory
ENCS	Not in compliance with the inventory
KECI	Not in compliance with the inventory
PICCS	Not in compliance with the inventory
IECSC	Not in compliance with the inventory

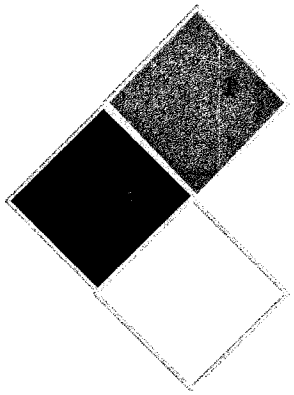
SECTION 16. OTHER INFORMATION

HMIS Classification:

Health hazard: 3
Flammability: 1
Reactivity: 0

NFPA Classification:

Health hazard: 3
Fire hazard: 1
Reactivity hazard: 0



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

Mr. Roland L. Cargill
Fair Products, Inc
PO Box 38626 Davis Drive
Cary, NC 27512

FEB 10 2014

Subject: Product name: N-TAC
Reg. Number 51873-20
Amendment Dated 9/11/13
New product chemistry and acute toxicology studies replace those previously cited on data matrix
Decision Number: 483319

Dear Registrant:

The amendment referred to above, submitted in connection with registration under the Federal Insecticide, Fungicide and Rodenticide Act as amended is acceptable under 3(c) (5).

The new product chemistry and acute toxicology studies submitted are acceptable and will be placed on file. The revised label reflects the new acute toxicology studies and is acceptable

If you have questions concerning this letter, please contact Banza Djapao at 703-305-7269, or via email at djapao.banza@epa.gov, or myself at 703-308-9443.

Sincerely,

Tony Kish
Product Manager, Team 22
Fungicide Branch
Registration Division (7504P)

Material Safety Data Sheet

fair products, inc.

N-TAC

Version: 1.2 Revision Date: 09/07/2012 Print Date: 09/07/2012

SECTION 1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	N-TAC Tobacco Sucker Control
Product Use Description:	Plant Growth Regulator
EPA Registration Number	51873-XX
Company:	Fair Products, Inc. P.O. Box 386 Cary, NC 27512 United States of America Telephone: (US) 919-467-1599
Emergency Telephone:	Chemtrec: (24 hours) 800-424-9300
Prepared by:	Fair Products, Inc.

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

WARNING!

Form: liquid Color: light yellow Odor: Characteristic Fatty Alcohol Odor

Hazard Summary	Risk of serious damage to eyes. Irritating to respiratory system and skin. Irritating to mucous membrane. May cause allergic skin reaction.

Potential Health Effects

Primary Routes of Entry	Skin contact Eye contact Inhalation
Aggravated Medical Condition	Respiratory disorders Skin disorders

Target Organs	Eyes Respiratory system Skin
Inhalation	Irritating to respiratory system.
Skin	Irritating to skin. May cause allergic skin reaction.
Eyes	Risk of serious damage to eyes.
Ingestion	Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
Chronic Exposure	May cause respiratory system effects. Lung damage. Repeated or prolonged skin contact may cause allergic reactions with susceptible persons.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous components

Component / CAS-No.	Weight percent
Octanol/111-87-5	36.2%
Decanol/112-30-1	48.2%
Polyoxyethylene sorbitan monooleate/9005-65-6	15.3%
Related compounds (dodecanol C-12)/112-53-8	0.3%

SECTION 4. FIRST AID MEASURES

First aid procedures

Inhalation	If breathed in, move person to fresh air. Give oxygen or artificial respiration if needed. Obtain medical attention.
Skin contact	If on clothes, remove clothes. Wash off immediately with plenty of water for at least 15 minutes. If skin irritation occurs, seek medical advice/ attention. Wash contaminated clothing in hot water and detergent before reuse. Destroy contaminated shoes.
Eye contact	In case of eye contact, remove contact lens and

	rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. If symptoms persist, call a physician.
Ingestion	DO NOT induce vomiting. Give small amounts of water to drink. Call a physician or poison control center immediately. Never give anything by mouth to an unconscious person.

SECTION 5. FIREFIGHTING MEASURES

Flammable properties

Flash Point	>200 °F

Fire fighting

Extinguishing media	Water spray, CO_2, dry chemical or foam.
Fire fighting procedures	Assure self-contained breathing apparatus is worn. Stay upwind.
Further information	Keep away from fire, sparks and heated surfaces. Use water spray to cool unopened containers. Prevent fire extinguishing water from contaminating surface water or the ground water system.

Protective equipment and precautions for firefighters

Special protective equipment	Body covering protective clothing, full "turn-out" for firefighters gear. Self-contained breathing apparatus

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions:	Evacuate personnel to safe areas. Wear suitable protective clothing, long-sleeve shirt and long pants, chemical resistant gloves, such as barrier laminate or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton. Wear shoes plus socks, protective eyewear such as goggles, safety glasses or face shield. Avoid contact with skin and eyes. Ventilate the area.
Environmental precautions:	Toxic to aquatic life.

	Do not allow uncontrolled discharge of product into the environment. Do not flush into surface water or sanitary sewer system.
Methods for containment/ Methods for cleaning up:	Soak up spills with an inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Shovel into suitable container for disposal. Prevent runoff from entering waterways. Assure protective clothing is worn.
Disposal:	Dispose of in accordance with Local, State and Federal Regulations.

SECTION 7. HANDING AND STORAGE

Handling procedures:	Handle and open container with care. Protect from contamination. Use only in well-ventilated areas. Avoid inhalation, ingestion and contact with skin and eyes. Wear suitable protective clothing, gloves and eye/face protection. Wash thoroughly after handling. Keep container closed when not in use.
Storage:	
Requirements for storage areas and containers	Keep only in the original container. Keep container tightly closed in a cool, dry and well-ventilated area. Store away from direct heat sources. Keep away from foodstuff.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

Contains no substance with occupational exposure limit values.

Engineering measures	Use mechanical ventilation for general area control. Ensure that extracted air cannot be returned to the workplace through the ventilation system. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal protective equipment

Eye protection	Tightly fitting protective eyewear, such as goggles, safety glasses or face shield.
Hand protection	Chemical resistant protective gloves, such as barrier laminate, or butyl or nitrile rubber, neoprene or polyvinyl chloride or Viton.
Skin and body protection	Long-sleeve shirt and long pants or coveralls. Shoes plus socks. Remove and wash contaminated clothing before re-use. Discard contaminated shoes.
Respiratory protection	In case of insufficient ventilation, wear a suitable "NIOSH approved organic mist respirator.
Hygiene measures:	Handle in accordance with good industrial hygiene and safety practices. Avoid contact with skin, eyes or clothing. Wear suitable gloves and eye/face protection. Avoid prolonged inhalation of mists. Ensure adequate ventilation. Wash hands before eating, drinking, chewing gum, using tobacco products or using the toilet. Remove and wash contaminated clothing before re-use.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form:	liquid
Color:	yellow liquid
Odor:	Characteristic fatty alcohol odor

Safety Data

Flash point:	>200°F
pH	7 – 8
Density:	0.85 gms/cc

SECTION 10. STABILITY AND REACTIVITY

Materials to avoid	Remarks: None known.
Hazardous decomposition	Note: Carbon monoxide, carbon dioxide and unburned hydrocarbons.
Hazardous reactions:	Hazardous polymerization does not occur.

SECTION 11. TOXICOLOGICAL INFORMATION

Acute Oral Toxicity:	LD_{50} 28 gms/kg (Rat)
Acute Inhalation Toxicity:	TLV 5mg/m^3 (Rat)
Acute Dermal Toxicity:	LD_{50} 2gm/kg (Rat)
Skin Irritation:	Causes moderate skin irritation (Rabbit)
Eye Irritation:	Causes severe eye irritation (Rabbit)
Sensitization:	Not a sensitizer (Guinea Pig)

Toxicological Assessment

CMR Effects:	Carcinogenicity:	negative
	Mutagenicity:	negative
	Teratogenicity:	negative
	Reproductive Toxicity:	negative

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity Effects

Toxicity to fish:	96 hours LC_{50} Rainbow trout: 20.4 ppm
	96 hours LC_{50} Bluegill: 9.96 ppm
Toxicity to Daphnia and other aquatic invertebrates:	48 hour LC_{50} to Daphnia magna (water flea): 8.24 mg/l
Toxicity to birds:	Acute oral LD_{50} to Mallard Ducks: >4640 mg/kg/bw
	Eight Day Dietary LC_{50} to: Bobwhite Quail - >10,000 ppm Mallard Ducks - >10,000 ppm

Toxicity of honey bees:	48 hour contact LD_{50} >25 µg/bee

Elimination Information (persistence and degradability)

Biodegradability:	Readily biodegradable

SECTION 13. DISPOSAL CONSIDERATION

Further information:

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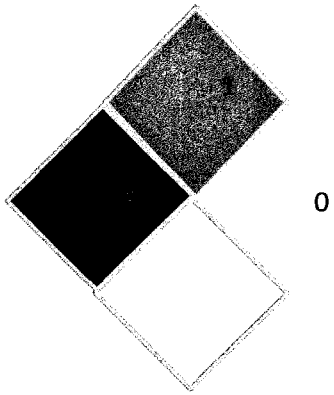

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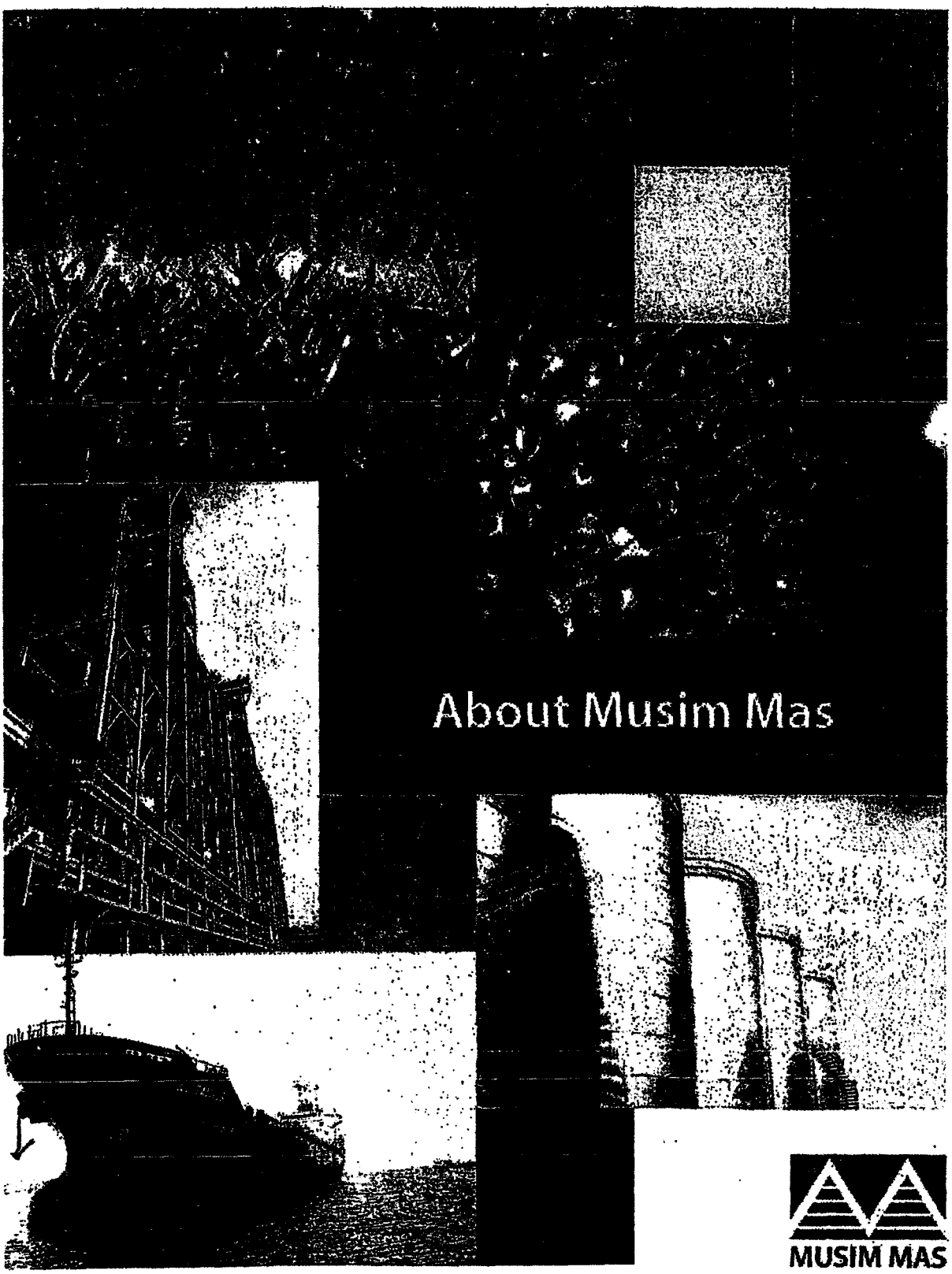
Background Information

Raw Material Manufacturer

Finish Product Producer



About Musim Mas

MUSIM MAS

About Musim Mas

Headquartered in Singapore, the Musim Mas Group is a valued global supply chain partner to multinational companies with sales to more than 125 countries. Its products are mainly used for food, renewable energy and other industrial sectors, backed by a fully integrated business operations spanning the palm oil value chain: from upstream oil palm plantations to midstream and downstream operations.

Musim Mas' wide geographical reach extends across 12 countries in North America, Europe and Asia Pacific, supported by a workforce of 28,500 people.

Musim Mas is committed to conduct its business in an environmentally sustainable, socially responsible and economically viable manner, by being accountable to the stakeholders.

For more information about Musim Mas, please visit www.musimmas.com

MUSIM MAS

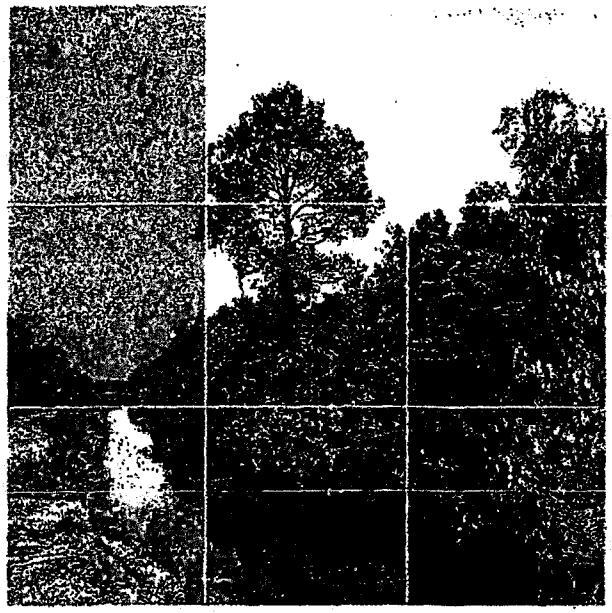
Why choose Musim Mas as your supply chain partner ?

Global Presence

Our presence in strategic locations worldwide means that there will always be someone from our team, who can provide the professional sales and technical support at your convenience.

We have operations in USA, UK, the Netherlands, Germany, Spain, Italy, China, India, Vietnam, Malaysia, Indonesia and Singapore.

The global marketing activities of the Musim Mas Group are undertaken by Inter-Continental Oils & Fats (ICOF).



Commitment to **Sustainability**

We believe in creating economic value that also creates value for society by addressing its needs and challenges, also known as the "Shared Values" approach.

Our sustainability strategy is based on the principles stipulated by Roundtable on Sustainable Palm Oil (RSPO) and our active engagement with stakeholders. RSPO is a multi-stakeholder organisation set up in 2004 to address environmental and social concerns in the palm oil sector. It culminates a decade's worth of stakeholders' consensus for solutions to material issues.

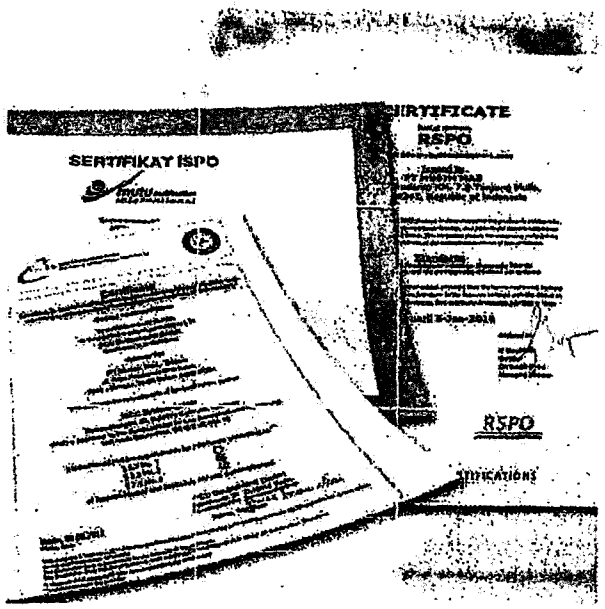
We have since achieved many milestones in the sustainability arena: the first major plantation group to be 100% RSPO certified for all its plantations and also the first to certify its smallholder scheme.

Quality Certifications

As a commitment towards manufacturing excellence, we have third-party audited certifications for quality assurance.

We offer a range of quality management certifications such as ISO and HACCP, including sustainability-based ones such as RSPO Supply Chain Systems, Indonesian Sustainable Palm Oil (ISPO) and International Sustainability and Carbon Certification (ISCC) for biofuels. We also have Kosher and Halal Certifications to cater for special needs.

Our quality assurance is undertaken by a dedicated team of experienced professionals to assist with your certification requirements.



Commitment to **Manufacturing Excellence**

First established as Nam Cheong Soap Factory in 1932, we started as a soap manufacturer who went upstream as Musim Mas to set up palm plantations and build mills, refineries and downstream processing plants, ensuring consistent quality along the supply chain.

We produce personal care and food products directly for consumers too. Our personal care and household brands are available in retail stores.

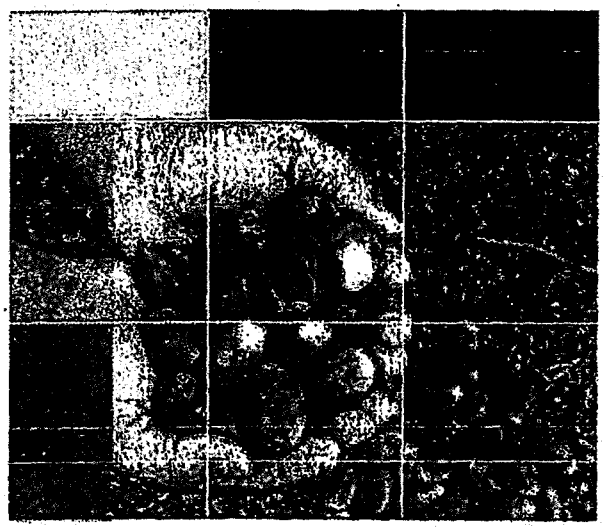
Our commitment to manufacturing excellence will help you achieve your commercial differentiation.

Large Operational Scale

We own a significant oil palm plantation area, making us one of the largest plantation owners in the palm oil space. We also own one of the largest palm oil refineries and oleochemicals plants in the world, and are among the biggest producers in the palm oil refining and soap manufacturing sector.

Our fully integrated business spans the palm oil value chain, complemented by our own bulk tank terminals, ships and tankers.

Our operational scale will ensure a reliable supply of feedstock and efficient backend logistics, creating more value for your supply chain needs.



How to Successfully Use O-TAC to Control Suckers in Your Organic, PRC or MH-Free Tobacco Contracted to Santa Fe Natural Tobacco Co.

As a processor and manufacturer of 100 percent additive-free natural tobacco for more than 25 years, Santa Fe Natural Tobacco Company's (SFNTC) commitment to earth-friendly products and the land from which they come runs deep. That commitment led to the development of an overall growing approach that is reducing the use of pesticides on the farm and promotes other sustainable practices.

Growers producing Organic, PRC, and MH-Free tobacco for SFNTC know that it is good for them -- financially and environmentally. By reducing and even eliminating the use of many chemicals, the risk of mishandling is minimal—and that it is good for the environment.

Over the years, our growers have found it hard to find products or determine ways they can grow a tobacco crop without most of the crop protection products that are available when they grow conventional tobacco. All the time, SFNTC has been there to assist in finding them the resources they need to grow a high quality, high-yielding crop.

One early challenge for our Organic growers was to obtain organic sources of fertilizer. To assist them, SFNTC searched high and low to find a product that would work and be affordable to the grower. Now Nature Safe fertilizer is key to the fertility programs of all SFNTC Organic growers.

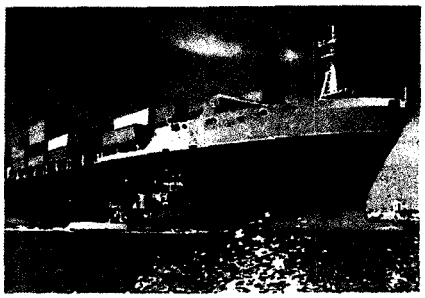
Controlling suckers in their tobacco has been another one of our grower's biggest challenges. While vegetable oil was plentiful and affordable, its application by hand often was a hit-and-miss proposition. As a result, growers would often send workers out to sucker a crop as many as 7 to 8 times to get all the suckers out of the tobacco plants.

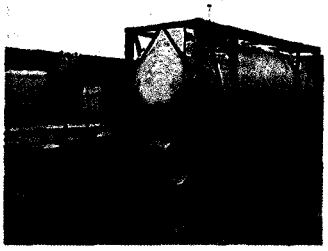
At the same time, misapplication to the growing crop would sometimes result in leaf drop of the tobacco and/or yield loss. This was not good for either the grower or SFNTC, who uses the residue free tobacco in their organic cigarettes, pouch and canned tobacco products.

To help solve the "suckers" challenge, SFNTC teamed up with Fair Products, Inc. to develop a suckercide that would meet organic standards.

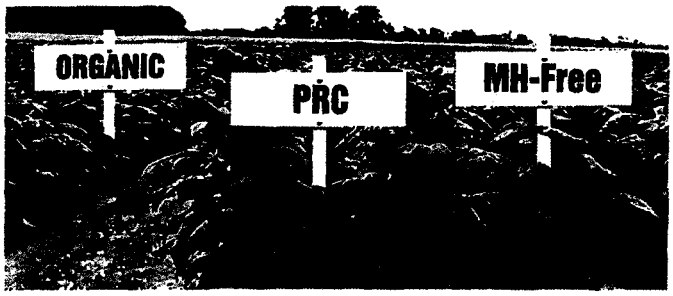
After searching literally across the globe, Fair Products found an organic source of an 85% fatty-alcohol for use in the formulation. The oil of palm trees, grown in the Far East for use in cosmetics, proved to be ideal. They were able to buy a supply of palm oil-based, fatty-alcohol that would meet the present and future needs for O-TAC.

The organically approved ingredient was loaded on to a container ship and sent first to Charleston, SC, then by train to Wilmington, NC, where it was off-loaded on a truck and delivered to the site of South Atlantic Services, where Fair Products formulates its expansive line of suckercides.





Sourcing and developing this suckercide for use by SFNTC growers has not been easy nor inexpensive. But, believing that the results will benefit both the growers and them greatly, SFNTC underwrote the cost of bringing O-TAC to the market.



This season, O-TAC will be available for use only by SFNTC contract Organic, PRC and MH-Free growers. SFNTC, Fair Products, or the vendors we assign to make O-TAC available to you are not marking up any prices of O-TAC sold to growers.

Just what is O-TAC?

O-TAC Plant Contact Agent is a carefully balanced combination of active ingredients and wetting agents to be used for the control of sucker growth in tobacco. The concentrated product is diluted with water to form a creamy emulsion, which is applied as a coarse spray. The emulsion is effective only when is comes in direct contact with suckers; therefore, the material is applied so that maximum contact is made with the suckers. It's important that growers follow these directions in handling and applying O-TAC, regardless of the type of tobacco they are growing under contract to SFNTC.

Benefits of Using O-TAC

compared to vegetable oil to control suckers

- Kills small suckers upon contact and within one hour after application.
- Formulated from palm oil fatty alcohols scientifically balanced for greatest effectiveness & safety.
- Most helpful in reducing labor of hand suckering.
- Can be used at button stage effectively killing upper suckers without stopping the growth of upper leaves.
- Reduces tender food supply (suckers) for insects, and consequently, the need for insecticides.

When to Apply O-TAC

O-TAC Plant Contact Agent can be applied before or after topping. The best results are usually obtained by spraying the tobacco with O-TAC before topping in the early to late button stage and then topping the tobacco immediately followed by additional applications of O-TAC.

Suckers at button stage

If the tobacco is topped before spraying, remove any suckers over one inch in length as you top and apply O-TAC after topping. Because O-TAC is a contact type agent, it is necessary to straighten any plants that are leaning so that the emulsion flows down the stalk evenly and contacts each sucker.

O-TAC usually can be applied anytime during the day, but not to wilted plants. For the best results, it is recommended that growers wait until the dew dries before spraying. Do not spray after the upper leaves begin to close in the evening. Because the underside of the leaves may be injured by contact with O-TAC, do not apply when the wind is high enough to turn the top leaves over. Do not apply during the rain or when plants are wet. If, however, it rains after O-TAC has been on the plants for over an hour, you should not have to apply O-TAC again. Do not apply during periods of high heat or if plants are wilted.

How Much O-TAC to Apply

Flue-Cured

For power sprayer -

Use **2** gallons (7.57 liters) in
48 gallons (182 liters) of water for a total of 50 gallons (189 liters) for a 4% spray solution.

or

Use **2.5** gallons (9.4 liters) in
47.5 gallons (180 liters) of water for a total of 50 gallons (189 liters) for a 5% spray solution.

For hand sprayer –

Use **4** to **5** ounces (118-148 milliliters) in per gallon (3.785 liters) of water

or

Use **6** ounces (177 milliliters) per gallon in (3.785 liters) of water.

Burley

For power sprayer –

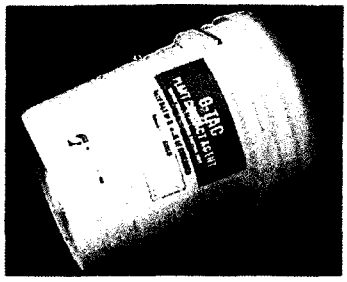
Use **1.75** to **2** gallons (6.62-7.57 liters) in
48 to **48.25** gallons (182-183 liters) of water for a total of 50 gallons (189 liters) for a 3.5-4% spray solution.

Note:

* When applied by hand, **1** gallon (3.785 liters) of diluted O-TAC will treat approximately 190 plants.
* If a power sprayer is used, **50** gallons (189 liters) of diluted product should be applied per acre of tobacco.

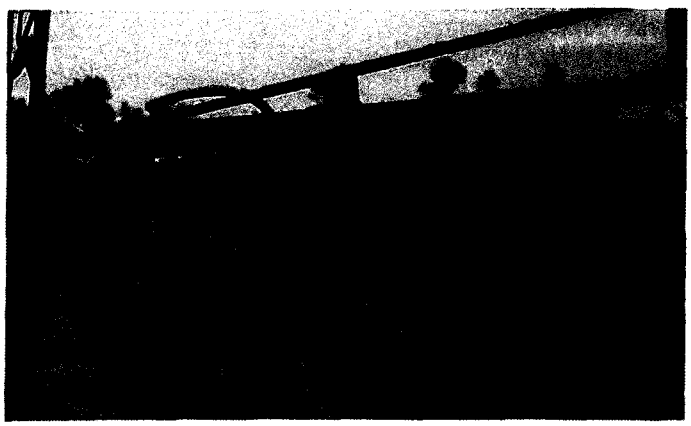
How to Apply O-TAC

The diluted emulsion is most easily prepared by adding the required amount of O-TAC Plant Contact Agent to the spray tank and then adding the water. In order to obtain the best results, it is important that the water be added to the O-TAC rather than the O-TAC to the water to enhance mixing and reduce floating.



When applied with power equipment, three nozzles per row should be used (TG full cone tips, or larger, are satisfactory). One TG-5 nozzle should be directed downward over the center of the row and two TG-3s should be positioned approximately 11 inches on either side directed at or slightly above the top of the stalk.

The diluted O-TAC should be applied to the tobacco from a height of 12 to 16 inches above the top of the stalk. It is recommended that boom pressure be kept at 20 lbs. By using the recommended spray tips, spraying at approximately 20 lbs. pressure, and operating a tractor speed of 2.5 to 3 mph, approximately 50 gallons of diluted emulsion per acre of tobacco will be applied.



Power sprayer application with triple nozzle arrangement to apply O-TAC.

If a hand-held or backpack sprayer is used, the diluted solution should be applied at a rate of 2/3 to 1 ounce (20-30 milliliters) per plant to insure rundown to the bottom of the plant. A coarse spray is recommended, directed downward at the top of the stalk from 6-8 inches above the top leaves. Very little tank pressure is required, and in no case should more than 20 pounds be used.

How Often to Apply O-TAC

Usually one application of O-TAC Plant Contact Agent will give good control of both primary and secondary suckers and produce excellent leaf quality. However, in most cases, a dual treatment of O-TAC is recommended 5 to 7 days apart to allow time for uneven crops to become uniform. For season long sucker control, apply multiple treatments of O-TAC in accordance with label instructions.

button stage → 5-7 days → early flower stage → 5-7 days → full flower stage → 5-7 days → late flower stage

More Key Points on the Use of O-TAC on tobacco

1. Mix well prior to use and, if allowed to stand during the use, mix again before applying since the diluted emulsion may separate on standing.

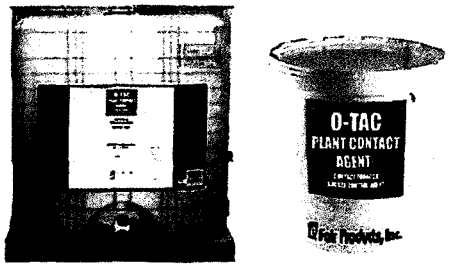
2. Do not use on Burley tobacco during periods of high heat and high humidity.

3. Use according to the directions outlined has resulted in adequate sucker control with very little or no leaf injury. Application not in accordance with the directions may lead to injury of leaves or improper sucker control.

4. Make sure spray equipment is clean before using. (Note: Organic and PRC growers must use dedicated equipment—can not have been used for spraying conventional tobacco)

5. Do not mix with other pesticides, fertilizers, surfactants, adjuvants or any other materials as plant damage or death may result.

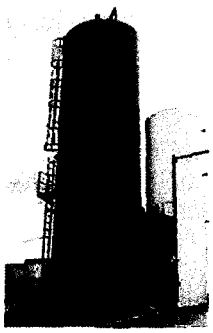
6. **Refer to the O-TAC label for complete use directions**



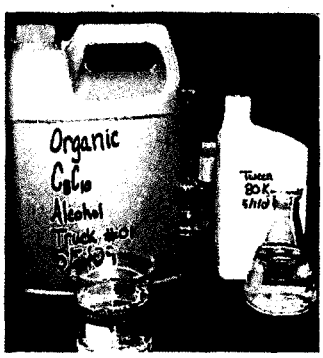
WARRANTY STATEMENT:
Seller's guarantee shall be limited to the terms of the label, and subject thereto the buyer assumes any risk to persons or property arising out of use or handling and accepts the product on these condition.

How O-TAC Plant Contact Agent is Formulated by Fair Products, Inc.

In preparing for handling the new "organic" product, Fair Products first erected two holding tanks – the 35,000 gallon tank holds the palm oil-based alcohol and the 10,000-gallon tank holds the surfactants used in the formulation-and painted them green.

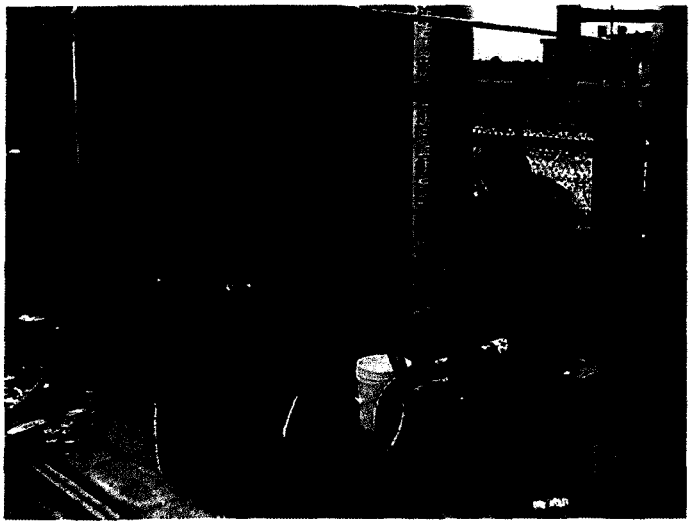


Everything else from those tanks throughout the formulation and packaging area are painted green – to indicate where O-TAC is being made to maintain compliance with organic standards.

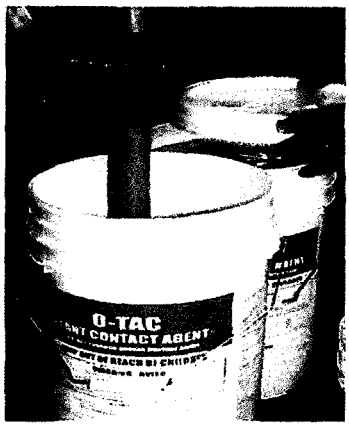


In the chemist's lab in the plant, the palm oil-based alcohol and tween are tested using a gas chromatograph, as well as a UV Spectra Photo to check for pH and other characteristics.

Following confirmation that the ingredients meet specifications, the surfactants are mixed in the alcohol tank.

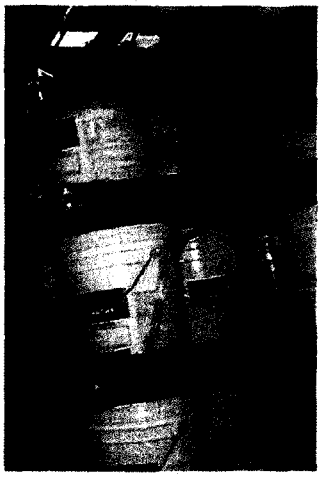


When the formulated mix is completed, it is piped into the container filling equipment, where O-TAC is either packaged in 5-gal. FDA-food grade-approved buckets or into 275-gallon Mini-Bulk containers.



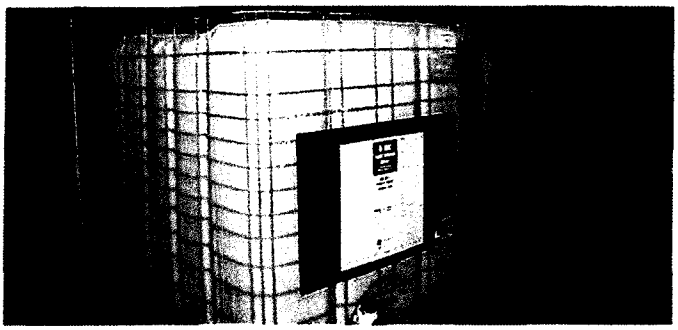
In the line filling the 5-gallon containers, two buckets are filled side by side, with a lid placed over the top of each bucket. Once it has been verified to have precisely the 5-gallon amount of O-TAC, the bucket moves under an automatic sealer that securely fastens the lid on to the bucket.

The pallet is then taken by a lift-truck for shrink-wrapping and then is stored ready for distribution.



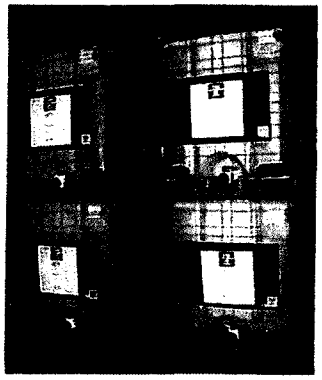
Each is then placed on a pallet, which eventually will contain a total of 45 gallons or nine 5-gallon buckets.

In the line where O-TAC is packaged in labor-saving 275-gallon Mini-Bulk containers, once again, the precise mix of ingredients enter the top of the large container until filled to the top. An operator then places a cap securely on top of the Mini-Bulk container, and affixes a seal to it. An O-TAC product label is then attached to the container at that time.



From the assembly line, the Mini-Bulk containers are taken to storage, ready for distribution.

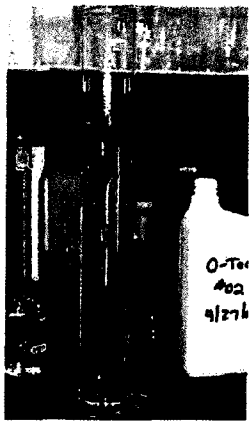
With Fair Products' large, 275- gallon Mini-Bulk II container, tobacco growers have the most versatile, environmentally-friendly sucker control system available today.



The tough 275-gallon polyethylene tank is contained inside a 1/4 inch welded steel cage. Attached to a four-way access pallet, it is easy to handle, weatherproof and fits easily in the bed of a pickup truck. With the 275-gallon Mini-Bulk container, attaching a pump and meter system requires only 2-inch connectors and a proper length of suction hose.

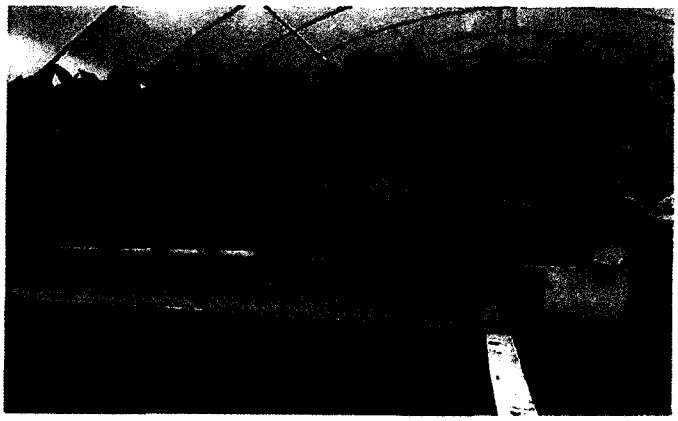
Testing the Formulated O-TAC

Just as samples were tested of the ingredients used to make O-TAC before the formulation was made, testing is also conducted on finished formulations prior to storage and ready for distribution. On certain occasions, samples are also sent to outside laboratories for evaluation. Samples are kept from each batch of formulated O-TAC. Each contains a Code # for potential tracking of each of product, should a recall be needed.



Testing O-TAC on Young Tobacco Plants

Samples of O-TAC are tested on young tobacco plants to assure that the formulation causes no problems on the growers' tobacco. This assures that the product will perform correctly when when growers apply it to their crop of tobacco.



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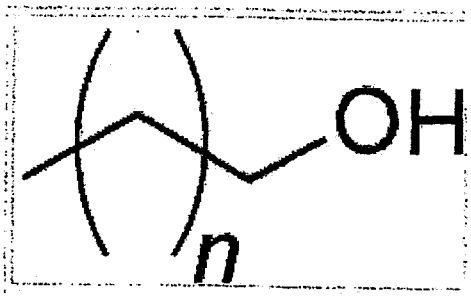
Fatty Alcohols

Background Information

Fatty alcohol

From Wikipedia, the free encyclopedia



Fatty alcohol

atty alcohols (or long-chain alcohols) are usually high-molecular-weight, straight-chain primary alcohols, but can also range from as few as 4-6 carbons to as many as 22-26, derived from natural fats and oils. The precise chain length varies with the source.[1][2] Some commercially important fatty alcohols are lauryl, stearyl, and oleyl alcohols. They are colourless oily liquids (for smaller carbon numbers) or waxy solids, although impure samples may appear yellow. Fatty alcohols usually have an even number of carbon atoms and a single alcohol group (-OH) attached to the terminal carbon. Some are unsaturated and some are branched. They are widely used in industry. As with fatty acids, they are often referred to generically by the number of carbon atoms in the molecule, such as "a C12 alcohol", that is an alcohol having 12 carbons, for example dodecanol.

Contents

Production and occurrence

Most fatty alcohols in nature are found as waxes which are esters with fatty acids and fatty alcohols.[1] They are produced by bacteria, plants and animals for purposes of buoyancy, as source of metabolic water and energy, iosonar lenses (marine mammals) and for thermal insulation in the form of waxes (in plants and insects).[3] Fatty alcohols were unavailable until the early 1900s. They were originally obtained by reduction of wax esters with sodium by the Bouveault–Blanc reduction process. In the 1930s catalytic hydrogenation was commercialized, which allowed the conversion of fatty acid esters, typically tallow, to the alcohols. In the 1940s and 1950s, petrochemicals

became an important source of chemicals, and Karl Ziegler had discovered the polymerization of ethylene. These two developments opened the way to synthetic fatty alcohols.

From natural sources

The traditional and still important source of fatty alcohols are fatty acid esters. Wax esters were formerly extracted from sperm oil, obtained from whales. An alternative plant source is jojoba. Fatty acid triesters, known as triglycerides, are obtained from plant and animal sources. These triesters are subjected to transesterification to give methyl esters, which in turn are hydrogenated to the alcohols. Although tallow is prodominantly C16-C18, the chain length from plant sources are more variable (C6-C24). Higher alcohols (C20–C22) can be obtained from rapeseed or mustard seed. Midcut alcohols (C12-C14) are obtained from coconut or palm oil.

From petrochemical sources

Fatty alcohols are also prepared from petrochemical sources. In the Ziegler process, ethylene is oligomerized using triethylaluminium followed by air oxidation. This process affords even-numbered alcohols:

$$Al(C_2H_5)_3 + 18\ C_2H_4 \rightarrow Al(C_{14}H_{29})_3$$

$$Al(C_{14}H_{29})_3 + 1.5\ O_2 + 1.5\ H_2O \rightarrow 3\ HOC_{14}H_{29} + 0.5\ Al_2O_3$$

Alternatively ethylene can be oligomerized to give mixtures of alkenes, which are subjected to hydroformylation, this process affording odd-numbered aldehyde, which is subsequently hydrogenated. For example, from 1-decene, hydroformylation gives the C11 alcohol:

$$C_8H_{17}CH{=}CH_2 + H_2 + CO \rightarrow C_8H_{17}CH_2CH_2CHO$$

$$C_8H_{17}CH_2CH_2CHO + H2 \rightarrow C_8H_{17}CH_2CH_2CH_2OH$$

In the Shell higher olefin process, the chain-length distribution in the initial mixture of alkene oligomers is adjusted so as to more closely match market demand. Shell does this by means of an intermediate metathesis reaction.[4] The resultant mixture is fractionated and hydroformylated/hydrogenated in a subsequent step.

Applications

Fatty alcohols are mainly used in the production of detergents and surfactants. They are components also of cosmetics, foods, and as industrial solvents. Due to their amphipathic nature, fatty alcohols behave as nonionic surfactants. They find use as emulsifiers, emollients and thickeners in cosmetics and food industry. About 50% of fatty alcohols used commercially are of natural origin, the remainder being synthetic.[1]

Nutrition

Very long chain fatty alcohols (VLCFA), obtained from plant waxes and beeswax have been reported to lower plasma cholesterol in humans. They can be found in unrefined cereal grains, beeswax, and many plant-derived foods. Reports suggest that 5–20 mg per day of mixed C24–C34 alcohols, including octacosanol and triacontanol, lower low-density lipoprotein (LDL) cholesterol by 21%–29% and raise high-density lipoprotein cholesterol by 8%–15%. Wax esters are hydrolyzed by a bile salt–dependent pancreatic carboxyl esterase, releasing long chain

alcohols and fatty acids that are absorbed in the gastrointestinal tract. Studies of fatty alcohol metabolism in fibroblasts suggest that very long chain fatty alcohols, fatty aldehydes, and fatty acids are reversibly inter-converted in a fatty alcohol cycle. The metabolism of these compounds is impaired in several inherited human peroxisomal disorders, including adrenoleukodystrophy and Sjögren-Larsson syndrome.[5]

Safety

Human Health

Fatty alcohols are relatively benign materials, with LD50s (oral, rat) ranging from 3.1-r g/kg for hexanol to 6 -8 g/kg for octadecanol.[1] For a 50 kg person, these values translate to more than 100 g. Tests of acute and repeated exposures have revealed a low level of toxicity from inhalation, oral or dermal exposure of fatty alcohols. Fatty alcohols are not very volatile and the acute lethal concentration is greater than the saturated vapor pressure. Longer chain (C12-C16) fatty alcohols produce fewer health effects than short chain (< C12). Short chain fatty alcohols are considered eye irritants, while long chain alcohols are not.[6] Fatty alcohols exhibit no skin sensitization.[7]

Repeated exposure to fatty alcohols produce low level toxicity and certain compounds in this category can cause local irritation on contact or low-grade liver effects (essentially linear alcohols have a slightly higher rate of occurrence of these effects). No effects on the central nervous system have been seen with inhalation and oral exposure. Tests of repeated bolus dosages of 1-hexanol and 1-octanol showed potential for CNS depression and induced respiratory distress. No potential for peripheral neuropathy has been found. In rats, the no observable adverse effect level (NOAEL) ranges from 200 mg/kg/day to 1000 mg/kg/day by ingestion. There has been no evidence that fatty alcohols are carcinogenic, mutagenic, or cause reproductive toxicity or infertility. Fatty alcohols are effectively eliminated from the body when exposed, limiting possibility of retention or bioaccumulation.[7]

Margins of exposure resulting from consumer uses of these chemicals are adequate for the protection of human health as determined by the Organization for Economic Co-operation and Development (OECD) high production volume chemicals program.[6][8]

Environment

Fatty alcohols up to chain length C18 are biodegradable, with length up to C16 biodegrading within 10 days completely. Chains C16 to C18 were found to biodegrade from 62% to 76% in 10 days. Chains greater than C18 were found to degrade by 37% in 10 days. Field studies at waste-water treatment plants have shown that 99% of fatty alcohols lengths C12-C18 are removed.[7]

Fate prediction using fugacity modeling has shown that fatty alcohols with chain lengths of C10 and greater in water partition into sediment. Lengths C14 and above are predicted to stay in the air upon release. Modeling shows that each type of fatty alcohol will respond independently upon environmental release.[7]

Aquatic Organisms

Fish, invertebrates and algae experience similar levels of toxicity with fatty alcohols although it is dependent on chain length with the shorter chain having greater toxicity potential. Longer chain lengths show no toxicity to aquatic

organisms.[7]

Chain Size	Acute Toxicity for fish	Chronic Toxicity for fish
< C11	1–100 mg/l	0.1-1.0 mg/l
C11-C13	0.1-1.0 mg/l	0.1 - <1.0 mg/l
C14-C15	NA	0.01 mg/l
>C16	NA	NA

This category of chemicals was evaluated under the Organization for Economic Co-operation and Development (OECD) high production volume chemicals program. No unacceptable environmental risks were identified.[8]

Common names and related compounds

Name	Carbon atoms	Branches/saturated?	Formula
tert-Butyl alcohol	4 carbon atoms		$C_4H_{10}O$
tert-Amyl alcohol	5 carbon atoms		$C_5H_{12}O$
3-Methyl-3-pentanol	6 carbon atoms		$C_6H_{14}O$
Ethchlorvynol	7 carbon atoms		C_7H_9ClO
1-Octanol (capryl alcohol)	8 carbon atoms		$C_8H_{18}ClO$
2-ethyl hexanol	8 carbon atoms	branched	
pelargonic alcohol (1-nonanol)	9 carbon atoms		
1-Decanol (decyl alcohol, capric alcohol)	10 carbon atoms		
Undecyl alcohol (1-undecanol, undecanol, Hendecanol)	11 carbon atoms		
Lauryl alcohol (Dodecanol, 1-dodecanol)	12 carbon atoms		
Tridecyl alcohol (1-tridecanol, tridecanol, isotridecanol)	13 carbon atoms		
Myristyl alcohol (1-tetradecanol)	14 carbon atoms		
Pentadecyl alcohol (1-pentadecanol, pentadecanol)	15 carbon atoms		
cetyl alcohol (1-hexadecanol)	16 carbon atoms		
palmitoleyl alcohol (cis-9-hexadecen-1-ol)	16 carbon atoms	unsaturated	
Heptadecyl alcohol (1-n-heptadecanol, heptadecanol)	17 carbon atoms		
stearyl alcohol (1-octadecanol)	18 carbon atoms		
Nonadecyl alcohol (1-nonadecanol)	19 carbon atoms		
arachidyl alcohol (1-eicosanol)	20 carbon atoms		
Heneicosyl alcohol (1-heneicosanol)	21 carbon atoms		
behenyl alcohol (1-docosanol)	22 carbon atoms		
erucyl alcohol (cis-13-docosen-1-ol)	22 carbon atoms	unsaturated	
lignoceryl alcohol (1-tetracosanol)	24 carbon atoms		
ceryl alcohol (1-hexacosanol)	26 carbon atoms		
1-heptacosanol	27 carbon atoms		
montanyl alcohol, cluytyl alcohol, or 1-octacosanol	28 carbon atoms		
1-nonacosanol	29 carbon atoms		
myricyl alcohol, melissyl alcohol, or 1-triacontanol	30 carbon atoms		
1-dotriacontanol	32 carbon atoms		$C_{32}H_{66}O$
geddyl alcohol (1-tetratriacontanol)	34 carbon atoms		
Cetearyl alcohol			

References

1. ^ *a b c d* Klaus Noweck, Wolfgang Grafahrend, "Fatty Alcohols" in Ullmann's Encyclopedia of Industrial Chem 2006, Wiley-VCH, Weinheim. doi:10.1002/14356007.a10_277.pub2 (http://dx.doi.org/10.1002%2F14356007.a10_277.pub2)
2. ^ http://goldbook.iupac.org/F02330.html
3. ^ Stephen Mudge; Wolfram Meier-Augenstein, Charles Eadsforth and Paul DeLeo (2010). "What contribution do detergent fatty alcohols make to sewage discharges and the maine environment?". *Journal of Environmental Monitoring*: 1846–1856. doi:10.1039/C0EM00079E (http://dx.doi.org/10.1039%2FC0EM00079E).
4. ^ Ashford's Dictionary of Industrial Chemicals, Third edition, 2011, page 6706-6711
5. ^ Nutritional Significance and Metabolism of Very Long Chain Fatty Alcohols and Acids from Dietary Waxes - Hargrove et al. 229 (3): 215 - Experimental Biology and Medicine (http://www.ebmonline.org/cgi/content/abstract/229/3/215)
6. ^ *a b* Veenstra, Gauke; Catherine Webb, Hans Sanderson, Scott E. Belanger, Peter Fisk, Allen Nielson, Yutaka Kasai, Andreas Willing, Scott Dyer, David Penney, Hans Certa, Kathleen Stanton, Richard Sedlak (2009). "Human health risk assessment of long chain alcohols". *Ecotoxicology and Environmental Safety*: 1016–1030. doi:10.1016/j.ecoenv.2008.07.012 (http://dx.doi.org/10.1016%2Fj.ecoenv.2008.07.012).
7. ^ *a b c d e* UK/ICCA (2006). "SIDS Initial Assessment Profile" (http://webnet.oecd.org/hpv/UI/handler.axd?id=03441f78-d135-4cab-b832-edfb1d0d677e). *OECD Existing Chemicals Database.*
8. ^ *a b* Sanderson, Hans; Scott E. Belanger, Peter R. Fisk, Christoph Schäfers, Gauke Veenstra, Allen M. Nielsen Yutaka Kasai, Andreas Willing, Scott D. Dyer, Kathleen Stanton, Richard Sedlak, (May 2009). "An overview of hazard and risk assessment of the OECD high production volume chemical category—Long chain alcohols [C6–C22] (LCOH)". *Ecotoxicology and Environmental Safety* 72 (4): 973–979. doi:10.1016/j.ecoenv.2008.10.006 (http://dx.doi.org/10.1016%2Fj.ecoenv.2008.10.006).

External links

- Cyberlipid. "Fatty Alcohols and Aldehydes" (http://www.cyberlipid.org/simple/simp0003.htm). Retrieved 2007-02-06. General overview of fatty alcohols, with references.
- CONDEA. "Dr. Z Presents All about fatty alcohols" (http://www.zenitech.com/documents/new%20pdfs/articles/All%20about%20fatty%20alcohols%20Condea.pdf). Retrieved 2007-02-06.

Retrieved from "http://en.wikipedia.org/w/index.php?title=Fatty_alcohol&oldid=614893144"
Categories: Fatty alcohols | Lipids | Commodity chemicals

Advice + Tips

All the latest natural skin care, anti-aging and healthy lifestyle tips from Marie Veronique Organics.

A Word About Fatty Alcohols

There are alcohols and then there are alcohols, especially when it comes to skin care ingredients. Chemically, alcohols are carbon chains with a functional hydroxyl (OH) group attached. On an ingredients list they will usually be the ones ending in an "ol", as in ethanol, methanol, panthenol. While alcohols are used in skin care for their anti-bacterial properties alcohols like isopropyl alcohol, SD alcohol and ethanol can be drying and irritating to the skin. However, the fatty alcohols are a different category altogether, with some definitely offering skin benefits such as skin permeation, moisture retention and anti-aging support. Fatty alcohols are a mixed bag, though, as even ones known to be beneficial can cause skin irritation and should be used with caution.

There are some others that are commonly used in skin care products for their humectant properties that organic companies shy away from using, as their safety profile is open to question, and the risks may outweigh the benefits. And then there are some that consumers should avoid even though they are deemed safe, and frequently show up on ingredients lists. Given the potential risks, it is important to read your labels with some understanding of the "ols"—what is their function, why are they there, and most important, do you want them in products that will be absorbed by your body?

To help demystify your shopping experience, here is a list of fatty alcohols that are commonly used in skin care products.

Fatty Alcohol	Common Name	Function	Benefit	Safety
Tocopherol	Vitamin E	Vitamin, Anti-oxidant	Passes through the dermis, smoothes the skin and reduces TEWL (trans-epidermal water loss). Provides excellent anti-oxidant protection, particularly when used in conjunction with Vitamin C	May cause skin irritation, and causes allergic reactions in some people.
panthenol	Vitamin B5	Pro-Vitamin, part of Vitamin B complex	Promotes wound healing	May cause skin irritation.
retinol	Vitamin A	Vitamin From chemical family of retinoids	Studies show it contributes to reversing the effects of photo-aging	Precautions: Retinyl palmitate in day creams and sunscreens may encourage cancerous and precancerous cell growth Recommendation: Use with caution.
Dodecanol	Lauryl alcohol	emollient	From palm kernel or coconut fatty acids	Can be mildly irritating, is harmful to marine life Recommendation: Avoid if possible due to its environmental toxicity
Octadecanol	Stearyl alcohol, oleyl alcohol	Emulsifier, emollient, thickener	From stearic acid Stearic acid is typically derived from animal fat, but may be obtained from unsaturated vegetable oils	Recommendation: Avoid if acne prone Check source if avoiding animal products is desired.

Marie Veronique Nadeau founded Marie Veronique Organics over 10 years ago and is a nationally recognized formulator and beauty expert. She collaborates with her daughter, Jay Nadeau, physicist and bio-medical engineer, to carefully choose each ingredient in her products to address the causes of aging at the source. Marie holds a BS in Math and Chemistry as well as an esthetics license from Paris Beauty College. She is a mother of 2 and a grandmother of one. When she is not developing cutting edge anti-aging products, she can be found reading at her local library or foraging for mushrooms with her granddaughter.

Tetradecanol	Myristyl alcohol	Emulsifier, emollient	Prepared from myristic acid	Recommendation: Tends to be more more irritating than stearyl, cetyl alcohol.
Hexadecanol	Cetyl alcohol, palmityl alcohol	Emulsifier, emollient	From the end product of the petroleum industry, or produced from palm oil or coconut oil	Mildly irritating Recommendation: Check source to avoid petroleum products
Propylene glycol	PG	humectant	A glycol	Can be a strong irritant Recommendation: Avoid
Butylene glycol	BG	humectant	A glycol	Considered safe, not an irritant Recommendation: A cautious avoid, simply because there is not much data regarding its safety

Cosmetics &Toiletries

Research

Comparatively Speaking: Fatty Alcohols vs. Fatty Acids vs. Esters

Jul 6, 2010 | View online to Contact Author | By: Anthony J. O'Lenick Jr., Siltech LLC

In the present discussion, Tony O'Lenick recruits Ismail Walele of Phoenix Chemical to explain the differences between fatty alcohols, fatty acids and esters.

Alcohols

Alcohols are alkanes with a hydroxyl group on the terminal carbon, which makes them primary alcohols. These are also called 1-alcohols, an example being 1-butanol or n-butanol. Some alcohols have their hydroxyl group on the c-chain, excluding the terminal primary carbon and making them secondary alcohols. Butanol has three isomers: n-butanol (1-butanol), 2-butanol (secondary butanol) and t-butanol, meaning tert-butanol with hindered hydroxyl on the same carbon with three methyl groups.

Fatty alcohols are aliphatic alcohols derived from natural fats and oils originating in plants and animals. Fatty alcohols are derived from fatty acids and have an even number of carbon atoms. The production of fatty alcohols from fatty acids yields normal-chain alcohols wherein the –OH group attaches to the terminal carbon. Fatty alcohols, due to their amphipatic nature, act as non-ionic surfactants/co-surfactants. Fatty alcohols can be used in cosmetic formulations as emulsifiers, emollients and thickeners.

Generally, alcohols are normal alcohols from natural fats and oils, meaning that they all have an even number of carbons. They can be saturated or unsaturated alcohols. Another type of alcohol is a branched chain alcohol, which is termed a *synthetic higher alcohol* or an *oxo alcohol*. Branched alcohols can be mono-methyl branched or multi-carbon chained on the side at any or specific interior carbon of the main carbon chain. **Table 1** provides the common names, carbon numbers and the synthetic branched counterparts of alcohols.

Named after inventor M. Guerbet, Guerbet alcohols are alkaline condensation reaction products of primary alcohols. They are primary, alpha branched dimeric alcohols and are 100% defined branched at the second carbon position.

Oxo alcohols and iso-alcohols are alpha-olefin based and are approximately 50% branched at the second carbon position. Oxo alcohols are about 50% linear. Iso-alcohols are 100% multiple methyl branched.

Melting points or pour points are much lower for branched/Guerbet alcohols than for their linear counterparts of the same number of c-chains. Linear unsaturated alcohols are liquid; however, they suffer from poor heat stability due to unsaturation. The saturated Guerbet alcohols or branched iso alcohols offer fluidity and also thermal stability and oxidation stability. These differentiating physico-chemical properties of branched chain alcohols make them immensely important in the synthesis and derivatization into cosmetics and personal care emollients.

Fatty Acids

Fatty acids are organic acids comprised of carbon chains with a carboxyl group at the end. Saturated fatty acids have all carbons with a full quota of hydrogens. There is a single bond between adjacent carbon atoms. Unsaturated fatty acids have one or more carbon-carbon double bond in the molecule. Chemically, these double bonds will take up hydrogen, a process termed *hydrogenation*, that yields saturated fatty acids. **Table 2** gives common names, IUPAC names, chemical structures and abbreviation designating presence or absence of unsaturation for fatty acid.

Saturated and unsaturated fatty acids are different in their form, as unsaturated fatty acids have one or more alkenyl functional group along the chain. Each alkene substitutes a single bonded CH2-CH2 segment of the chain with a double bonded CH2=CH2 segment, thus a carbon double-bonded to another carbon. Unsaturated fatty acids such as oleic acid can show two of their distinct forms (isomers), i.e. *cis* and *trans* forms. The *cis* form has adjacent carbons on the same side of the double bond. The *trans* form has adjacent carbons bound to the opposite side of the double bond. The *trans* form is more rigid than the *cis* form. Oleic acid has one double bond whereas linoleic acid has two double bonds and liolenic acid has three double bonds.

Fatty acids react just like any other carboxylic acid, meaning they can undergo esterification and acid-base reactions. Reduction of fatty acids gives corresponding fatty alcohols. Unsaturated fatty acids undergo addition reactions, with the most prominent being hydrogenation. Such hydrogenation is used to convert vegetable oils into margarines. Partial hydrogenation of unsaturated fatty acids gives isomers mainly converting cis form to trans form.

Esters

Esterification is a condensation reaction where an acid molecule reacts with an alcohol molecule, producing an ester and water,

as shown in **Figure 1.**

Esterification is analogous to neutralization in the way that the resultant ester is named as if it is the alkyl salt of the acid. For example, sodium benzoate is the sodium salt of benzoic acid while lauryl benzoate is the ester of benzoic acid and lauryl alcoh

There are a wide variety of esters due to the wide range of fatty acids and fatty alcohols available. The properties can be varie due to this wide array of variations.

Media

Tables

Table 1. Alcohols

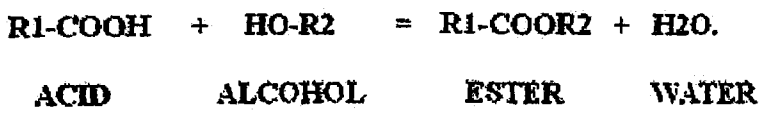
Alcohols from Natural Fats/Oils	No. of Carbons	Alcohols from Synthetic Origin
Capryl alcohol(1-octanol)	8	2-ethyl hexanol (oxo, branched)
Pelargonyl alcohol(1-nonanol)	9	Isononanol (iso, branched)
Capric alcohol (1-decanol)	10	Isodecyl alcohol (branched)
Lauryl alcohol(1-dodecanol)	12	Dodecyl/tridecyl alcohol(mixed branched)
	13	Tridecyl alcohol (iso, branched)
Myristyl alcohol (1-tetradecanol)	14	
Cetyl alcohol(1-hexadecanol)	16	Isocetyl alcohol (branched)
Stearyl alcohol(1-octadecanol)	18	Isostearyl alcohol (branched)
Oleyl alcohol (1-octadecenol)	18^{-1}	
Arachidyl alcohol (1-eicosanol)	20	
Behenyl alcohol (1-docosanol)	22	

Table 2. Fatty acids

Common Name	IUPAC Name	Chemical Structure	Abbreviated Acid
Butyric	Butanoic acid	CH3(CH2)2COOH	C4:0
Caproic	Hexanoic acid	CH3(CH2)4COOH	C6:0
Caprylic	Octanoic acid	CH3(CH2)6COOH	C8:0
Capric	Decanoic acid	CH3(CH2)8COOH	C10:0
Lauric	Dodecanoic acid	CH3(CH2)10COOH	C12:0
Myristic	Tetradecanoic acid	CH3(CH2)12COOH	C14:0
Palmitic	Hexdecanoic acid	CH3(CH2)14COOH	C16:0
Stearic	Octadecanoic acid	CH3(CH2)16COOH	C18:0
Arachidic	Eicosanoic acid	CH3(CH2)18COOH	C20:0
Behenic acid	Docosanoic acid	CH3(CH2)20COOH	C22:0

Figures

Figure 1. Esterification



Esterification is a condensation reaction where an acid molecule reacts with an alcohol molecule to produce an ester and water.

FATTY ALCOHOLS

Aliphatic alcohols occur naturally in free form (component of the cuticular lipids) but more usually in esterified (wax esters) or etherified form (glyceryl ethers). Several alcohols belong to aroma compounds which are found in environmental or food systems (see the website: Flavornet).
They are found with normal, branched (mono- or isoprenoid), saturated or unsaturated of various chain length and sometimes with secondary or even tertiary alcoholic function. An unusual phenolic alcohol is found as a component of glycolipids in *Mycobacteria*. Some cyclic alcohols have been described in plants.

A classification according to the carbon-chain structure is given below.

1. Normal-chain alcohols
2. Branched-chain alcohols
3. Phenolic alcohols
4. Cyclic alcohols

1 - Normal-chain alcohols

The carbon chain may be fully saturated or unsaturated (with double and/or triple bonds), it may also be substituted with chlorine, bromine or sulfate groups. Some acetylenic alcohols have been also described.

- Saturated alcohols
- Unsaturated alcohols
- Acetylenic alcohols
- Sulfated alcohols

- Saturated alcohols

Among the most common, some are listed below

Formula	Normal alcohols	*Iso*-alcohols	*Anteiso*-alcohols
$C_{12}H_{25}OH$	1-dodecanol (lauryl alcohol)	10-methyl-1-hendecanol (isolauryl alcohol)	9-methyl-1-hendecanol (anteisolauryl alcohol)
$C_{14}H_{29}OH$	1-tetradecanol (myristyl alcohol)	12-methyl-1-tridecanol (isomyristyl alcohol)	11-methyl-1-tridecanol (anteisomyristyl alcohol)
$C_{16}H_{33}OH$	1-hexadecanol (cetyl alcohol)	14-methyl-1-pentadecanol (isopalmityl alcohol)	13-methyl-1-pentadecanol (anteisopalmityl alcohol)
$C_{18}H_{37}OH$	1-octadecanol (stearyl alcohol)	16-methyl-1-heptadecanol (isostearyl alcohol)	15-methyl-1-pentadecanol (anteisostearyl alcohol)

Free fatty alcohols are not commonly found in epicuticular lipids of insects, although high molecular weight alcohols have been reported in honeybees (*Blomquist GJ et al., Insect Biochem 1980, 10, 313*). Long-chain alcohols also have been reported in the defensive secretions of scale insects (*Byrne DN et al., Physiol Entomol 1988, 13,267*). Typically, insects more commonly produce lower molecular weight alcohols. Honeybees produce alcohols of 17–22 carbons, which induce arrestment in parasitic varroa mites (*Donze G et al., Arch Insect Biochem Physiol 1998, 37, 129*). Two female-specific fatty alcohols, docosanol (C22) and eicosanol (C20), which have been found in epicuticle of *Triatoma infestans* (a vector of Chagas disease in South America), are able to trigger copulation in males (*Cocchiararo-Bastias L et al., J Chem Ecol 2011, 37, 246*). Hexadecyl acetate is found in the web of some spiders (Pholcidae) to attract females (*Schulz S, J Chem Ecol 2013, 39, 1*).
Long-chain alcohols (C18, C24, C28) from the femoral glands in the male lizard *Acanthodactylus boskianus* play a role in chemical communication as a scent marking pheromone (*Khannoon ER et al., Chemoecology 2011, 21, 143*).

Various fatty alcohols are found in the waxy film that plants have over their leaves and fruits. Among them, octacosanol (C28:0) is the most frequently cited.
Policosanol is a natural mixture of higher primary aliphatic alcohols isolated and purified from sugar cane (*Saccharum officinarum, L.*) wax, whose main component is octacosanol but contains also hexacosanol (C26:0) and triacontanol or melissyl alcohol (C30:0). Policosanol is also extracted from a diversity of other natural sources such as beeswax, rice bran, and wheat germ (*Irmak S et al., Food Chem 2006, 95, 312*) but is also present in the fruits, leaves, and surfaces of plants and whole seeds. A complex policosanol mixture has been identified in peanut (*Cherif AO et al., J Agric Food Chem 2010, 58, 12143*). More than 20 aliphatic alcohols were identified (C14-C30) and four unsaturated alcohols (C20-24). The total policosanol content of the

whole peanut samples varied from 11 to 54 mg/100 g of oil.
This mixture was shown to have cholesterol-lowering effects in rabbits (*Arruzazabala ML et al., Biol Res 1994, 27, 205*). Octacosanol was also able to suppress lipid accumulation in rats fed on a high-fat diet (*Kato S et al., Br J Nutr 1995, 73, 433*) al to inhibit platelet aggregation (*Arruzazabala ML et al., Thromb Res 1993, 69, 321*).
The effectiveness of policosanol is still questionable but it has been approved as a cholesterol-lowering drug in over 25 countries (*Carbajal D et al., Prostaglandins Leukotrienes Essent Fatty Acids 1998, 58, 61*), and it is sold as a lipid-lowering supplement in more than 40 countries. More recent studies in mice question about any action on improvement of lipoprotein profiles (*Dullens SPJ et al., J Lipid Res 2008, 49, 790*). The authors conclude that individual policosanols, as well as natural policosanol mixtures, have no potential for reducing coronary heart disease risk through effects on serum lipoprotein concentrations. Furthermore, sugar cane policosanol at doses of 20 mg daily has shown no lipid lowering effects in subjects with primary hypercholesterolemia (*Erancini-Pesenti F et al., Phytother Res 2008, 22, 318*). It must be noticed that, for the most part, positive results have been obtained by only one research group in Cuba. Outside Cuba, all groups have failed to validate the cholesterol-lowering efficacy of policosanols (*Marinangeli C et al., Crit Rev Food Sci Nutr 2010, 50, 259*). Independent studies are required before evaluating the exact value of the therapeutic benefits of that mixture.
An unsaturated analogue of octacosanol, octacosa-10, 19-dien-1-ol was synthesized and was as effective as policosanol in inhibiting the upregulation of HMGCoA reductase (*Oliaro-Bosso S et al., Lipids 2009, 44, 907*). This work opens promising perspectives for the design of new antiangiogenic compounds (*Thippeswamy G et al., Eur J Pharmacol 2008, 588, 141*). An unsaturated analogue of octacosanol, octacosa-10, 19-dien-1-ol was synthesized and was as effective as policosanol in inhibiting the upregulation of HMGCoA reductase (*Oliaro-Bosso S et al., Lipids 2009, 44, 907*). This work opens promising perspectives for the design of new antiangiogenic compounds.

1-Octanol and 3-octanol are components of the mushroom flavor (*Maga JA, J Agric Food Chem 1981, 29, 1*). 3-Octanol is a volatile infochemical present in fungi and recognisable by fungivores (*Holighaus G et al., Chemoecology 2014, 24, 57*).
Many alcohols in the C10 to C18 range, and their short-chain acid esters are potent sex or aggregation pheromones. They are mainly found as components of specialized defensive glands, pheromone glands or glands of the reproductive system.

A series of C22 up to C28 saturated n-alcohols, with even carbon numbers predominating, and a maximum at C26 and C28, has been identified in the cyanobacterium *Anabaena cylindrica* (*Abreu-Grobois FA et al., Phytochemistry 1977,*

16, 351). Several authors have reported high contents of the 22:0 alcohol in sediments where an algal origin is plausible. For example, the major alcohol in a sample of the lacustrine Green River Shale of Eocene age is also 22:0 which comprises over 50% of the alcohols present (*Sever JR et al., Science 1969, 164, 1052*)

Long-chain alcohols are known as major surface lipid components (waxes) with chains from C20 up to C34 carbon atoms, odd carbon-chain alcohols being found in only low amounts. Very long-chain methyl-branched alcohols (C38 to C44) and their esters with short-chain acids were shown to be present in insects, mainly during metamorphosis. A series of long-chain alkanols (more than 23 carbon atoms) were identified in settling particles and surface sediments from Japanese lakes and were shown to be produced by planktonic bacteria being thus useful molecular markers (*Fukushima K et al., Org Geochem 2005, 36, 311*).
Cutin and suberin contain as monomer saturated alcohols from C16 to C22 up to 8% of the total polymers. C18:1 alcohol (oleyl alcohol) is also present.

Long-chain di-alcohols (1,3-alkanediols) have been described in the waxes which impregnate the matrix covering all organs of plants (*Vermeer CP et al., Phytochemistry 2003, 62, 433*). These compounds forming about 11% of the leaf cuticular waxes of *Ricinus communis* were identified as homologous unbranched alcohols ranging from C22 to C28 with hydroxyl group at the carbon atoms 1 and 3. Very-long-chain compounds were identified and quantified in the petal wax of *Cosmos bipinnatus* (Asteraceae). The most important were homologous series of alkane 1,2-diols and 1,3-diols, both ranging from C20 to C26 (*Buschhaus C et al., Phytochemistry 2013, 91, 249*). Relatively little is known about the functions of these compounds in the ecological and physiological fields.
In the leaf cuticular waxes of *Myricaria germanica* (Tamaricaceae) several alkanediols were identified (*Jetter R, Phytochemistry 2000, 55, 169*). Hentriacontanediol (C31) with one hydroxyl group in the 12-position and the second one in positions from 2 to 18 is the most abundant diol (9% of the wax). Others were far less abundant : C30-C34 alkanediols with one hydroxyl group on a primary and one on a secondary carbon atom, C25-C43 β-diols and C39-C43 γ-diols. Very-long-chain 1,5-alkanediols ranging from C28 to C38, with strong predominance of even carbon numbers, were identified in the cuticular wax of *Taxus baccata* (*Wen M et al., Phytochemistry 2007, 68, 2563*). The predominant diol had 32 carbon atoms (29% of the total).
Long-chain saturated C30-C32 diols occur in most marine sediments and in a few instances, such as in Black Sea sediments, they can be the major lipids (*de Leeuw JW et al., Geochim Cosmochim Acta 1981, 45, 2281*). A microalgal source for these compounds was discovered when Volkman JK et al. (*Org Geochem 1992, 18, 131*)

identified C30-C32 diols in marine eustigmatophytes from the genus *Nannochloropsis*.
Two nonacosanetriols (7,8,11-nonacosanetriol and 10,12,15-nonacosanetriol) hav been isolated from the outer fleshy layer (sarcotesta) of the *Ginkgo biloba* "fruit" (*Zhou G et al., Chem Phys Lipids 2012, 165, 731*). They exhibited slight activity of antithrombin and moderate activities of platelet aggregation *in vitro*.

The chief lipid fraction in the uropygial gland excretion of the domestic hen is a diester wax. The unsaponifiable fraction consists of a series of three homologous compounds, which have been named the **uropygiols** and identified as 2,3-alkanediols containing 22-24 carbon atoms. These fatty alcohols are esterified by saturated normal C22-C24 fatty acids (*Haahti E et al., J Lipid Res 1967, 8, 131*).

- Unsaturated alcohols

Some fatty alcohols have one double bond (monounsaturated). Their general formula is:

$CH_3(CH_2)_xCH=CH(CH_2)_y-CH_2OH$

The unique double bond may be found in different positions: at the C6: i.e. cis-6-octadecen-1-ol (petroselenyl alcohol), C9 i.e cis-9-octadecen-1-ol (oleyl alcohol) and C11 i.e cis-11-octadecen-1-ol (vaccenyl alcohol). Some of these alcohols have insect pheromone activity. As an example, 11-eicosen-1-ol is a major component of the alarm pheromone secreted by the sting apparatus of the worker honeybee. In zooplankton, the cis-11-docosen-1-ol (22:1 (n-11) alcohol) is not only present in high proportion in wax esters (54 to 83%) but may be also predominant in free form (75-94% of free alcohols) in ctenophores (*Graeve M et al., Mar Biol 2008, 153, 643*). This presence is unexplained because pathways for conversion and catabolism of fatty alcohols in ctenophores are still unknown.
Some short-chain unsaturated alcohols are components of mushroom flavor, such as 1-octen-3-ol, t2-octen-1-ol, and c2-octen-1-ol (*Maga JA, J Agric Food Chem 1981, 29, 1*). 1-Octen-3-ol is a volatile infochemical present in fungi and recognisable by fungivores (*Holighaus G et al., Chemoecology 2014, 24, 57*)
An acetoxy derivative of a 16-carbon alcohol with one double bond, **gyptol** (10-acetoxy cis-7-hexadecen-1-ol), was described to be a strong attractive substance secreted by a female moth (*Porthetria dispar*, "gypsy moth").

A fatty alcohol with two double bonds, **bombykol** (tr-10,cis-12-hexadecadien-1-ol), was also shown to be excreted as a very strong attractive substance by the female of silk-worm (*Bombyx mori*).

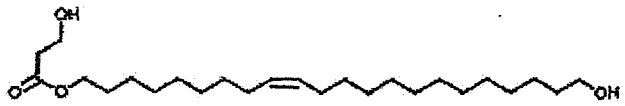
Bombycol

This first discovery of a pheromone was made by Butenandt A et al. (*Z Naturforsch 1959, 14, 283*) who was formerly Nobel laureate (in 1939) for his work in sex hormones. Another pheromone, 8,10-dodecadienol (codlemone), is secreted by the codling moth *Cydia pomonella*, has been used for monitoring and mating in apple and pear orchards in the USA and Europe. This molecule was also used to monitor the population of the pea moth *Cydia nigricana*. Likewise, 7,9-dodecadienol, the female pheromone of the European grapewine moth *Lobesia botrana*, was used to control this important pest in vineyards.

A fatty triol with one double bond, **avocadene** (16-heptadecene-1,2,4-triol) is found in avocado fruit (*Persea americana*) and has been tested for anti-bacterial and anti-inflammatory properties. These properties are likely related with the curative effects of avocado described for a number of ailments (diarrhea, dysentery, abdominal pains and high blood pressure). Several others heptadecanols with one primary and two secondary alcohol functions and with one double or triple bond have been identified in the leaves of *Persea americana* (*Lee TH et al., Food Chem 2012, 132, 921*). One or two of these alcohol groups may be acetylated. These compounds may be related to the known antifungal activity of *Persea* leaves.

Long-chain alkenols (C37 to C39) with 2 to 4 double bonds, the reduced form of the alkenones, have been described in the benthic haptophyte *Chrysotila lamellosa* (*Rontani JF et al., Phytochemistry 2004, 65, 117*). al., 1986). C30 to C32 alcohols having one or two double bonds are significant constituents of the lipids of marine eustigmatophytes of the genus *Nannochloropsis* (*Volkman JK et al., Org Geochem 1992, 18, 131*). These microalgae could be partially the source of the alkenols found in some marine sediments.

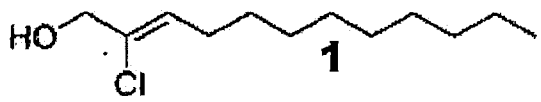
Long-chain α,ω-diols, esterified at one or both oxygens with 3-hydroxypropanoic acid, named bruchins, have been described as insect-derived plant regulators which are able to induce the formation of neoplasm on plant (*Doss RP et al., PNAS 2000, 97, 6218*). One of them is shown below.

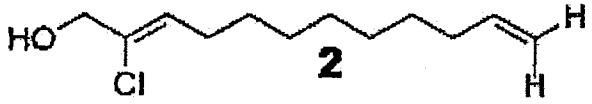


Bruchin A

Two chlorinated derivatives of unusual alcohols were described in a red alga *Gracilaria verrucosa* (*Shoeb M et al., J Nat Prod 2003, 66, 1509*). Both compounds have a C12 aliphatic chain chlorinated in position 2 and with one double bond at carbon 2 (compound 1 : 2-chlorododec-2-en-1-ol) or two double bonds at carbon 2

and 11 (compound 2 : 2-chlorododec-2,11-dien-1-ol).

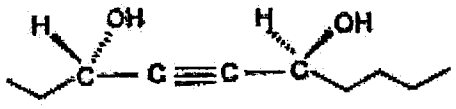




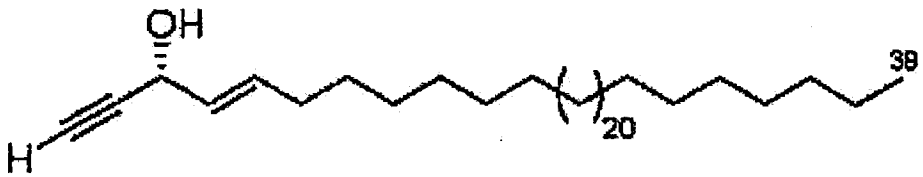
- Acetylenic alcohols

Natural acetylenic alcohols and their derivatives have been isolated from a wide variety of plant species, fungi and invertebrates. Pharmacological studies have revealed that many of them display chemical and medicinal properties.

Monoacetylenic alcohols : were isolated from culture of *Clitocybe catinus* (Basidiomycetes) and the study of their structure revealed the presence of two or three hydroxyl groups (*Armone A et al., Phytochemistry 2000, 53, 1087*). One of these compounds is shown below.

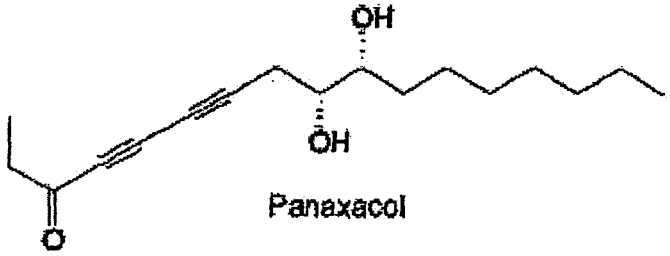


Acetylenic alcohols have been also described in a tropical sponge *Reniochaline sp* (*Lee HS et al., Lipids 2009, 44, 71*). One of the two described in that species is shown below, it exhibited a significant growth effect against human tumor cell lines.



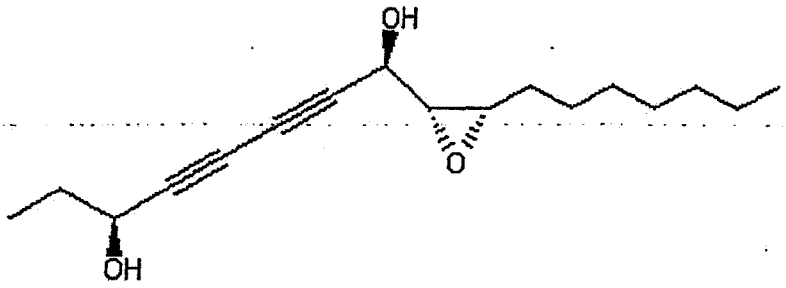
Polyacetylenic alcohols : Several examples with different chain lengths, unsaturation degrees, and substitution have been reported from terrestrial plants a marine organisms. Food plants of the Apiaceae (Umbellifereae) plant family such as carrots, celery and parsley, are known to contain several bioactive bisacetylenic alcohols. The main plant sources of these compounds are *Angelica dahurica,*

Heracleum sp and *Crithmum maritimum* (falcarindiol, falcarinol), red ginseng (*Panax ginseng*) (panaxacol, panaxydol, panaxytriol), *Cicuta virosa* (virol A), and *Clibadium sylvestre* (cunaniol). All these compounds display antibiotic or cytotoxic activities.



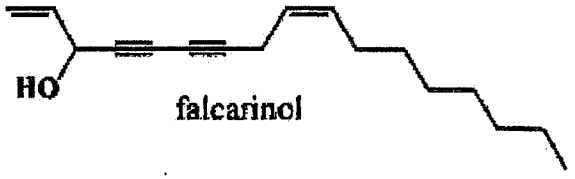
Panaxacol

Polyacetylenes have been isolated from the stems of *Oplopanax elatus* (Araliaceae), plant used in Korean and Chinese traditional medicine for anti-inflammatory and analgesic purposes (*Yang MC et al., J Nat Prod 2010, 73, 801*). Among the most efficient in inhibiting the formation of nitric oxide in LPS-induced cells is a seventeen-carbon diyne diol with an epoxy cycle, oploxyne A. Other parent compounds without the epoxy group were also described.

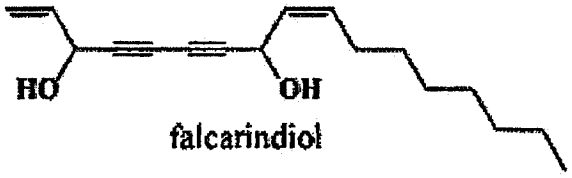


Oploxyne A

Falcarinol, a seventeen-carbon diyne fatty alcohol (1,9-heptadecadiene-4,6-diyn-3-ol), was first isolated from *Falcaria vulgaris* (*Bohlmann F et al., Chem Ber 1966, 99, 3552*) as well as from Korean ginseng (*Takahashi et al., Yakugaku Zasshi 1966, 86, 1053*). It was also isolated from carrot (*Hansen SL et al. J. Sci. Food Agric. 2003, 83, 1010*). Falcarinol has potent anticancer properties on primary mammary epithelial cells and was compared with that of β-carotene. These results might be important in developing new cancer treatments with simple and common vegetables. At high concentrations, falcarinol is capable to induce contact dermatitis.



falcarinol

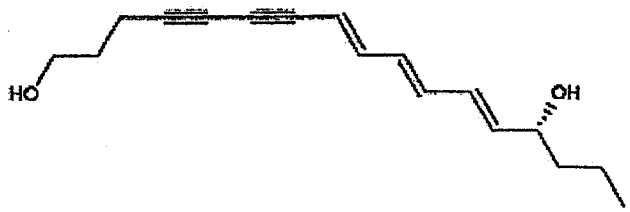


falcarindiol

Falcarinol protects the vegetable from fungal diseases, it showed biphasic activity, having stimulatory effects between 0.01 and 0.05 µg per ml and inhibitory effects between 1 and 10 µg per ml, whereas β-carotene showed no effect in the concentration range 0.001–100 µg per ml (*Hansen SL et al., J Sci Food Agric 2003, 83, 1010*). Experiments with macrophage cells have shown that falcarinol (and its C-8 hydroxylated derivative, falcarindiol) reduced nitric oxide production, suggesting that these polyacetylenes are responsible for anti-inflammatory bioactivity (*Metzger BT et al., J Agric Food Chem 2008, 56, 3554*). Falcarindiol was first reported as phytochemicals in carrots (*Daucus carota*) (*Bentley RK et al., J Chem Soc 1969, 685*). Besides falcarinol, falcarindiol, and falcarindiol 3-acetate, nine additional bisacetylene alcohols were identified in Daucus carota (*Schmiech L et al., J Agric Food Chem 2009, 57, 11030*).

Experiments with human intestinal cells demonstrate that aliphatic C17-polyacetylenes (panaxydol, falcarinol, falcarindiol) are potential anticancer principles of carrots and related vegetables (parsley, celery, parsnip, fennel) and that synergistic interaction between bioactive polyacetylenes may be important for their bioactivity (*Purup S et al., J Agric Food Chem 2009, 57, 8290*). Compounds very similar to falcarinol and extracted from *Panax japonicus* are potent a-glucosidase inhibitors (*Chan HH et al., Phytochemistry 2010, 71, 1360*). These inhibitors may potentially reduce the progression of diabetes by decreasing digestion and absorption of carbohydrates.

The water dropwort (*Oenanthe crocata*), which lives near streams in the Northern Hemisphere, contains a violent toxin, **cicutoxin**, resulting in convultions and respiratory paralysis (*Uwai K et al., J Med Chem 2000, 43, 4508*).

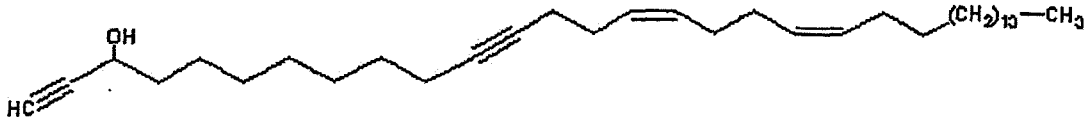


Cicutoxin

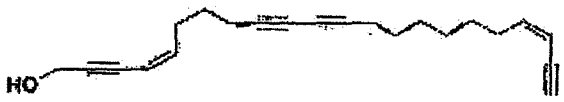
The biochemistry and bioactivity of polyacetylenes are presented in a review (*Christensen LP et al., J Pharm Biomed Anal 2006, 41, 683*) as well methods for the isolation and quantification of these compounds.

Many other polyacetylenic alcohols were found in primitive marine organisms, such as sponges and ascidians. These invertebrates have no physical defenses and thus they have developed efficient chemical mechanisms such as polyacetylenic metabolites to resist predators and bacteria.

A C36 linear diacetylene alcohol named **lembehyne** was found in an Indonesian marine sponge (*Haliclona* sp) (*Aoki S et al., Tetrahedron 2000, 56, 9945*) and was later able to induce neuronal differentiation in neuroblastoma cell (*Aoki S et al., Biochem Biophys Res Comm 2001, 289, 558*).

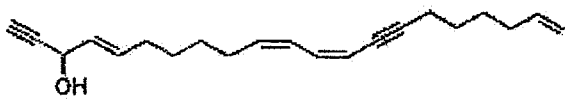


Several **polyacetylenic alcohols** with 22 carbon atoms were isolated and identified in lipid extract from a Red Sea sponge, *Callyspongia* sp (*Youssef DT et al., J Nat Prod 2003, 66, 679*). Their physical study revealed the presence of 4 triple bonds and one, two or three double bonds. The structure of one of these **Callyspongenols** is given below.

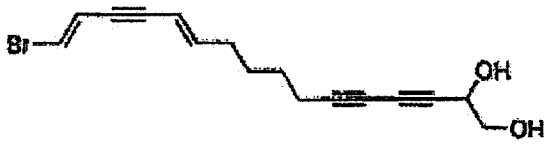


Several di- and tri-acetylenic di-alcohols with a chain of 26 up to 31 carbon atoms, named **strongylodiols**, have been isolated from a *Petrosia* Okinawan marine sponge (*Watanabe K et al., J Nat Prod 2005, 68, 1001*). Some of them have cytotoxic properties.

Several polyacetylenic alcohols with 21 carbon atoms were isolated from a marine ascidian (*Polyclinidae*) and were determined to have two triple bonds combined with a conjugated dienyne group (*Gavagnin M et al., Lipids 2004, 39, 681*). Some of them have an additional hydroxyl group or only three double bonds. The structure of one of these molecules is given below.



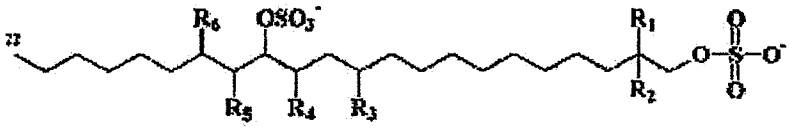
Several brominated polyacetylenic diols with cytotoxic properties were isolated from a Philippines sponge *Diplastrella* sp (*Lerch ML et al., J Nat Prod 2003, 66, 667*). One of these molecules is shown below.



A comprehensive survey of acetylenic alcohols in plant and invertebrates with information on their anticancer activity has been released by Dembitsky VM (*Lipids 2006, 41, 883*).

- Sulfated alcohols

Long-chain di-hydroxy alcohols in which both the primary and secondary hydroxyl groups are converted to sulfate esters and one to five chlorine atoms are introduced at various places have been discovered in the alga *Ochromonas danica* (*Chrysophyceae, Chrysophyta*) where they constitute 15% of the total lipids (*Haines TH, Biochem J 1969, 113, 565*). An example of these **chlorosulfolipids** is given below. There may be several types of chlorine addition : one at R_4, two at R_3 and R_5 or R_1 and R_2, five at R_1 to R_5 and six at R_1 to R_6.



Similar molecules with a 24 carbon chain was also described in *Ochromonas malhamensis* (review in *Dembitsky VM et al., Prog Lipid Res 2002, 41, 315* and in *Bedke DK et al., Nat Prod Rep 2011, 28, 15)*. It was suggested that the chlorosulfolipids replace sulfoquinovosyl diglyceride, since when the later is high the former is low and vice versa. They have been associated with the human toxicity of the mussel-derived lipids (Diarrhetic Shellfish Poisoning).

Several of these chlorosulfolipids have also been identified from more than 30 species of both freshwater and marine algae belonging to green (*Chlorophyceae*), brown (*Phaeophyceae*), red (*Rhodophyceae*) macrophytic algae (*Mercer EI et al.,*

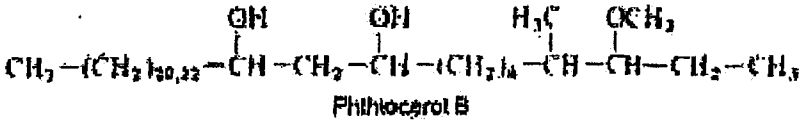
Phytochemistry 1979, 18, 457), and other microalgal species (*Mercer EI et al., Phytochemistry 1975, 14, 1545*).

Some fatty alcohols, such as dodecanol (lauryl or dodecyl alcohol), are used for the manufacture of detergents after sulphonation (by action of SO3 gas). The salt sodium laurylsulfate (or sodium dodecylsulfate) is a detergent and strong anionic surfactant, used in biochemistry and in the composition of cosmetic products (shampoos, toothpastes).

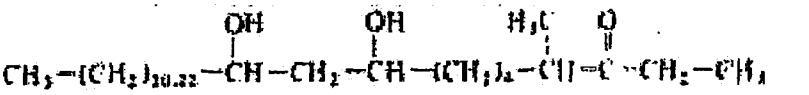
2 - Branched-chain alcohols

- Mono-methylated alcohols

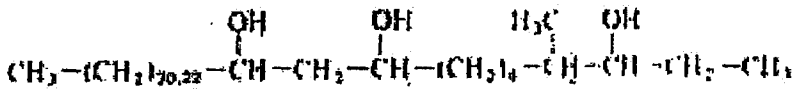
They are components of the waxes found in several species of *Mycobacterium* but are not present in other actinomycetes (*Minnikin DE et al., Chem Biol 2002, 9, 545*). These alcohols are named **phthiocerols**. Among that family of long-chain secondary alcohols, phthiocerol A, phthiodiolone A and phthiotriol are shown below.



Phthiocerol B



Phthiodiolone A



Phthiotriol

In 1936, Stodola et al. characterized an optically active substance recovered on saponification of "purified waxes" of *Mycobacterium tuberculosis,* determined its global formula and proposed to name it phthiocerol *(Stodola FH et al., J Biol Chem 1936, 114, 467)*. In 1959, after several chemical studies, its structure was determined as a mixture of C36 and C34 β-glycols. It has been proposed that the term **phthiocerol** be reserved for the original 3-methoxy congener (phthiocerol A) and that the term **phthioglycol** be used to refer to the family of compounds (*Onwueme KC et al., Prog Lipid Res 2005, 44, 259*).

Some branched alcohols play a role of pheromone in various insects. Among them, 4-methyl-5-nonanol (ferrugineol) is the aggregation pheromone of various species feeding on palm but especially the aggregation pheromone of the red palm weevil, *Rhynchophorus ferrugineus* (*Hallett RH et al., Naturwissenschaften 1993, 80, 328*)

and 5-methyl-octan-4-ol, the aggregation pheromone of the palmetto weevil, *Rhynchophorus cruentatus*. These compounds have been proposed for the biological control of these pest insects.

- Polyisoprenoid alcohols

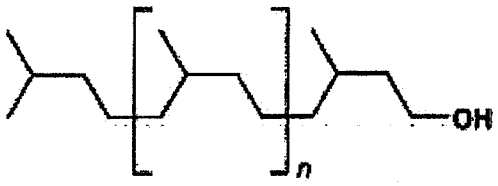
These compounds are fatty alcohols built of several **isoprenoid units (C5).** They are widespread among eukaryotes and prokaryotes and play important roles in cell function. They have been also found in geological sediments under saturated forms.

The isoprenoid chain may be either saturated or unsaturated.
A general nomenclature of these compounds may be found at the IUPAC web site.

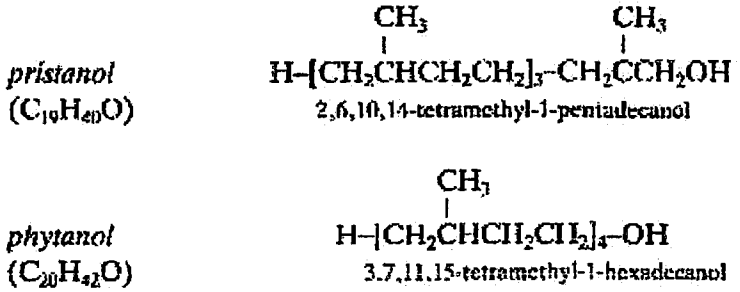
A - Saturated polyisoprenoids (Isopranols)

They have the following general structure :

Isopranols



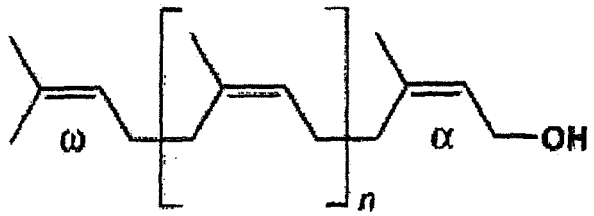
Among the most important saturated isopranols found in plants or in geological sediments are those having two (tetrahydrogeraniol), three (farnesanol), or four (phytanol) isoprenoid units. Pristanol (2,6,10,14-tetramethyl-1-pentadecanol) is tetramethylated but with only three complete isoprenoid units.



B - Unsaturated polyisoprenoids (prenols or polyprenols)

They have the following general structure :

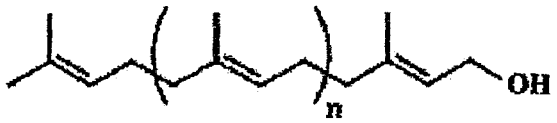
Polyprenols



These molecules consist of several up to more than 100 isoprene residues linked head-to-tail, with a hydroxy group at one end (α-residue) and a hydrogen atom at the other (ω-end).
Isoprenoid alcohols are also known as terpenols. Search for polyisoprenoid alcohols was initiated with the accidental discovery of solanesol in tobacco leaves (*Rowland RL et al., J Am Chem Soc 1956, 78, 4680*) and isolation of several polyprenols (C30-C45) in cellulose pulp extracts (*Lindgren BO, Acta Chem Scan 1965, 19, 1317*). Pioneer studies were summarized in a review by Hemming FW (*Biochem Cell Biol 1992, 70, 377*).
Head-to-tail assembly of the isoprenyl units produces polymers differing not only in chain length but in geometrical configuration.
Polyprenols are present in several bacteria, where they act as lipid carriers in the biosynthesis of cell surface polymers (*Rezanka et al., J Chromatogr A 2001, 936, 95*). They have also been described from cyanobacteria. The presence of C35–C45 polyprenols has been described in unicellular and filamentous cyanobacteria (*Bauersachs T et al., Org Geochem 2010, 41, 867*).

Naturally occurring polyprenols can be classified into four groups :

- 1. all *trans* forms : They have the following structure:



trans-Polyprenol

Some important members of the series are as follows:

n	Number of isoprene unit	Number of carbons	Name
0	2	10	Geraniol
1	3	15	Farnesol
2	4	20	Geranylgeraniol
3	5	25	Geranylfarnesol

7	9	45	Solanesol
8	10	50	Spadicol

Long-chain *trans*-polyprenol (n>8) have been characterized from *Eucommia ulmoides*.

Geraniol (from rose oil) is a monoterpene (2 isoprene units). It has a rose-like odor and is commonly used in perfumes and as several fruit flavors. Geraniol is also an effective mosquito repellent. Inversely, it can attract bees as it is produced by the scent glands of honey bees to help them mark nectar-bearing flowers and locate the entrances to their hives.

Farnesol is a sesquiterpene (3 isoprene units). It is the prenol that corresponds to the carbon skeleton of the simplest juvenile hormone described for the first time in insects in 1961 (*Schmialek PZ, Z Naturforsch 1961, 16b, 461; Wigglesworth VB, J Insect Physiol 1961, 7, 73*). It is present in many essential oils such as citronella, neroli, cyclamen, lemon grass, rose, and others. It is used in perfumery to emphasize the odors of sweet floral perfumes. It is especially used in lilac perfumes. As a pheromone, farnesol is a natural pesticide for mites. The dimorphic fungus *Candida albicans* has been shown to use farnesol as quorum-sensing molecule (*Hornby JM et al., Appl Environ Microbiol 2001, 67, 2982*).

Geranylgeraniol is a diterpene (4 isoprene units). Geraniol and geranylgeraniol are important molecules in the synthesis of various terpenes, the acylation of proteins and the synthesis of vitamins (Vitamins E and K). The covalent addition of phosphorylated derivatives of typical isoprenoids, farnesyl pyrophosphate and geranylgeranyl pyrophosphate, to proteins is a process (prenylation) common to G protein subunits. These isoprenylated proteins have key roles in membrane attachment leading to central functionality in cell biology and pathology. It has been demonstrated that a sufficient production of geranylgeraniol is required to maintain endotoxine tolerance in macrophages (*Kim J et al., J Lipid Res 2013, 54, 3430*).

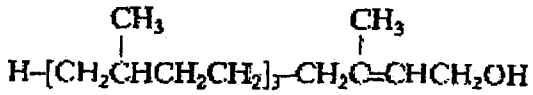
Solanesol, discovered in tobacco leaves in 1956 (*Rowland RL et al., J Am Chem Soc 1956, 78, 4680*), may be an important precursor of the tumorigenic polynuclear aromatic hydrocarbons of smoke but is also a possible side chain for plastoquinone. Solanesol is also present in the leaves of other Solanaceae plants including tomato, potato, eggplant and pepper. It has useful medicinal properties and is known to possess anti-bacterial, anti-inflammation, and anti-ulcer activities (*Khidyrova NK et Chem Nat Compd 2002, 38, 107*). Industrially, solanesol is extracted from Solanaceae leaves (about 450 tons in 2008) and used as an intermediate in the synthesis of

coenzyme Q10 and vitamin K analogues.

Spadicol was discovered in the spadix (inflorescence) of the Araceae *Arum naculatum* (*Hemming FW et al., Proc R Soc London 1963, 158, 291*). Its presence is likely related to its presence in the ubiquinone as the side-chain.

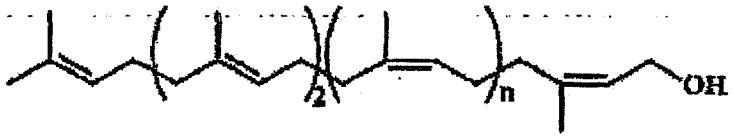
Phytol is a partially saturated diterpene, a monounsaturated derivative of geranylgeraniol which is part of the chlorophyll molecule :

phytol ($C_{20}H_{40}O$),



3,7,11,15-tetramethylhexadec-2-en-1-ol

- 2. di*trans*-poly*cis*-prenols, such as the bacteria prenol and betulaprenol types. In general, bacteria, as all prokaryotic cells, possess di*trans*-poly*cis*-prenols containing between 10 and 12 units, the most abundant being undecaprenol (trivial name bactoprenol).

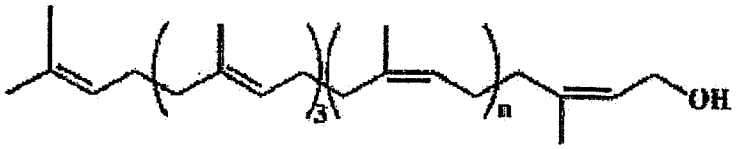


Bacteriaprenol type

Betulaprenols with n = 3-6 were isolated from the woody tissue of *Betula verrucosa* (*Wellburn AR et al., Nature 1966, 212, 1364*), and bacterial polyprenol with n = 8 were isolated from *Lactobacillus plantarum* (*Gough DP et al., Biochem J 1970, 118, 167*). Betulaprenol-like species with 14 to 22 isoprene units have been discovered in leaves of *Ginkgo biloba* (*Ibata K et al., Biochem J 1983, 213, 305*).

Polyisoprenoid alcohols are accumulated in the cells most often as free alcohols and/or esters with carboxylic acids. A fraction of polyisoprenoid phosphates has also been detected, and this form is sometimes predominant in dividing cells and *Saccharomyces cerevisiae* (*Adair WL et al., Arch Biochem Biophys 1987, 259, 589*).

- 3. tri*trans*-poly*cis*-prenols, of the ficaprenol type. Some of the earliest samples were obtained from *Ficus elastica*, giving rise to the trivial names ficaprenol-11 and ficaprenol-12 (*Stone KJ et al. Biochem J 1967, 102, 325*).



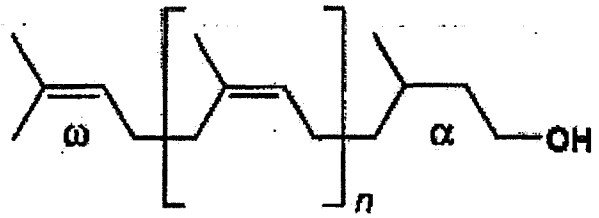
Ficaprenol type

In plants, the diversity of polyprenols is much broader, their chain length covers the broad spectrum of compounds ranging from 6 up to 130 carbon atoms (*Rezanka T et al., J Chromatogr A 2001, 936, 95*).

- 4. dolichol types, the α terminal is saturated.

Most eukaryotic cells contain one type of polyisoprenoid alcohols with one α-saturated isoprenoid unit (2,3-dihydro poly*cis*-prenols) which have been called **dolichol** by Pennock JF et al. (*Nature 1960, 186, 470*), a derivative of prenols. Most of these carry two *trans* units at the ω-end of the chain.
Dolichols (fro the Greek dolikos: long) have the general structure :

Dolichols



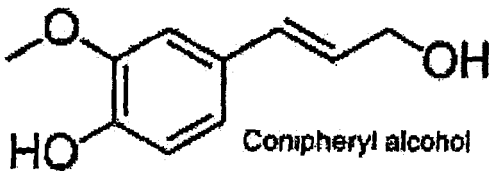
Dolichols isolated from yeast or animal cells consist mainly of seven to eight compounds, those with 16, 18, or 19 isoprenoid units being the most abundant (*Ragg SS, Biochem Biophys Res Comm 1998, 243, 1*). In human, dolichol-19 (D19, containing 19 isoprene units) is the most abundant species. Dolichol amount was shown to be increased in the brain gray matter of elderly (*Pullarkat RK et al., J Biol Chem 1982, 257, 5991*). Dolichols with 19, 22 and 23 isoprenoid units were described as early as 1972 in marine invertebrates (*Walton MJ et al., Biochem J 1972, 127, 471*). Furthermore, the pattern of their distribution may be considered as a chemotaxonomic criterion. It has been reported that a high proportion of dolichols is esterified to fatty acids. As an example, 85-90% of dolichols are esterified in mouse testis (*Potter J et al., Biochem Biophys Res Comm 1983, 110, 512*). In addition, dolichyl dolichoate has been found in bovine thyroid (*Steen L. et al., Biochim Biophys Acta, 1984, 796, 294*).
A characteristic shortening of plasma and urinary dolichols in retinitis pigmentosa

patients was observed (*Wen R et al., J Lipid Res 2013, 54, 3516*). Dolichol-18 (D18) became the dominant dolichol species in patients instead of dolichol-19 (D19) in normal individuals.
They are well known for their important role as glycosyl carrier in a phosphorylated form in the synthesis of polysaccharides and glycoproteins in yeast cells, and animals. Dolichyl phosphate is an obligatory intermediate in the biosynthesis of N-glycosidically linked oligosaccharide chains. Conversely, they have been identified as the predominant isoprenoid form in roots (*Skorupinska-Tudek K et al., Lipids 2003, 38, 981*) and in mushroom tissue (*Wojtas M et al., Chem Phys Lipids 2004, 130, 109*). Similar compounds (**ficaprenols**) have the same metabolic function in plants.

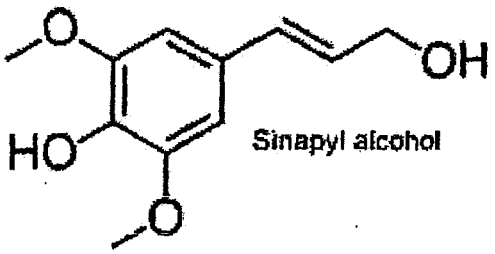
The repartition of the various types of polyisoprenoid alcohols between plants and animals and their metabolism have been extensively discussed (*Swiezewska E et al., Prog Lipid Res 2005, 44, 235*). Biosynthesis of polyisoprenoid alcohols and their biological role have been reviewed in 2005 (*Swiezewska E et al., Prog Lipid Res 2005, 44, 235*).

3 - Phenolic alcohols

Among the simple phenolic alcohols, **monolignols** are the source materials for biosynthesis of both lignans and lignin. The starting material for production of monolignols (phenylpropanoid) is the amino acid phenylalanine. There are two main monolignols: **coniferyl** alcohol and **sinapyl** alcohol. Para-coumaryl alcohol is similar to conipheryl alcohol but without the methoxy group.



Conipheryl alcohol

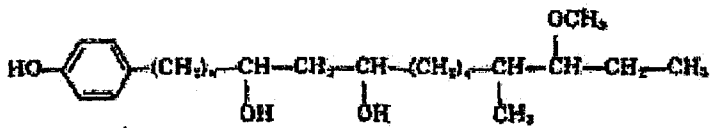


Sinapyl alcohol

Conipheryl alcohol is found in both gymnosperm and angiosperm plants. Sinapyl alcohol and para-coumaryl alcohol, the other two lignin monomers, are found in angiosperm plants and grasses. Conipheryl esters (conypheryl 8-methylnonanoate) have been described in the fruits of the pepper, *Capsicum baccatum* (*Kobata K et al.,*

Phytochemistry 2008, 69, 1179). These compounds displayed an agonist activity for transient receptor potential vanilloid 1 (capsaicin receptor) as the well known capsaicinoids present in these plant species.

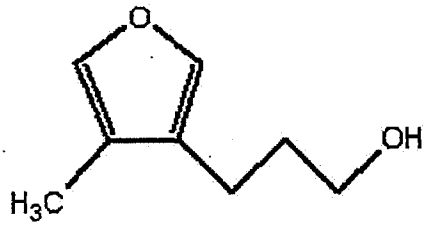
Complex phenolic alcohols (**phenolphthiocerol**) were shown to be components of *Mycobacterium* glycolipids which are termed glycosides of phenolphthiocerol dimycocerosate (*Smith DW et al., Nature 1960, 186, 887*) belonging to the large family of "mycosides". The chain length differs according to the homologues, 18 and 20 carbon atoms in mycosides A, and B, respectively. One of these phenolphthiocerols is shown below.



An analogue component but with a ketone group instead of the methoxy group, a phenolphthiodiolone, has been detected in mycoside A (*Fournie JJ et al., J Biol Chem 1987, 262, 3174*).

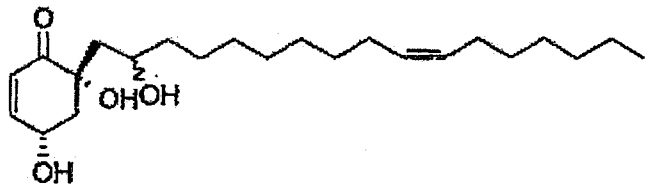
4 - Cyclic alcohols

An alcohol with a furan group, identified as 3-(4-methylfuran-3-yl)propan-1-ol, has been isolated from a fungal endophyte living in a plant, *Setaria viridis* (*Nakajima H et al., J Agric Food Chem 2010, 58, 2882*). That compound was found to have a repellent effect on an insect, *Eysarcoris viridis*, which is a major pest of rice.



3-(4-methylfuran-3-yl)propan-1-ol

Some cyclic alkyl polyols have been reported in plants. Among the various form present in an Anacardiaceae, *Tapirira guianensis*, from South America, two displayed anti-protozoal (*Plasmodium falciparum*) and anti-bacterial (*Staphylococcus spp*) activities (*Roumy V et al., Phytochemistry 2009, 70, 305*). The structure shown below is that of a trihydroxy-alcohol containing a cyclohexene ring.



4,6,2'-trihydroxy-6-[10'(Z)-heptadecenyl]-1-cyclohexen-2-one

As emphasized by the authors, external application of the active plant extract or of the purified compounds could represent an accessible therapeutic alternative to classical medicine against leishmaniasis.

FATTY ALDEHYDES

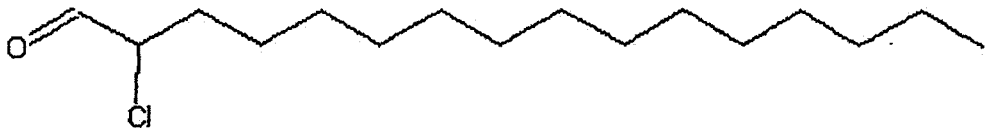
Long-chain aldehydes are found in free form, but also in the form of vinyl ether (known as alk-1-enyl ether) integated in glycerides and phospholipids (plasmalogens).
The free aldehydes can be as fatty acids saturated or unsaturated. They have a general formula $CH_3(CH_2)_nCHO$ with n=6 to 20 or greater. The most common is palmitaldehyde (hexadecanal) with a 16 carbon chain. Normal monoenoic aldehydes are analogous to the monoenoic fatty acids.
It must be noticed that an aldehyde function may be found at a terminal (ω) position while an acid function is present at the other end of the carbon chain (oxo fatty acids). These compounds have important signaling properties in plants.
Long-chain aldehydes have been described in the waxes which impregnate the matrix covering all organs of plants (*Vermeer CP et al., Phytochemistry 2003, 62, 433*). These compounds forming about 7% of the leaf cuticular waxes of *Ricinus communis* were identified as homologous unbranched aldehydes ranging from C22 to C28 with a hydroxyl group at the carbon 3. Long-chain 5-hydroxyaldehydes with chain lengths from C24 to C36, the C28 chain being the most abundant, were identified in the cuticular wax of *Taxus baccata* needles (*Wen M et al., Phytochemistry 2007, 68, 2563*). Long-chain aliphatic aldehydes with chain-length from C22 to C30 are also present in virgin olive oils, hexacosanal (C26) being the most abundant aldehyde (*Perez-Camino MC et al., Food Chem 2012, 132, 1451*).

Aldehydes may be produced during decomposition of fatty acid hydroperoxides following a peroxidation attack. Several aldehydes (hexanal, heptanal..) belong to aroma compounds which are found in environmental or food systems (see the website: Flavornet). Aldehydes (mono- or di-unsaturated) with 5 to 9 carbon atoms are

produced by mosses (Bryophyta) after mechanical wounding (*Croisier E et al., Phytochemistry 2010, 71, 574*). It was shown that they were produced by oxidative fragmentation of polyunsaturated fatty acids (C18, C20). Trans-2-nonenal is an unsaturated aldehyde with an unpleasant odor generated during the peroxidation of polyunsaturated fatty acids. It participates to body odor and is found mainly covalently bound to protein in vivo (*Ishino K et al., J Biol Chem 2010, 285, 15302*).
Fatty aldehydes may be determined easily by TLC or gas liquid chromatography (follow that link). The most common method for the determination of aldehydes involves derivatization with an acidic solution of 2,4-dinitrophenylhydrazine to form corresponding hydrazones followed by HPLC separation and UV–VIS detection. An optimized derivatization procedure for the determination of aliphatic C1-C10 aldehydes has been described (*Stafiej A et al., J Biochem Biophys Meth 2006, 69, 15*).
Other short-chain aldehydes (octadienal, octatrienal, heptadienal) are produced via a lipoxygenase-mediated pathway from polyunsaturated fatty acids (mainly C16 and C20) esterifying glycolipids in marine diatoms (*D'Ippolito G et al., Biochim Biophys Acta 2004, 1686, 100*). In nature, processes producing the disruption of phytoplankton cells are viral infection, grazing or/and cell lysis during senescence. Heighteen species of diatoms have been shown to release unsaturated aldehydes (C7:2, C8:2, C8:3, C10:2, and C10:3) upon cell disruption (*Wichard T et al., J Chem Ecol 2005, 31, 949*). The analyzis of the spatial distribution of the aldehydes produced by the phytoplankton in the Atlantic Ocean surface has shown that the total potential fatty adehyde concentrations ranged from zero to 4.18 pmol from cells in 1 L with, besides octadienal and decadienal, heptadienal being the most common (*Bartual A et al., Mar Drugs 2014, 12, 682*).
Several short-chain aldehydes were shown to induce deleterious effects on zooplankton crustaceans and thus limiting the water secondary production (birth-control aldehydes) (*D'Ippolito G et al., Tetrahedron Lett 2002, 43, 6133*). In laboratory experiments, three decatrienal isomers produced by various diatoms were shown to arrest embryonic development in copepod and sea urchins and have antiproliferative and apoptotic effects on carcinoma cells (*Miralto A et al., Nature 1999, 402, 173*). Later, the copepod recruitment in blooms of planktonic diatom was shown to be suppressed by ingestion of dinoflagellate aldehydes (*Nature 2004, 429, 403*). It was demonstrated that diatoms can accurately sense a potent 2E,4E/Z-decadienal and employ it as a signaling molecule to control diatom population sizes (*Vardi A et al., PLoS Biol 2006, 4, e60*). This aldehyde triggered a dose-dependent calcium transient that has derived from intracellular store. Subsequently, calcium increase led to nitric oxide (NO) generation by a calcium-dependent NO synthase-like activity, resulting in cell death in diatoms.

Myeloperoxidase-derived **chlorinated aldehydes** with plasmalogens has been reported. Thus, the vinyl-ether bond of plasmalogens is susceptible to attack by HOCl

to yield a lysophospholipid and an α-chloro-fatty aldehyde (*Albert C.J et al., J Biol Chem 2001, 276, 23733*). For example, 2-chloro-hexadecanal is formed by HOCl attack on the plasmalogen 1-O-hexadec-1'- enyl-*sn*-glycero-3-phosphocholine. Similarly, 2-chloro-octadecanal is formed from 1-O-octadec-1'-enyl-*sn*-glycero-3-phosphocholine.



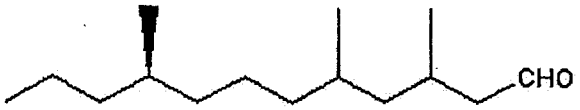
2-Chloro-hexadecanal

Both these chloro-fatty aldehydes have been detected in neutrophils activated with PMA (*Thukkani AK et al., J Biol Chem 2002, 277, 3842*) and in human atherosclerotic lesions (*Thukkani AK et al., Circulation 2003, 108, 3128*). Furthermore, 2-chlorohexadecanal was shown to induce COX-2 expression in human coronary artery endothelial cells (*Messner MC et al., Lipids 2008, 43, 581*). These data suggest that 2-chlorohexadecanal and possibly its metabolite 2-chlorohexadecanoic acid, both produced during leukocyte activation, may alter vascular endothelial cell function by upregulation of COX-2 expression.

Long after the demonstration of the presence of iodinated lipids in thyroid (besides iodinated aminoacids), it was shown that the major iodinated lipid formed in thyroid when incubated in vitro with iodide was 2-iodohexadecanal (*Pereira A et al, J Biol Chem 1990, 265, 17018*). In rat and dog thyroid, 2-iodooctadecanal was determined to be more abundant that the 16-carbon aldehyde. These compounds, which are thought to play a role in the regulation of thyroid function, were recently shown to be formed by the attack of reactive iodine on the vinyl ether group of PE plasmalogen. This attack generates an unstable iodinated derivative which breaks into lysophosphatidylethanolamine and 2-iodo aldehydes (*Panneels V et al, J Biol Chem 1996, 271, 23006*).

In some bacteria, aldehyde analogs of cyclopropane fatty acids were described.

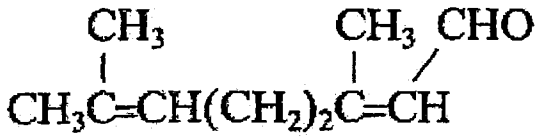
Several fatty aldehydes are known to have pheromone functions. Studies in African and Asian countries have shown that the use of 10,12-hexadecadienal could be effective for control of the spiny bollworm *Earias insulana*, a cotton pest. The sex pheromone of the navel orange worm, *Amyelois transitella*, 11,13-hexadecadienal, is usually used in the control of this citric pest.
A branched saturated aldehyde (3,5,9-trimethyldodecenal, stylopsal) has been identified as a female-produced sex pheromone in *Stylops* (Strepsiptera), an entomophagous endoparasitic insect (*Cvacka J et al., J Chem Ecol 2012, 38, 1483*).



Stylopsal

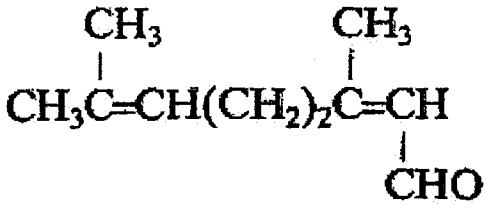
Several isoprenoid aldehydes are important in insect biology as pheromones and in botany as volatile odorous substances. Some examples are given below:

geranial
($C_{10}H_{16}O$)



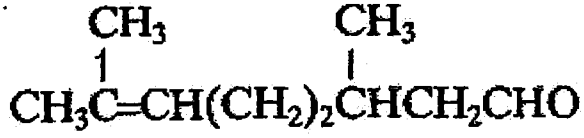
3,7-dimethyl-*cis*-2,6-octadienal

neral
($C_{10}H_{16}O$)



3,7-dimethyl-*trans*-2,6-octadienal

citronellal
($C_{10}H_{18}O$)



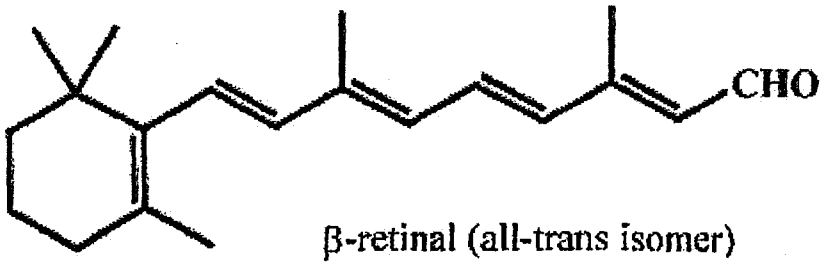
3,7-dimethyl-6-octenal

These three terpenic aldehydes are produced in large amounts by the mandibular glands of ants and may function as defensive repellents (*Regnier FE et al., J Insect Physiol 1968, 14, 955*). In contrast, the same molecules have a role of recruiting pheromones in honeybees

Citral, a mixture of the tautomers geranial (trans-citral) and neral (cis-citral) is a major component (more than 60%) of the lemongrass (*Cymbopogon flexuosus*) oil. Lemongrass is widely used, particularly in Southeast Asia and Brazil, as a food flavoring, as a perfume, and for its medicinal properties (analgesic and anti-inflammatory). It was found that citral is a major suppressor of COX-2 expression a an activator of PPAR$_\alpha$ and $_\gamma$ (*Katsukawa M et al., Biochim Biophys Acta 2010, 180*, *1214*).

It was demonstrated that damaged leaves released 2-hexenal, among other C6-volatile aldehydes, produced from the catalytic activity of hydroperoxide lyase (*Turlings TC et al., Proc Ntl Acad Sci USA 1995, 92, 4169*). These compounds, considered as signal molecules, can trigger several responses in neighboring plants and may also act as antimicrobial agents (*Farmer EE, Nature 2001, 411, 854*).

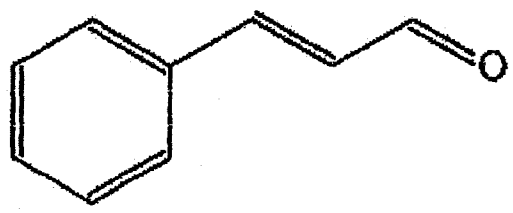
One important constituent of this group of aldehydes is **retinal**, one active form of vitamin A involved in the light reception of animal eyes but also in bacteria as a component of the proton pump.



β-retinal (all-trans isomer)

Retinal exist in two forms, a cis and a trans isomer. On illumination with white light, the visual pigment, rhodopsin is converted to a mixture of a protein (opsin) and trans-retinal. This isomer must be transformed into the cis form by retinal isomerase before it combines again with opsin (dark phase). Both isomers can be reduced to retinol (vitamin A) by a NADH dependent alcohol dehydrogenase. Retinol is stocked in retina mainly in an acylated form.

Cinnamic aldehyde (cinnamaldehyde) is the key flavor compound in cinnamon essential oil extracted from *Cinnamomum zeylanicum* and *Cinnamomum cassia* bark. Investigations have revealed than that benzyl aldehyde activates the Nrf2-dependent antioxidant response in human epithelial colon cells (*Wondrak GT et al., Molecules 2010, 15, 3338*). Cinnamic aldehyde may therefore represent a precious chemopreventive dietary factor targeting colorectal carcinogenesis.

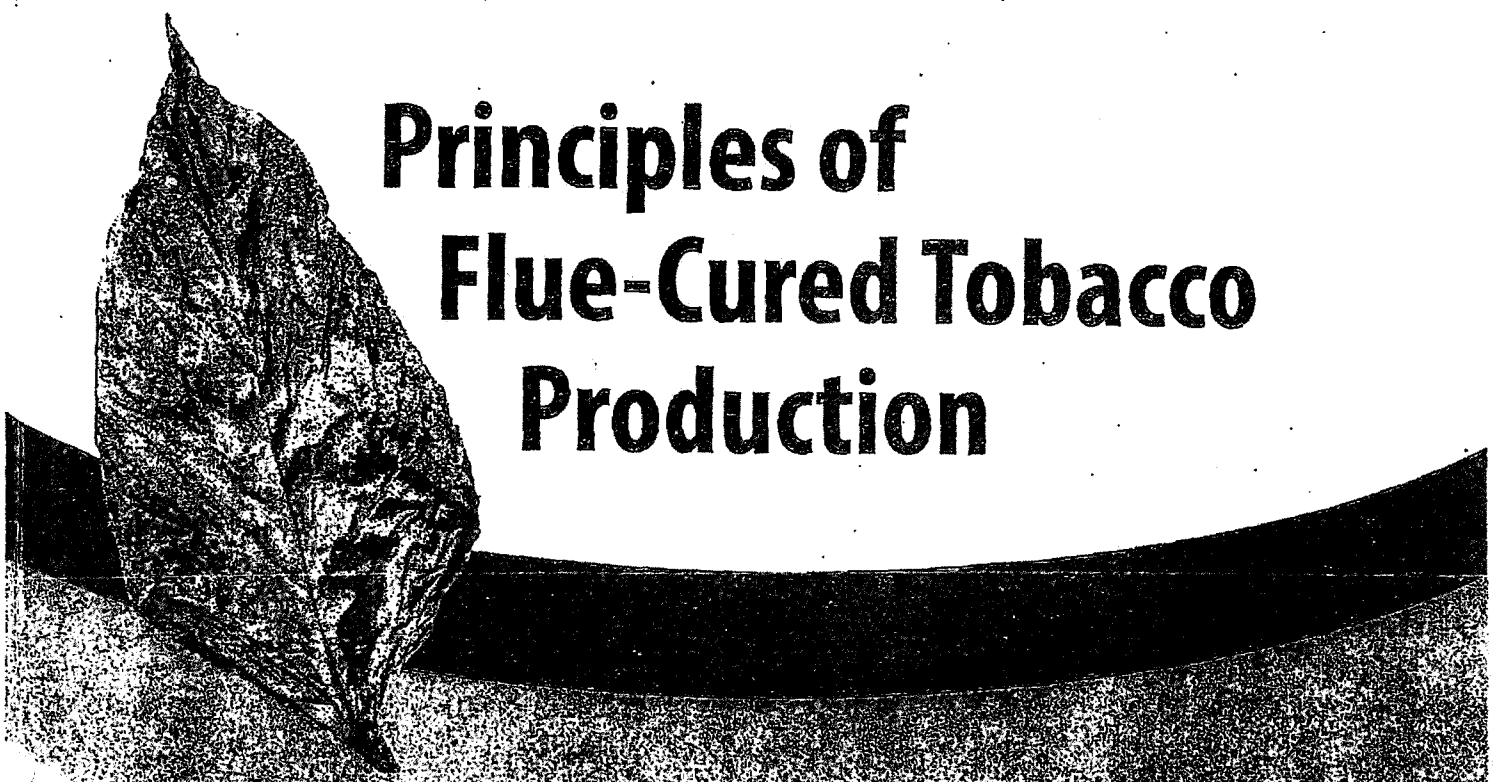


Cinnamic aldehyde

Use of Fatty Alcohols

For Sucker Control On Tobacco

Economic Benefits of Sucker Control



Principles of Flue-Cured Tobacco Production

Chapter XII

TOPPING AND SUCKERING

The tobacco plant grows with a single stem having a terminal (apical) bud which is apically dominant. Eventually, the terminal vegetative bud develops into a reproductive bud that produces flowers. If the seed head is allowed to develop, lateral buds ("suckers") begin to grow in the leaf axils. If the terminal bud is removed (topped), the suckers in comparison grow very rapidly. The sucker shoot is vegetative at first and then, like the terminal bud, becomes reproductive.

The tobacco plant produces a hormone in the terminal bud that inhibits the growth of suckers. When this source of the inhibition is removed the sucker buds begin to grow. At first, the upper three to four suckers develop. The terminal buds of these suckers also produce this hormone. If these are removed, additional suckers will develop down the stalks as well as secondary suckers at the upper leaf axils. A tobacco plant has the potential of producing three suckers at each leaf axil particularly at upper stalk positions. Under most cultural practices, however, we usually have only two that are of any consequence.

Most growers and buyers have found that removal of the tops along with the removal or restriction of growth of suckers results in certain desirable changes in the cured leaf. Experiments have shown that manual topping and hand suckering lead to an increase in root growth. This, in turn, increases the plant's potential to absorb water and nutrients and to synthesize nicotine. Also, topping and suckering reduce the weight at the top of the plant which makes the plant less likely to blow over during windstorms. The practice of topping and suckering reduces the drain on the leaves of certain organic and inorganic compounds used for growth by the plant; therefore, this practice can be expected to increase the weight and body of the leaves and to change their chemistry, especially those produced in the upper leaf positions.

Figure 32. Topping and sucker control (R) provide many benefits compared to not topped (L).

TOPPING

Whether or not a plant is topped, and if topped, the time of topping can have a pronounced effect on the cured leaf.

The data in Table 51 indicate that topping improves yield, increases price and value per acre, and increases the alkaloid and sugar content of the cured leaf. The yield increase is much greater for topping plus suckering than for topping and not suckering when compared to the not-topped plant. The same is true for the alkaloid and sugar content of the cured leaf. For maximum yield and dollar return, the plants should be topped and the suckers must be controlled either by hand or with plant growth regulators (chemicals).

The time of topping with manual sucker control will influence the yield and the quality of a tobacco crop as shown in Table 52 where manual sucker control was practiced and in Table 53 and Figure 33 with maleic hydrazide used for sucker control.

Table 51. Effect of Topping and Hand Suckering on Yield, Price, Total Alkaloids, and Reducing Sugars.[1/]

	1960-62			1962	
Treatment	Yield (lbs/A)	Price ($/cwt.)	Value $/A	% Total Alkaloids	% Reducing Sugars
Not topped or suckered	1390	63.99	890	1.76	13.30
Topped—not suckered	1487	64.99	966	2.36	17.30
Topped and suckered	1806	65.65	1186	2.80	18.20

[1/] Tests conducted by J.F. Chaplin, Z.T. Ford, and R.E. Currin, Agricultural Experiment Station, South Carolina.

The data in Table 52 show there was a marked reduction in yield and price/cwt. when topping was delayed beyond the early flower stage. Yield was lowered an average of 15 pounds per day. Total alkaloid content was reduced as topping time was delayed, except from the full to late flower stage, and sugar content was lowered with delayed topping after the early flower stage. Total nitrogen content

Table 52. Effects of Time (Flower Stage) of Topping of Flue-Cured Tobacco with Maleic Hydrazide Sucker Control, 1958-59.[1/]

Treatment2/	Yield lbs/A	Price $/cwt.	% Total Alkaloids	% Reducing Sugars	% Total Nitrogen
Button stage	2305	55.49	2.16	24.6	1.75
Early flower stage	2122	55.80	1.98	24.3	1.83
Full flower stage	1902	56.97	1.85	22.7	1.87
Late flower stage	1741	54.49	1.81	20.9	1.87

[1/]Tests conducted by H.V. Marshall, Jr., and Heinz Seltmann, N. C. State University.

[2/]Time lapse of 7 days between each of the 4 stages.

Table 53. Effects of Time (Flower Stage) of Topping Flue-Cured Tobacco with Manual Sucker Control, 1958-59. [1/]

Treatment	Yield lbs/A	Price $/cwt.	Suckers No./pl.	Pulled Wt./pl. (grams)	% Total Alkaloids	% Reducing Sugars	% Total Nitrogen
Button stage	1910	56.49	15.0	124	2.59	21.8	2.0
Early flower stage	1890	57.39	12.2	68	2.02	22.8	1.9
Full flower stage	1774	54.41	6.4	32	1.86	21.8	1.9
Late flower stage	1676	54.43	6.0	10	1.95	20.0	1.9

[1/]Tests conducted by H.V. Marshall, Jr., and Heinz Seltmann, N. C. State University.

Note: When the plants were topped in the button stage the first floral buds were well formed but no flowers were opened. There was a time lapse of 7 days between each of the 4 stages. All treatments were hand suckered.

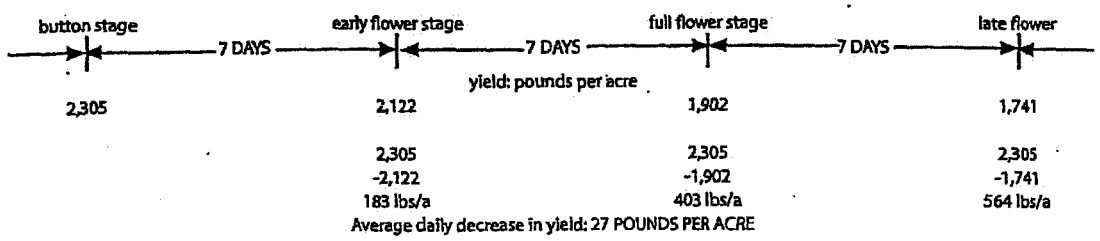


Figure 33. Four stages of flowering with yield for sucker control.

was not materially affected by topping time. As would be expected, a delay in topping reduced number of suckers and weight of suckers pulled. Leaves from plants which are topped earlier will be thicker, and have more oil and body, particularly those from the upper part of the plant.

Early topping with chemical sucker control (Table 52) consistently improved the yield more than when the suckers were controlled by hand (Table 53). And, topping in the button stage with chemical sucker control provided a yield improvement compared to topping at the early flower stage. This was not observed (Table 53) with manual sucker control.

There are several other benefits of topping in the button stage. Topping is completed before harvest begins. This helps spread the workload away from the peak harvest period. The chance of plants being blown over in a windstorm is reduced when they are topped. The populations of certain insects are lowered because eggs and larvae survival is nil on floral parts which are removed from the plants. The egg-laying moths of certain harmful insects are more attracted to the floral parts of the plant than older leaf tissue. If these eggs and larva can be effectively destroyed by topping, then costs, chemical residues, and possible hazards of insecticides are reduced.

Early topping is always important, especially when the plants grow under adverse conditions. Plants that reach the button stage in dry weather should be topped immediately to shift the available plant resources to the leaves. Under drought conditions, topping may reduce the need to be irrigated, due to stimulated root growth.

Plants that have a restricted root system from growing under relatively wet soil conditions should be topped as soon as the buttons appear and topped to fewer leaves than normal. As topping stimulates root development, plants will recover more rapidly as the soil dries.

Plants grown with excess nitrogen should be topped at the normal height rather than higher than normal. Thin leaves have been associated with excess nitrogen. Because of the extra number of leaves on high-topped plants, the leaves may be thin all the way to the top of the plant. When plants that are over-fertilized with nitrogen are topped normally, the leaves will be thin at first because of rapid growth, but after they have fully expanded they will thicken.

Chemical Topping

On most farms, plants should be topped when they have 18 to 20 harvestable leaves. Plants usually have this ma harvestable leaves in the prebutton stage. From a practi viewpoint, chemical topping is the only way topping can be accomplished at this stage of plant growth. Chemical topping maximizes the many benefits associated with early topping.

Chemical topping of some plants in the prebutton stage should be expected in crops with irregular growth and flowering when contact-type sucker control chemicals are applied with mechanical sprayers. This indicates that the time of application and the strength (concentration) of the contact spray were correct.

Chemically topped plants appear to be injured; however, there are several important benefits obtained from chemical topping. First, when chemical topping is observed on a percentage of plants in the field, a high degree of sucker kill is obtained, even on plants that were not chemically topped. The two sucker buds in contacted leaf axils are killed in most of the leaf axils.

Second, results from on-farm tests show plants topped in the prebutton stage yield more than if topped later. Th an appreciable amount of tissue destroyed in the butto when plants are chemically topped. The remaining leaf t sue continues to develop and produce good bodied leaf.

Leaf tissue and stems of the plants that are topped out by hand or by a topping machine are losses or reduction from maximum yield. Early chemical topping stops the plant from channeling plant resources into certain leaf tissue and floral parts that are not saved for market, but rather discarded on the ground.

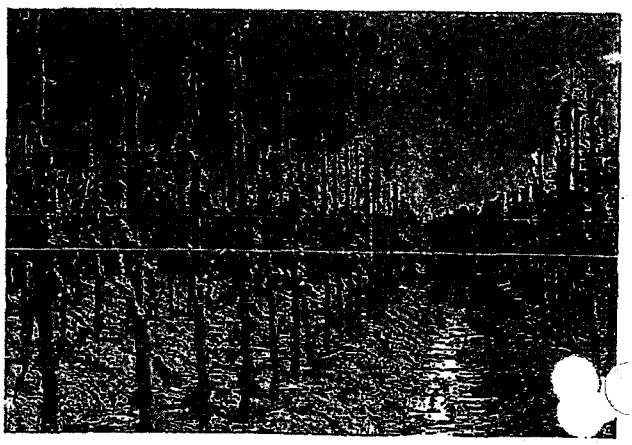


Figure 34. Elimination of sucker growth reduces food supplies for insects.

Third, the body of the remaining leaves on chemically topped plants will increase compared to those topped later by hand or mechanically.

Floral parts on tobacco plants should be looked at as pests. They rob the plant of its resources and reduce yield and leaf useability. Without exception, they are on every plant in every field. Therefore, time of topping is a management decision that must be made every year. Obtaining some chemical topping when the first contact spray is applied should be an objective each season.

A study conducted in Canada for three years, using five varieties with three topping times—early, normal, and late—showed a reduction in leaf size, length, and width when topping was delayed beyond the normal time.

Different varieties of tobacco reach the flowering stage at different times as measured from day of transplanting. The range with current varieties, under normal conditions, is from 55 to 65. A given variety may vary as much as 10 to 15 days from transplanting to flowering because of differences in soil and weather conditions. For a given variety, there is a good correlation between days to flower and number of leaves per plant. The varieties that bloom later will usually have a larger leaf number.

The height of topping often referred to as the number of leaves per plant, has been studied from many different aspects, i.e., different spacings, different nitrogen rates, different times of topping, different varieties, etc. This work can best be summarized as follows: with a given row width and spacing within a row, as plants are topped with fewer leaves, the yield is lowered. Nicotine content, leaf size, leaf thickness, and body of the cured leaf are increased. The degree of change in the leaf is influenced by the number of leaves per plant and by when the plants are topped. For example, plants which are topped as soon as the leaves to be saved are large enough to allow topping will be considerably different from plants which are allowed to flower out and then broken down to a low height. The leaf from the former will be heavier in yield and body than the latter. The low topped plants which are topped early, will have earlier increased root activity. Growth that would normally go to the upper leaves will be delivered to the leaves which will be saved. Conversely, plants topped low but late will have considerable growth in the upper part of the plant thrown away.

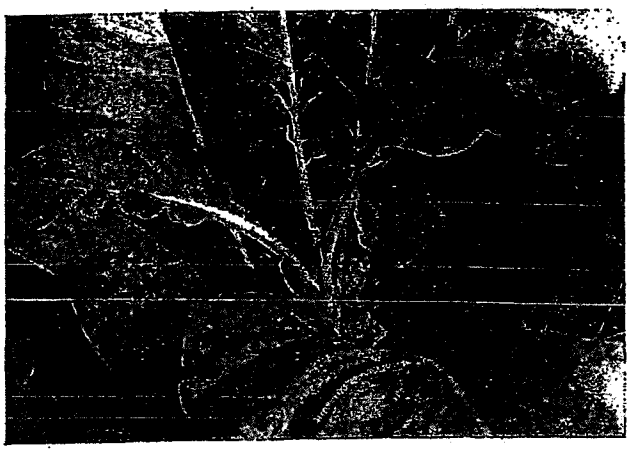


Figure 35. Chemically topping maximizes the benefits of early topping.

With a constant row and plant spacing, lower topping increases nicotine content as shown in Table 54. Lower topping is usually associated with early topping which would tend to increase nicotine. Also, lower topping reduces the leaf area per plant which would increase the concentration of nicotine.

The data in Table 55 show the effect of topping height on yield and price per cwt. using three populations of plants per acre. The yield was increased with higher topping at all plant populations and there was a general tendency for the price to be lowered with the higher topping. Tobacco from this test was evaluated by tobacco buyers. The preference was for tobacco from the higher topped plants where the low plant population was used. On the other hand, buyers preferred the tobacco from the lower topped plants where the high plant population was used. Consequently, the most desirable topping height is partially determined by the plant spacing or plant population. Plant population and leaf number per acre are discussed in more detail in Chapter XI.

Table 54. Effect of Topping Height on Nicotine Content.

Topping Height	Nicotine %
Not topped	1.49
20 leaves	1.61
10 leaves	2.64

Table 55. Effect of Plant Population and Topping Height on Yield and Price.[1/]

Treatment	Yield (lbs./A			Price ($/cwt.)		
Plants	(Leaves No./Plant)			(Leaves No./Plant)		
(No./A)	12	16	20	12	16	20
4800	1776	1925	2217	60.76	59.68	55.89
6400	1941	2149	2367	60.16	61.03	59.27
8000	2098	2195	2587	61.64	57.95	58.79

[1/]Test conducted by W.G. Woltz, N.C. State University.

SUCKER CONTROL

The degree of sucker control and yield are closely correlated. The higher degree of control normally results in a higher yield. The data in Table 56 show the effect of removing suckers of different lengths on yield and price of tobacco. Suckers were removed by hand when they were 12", 8", and 4" long and in one treatment they were "rubbed out" almost daily so that there was very limited growth. The degree of control had a very definite effect on yield, but a less pronounced effect on price. The higher percent sucker control also increased the body and nicotine content of the cured leaf.

Removing suckers by hand has always been a difficult and time-consuming job. In a 1978 study, Dr. Heinz Seltmann found that approximately 60 worker hours of labor were required to hand sucker an acre of flue-cured tobacco when the suckers were removed when they were four to eight inches long. This job is not only tiresome and monotonous, but it occurs during the harvest season which is a peak labor requirement period.

Chemical Sucker Control

Maleic hydrazide (MH), a systemic-type growth regulator that can be applied with a mechanical sprayer, was first used commercially on tobacco for sucker control in the early 1950's. The effects of MH on sucker control, yield, and price are shown in Table 57 and certain chemical properties in Table 58. Since MH became available, contact-type and contact local-systemic chemicals for tobacco sucker control have been developed and a standard practice has evolved to use one or two applications of a contact-type chemical applied in the button to early flower stage of floral development, followed by a MH-containing product or a contact-local-systemic chemical or a combination of two of these chemicals.

An understanding of how the various sucker control chemicals work is necessary to know the correct application technique for any sucker control chemical. Many factors are involved; however, the time of leaf and floral develop-

Table 56. Effect of Degree of Sucker Control on Yield and Price.[1/] Two locations, 1965-66.

Treatment	Sucker Control	% Yield lbs/A	Price $/cwt.	% Nicotir
Not suckered	—	1409	65.61	1.56
Topped not suckered	0	1566	65.00	2.03
(Topped and Hand Suckered)				
12 inch suckers	42	1847	67.75	2.61
8 inch suckers	53	1903	66.79	2.79
4 inch suckers	73	1926	66.73	3.10
Suckers rubbed out	99	2111	65.61	3.41

[1/]Tests conducted by Gerald Peedin and Heinz Seltmann, N.C. State Univ sity.

Table 57. Effect of Maleic Hydrazide on Sucker Control, Yield, and Pric of Flue-Cured Tobacco. 7 locations, 1967. [1/]

Treatment	Sucker Control (%)	Suckers No./pl.	Suckers Green Wt./pl. (grams)	Yield lbs/A	Pric
Topped not suckered	0	6.0	726	1672	
Topped hand suckered	42	20.6	418	2024	67.9
MH, 170 mg.	74	6.2	186	2280	68.3

[1/]Regional sucker control tests conducted in Florida, Georgia, South Carolina, North Carolina, and Virginia.

Table 58. Effect of Maleic Hydrazide on Certain Chemical and Physical Properties of Flue-Cured Tobacco. [1/] (Av. Middle and Top 1/3 of Plant).

Treatment	Equilib. Moisture @60% RH	Filling Value @60% RH	Total Nitrogen %	Total Alkaloid %	Reducin Sugars %
Hand suckered	13.40	4.29	2.34	3.75	13.90
MH, 170 mg.	14.04	3.74	2.30	3.38	17.47

[1/]Regional sucker control tests, 1963, conducted in Georgia, South Carolina North Carolina, and Virginia.

Weak contact solutions may contribute to poor, late-season sucker control as shown in Table 59.

Table 59.Sucker Growth with Three Contact Solutions.

Gallons		Percent	Suckers per Acre	
Contact	Water	Contact	Number	Pounds
1	49	2	29,900	6,256
1.5	48.5	3	15,600	4,794
2	48	4	7,800	1,950

Tests conducted by W.K. Collins with Off-Shoot-T.

ment that is desirable for a given chemical is of paramount importance.

Sucker control chemicals can be classified into the following four groups based upon how they must be used and how they affect the plant and sucker growth.

- **Contacts:** normal fatty alcohols (C_{10} or a mixture of C_6–C_{12} alcohols).
- **Systemic::** maleic hydrazide (potassium salt).
- **FST-7:** (a combination of C_{10} fatty alcohol and potassium salt maleic hydrazide).
- **Contact-local-systemic:** flumetralin (Prime+), butralin (Tamex), DCPA (Razor), and pendimethalin (Stomp).

Alcohol Contact Solutions must wet the small suckers to be effective. When the spray solution wets the more tender sucker tissues, it destroys the "waterproofing" layers by a drying action. As these cell membranes are being destroyed, the sucker will discolor. After several hours, the sucker will become brown and even black by the next day. The concentration of the solution is very important! If the concentration is too weak, sucker control is reduced; if the concentration is too strong, the leaves can be burned or leaf axils can be weakened which can cause leaf drop or an entry site for certain disease organisms.

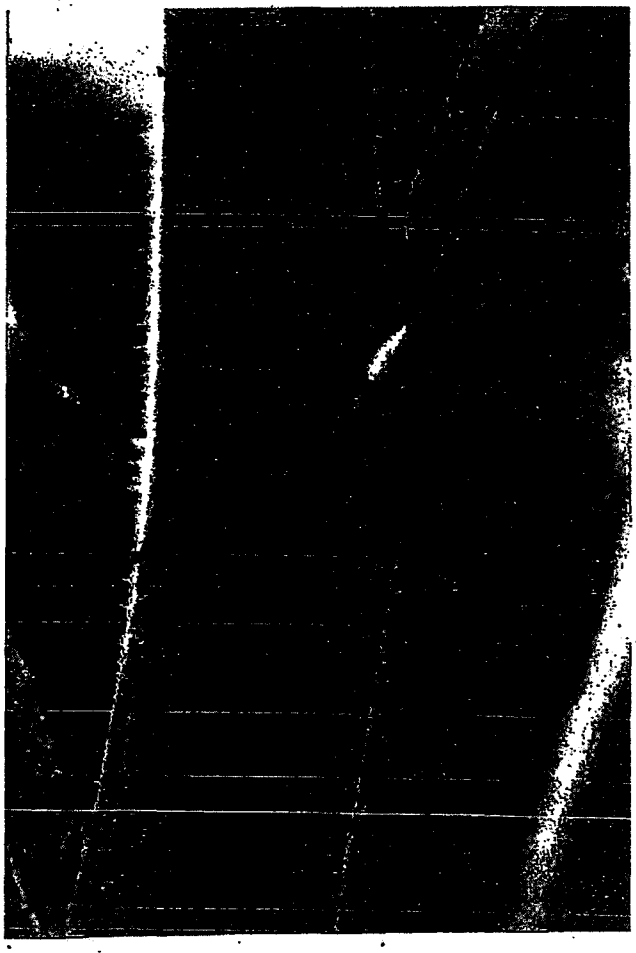


Figure 36. Contact solutions should be high enough concentration to kill both primary and secondary suckers

Weak contact solutions, those that are less than 4 percent of C_8 – C_{10} fatty alcohol, often visually do an acceptable job; however, experience has shown the secondary suckers grow rapidly and become too large for the second application of the contact to provide control. Then the sucker growth on vigorous growing tobacco cannot be controlled with the suggested rates of systemic-acting chemicals. A rule of thumb to use is to apply a contact solution that chemically tops 5 to 10 percent of the small, late plants in a field. If no plants are chemically topped during the first application, the solution may be too weak to provide maximum sucker control.

Data collected in on-farm sucker control tests (Table 60) show that sucker control with contact solutions is improved by applying a 5 percent concentration rather than a 4 percent solution for the second application.

The 4 and 5 percent concentrations of contact solutions are guidelines to follow. If plant growth is tender, good sucker control may be obtained with slightly reduced concentrations. If plant growth is tough, an increase in concentration is suggested to obtain good sucker control. Contact solutions kill suckers by a dehydration or drying action; therefore, if weather conditions favor evaporation, then the contact solutions kill suckers more quickly. Bright days with low relative humidity favor quick evaporation.

On the other hand, overcast or cool conditions reduce the speed of evaporation and also the degree of sucker kill. Under these conditions it may be in order to increase the concentration of the contact solution.

If the alcohol used is a C_{10} fatty alcohol, usually equal control is provided compared to the C_8–C_{10} with one percent less concentration.

Application should be with a relatively low pressure (20–25 psi) giving a large droplet size delivered from a triple nozzle arrangement for mechanical spraying. Plants should be standing straight up and application during high temperatures should be avoided.

The first application of a contact should be made when

Table 60. Sucker Control Treatments Used in On-Farm Tests Conducted by the N. C. Cooperative Extension Service in Alexander, Brunswick, Cumberland, Durham, Lenior, Granville, Person, Surry, and Yadkin Counties.

	Time of Topping[1]			Yield[2]	Quality[2]	Suckers/Acre	
Treatment	Button	3-5 days	About 7 Days After No. 2	lbs/A	Index[3]	No.	Lbs.
A	OST 4%[4]	OST 4%	RMH 1.5 gal/A[5]	2434	36.6	2029	170
B	OST 4%	OST 5%	RMH 1.5 gal/A	2483	36.8	1049	66

[1]The first application of contact agents applied with top on and plants topped immediately.
[2]No data from Granville and Yadkin Counties.
[3]Quality Index is a 1-99 rating based on government grades. Higher ratings indicated better quality.
[4]OST = Off-Shoot-T.
[5]RMH = Royal MH-30.

about 50–60 percent of the plants are in the button stage, the time when sucker buds are small and tender. A second application of the contact three to five days later will increase the chances that control will be effective on all suckers. A 5 percent solution of the contact at this stage usually increases the effectiveness.

A 5 percent strength is suggested because the plant is usually more developed and leaf tissue is thicker and able to withstand the increased concentration. Also sucker growth is likely to be less tender than at the time of the first application.

Make sure all solutions are kept mixed because the active ingredients (fatty alcohols) are lighter than water; therefore, they tend to float and must be constantly agitated to prevent separation. Because fatty alcohols are lighter than water, it is suggested that they be added to the spray tank while simultaneously adding water.

Some growers are applying a third contact application on irregular flowering crops three to five days after the second application. A 5 percent solution should be used when a third contact application is made.

If a contact solution is applied to a wet plant, the water present will dilute the solution, resulting in weaker concentration than planned.

The use of strong contact solutions increases the chance of leaf drop; however, this is rarely a problem unless excess nitrogen has been applied.

Some growers apply their contact solutions with hand-operated applicators. This method of application greatly increases the chance of the spray solution coming in contact with the sucker, especially where it is difficult to correctly apply contacts with mechanical sprayers. One hand application of a contact solution is usually adequate before a systemic chemical is applied.

The contact solutions do not move into the plant leaves and interfere with growth; therefore, leaf development continues and the production of good, medium-bodied tobacco is maximized. The chief role of a contact solution is to suppress sucker growth for one to two weeks after early topping (since yields are maximized by topping in the button stage), which allows immature, upper leaves to develop enough so that other chemicals that inhibit cell division can be applied without leaf damage.

Maleic Hydrazide (MH)

MH is one of the oldest pesticides in use today. It was synthesized and the plant growth inhibiting properties were discovered in 1947. MH is the only true systemic plant growth regulator used for sucker control on tobacco. Once absorbed by the plant, MH is freely translocated in the symplast to active growing points in the plant where its mechanism of action is a uracil antimetabolite. Translocation is more effective downward and once in growing points, MH inhibits cell division. Cell elongation remains unaffected.

For these reasons, small suckers are stopped after MH treatment. Slightly larger suckers develop at a greatly reduced rate but with very narrow leaves, and upper leaves that are 10 to 12 inches long will develop to their normal size.

MH is most effective when applied on a crop growing under good moisture conditions. This is because the cuticle of the

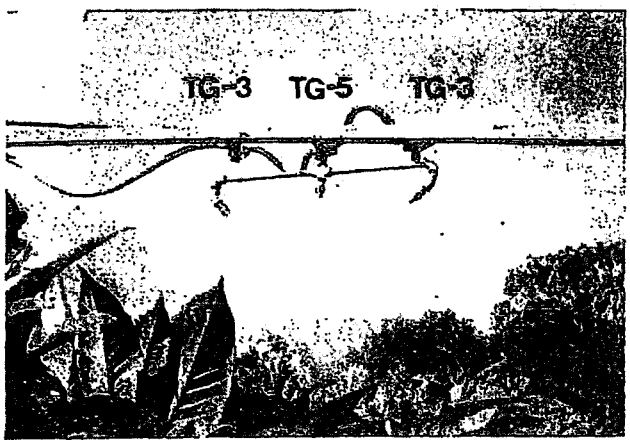


Figure 37. Triple nozzle arrangement for spraying contact-type solutions.

Figure 38. Application of contact-type solution with hand-operated applicators.

leaf is easier to penetrate when the plant is actively growing. Therefore, MH is more readily absorbed when conditions exist that favor good growth. Preferably, MH should be applied in the morning to dry plants about a week after the button stage.

Under normal conditions, MH can be expected to provide sucker control for only about six weeks after application. However, proper use of two contact solutions before MH is applied allows for late application of MH, which lengthens the period of effective sucker control.

The use of a contact-local systemic before, after, or in a tankmix with MH can extend sucker control well beyond the point at which control with MH alone would start to breakdown. This can be important because varieties developed in the last several years tend to mature later and remain in the field much longer than older varieties. Therefore, extended control is often needed.

MH residues are significantly higher than other pesticides used on tobacco. There are several reasons why this is the case. High residues can be explained by chemical properties of the MH molecule and use patterns by growers. Chemically, MH is a very stable molecule in and on plants. Several of the degradation and/or transfer processes for organic chemicals do not affect MH. For example, MH is resistant to decomposition by ultraviolet irradiation (UV) which is a major route of degradation for many pesticides. The decomposition temperature for MH is 260°C which is much higher than the maximum temperature that is used for stem drying flue-cured leaf, which is approximately 74°C. In addition, the vapor pressure of MH is essentially zero. Therefore, the amount of MH lost to volatilization is insignificant. Once inside the plant, MH becomes fixed and is not metabolized which also leads to a high percentage of applied chemical remaining.

These factors result in a higher percentage of the chemical in and on the cured leaf than is the case with most pesticides. However, MH has a water solubility of 6,000 ppm which is very high. Therefore, rainfall and/or irrigation plays a significant role in control of suckers and resulting MH residues. Rainfall too soon after application can reduce effectiveness of MH but rainfall after MH is absorbed has no effect on control but greatly reduces leaf residues.

For this reason, MH should be used according to the label, especially the precaution which states to wait at least seven days after application before the next harvest. Hopefully, a rain or irrigation or some dews will wash off the unbound MH left on the leaf surfaces and reduce those residues as shown in Table 61.

FST-7 which contains both a fatty alcohol (contact) and MH should be applied at the same stage of plant development as MH; but because it contains a contact, the mixture

Table 61. MH Residue Levels on Mid-Stalk Tobacco Between 0 and 4 Days After Application of MH at Upper Piedmont Research Station.[1/]

HARVEST TIME (Days After Application)	ppm	% Reduction
0	140	0
1	115	18
3[2/]	107	24
4	48	66

[1/] Conducted by Dr. T. J. Sheets (1978).
[2/] 2.2 inch rain on Day 3.

must be applied by the same methods used to apply contact chemicals. FST-7 should be applied no later than a week after the last contact application. This product contains 11 percent less MH than standard rates of other MH-containing products.

Flumetralin (Prime+), Butralin (Tamex), DCPA (Razor), and Pendimethalin (Stomp)

Of these chemicals, all but DCPA belong to a family of compounds known as dinitroanilines. Also, only Prime+ is currently labeled for use in the United States; however, Tamex, Razor, and Stomp are used for sucker control in many parts of the world.

All of these chemicals must wet the sucker, or the area where the suckers occur, to be effective. Their effectiveness is through systemic action by stopping localized cell division, but they do not move readily throughout the plant. Unlike MH, these products will cause malformed upper leaves if applied before the upper leaves have sufficient development.

Because these chemicals do not translocate readily, the systemic activity occurs locally where the chemicals are absorbed. Suckers will not turn brown or dry up. However, suckers may remain in leaf axils but will not grow.

The contact-local-systemic products must wet the sucker-growing areas (leaf axils); and for this reason plants should be standing straight at the time of application with contact-type nozzles and pressure. In this respect they also resemble the contacts. If a sucker is not wet by the spray solution, it will continue to grow with vigor and will become very large if not removed by hand.

Topping and Chemical Sucker Control Programs

Two topping and chemical sucker control programs have been developed. Each program is based on application of the correct rate of nitrogen fertilizer (50-80 lb/A), depending upon soil type plus adjustments for leaching. Excess nitrogen availability promotes excess sucker growth as well as leaf drop and breakage. Excess nitrogen delays maturity and thereby extends the length of time suckers must be controlled.

Program I (Machine Sprayer Application)

Step 1. Apply an alcohol contact spray, usually at 4% concentration (2 gals contact in 48 gals water), before topping when about 50-60% of the plants reach the button stage. The floral parts help to intercept sprays to increase sucker kill in the upper leaf axils.

Step 2. Top plants that are ready for topping immediately after the application of the contact solution.

Step 3. Apply a second application of an alcohol contact at 5% concentration (2.5 gals contact in 47.5 gals water) 3-5 days after the first contact application. (Fields with irregular growth and flowering may need a third alcohol contact several days after the second contact application.)

Step 4. Top remaining plants that were not topped during the first topping.

Step 5.

Alternative A
Apply 1.5 gal/A of MH (for products containing 1.5 lb/gal active MH) about 5-7 days after the second or third contact.

Alternative B
Apply the tankmix of 1.5 gal/A of MH (for products containing 1.5 lb/gal active of MH) and 2 qts/A of Prime+ at the normal time for MH application. Application should be made as a coarse spray in 50 gpa of total solution such as with contact application (3 nozzles/row: TG-3, TG-5, TG-3, or equivalents).

Alternative C
Apply 3 gals/A of FST-7 about 5-7 days after the second or third contact. This product is a combination of a contact (C_{10}) alcohol and MH, but contains 11% less MH than other MH products, based on labeled rates.

Alternative D
In place of the second or third (if applicable) contact, apply 2 qts/A of local contact-systemic acting Prime+ mixed in 49.5 gals of water in the elongated button to early flower stage. Application can be by the dropline method or by tractor-mounted sprayer. If applied by tractor-mounted sprayer, apply as a coarse spray with low pressure just as a contact application would be made. Other local-contact-systemic products in use in some countries are being developed for U.S. growers that should be applied the same way. About 1 week after Prime+ application, apply the labeled rate of MH.

Step 6. (Needed only if sucker regrowth is anticipated late in the season)

Alternative A
Apply a 5% contact solution (2.5 gals in 47.5 gals) using the standard application procedure for contacts. This should be done 3-4 weeks after MH application when suckers are small and susceptible to contact burn. Large suckers (greater than 1 inch) should be removed by hand.

Alternative B
Apply 2 quarts/A of Prime+ using the standard application procedure for contacts. (50 gals total solution/acre, 3 nozzles/row, low pressure, etc). This should be initiated 3-4 weeks after MH application. Large suckers (greater than 1 inch) should be removed by hand. If Prime+ was used earlier for sucker control, allow 1 week between Prime+ application and harvest.

Soil residues of Prime+ from the previous tobacco crop may contribute to stunted early-season growth of following crops, especially small grains and corn but may also include nonrotated tobacco, especially if the full labeled rate of Prime+ is used for sucker control. To minimize possible injury to crops planted in the fall or following spring, follow labeled mixing instructions and do not apply an excessive volume to the point of runoff. Also, after the last priming, follow stalk and root destruction practices, and two weeks later bury the stalks and roots using a moldboard plow set at a depth of 5-6 inches. Disk 1 or 2 times before planting a small grain cover crop.

In recent years, carryover of Prime+ has not been observed where the 2 qt/acre rate of Prime+ has been used. Current recommended sucker control programs include Prime+ at 2 qts/acre. From both a sucker control and carryover standpoint, growers are advised not to exceed 2 qts/acre of Prime+ per crop per year.

Program II (Hand or Dropline Application)

Alternative A
Apply Prime+ using the dropline method with 1/3-2/3 fl. oz. of solution per plant without using a contact solution; prepare the Prime+ solution by mixing 1 gal Prime+ in 49 gals of water (2.5 fl. oz. Prime+ per gal of water). Top and hand sucker when approximately 50% of the plants are in the elongated bud-to-early flower stage. During topping or within a few hours, treat with Prime+. As the remainder of the plants reach this stage, they should be topped, large suckers removed and treated, being careful not to treat any previously treated plants or use more solution than necessary to reach the bottom of the stalk.

Alternative B
Apply a contact solution at the button stage. When 50% of the plants reach the elongated button-to-early flower stage, apply Prime+ preferably with the dropline method as in Alternative A, Program II above, or use a power sprayer to apply 30-50 gals/A of Prime+ solution made by mixing 2 quarts of Prime+ with 49.5 gals of water. The purpose of the initial contact is to allow the smaller plants to become more mature before Prime+ application. However, spraying Prime+ may cause distortion of upper leaves on young plants, so a judgement must be made to spray Prime+, use the dropline with Prime+, or another alternative in Program I based on the amount of unevenness in the crop.

The Use of Surfactants with Prime+. In on-farm tests, 0.25% X-77 (1 pt/50 gal) is often added to the spray solution where Prime+ is used alone. Some other surfactants have been phytotoxic to tobacco when added to Prime+. The use of surfactants other than X-77 with Prime+ is discouraged due to some surfactants showing phytotoxicity and also a lack of research data to indicate which surfactants can be successfully used. [Surfactants or adjuvants, including X-77, should never be added to the tankmix of Prime+ and MH].

Additional Items to Consider

(1) Large suckers missed by the contact or contact-local-systemic chemical have to be removed by hand.

(2) MH should be applied only once, according to label, unless there is a "wash-off" within 6 hours after application.

(3) MH is known to retard the development of the brown spot organism.

(4) MH residues continue to be a concern among buyers. Prime+ does not contain MH and the low residues of its active ingredient may be an advantage in the expansion of markets.

(5) MH will tend to make the upper leaves turn yellow or bronze, especially if applied too early or if excessive amounts are used. Bronzing is a result of destruction of chlorophyll and does not mean that the leaves are ripe.

(6) Prime+ and other local-systemics may tend to keep upper leaves green longer.

(7) MH has been observed to greatly reduce broomrape (OROBANCHE) when sprayed on tobacco in fields infested with this parasite.

Chapter XIII

HARVESTING AND CURING

There are two major objectives in curing flue-cured tobacco:

(1) to provide temperature and humidity conditions which will encourage certain desirable chemical and biological changes to take place, while using minimum quantities of fuel and
(2) to preserve the leaf by timely drying to retain the potential quality. Curing is more than drying the leaf. It involves chemical and physical changes which are necessary for high quality tobacco suitable for manufacturer and consumer acceptance.

The harvesting and barning operation requires more labor than any other part of tobacco production. It has been estimated that 247 man-hours are required to harvest and barn one acre of tobacco when the crop is harvested and the leaves are strung on sticks by hand. The use of tying machines and conventional barns offers a significant reduction in labor. Machines for harvesting and bulk barns for curing are being used which reduce the labor requirement considerably.

HARVESTING

The first requirement in having a good uniform cure is to start with uniformly ripe tobacco. Under normal conditions, flue-cured tobacco ripens at the rate of 2 to 4 leaves per week, thus the normal harvest rate before mechanization was from 2 to 4 leaves per plant per week for a period of 5 to 7 weeks. Many factors can influence the maturity and harvest rate. For example, certain diseases such as root knot

Figure 39. Hand harvesting for curing on sticks or bulk barns.

Recommendations for the use of agricultural chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by North Carolina State University nor discrimination against similar products or services not mentioned. Individuals who use agricultural chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage regulations and examine a current product label before applying any chemical. For assistance, contact your county Cooperative Extension Center.

A PRECAUTIONARY STATEMENT ON PESTICIDES

Pesticides must be used carefully to protect against human injury and harm to the environment. Diagnose your pest problem, and select the proper pesticide if one is needed. Follow label use directions, and obey all federal, state, and local pesticide laws and regulations.

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Select **Crop Production** and **Tobacco.**

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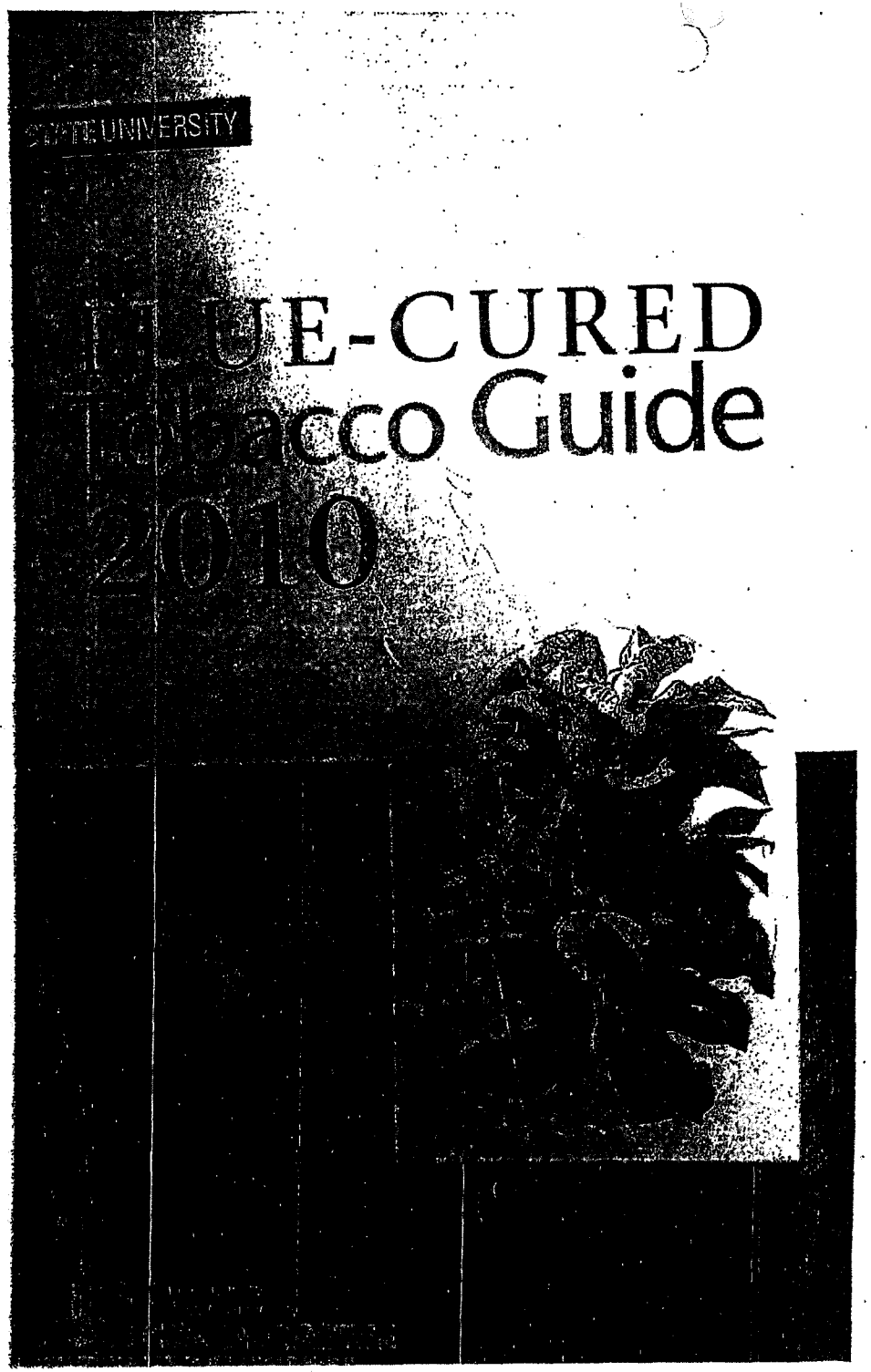

Table 1-3. Flue-cured tobacco—machine harvest—eastern North Carolina: 2010 estimated costs per acre

	Unit	Quantity	Price/Cost per Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		Yield	Price/lb		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou	6.20	$34.00	$210.80	
Multipurpose fumigation	gal	10.50	$13.00	$136.50	
Fertilizer					
8-16-24	lb	7.00	$25.19	$176.33	
15.5-0-0	lb	300.00	$0.33	$99.00	
Lime (prorated)	ton	0.33	$51.75	$17.08	
Herbicides	acre	1.00	$40.55	$40.55	
Insecticides	acre	1.00	$36.59	$36.59	
Fungicides	acre	1.00	20.31	20.31	
Sucker control	acre	1.00	$109.26	$109.26	
Hauling	lb	2,400.00	$0.04	$96.00	
Cover crop	acre	0.00	$15.00	$0.00	
Curing fuel	gal	275.00	$1.30	$357.50	
Electricity	kwh	1,580.00	$0.08	$126.40	
Crop insurance	$	1.00	$65.00	$65.00	
Baling supplies	$	2,400.00	$0.003	$7.20	
Tractor/machinery	acre	1.00	$227.33	$227.33	
Labor					
Preharvest	hr	29.00	$8.85	$256.65	
Harvest (trash)	hr	51.00	$8.85	$451.35	
Machinery preharvest	hr	3.82	$8.85	$33.81	
Machinery harvest	hr	18.25	$8.85	$161.51	
Interest on op. capital	$	$423.21	9.25%	$39.15	
Total variable costs				$2,668.32	
3. Income above variable costs					
4. Fixed costs					
Tractor/machinery	acre	1.00	$328.12	$328.12	
Bulk barn	acre	1.00	$173.33	$173.33	
Total fixed costs:				$501.45	
5. Total costs				$3,169.77	
6. Net returns to land, risk, and management					

- Crop Insurance: 65% based premiuim. No disaster subsidies.
- Producers who employ guest workers should also include other expenses (such as housing, and transportation) associated with labor.
- Please note: This budget is for planning purposes only.
- May need two applications of Ridomil for black shank @ $40/application.

Prepared by Gary Bullen, Loren Fisher, and Emily Weddington, N.C. State University, Department of Agricultural and Resource Economics.

Table 1-4. Flue-cured tobacco—machine harvest—piedmont North Carolina: 2010 estimated costs per acre

	Unit	Quantity	Price/Cost per Unit	Total per Acre	Your Farm
1. Gross receipts					
Stalk position		Yield	Price/lb		
Lugs	lb	0.00	$0.00	$0.00	
Cutter	lb	0.00	$0.00	$0.00	
Leaf	lb	0.00	$0.00	$0.00	
Tips	lb	0.00	$0.00	$0.00	
Total receipts				$0.00	
2. Variable costs					
Plants (greenhouse)	thou.	6.20	$34.00	$210.80	
Multipurpose fumigation	gal	10.50	$13.00	$136.50	
Fertilizer					
8-16-24	lb	7.00	$25.19	$176.33	
30% UAN	lb	160.00	$0.32	$51.20	
Lime (prorated)	ton	0.33	$51.75	$17.08	
Herbicides	acre	1.00	$40.55	$40.55	
Insecticides	acre	1.00	$36.59	$36.59	
Sucker control	acre	1.00	$109.26	$109.26	
Hauling	lb	2,500.00	$0.04	$100.00	
Irrigation	times	3.00	$26.47	$79.41	
Cover crop	acre	0.00	$15.00	$0.00	
Curing fuel	gal	275.00	$1.30	$357.50	
Electricity	kwh	1,580.00	$0.08	$126.40	
Crop insurance	$	1.00	$65.00	$65.00	
Baling supplies	$	2,500.00	$0.003	$7.50	
Tractor/machinery	acre	1.00	$203.78	$203.78	
Labor					
Preharvest	hrs	29.00	$8.85	$256.65	
Harvest	hrs	51.00	$8.85	$451.35	
Machinery preharvest	hrs	3.82	$8.85	$33.81	
Machinery harvest	hrs	18.25	$8.85	$161.51	
Interest on op. capital	$	$389.16	9.25%	$36.00	
Total variable costs				$2,657.22	
3. Income above variable costs:					
4. Fixed costs					
Tractor/machinery	acre	1.00	$328.12	$328.12	
Irrigation	acre	1.00	$79.42	$79.42	
Bulk barn	acre	1.00	$173.33	$173.33	
Total fixed costs				$580.87	
5. Total costs				$3,238.09	
6. Net returns to land, risk, and management					

- Crop insurance: 65% based premiuim. No disaster subsidies.
- Producers who employ guest workers should also include other expenses (housing, transportation, etc.) associated with labor.
- Please note: This budget is for planning purposes only.

Prepared by: Gary Bullen, Loren Fisher, and Emily Weddington, N.C. State University, Department of Agricultural and Resource Economics

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1983

EARLY TOPPING AND GOOD SUCKER CONTROL GET JUMP ON R-9-P Program

W. K. Collins

It has been know for a long time that good sucker control reduces the supply of tender foliage which is a major food supply for insect buildups. In fact, many people believe the degree of sucker control achieved with MH containing products has played a significant role in sharply reducing hornworm populations.

The R-9-P Program of early stalk and root destruction reduces food supplies for certain insects and diseases to build up on after harvest. Good sucker control does a similar thing even while tobacco is still in the field.

Early topping of tobacco is known to help control budworms and reduce the need for insect applications just before harvest.

Early topping reduces the attractiveness of tobacco plants to budworm moths looking for a place to lay their eggs, and removes many larvae already present.

By reducing the need for pesticides, early topping increases worker safety and protects beneficial insects and the environment in general. Also, potential residues on the cured leaf are reduced.

Tobacco budworms do most of their damage to tobacco before flowering occurs. But tobacco budworm moths prefer buttons and flowers to leaves as sites to deposit eggs, and the moths are strongly inclined to lay eggs after the buttons appear.

Eggs laid by the moths hatch into tiny larvae in about three days. If topping is done early, many eggs and recently hatched larvae are thrown to the ground with the tops. Research shows that the survival rate of these eggs and larvae is practically nil.

Most growers could top their tobacco earlier than they do and get this important job completed before harvest begins. And when topping is done in the

button stage, the stems are easier to break than later when the seedhead is more mature. If topping is done with a machine it is suggested to run the topping machine over the field several times.

Tops in tobacco tend to suppress sucker growth down the stalk, however. So when tops are removed, suckers must be controlled, or rapid and profuse sucker growth is likely to occur. Sucker growth limits development of upper leaves, which are by far the most profitable ones on the plant. Also, suckers provide food for young budworms and hornworms in addition to supplying a preferred site for hornworm egg laying.

Contact sucker control agents that have come into widespread use during the last 10 years are the answer to controlling early sucker growth. These chemicals hold down sucker development until a systemic acting chemical is applied. The contact solution does not interfere with development of harvestable leaves or leave objectionable chemical residues.

Most growers using contact sucker control agents are not applying them early enough or in solutions that are strong enough to kill both of the suckers in the leaf axils contacted.

Contact solutions should be applied just prior to topping when the tobacco is in the button stage. Tops tend to intercept spray patterns and increase the amount of rundown into the leaf axils. This is particularly needed to increase the degree of sucker control in upper leaf axils. Plants should be topped as soon as possible after spraying the contact sucker control agent.

Here is a list of reasons why you should top early:

- Yields are increased 20 to 25 pounds per acre per day for each day plants are topped in the button stage compared to later topping. There is some, but much smaller, yield increase by topping before the button stage.

- Budworm populations very likely would be lowered by the destruction of eggs and larvae on the developing flower.
- The need for insecticide applications may be reduced. Reduction in insecticide applications also would reduce possible hazards to workers handling green tobacco.
- Blowing over by wind is less likely to occur to topped plants.
- Topping is completed before harvesting starts. This spreads your work-load away from the harvest period and puts you ahead in profits. You stay ahead of your work.

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May 18, 1983

1983

ECONOMICS OF EARLY TOPPING AND GOOD SUCKER CONTROL

W. K. Collins

Growers are more concèrned about controlling production costs in this crop than in previous years. One of the best ways to control production costs is by producing a high yield of tobacco that buyers find has high useability.

Many factors influence yield but one of the major ones is your topping and sucker control program. When you make decisions about topping and suckering most of your yield is made. However, too many people overlook the opportunity to greatly increase yield and value at this stage of production. They should not because the economics of an early topping and good sucker control program are fantastic not to mention the numerous other advantages.

Early topping and a good sucker control program make it possible for you to get some extra pounds at a relatively low cost. The table below shows a 137-pound-per-acre advantage for topping in the button stage compared to topping a week later in the early flower stage. Tobacco in the on-farm tests was topped in the button stage, treated with two applications of a contact chemical, and then treated again with a MH-containing product about a week later. Plants in the other treatment were topped in the early flower stage and treated only with a contact-local-systemic sucker control product.

Results of 5 On-Farm Tests, 1982

Topping Time	Yield lbs/A
Button	2354
Early Flower	2217
INCREASE	137

Here is how much you might expect net profits to increase using a suggested topping and sucker control program. Figure the increase (137 pounds per acre) in yield sells for $1.90 per pound or $260 extra per acre. This is gross return from which some costs should be subtracted. However, you will be surprised at the low costs involved because many of them are already spent on the crop regardless of yield.

The costs of the sucker control treatments are considered to be the same. Therefore, the only extra costs associated with the extra yield are for curing fuel, marketing to include the 7¢ per pound assessment costs, and the value of the quota.

Curing @ 12¢/lb X 137 lbs	$ 16.44
Selling @ 12¢/lb X 137 lbs	16.44
Value quota @ 60¢/lb X 137 lbs	82.20
TOTAL INCREASED COSTS	$115.08

Some costs are actually reduced. It takes only about half the labor for "cleaning up" and topping at the button stage as compared with doing this job later in the early flower stage. And insecticide costs may be lowered because certain insect populations are lowered more by early topping than performing this practice later.

To compute the net profits per acre, subtract the total costs ($115.08) from the gross return ($260.00) and you have $144.92. Divide this by your anticipated yield and you will have the net increase per pound of tobacco.

If your yields are 2354 pounds per acre, divide them into $144.92 and you will see net returns are increased 6.2¢ per pound.

A frequently asked question is, "Aren't harvesting costs increased for the extra (137 pounds per acre) yield?" The answer is no, because no additional leaves are harvested to obtain the extra yield. The extra weight comes from

an increase in size and weight of the leaves. Harvest costs are directly related to the number of leaves handled.

A contact-type sucker control solution should be applied at 4 percent concentration just before plants are topped in the button stage. A second application of a contact at 5 percent concentration should be made 3 to 5 days after the first application. Then apply a systemic acting chemical.

The use of contact solutions provide sucker control during the period when the numerous advantages from early topping can be obtained and to allow time for sufficient upper leaf development before a systemic acting chemical should be applied.

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TOP EARLY FOR TOP YIELD

W. K. Collins

1983

After tobacco plants reach the button stage, potential yield is reduced 20 to 25 pounds per acre per day for each day the seed producing floral part remains on the plant. And, the body of the tobacco is reduced. The best market outlook in 1983 is for good, medium-bodied mature leaf. Tobacco is grown for the leaves, not seed; therefore, top your tobacco early to increase chances for leaf growth. Topping followed by good sucker control decreases the opportunity for the plant to use plant resources for top growth aimed at seed production.

Plants go through two stages of development. One is the vegetable stage and the second is the reproductive or seed producing stage.

When plants are in the reproductive stage most of their resources are directed into the flower portion of the plant. When plants are topped, the reproductive phase is temporarily stopped and the energy of the plant redirected to foliage production, either leaf or sucker growth.

The development of a tobacco plant at a given time is directed primarily to either vegetative or reproductive growth but not equally to both at the same time.

The growth emphasis of tobacco plants can be kept on leaf development by early topping and good sucker control practices.

Early topping should be practiced under all growth conditions. Although early topping is important at all times, it is more important to top plants early under adverse growing conditions. For example, plants that reach the button stage in dry weather should be topped immediately to shift the available plant resources to the leaves.

Some growers hesitate to top plants in dry weather because of their concern about a shortage of leaves for future growth. But leaf number at this stage has already been determined, and topping will not affect the number of leaves the plant will have.

Some growers do not top in dry weather because they fear the possible effects of loss of water from where the stem is broken for a short time until the area heals over. This quantity of water loss is relatively small compared to the amount of water and other plant resources used and lost in flower development.

Plants that flower prematurely may be cut back or topped. Unless more than 10 percent of the plants have premature flowered, usually the best practice is to do nothing. If premature flowering plants are topped, a vigorously growing sucker should be turned out so additional leaves can form. Prematurely flowered plants should be topped low enough so the upper remaining leaf will get large enough to harvest. This may mean cutting the plant off fairly close to the ground.

Care should be taken to prevent the spread of mosaic when working with premature flowered plants. Avoid the use of tobacco products and use the milk treatment during the operation.

Plants that have a restricted root system because of wet soils should be topped as soon as flowering begins and topped with fewer than the normal number of leaves. Topping stimulates root development and will help plants recover from this adverse situation as soils dry out.

Plants that are growing with a deficient nitrogen supply should be topped as soon as flowering commences. This will promote the use of available nitrogen for leaf development instead of top growth.

Topping and good sucker control increase body and nicotine accumulation. Under present market conditions, good-bodied U.S.-grown tobaccos are in strong

demand. Much of this demand is related to the prices of our tobaccos and the use of U.S. tobaccos with lower price tobaccos that have less flavor and aroma.

Yield and value data collected in five on-farm tests in 1982 show a yield increase of 137 pounds per acre for topping in the button stage compared to topping one week later in the early flower stage. Such a yield increase is largely a bonus for net profits because the only added costs for this 137 pounds of tobacco are: curing, marketing, and value of the quota.

Many growers plan to top their tobacco this year several leaves lower than in previous years to increase the chances for producing good bodied tobacco.

Southeast Farm Press
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HOLD DOWN MH RESIDUES IN 1983

W. K. Collins

1983

MH residues on the last two tobacco crops were lower than in 1980. This is good news because important foreign buyers have often expressed concern about MH residues of our cured leaf.

According to ASCS findings the average MH residue was 98 ppm. This is still higher than the 80 ppm limit cigarette manufacturers in West Germany have agreed not to exceed in their products.

MH is not permitted to be used for sucker control in some countries such as Brazil, Zimbabwe (Rhodesia), and Canada. These are important competitors in domestic and international markets.

Two new sucker control products, Prime+ and Bud Nip, provide growers alternatives to the use or excess use of MH. These products do not contain MH.

All MH labels now prohibit the use of more than one application of MH at the suggested rate unless a wash off occurs within 6 hours after application. Therefore, multiple applications of MH is unlawful in most cases.

Suckers can be controlled with the aid of MH as prescribed on new MH labels. However, to do this nitrogen fertility and the degree of sucker kill obtained with contact-type sucker control products will have to receive more attention than in the past.

The following seven-step program is suggested to obtain acceptable sucker control and cured leaf with acceptable MH residues.

- Apply 50 to 80 pounds of nitrogen per acre plus adjustments for leaching. Excess nitrogen stimulates excess sucker growth, delays maturity, reduces curability, and market price.
- Apply a contact-type sucker control chemical at 4% concentration when about 50% of the plants reach the button stage.

- Top plants ready for topping.
- Apply a second application of a contact solution with at least 5% concentration 3 to 5 days after the first contact was applied.
- Top remaining plants.
- Apply FST-7 or MH about 7 days after the last contact, preferably in the morning about two days after a rain or irrigation.
- Allow at least 7 days after application before harvest.

Improved sucker control with the contact-type sucker control products will be essential for many growers if the suggested program works satisfactorily. An important factor to obtaining better control with contact solutions is to mix the product with water so that the solution is at least 4% strength. These products should be mixed at the rate of 2.0 gallons of chemical in 48 gallons of water to make a 4% solution. Some growers are increasing the strength of their contact solutions by mixing more than 2.0 gallons of the product with 48 gallons of water, especially for the second application of the contact solution. The reason for the emphasis on the proper strength of the contact solution is that weak solutions often only kill one of the two tiny suckers in each leaf axil. When this occurs, the sucker growth is only temporarily suppressed. Later this sucker growth becomes vigorous and encourages the misuse of MH.

The application technique with contact solutions also needs to be improved on many farms. Operating the sprayer through the field too fast is a common mistake. To obtain good results the sprayer should be operated about 2½ mph so that 50 gallons per acre of the solution are applied. A triple-nozzle arrangement should be used with 20 psi pressure about 12 inches directly above the button. The objective is to apply enough solution in the top of the plant so there is sufficient rundown to kill two sucker buds in as many leaf axils as possible

It is very difficult to apply enough solution in the upper leaf axils to accomplish this if there is anything abnormal with the application procedure.

Many growers in the Piedmont where fields slope apply their contact solutions with hand operated cut offs connected to a mainline from a tractor pump. Some growers apply the contact solutions with squeeze bottles and hand applicators. These growers consistently obtain a very high degree of control with contact solutions.

The use of MH products just prior to harvest must be avoided to help reduce MH. MH residues are related to the number of days between spraying and harvest. The longer the time between MH application and harvest, the greater the opportunity for wash off of MH residues from the leaves. This MH plays no role in sucker control.

Southeast Farm Press
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Dick Bass James

CONTROL BOTH LEAF AXIL SUCKERS WITH CORRECT CONTACT SOLUTION

W. K. Collins

1983

The mix rate of contact product to the water is extremely critical in relation to the degree of sucker control obtained with contact solutions. The objective is to make the solution strong enough to kill both suckers in each leaf axil and not cause more leaf injury than is acceptable. Some chemical topping and injury to the upper several leaves is considered acceptable.

A standard dilution rate for the first application of contact solution is to make a 4 percent strength solution. This is done by mixing at the rate of 2 gallons of contact sucker control product with 48 gallons of water. Solutions for second applications should be stronger such as a 5% strength.

If the two gallons of product are mixed with 65 gallons of water, the solution is 3% strength and is too weak to kill the secondary suckers. On the other hand, if the 2 gallons of product are mixed with, for example 35 gallons of water, the strength is nearly 6% and so strong unacceptable leaf injury may result. About 50 gallons of solution per acre should be applied to have enough solution to rundown the entire stalk.

A good understanding of how contacts work will help you understand why the mix rate may vary and yet achieve the objective of good sucker control and not too much leaf injury.

Contact sucker control solutions kill suckers by evaporating the water from the small suckers faster than the plant can replace the water. The suckers are dried out until they are killed. The smaller and the more tender the sucker, the less concentrated the solution has to be to obtain the desired kill. However, as the dilution or strength of the solution drops below the suggested 4%, chances are reduced of killing the embedded secondary sucker. This sucker is located behind the first sucker.

As long as the first sucker is present, this sucker tends to protect the second sucker bud, which is often just a bump, from the contact solution. When the contact solution is strong, it will dry up the base of the first sucker and wound the leaf axil enough to kill many of the secondary suckers.

Weak contact solutions, those that are less than 4%, often visually do an acceptable job; however, experience has shown the secondary suckers grow rapidly and become too large for the second application of the contact to provide control. Then the sucker growth on vigorous growing tobacco cannot be controlled with the labelled rates of systemic acting chemicals such as MH.

Because contacts kill suckers by a drying action, certain weather conditions such as a bright warm day favor increasing the degree of sucker control obtained with a given solution. Contact solutions sprayed on cool days or cloudy days are considerably less effective than those applied on bright warm days. This is one reason the mix rate of contact product to water should be adjusted as weather conditions may vary.

The mix of product to water should also vary according to the tenderness of the tobacco. Less than a 4% solution may provide suitable sucker control on the first application on a very young, tender crop. Most second applications which should be applied 3 to 5 days after the first application and all third applications (3 to 5 days after the second application) should be applied at 5% strength. This is 2.5 gallons of product mixed with 47.5 gallons of water. The 5% strength is suggested because the plant is usually more developed and leaf tissue is thicker and able to withstand the increase of concentration. Also sucker growth is likely to be less tender than at the time of the first application.

A rule of thumb to use is to apply a contact solution that chemically tops 5 to 10% of the small, late plants in a field. If no plants are chemically topped during the first application, the solution is too weak to provide maximum sucker control.

Chemically topped plants are usually late less vigorous plants. The chemical topping maximizes the chances of these plants to produce leaves that have an acceptable level of body rather than to be extremely thin and chaffy.

Some growers apply weak contact solutions such as 1.0 gallon of contact in 49 gallons of water. About the same degree of contact sucker control is obtained as might be expected with application of one-half the rate of MH. The sucker control with both of these comparisons appear acceptable for a while, then there is sucker growth.

There is considerable evidence that late sucker growth is related to the use of excess nitrogen fertilizer and use of weak contact solutions. The use of contact solutions at the correct strengths can be expected to greatly increase the up-front sucker control and make it possible for the labelled rate of systemic acting products such as MH to provide full season control even where excess nitrogen was used.

The use of strong contact solutions increases the chance of leaf drop; however, this is rarely a problem unless excess nitrogen has been applied.

Some growers apply their contact solutions with hand-operated applicators. This method of application greatly increases the degree of contact sucker control, especially in the Piedmont where it is difficult to correctly apply contacts with tractor sprayers. One hand application of a contact solution is usually adequate before a systemic acting product is applied.

Tops should be in the plants when the first application of a contact chemical is applied. The top will intercept the spray pattern and increase the chances of solution rundown and kill of tiny suckers.

HOW TO LOWER MH RESIDUES

W. K. Collins

Maleic hydrazide (MH) residues in U.S. flue-cured tobaccos have increased in recent years. Strong criticisms have been experssed by buying interests, particularly those in West Germany about the level of MH residues in our tobaccos.

The problem with MH residues appears to be one of numbers that fortunately do not appear to relate to any toxicological problems. However, the numbers are concerns that could unfavorably influence manufacturers' use of tobaccos containing high levels of MH.

The MH residue levels of German purchases from the U.S. have averaged about 200 ppm in recent years, but they have an expressed goal of manufacturing products with no more than 80 ppm of MH. They are staying below the 80 ppm level by using tobaccos with less or no MH from Brazil, Zimbabwe, Canada, and other countries that prohibit the use of MH for sucker control.

The much discussed 80 ppm MH level is not a law but rather a possible acceptable level in products. The 80 ppm level was arrived at after beginning with a much lower figure that was a gentlemen's agreement among public agency, chemical company, and West German cigarette manufacture representatives at a time when the MH residue levels in U.S. tobaccos were lower than currently found.

A simple solution to the MH residue problem would be to raise the acceptable level of MH residues from 80 ppm. But since MH is an additive to tobacco, to increase the MH residues could easily open manufacturers to criticism that could reduce product sales. The result would be a "numbers game" on MH residues in cigarettes and cause reductions in the use of U.S. tobacco in products. Furthermore, if the 80 ppm level were raised, it would indicate that U.S. growers are unable to reduce the use of MH at a time when certain major competitors can produce

tobacco without using MH. As the MH residue levels increase, our flue-cured tobacco becomes less competitive in world markets because foreign buyers have the alternative of buying tobaccos without residues from other countries. The U.S. share of world production of flue-cured tobacco has dropped from 41 percent in the late 1950's to 19 percent in 1979. Some of this may be attributed to increased MH residues; however, it must not be overlooked that the quality difference between U.S. flue-cured tobacco and certain foreign flue-cured tobaccos has decreased. In addition, new manufacturing technology available within the international tobacco industry makes it possible to make products that are acceptable to consumers with a wider range of tobacco than only a few years ago.

Although the tobacco industry has a wealth of processes to modify undesirable tobaccos, it does not appear to have a practical way to modify MH residues except by blending down with low MH tobaccos.

Many growers have shown an interest in a chemical sucker control program that can be expected to provide acceptable sucker control and cured leaf with acceptable residues; however, the use of high rates of nitrogen may be the limiting factor in accomplishing this. Many growers are applying such high rates of nitrogen that labelled rates of MH-containing products cannot provide full-season sucker control. Recent fertilizer sales in North Carolina show that the average tobacco grower uses 110 pounds of nitrogen per acre while 60-80 pounds per acre are recommended, plus adjustments for leached nitrogen.

Excess nitrogen (more than 60 to 80 lbs/A plus adjustment for leaching) stimulates excess sucker growth and delays maturity which adds to the length of time chemicals are expected to provide sucker control. A common error is to apply extra nitrogen for anticipated leaching before it occurs rather than applying additional nitrogen on a need basis after leaching rains. As a result, often excess nitrogen will be available at the end of the growing season. Excess

nitrogen delays maturity, reduces curability, reduces market price, is related to increases of certain insects, and makes it more difficult to control suckers.

Weak solutions of contact-type sucker control products often only kill one of the two tiny suckers in each leaf axil. All contact-type products currently on the market should be mixed at the rate of 2.0 gallons of product in 48 gallons of water, a 4% solution. One should use at least 50 gallons per acre of this solution. Numerous growers are mixing less than 2.0 gallons of contact product in the suggested quantity of water. The more dilute or weaker the solutions, the greater the tendency to just only temporarily suppress sucker growth. Later this sucker growth becomes vigorous and cannot be controlled with a single application of MH at the suggested rate.

Sucker control data collected in 1980 show the great difference observed in sucker growth at final harvest when three rates of a contact-type solution were applied (Table 1). In this test the suckers appeared to be under control for several weeks, then rapid growth of suckers occurred where the 2 and 3 percent solutions were applied.

Table 1. Sucker Growth with Three Contact Solutions [a/]

Contact + Water Gallons	Percent Contact	Suckers per Acre No.	Pounds
1	2	29,900	6,256
1.5	3	15,600	4,794
2	4	7,800	1,950

[a/] Normal suggested mix rate of 2 gallons of contact chemical in 48 gallons of water.

Contact-type sucker control chemicals alter the water proofing layers of the sucker tissues to a point where the moisture in the tissues escapes. This loss of

moisture kills the tender sucker tissue. Mature leaf tissue is not damaged because the water proofing layers on the upper leaf surfaces are thicker and consequently are not completely altered. However, high concentrations of the contact can destroy leaf tissue, especially it is is very tender like when it has been grown with excessive nitrogen.

The use of less than the suggested ratio of chemical to water often kills or damages no more than one of the two sucker buds at the leaf axil. The degree of sucker control is related to tenderness of the plant and growth conditions. If growth is tender, the sucker control will be much higher than if growing conditions are unfavorable such as under drought conditions. Grower experience tends to verify this observation. Some growers are applying contact solutions that contain as much as 5 percent of the formulated products on less tender crops.

There is concern among growers about leaf drop with strong contact solutions. This is not likely to be a problem unless the crop has an excessive amount of available nitrogen and the season is unusually wet for several days after application. If leaf drop occurs it most likely will be from the lower part of the stalk where there is high humidity due to lack of sunlight and air movement. These factors encourage survival and spread of soft rot bacteria which enters the wounds in the leaf axils.

Topping and Sucker Control Program.

Good equipment and timely applications are musts for good sucker control. It is essential to have properly adjusted, accurately calibrated equipment with adequate agitation to obtain satisfactory sucker control without injurying the leaves. Many growers would increase the degree of contact sucker control by operating their sprayers at 2 to 2½ mph, especially where application conditions are less

than desirable. Futhermore, apply the materials at the correct stage of plant development, button, for contact-type materials and about a week later for those that control by systemic action, for best results. Under normal growing conditions, with the suggested rate of nitrogen applied, the following topping and sucker control program has consistently given acceptable sucker control where materials were properly applied.

1) Apply a contact sucker control chemical at the proper concentration before topping when about 50 percent of the plants reach the button stage. To obtain the proper concentration, mix two gallons of product in 48 gallons of water to make a 4 percent solution. Concentrations lower than 4 percent may provide little, if any, control of secondary suckers and make it difficult for MH to provide full-season sucker control. Contact solutions with concentrations higher than suggested may cause some leaf injury; however, chemical topping of about 5 percent of the plants indicates the timing of the application and concentration of solution are correct. The chemically topped plants are usually late-developing plants. Topping these plants early and below thenormal number of leaves reduces the amount of thin, chaffy, cured leaf produced.

   Topping height is also very important. Plants should be topped at about 19 harvestable leaves in view of the demand for good-bodied leaves. Having to delay the MH application to allow for higher topping increases the likelihood of sucker problems. The proper use of a contact-type sucker control chemical makes it possible to obtain the numerous benefits of early topping before plants develop enough for MH to be applied without reducing leaf desirability. Also early applied MH often does not provide full-season sucker control.

2) Apply a second application of a contact sucker control solution 3 to 5 days after the first application in fields that have irregular growth and flowering. Later applications of contact-type solutions provide reduced control because the few suckers missed with the first contact spraying grow extremely fast and become too large for a contact to kill. Plants that were not topped after the first contact was applied should be topped following the second application.

3) Apply a product containing only MH or apply FST-7 (contains both MH and a contact) about 7 days after the last contact application preferably in the morning about two days after a rain or irrigation. For maximum effect, apply MH in the forenoon to plants having good soil moisture.

Only the recommended rate of MH should be applied to help avoid problems associated with high MH residues. Labels on all MH products now prohibit more than one application unless a wash-off occurs the first 6 to 12 hours after application. Tests have shown that as the rate of applied MH is increased, the residue on the cured leaf can be expected to increase. One application of MH at the recommended rate can be expected to leave a MH residue of about 80 parts per million. FST-7, a MH-containing product, when applied at the suggested rate, provides 11 percent less MH than the recommended rate of other MH-containing products; consequently, its use would be expected to reduce MH residues somewhat, but it may also affect control from the reduced MH applied if there is excess nitrogen.

Use of problems containing MH just prior to harvest must be avoided so that chemical residues will be at the minimum. MH residues are related to the number of days between spraying and harvest. Labels on MH products require at least a 7-day waiting period between MH application and harvest. The longer the time between MH application and harvest, the lower the MH residues. Some of the MH sprayed on the plants stays on the surface of the leaves. This surface MH can

be washed off by rains, irrigations, or dew if either should occur. A 66 percent reduction in MH residues occurred on mid-stalk tobacco the fourth day after treatment when there was a 2.2 inch rain on day 3 (Table 3). In another test where there was dry weather for ten days after application, the percent decrease was considerably less. The longer the time between MH application, and harvest, the greater the opportunity for wash-off of surface MH to occur. Therefore, MH should be applied as far as practical ahead of any harvest.

Table 3. MH Residue Levels on Mid-Stalk Tobacco Between 0 and 4 Days After Application of MH at Upper Piedmont Research Station 1/

HARVEST TIME Days After Application	ppm	% Reduction
0	140	0
1	115	18
2	107	24
4 2/	48	66

1/ Conducted by Dr. T. J. Sheets (1978)

2/ 2.2 inch rain on Day 3.

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1983

CHEMICAL TOPPING, A GOOD SIGN IN TOBACCO

W. K. Collins

It is desirable to chemically top 5% to 10% of the plants with the first application of a contact-type sucker control solution. Chemical topping of some plants should be expected in crops with irregular growth and flowering.

When some of the plants are chemically topped by the contact solution, this indicates the time of application and strength (concentration) of the contact spray was correct for the situation.

Chemically topped plants appear to be injured; however, there are several important benefits obtained from chemical topping. First, usually an extremely high degree of sucker kill is obtained when chemical topping is observed. The two sucker buds in contacted leaf axils are killed in most of the leaf axils on the chemically topped plants as well as the other plants in the field.

Second, results from on-farm tests show plants topped in the pre-button stage yield more than if topped any time later. There is an appreciable amount of tissue burned out in the button area when plants are chemically topped. The remaining leaf tissue continues to develop and produce good bodied leaf. This is the type of leaf expected to have highest demand at the warehouse this season.

Leaf tissue and the stem of the plant that is topped out by hand or by a topping machine is a sure loss or reduction from maximum yield. Early chemical topping stops the plant from channeling plant resources into certain leaf tissue and floral parts that are not saved for market but rather discarded on the ground. This plant material is a real and significant loss.

Research shows that after plants reach the button stage, yield potential of untopped plants is reduced 1% per acre per day. For many growers this is a

reduction of 20 to 25 pounds of cured leaf per acre per day. There is evidence this principle of increased yield with early topping applies to the pre-button stage.

Third, the body of the remaining leaves on chemically topped plants will increase compared to topping them later by hand or mechanically. Usually this will increase the desirability of these leaves as compared to thin-bodied chaffy leaves normally produced by late developing plants which are most likely to be chemically topped.

The market outlook for the 1983 season indicates a strong preference for good-bodied tobacco. Early topping will contribute to this. Delayed topping is known to be related to the production of light-bodied, thin tobacco. Buyers can purchase light-bodied leaf which lacks flavor and aroma from other markets at considerably lower prices than available in the U.S.

Floral parts on tobacco plants should be looked at as pests. They rob the plant of its resources and reduce yield and leaf useability. Tops in tobacco plants are the major pests in tobacco fields in North Carolina. They are on every plant in every field without exception. Therefore, time of topping is a management decision required every year. However, obtaining some chemical topping when the first contact spray is applied should be an objective each season.

There are several other benefits of topping in the button stage. Topping is completed before harvest begins. This helps spread the workload away from the peak harvest period. The chance of plants being blown over in a windstorm is reduced when plants are topped. The populations of certain insects are lowered because eggs and larvae survival is nil on floral parts removed from the plants. The moths of certain harmful insects are more strongly attracted to lay eggs on the floral parts of the plant than on older leaf tissue. If these eggs

and larva can be effectively destroyed when topping, then the need, costs and possible hazards of chemical control are reduced.

Early topping is always important; especially when the plants grow under adverse conditions. Plants that reach the button stage in dry weather should be topped immediately to shift the available plant resources to the leaves. Under drought conditions, it may be just as beneficial to top plants early as it would be to irrigate. Plants that have a restricted root system from growing under relatively wet soil conditions should be topped as soon as the buttons appear, but a little lower than normal. Topping will stimulate root development. Plants will then recover more rapidly as the soil dries.

Plants grown with excess nitrogen should be topped at the normal height rather than higher than normal. Thin leaves have been associated with excess nitrogen. Because of the extra number of leaves on high-topped plants, the leaves may be thin all the way to the top of the plant. When plants that are over-fertilized with nitrogen are topped normally, the leaves will be thin at first because of rapid growth but after they have fully expanded, they will thicken with time.

On most farms, plants should be topped when they have 18 to 20 harvestable leaves. Plants usually have this many harvestable leaves in the pre-button stage. From a practical viewpoint, chemical topping is the only way topping can be accomplished at this stage of plant growth. Chemical topping maximizes the many benefits associated with early topping.

The strength of the contact solution plays an important role in the degree of chemical topping. Weak solutions are unlikely to provide any chemical topping.

A 4% solution prepared by mixing at the rate of 2 gallons of contact sucker control product with 48 gallons of water normally is strong enough. Be sure to operate the pump pressure at no more than 20 psi and operate the spray boom about one foot above the button.

1986

Contacts control suckers early

By W.K. COLLINS
North Carolina Extension Tobacco Specialist

The 1986 tobacco crop has undergone some weather stresses in the plantbed and field. As a result, many fields have plants reaching the button stage at different times.

Collins

As plants reach the button stage it is time to begin the chemical sucker control program which will be followed by immediate topping.

Contact-type sucker-control chemicals are ideal to use to control suckers until the upper leaves develop enough for a systemic-acting chemical such as maleic hydrazide to be applied.

Spraying with contact solutions should begin as soon as most plants have the desired number of harvestable leaves. This could be before any floral parts appear.

As a general rule the first spraying with a contact solution should be at a 4 percent strength (two gallons of chemical with 48 gallons of water). The second application should be about a 5 percent strength (2.5 gallons of chemical with 47.5 gallons of water).

The degree of sucker kill on tobacco plants with contact-type solutions is directly related to the mix rate of chemical and water. Therefore, it is extremely important to mix a specific amount of contact chemical with a specific amount of water.

This requirement is different from that with other chemicals. For example, with chemicals used to control insects, weeds, grasses, and diseases the amount of water used is not critical other than to use enough to uniformly distribute the chemical.

Proper strength

The suggested rate of the contact-type products currently on the market is two gallons in 48 gallons of water. This makes a four percent solution.

The mixture should be strong enough to kill both of the tiny suckers at each leaf axil when the solution wets suckers less than one inch long.

Higher than the suggested amounts of water will weaken the mixtures so that good control is not obtained.

Higher than suggested amounts of chemicals will strengthen the mixture and may cause leaf burn.

Sucker control data (table) show the great differences observed in sucker growth at final harvest when three different rates of a contact-type solution were applied.

Suckers appeared to be under control for several weeks, but as the harvest season progressed suckers made rapid growth, especially where the 2 and 3 percent solutions were applied.

Sucker growth with three different concentrations of a contact solution[1]

Contact + water (gallons)	Percent contact	Suckers per acre	
		No.	Pounds
1 + 49	2	29,900	6,256
1.5 + 48.5	3	15,600	4,794
2 + 48	4	7,800	1,950

[1]Normal suggested rate of two gallons of contact chemical in 48 gallons of water.

Contact solutions control sucker buds by destroying cell membranes. As a consequence the sucker bud dries out to the point of being killed.

If the cells are not destroyed, the contact solution does not restrict cell division as MH does. That is why the contact can be applied in the button stage when upper leaves are expanding by cell division.

In fields with irregular flowering, two or three applications of contact solutions before a systemic-acting chemical application are recommended.

The number of sprayings may be reduced where application is by hand rather than mechanical sprayers. Application of contact solutions by hand methods at the top of the plant provides a very high degree of sucker control.

The amount applied should be enough for complete rundown to the soil line but not so much as to accumulate at the soil line and damage the stalk.

Weak contact solutions, those that are less than 4 percent, often control only one of the two sucker buds found in each leaf axil.

Often it appears that acceptable sucker control is achieved with weak contact solutions; however, experience has shown the suckers grow rapidly and become too large for the second application of the contact to provide control.

Then the sucker growth on vigorous growing tobacco cannot be controlled with the suggested rates of systemic-acting chemicals.

A rule of thumb to use is to apply a contact solution that chemically tops 5 to 10 percent of the small, late plants in a field. If no plants are chemically topped during the first application, the solution was too weak to provide maximum sucker control.

Data collected in on-farm sucker control tests show that sucker control with contact solutions is improved by applying a 5 percent concentration rather than a 4 percent solution for the second application.

The 4 and 5 percent concentrations of contact solutions are guidelines to follow. If plant growth is tender, good sucker control may be obtained with slightly reduced concentrations. If plant growth is tough, an increase in concentration is suggested to obtain good sucker control.

There is concern among growers about leaf drop with strong contact solutions. This is not likely to be a problem unless the crop has an excessive amount of nitrogen available and the season is unusually wet for several days after application.

If leaf drop occurs, it most likely will be from the lower part of the stalk where there is high humidity due to lack of sunlight and air movement. These factors encourage survival and spread of soft rot bacteria which enter the wounds in the leaf axils made by the contact.

Mechanical sprayers. When application is made with mechanical sprayers, 50 gallons per acre of the contact mixture should be applied at the button stage using three nozzles mounted about one foot directly over the row of tobacco.

Application should be with a relatively low pressure (20 to 25 psi) giving a large droplet size delivered from a triple nozzle arrangement for mechanical spraying. Plants should be standing straight up and application during hot afternoons should be avoided.

The low pressure will provide coarse spray droplets needed to avoid forcing the spray into leaves. That could damage leaves. As the pump pressure increases from 20 psi, the probability of leaf injury increases.

First contact application. The first application of a contact should be made when 50 percent of the plants are in the button or elongated button stage, the time when sucker buds are small and tender.

mixed because the active ingredients (fatty alcohols) are lighter than water. They tend to float and must be agitated to prevent separation. Avoid the use of cold water because it does not lend itself to a uniform emulsion.

Second contact application. It has become a standard practice to apply a second application of contact three to five days after the first application. The second application is used to kill suckers that may have been missed with the first application.

Systemic chemical

Because contact solutions are not likely to kill all of the sucker buds, an application of a systemic-acid chemical should be made about a week after the last application of the contact.

Advantages. The use of a contact chemical allows earlier topping, which increases yields. Therefore, it fills the sucker control gap between early topping and the time the upper leaves are large enough not to be damaged by a systemic-acting chemical.

A major advantage of contact solutions, especially if two or three applications are made, is that the period for the systemic-acting chemical to control suckers after topping is reduced.

Systemic-acting chemicals tend to give out and when tobacco remains in the field for as many weeks as it should, sucker growth can be reinitiated. For example, MH normally will restrict sucker growth for about six weeks.

The use of a contact allows the systemic-acting chemicals applied later to provide full-season control (unless there's too much nitrogen from tobacco fertilizers, carryover from high rates of nitrogen used on a previous rotation crop, or residual nitrogen from a legume is available).

Chemical Topping

by W.K. Collins, North Carolina Extension Tobacco Specialist

It is desirable to chemically top 5 percent to 10 percent of the plants with the first application of a contact type sucker control solution. Chemical topping of some plants should be expected in crops with irregular growth and flowering.

When some of the plants are chemically topped by the contact solution, this indicates the time of application and strength (concentration) of the contact spray was correct for the situation.

Chemically topped plants appear to be injured; however, there are several important benefits obtained from chemical topping. First, usually an extremely high degree of sucker kill is obtained when chemical topping is observed. Both primary and secondary sucker buds in contacted leaf axils are killed in most of the leaf axils on the chemically topped plants as well as the other plants in the field.

Second, results from on-farm tests show plants topped in the pre-button stage yield more than if topped any time later. There is an appreciable amount of tissue burned out in the button area when plants are chemically topped. The remaining leaf tissue continues to develop and produce good bodied leaf. This is the type of leaf expected to have highest demand at the warehouse.

Leaf tissue and the stem of the plant that is topped out by hand or by a topping machine is a sure loss or reduction from maximum yield. Early chemical topping stops the plant from channeling plant resources into certain leaf tissue and floral parts that are not saved for market but rather discarded on the ground. This plant material is a real and significant loss.

Research shows that after plants reach the button stage, yield potential of untopped plants is reduced by 1 percent per acre per day. For many growers this is a reduction of 20 to 25 pounds of cured leaf per acre per day. There is evidence this principle of increased yield with early topping applies to the prebutton stage.

Third, the body of the remaining leaves on chemically topped plants will increase compared to topping them later by hand or mechanically. Usually this will increase the desirability of these leaves as compared to thin bodied chaffy leaves normally produced by late developing plants which are most likely to be chemically topped.

In the market there is a strong preference for good bodied tobacco; early topping will contribute to this. Delayed topping is known to be related to the production of light bodied, thin tobacco. Buyers can purchase light bodied leaf which lacks

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This plant has been chemically topped by contact chemical with little or no damage to marketable leaves.

flavor and aroma from other countries at considerably lower prices than available in the U.S.

Floral parts on tobacco plants should be looked at as pests. They rob the plant of its resources and reduce yield and leaf usability. Tops in tobacco plants are the major pests in tobacco fields in North Carolina. They are on every plant in every field without exception.

Therefore, time of topping is a management decision required every year. However, obtaining some chemical topping when the first contact spray is applied should be objective each season.

There are several other benefits of topping in the button stage. Topping is completed before harvest begins. This helps spread the workload away from the peak harvest period. The chance of plants being blown over in a windstorm is reduced when plants are topped. The populations of certain insects are lowered because eggs and larvae survival is nil on floral parts removed from the plants. The moths of certain harmful insects are more strongly attracted to lay eggs on the floral parts of the plant than on older leaf tissue. If these eggs and larva can be effectively destroyed when topping, then the need, cost and possible hazards of chemical control are reduced.

Early topping is always important, especially when the plants grow under adverse conditions. Plants that reach the button stage in dry weather should be topped immediately to shift the available plant resources to the leaves. Under drouth conditions, it may be just as beneficial to top plants early as it would be to irrigate.

Plants that have a restricted root system from growing under relatively wet soil conditions should be topped as soon as the buttons appear, but a little lower than normal. Topping will stimulate root development.

Plants grown with excess nitrogen should be topped at the normal height rather than higher than normal. Thin leaves have been associated with excess nitrogen. Because of the extra number of leaves on high topped plants, the leaves may be thin all the way to the top of the plant. When plants that are over fetilized with nitrogen are topped nromally, the leaves will be thin at first because of rapid growth but after they have fully expanded, they will thicken with time.

First contact sucker control application should be made at the early button stage.

On most farms, plants should be topped when they have 18 to 20 harvestable leaves. Plants usually have this many harvestable leaves in the prebutton stage. From a practical viewpoint, chemical topping is the only way topping can be accomplished at this stage of plant growth. Chemical topping maximizes the many benefits associated with early topping.

The strength of the contact solution plays an important role in the degree of chemical topping. Weak solutions are unlikely to provide any chemical topping.

A 4 percent solution prepared by mixing at the rate of two gallons of contact sucker control product with 48 gallons of water normally is strong enough. Be sure to operate the pump pressure at no more than 20 psi and operate the spray boom about one foot above the button.

Benefits of Early Topping

by Ben Kittrell, Tobacco Specialist, Clemson University

Topping tobacco early is an important practice. All growers will top their tobacco eventually, but the good manager, by topping early, will reap the most benefits with the bottom line being profit. These benefits include a better root system, more tolerance to drought, less stalks leaning from wind, higher yield, better quality, less labor, bigger leaves and better sucker control.

The tobacco plant will normally flower 60-70 days after transplanting. Once the plant develops a button (the early stage of flowering) no more leaves will develop. This is the normal process whereby a plant changes from the vegetative stage (making leaves) to the reproductive stage (making seed).

Tobacco growers are not interested in making seed. Therefore, the quicker the top is removed after the desired number of leaves have developed on the plant, the more plant energy will be stored in the remaining leaves rather than being wasted in the heavy flower. This usually means an increase in pounds of tobacco per acre. Research and on farm tests have demonstrated a loss of 25 pounds per acre per day when plants are left untopped.

Quality is improved when tobacco is topped early. Leaf size in the upper part of the plant expands rapidly after topping. Expansion takes place both in length and width. Most important is the increase in body or weight per unit area of leaf. Tobacco buying companies are very interested in full bodied tobacco. U.S. Government grades are based partly on length and width of the leaf and assign higher grades to larger leaf areas. These factors translate into higher prices at the warehouse.

When tobacco is topped, root growth also expands. Early topping encourages this increase in root growth to occur earlier. This allows the plant to produce more nicotine which is made in the roots of the tobacco plant and stored in the leaves. The proper ratio of sugar to nicotine is essential to the proper chemistry of the tobacco smoke.

Early topping also eliminates the heavy flower head that is vulnerable to wind. Eliminating the flower early along with a better root system will result in less tobacco plants being blown over. This is important in proper application of sucker control chemicals as well as harvesting with machines.

Tobacco plants will withstand periods of water stress much better after topping. The large flower requires a lot of water that is actually taken from the leaves. Expanded root growth also aids in better absorption of water from the soil. The results are less wilting of leaves where plants are topped as compared to plants with tops remaining.

Less labor is required when topping early. The longer a grower waits to top, the stalk becomes more woody and harder to break as the flower matures. If hand topping, it will usually take about three times as long to top after the full flower stag as compared to the button or early flower stage.

Topping early will also aid in sucker control. Suckers in the top begin to form as the plant starts to flower. If contact type sucker control materials are applied when 50 percent of the plants have reached the button stage, most of the suckers can easily be controlled. At this stage they are small and tender and are more vulnerable to the chemical. Topping should be done immediately after the first application of the contact.

When topping, do not make the mistake of leaving too many leaves per plant. A plant with 18 to 22 leaves will produce a normal crop. Topping low may also aid in sucker control since a larger leaf will remain at the top of the plant. A larger leaf will aid in directing contact type chemicals to run down the stalk. When plants are topped too high, small leaves may be left which will not "catch" the chemical. Also, small leaves may sand up against the stalk where they may protect the sucker rather than aiding in its destruction.

Profitable tobacco production requires many management decisions. Topping early may be one of the most profitable decisions that a grower can make.

Transplant Performance

by Donald J. Fowlkes, Assistant Professor, University of Tennessee

Tobacco growers want plants to resume rapid growth quickly after transplanting. Minimization of transplant stress can help young tobacco plants avoid insect and disease problems and attain maximum growth and yield. The first step in getting plants off to a quick, healthy start in the field is to produce healthy, vigorous seedlings in the plant bed. Poor quality seedlings will not perform well in the field even under favorable growing conditions. However, even top quality seedlings will perform poorly in the field if certain production practices are not followed before and after transplanting.

First, if a disease is present in a specific field, select a variety (if available) that has resistance to that

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disease or combination of diseases. Diseases can reduce the performance of the very best transplants. Burley growers have available a new variety, "TN 86," which was released in 1986 by the University of Tennessee Tobacco Experiment Station in Greeneville. TN 86 is the only commercial burley variety with resistance to viruses other than tobacco mosaic virus. TN 86 has high resistance to tobacco vein mottling virus, medium reistance to tobacco etch virus and high reistance to most races of potato virus Y. TN 86 is susceptable to tobacco mosaic virus. In addition, this new variety has medium resistance to black shank, high resistance to black root rot and wildfire and has high yield potential. TN 86 is late maturing, approximately 7-10 days later than 14 x L8. TN 86 does a significant amount of its growing late in the season, so late-season drought may stunt TN 86 moreso than some other varieties. On the other hand, late-season rains can improve the yields of TN 86 compared to some other varieties.

In addition to variety selection, a properly prepared field can help tobacco plants start off well after transplanting. What is involved in proper field preparation? For burley tobacco, the soil pH should be maintained in the 6.1 to 6.5 range. The soil should be well tilled but not powdery, and should not be worked when excessively wet. Soil worked when wet tends to compact, and young tobacco plants will not grow well in tight soil. Crop rotation will improve soil moisture holding capacity and fertility and is an often overlooked component of soil preparation.

Proper field preparation also involves the wise use of preplant pesticides. Preplant soil insecticides and transplant water insecticides can help protect young transplants from early season insects such as wireworms, cutworms and flea beetles. A preplant, systemic fungicide can help control blue mold and black shank disease problems. Preplant herbicides should be applied at the proper rates and be properly incorporated into the soil to control weeds effectively without injuring the newly-set tobacco plants.

Growers should also pay attention to fertilization rates. Excessive fertilizer and/or fertilizer placed too close to the root system can seriously injure or kill newly-set tobacco plants. Research in burley tobacco fertilization has shown that maximum yields will generally be obtained by the application of no more than approximately 150 to 200 pounds of nitrogen per acre. Phosphate and potash rates should be applied according to soil test results for each field.

Minimization of transplant stress is an important part of getting plants to grow quickly after transplanting. Transplant stress can be reduced by thoroughly wetting the plant bed before pulling plants. This permits plant roots to retain moist soil when pulled. Pulled seedlings should be kept out of the sun prior to transplanting. Then make sure the transplanter supplies a sufficient amount of water to the plant root zone during the setting operation. At least 300 gallons of water per acre is suggested for mechanical setters. Also, for growers set up to do so, a light irrigation soon after transplanting can further reduce transplant stress, especially under dry soil conditions.

Burley tobacco in Tennessee should usually be transplanted during May 10 to June 1. Tobacco set too early will usually encounter cool weather, which slows growth, whereas tobacco set too late will often be exposed to increased transplant stress from hot weather.

Finally, a cultivation soon after transplanting will loosen and aerate the soil and help the young transplants resume growth quickly.

Tobacco growers who follow these practices will increase their chances of getting plants growing quickly after transplanting and ensure maximum performance of transplanted seedlings.

North Carolina State University (NCSU)

Research Programs Sucker Control

Summary of Sucker Control Trials on Burley Tobacco with N-Tac Sucker Control

Report Submitted to
British American Tobacco Company

By
Dr. Bob Pearce
University of Kentucky

February 16, 2015

Purpose: To test the efficacy of an organic contact sucker control (N-TAC) for controlling sucker growth in burley tobacco. Second was to determine the best use patterns including rates and application timing for the use of N-TAC for burley tobacco sucker control.

Methods: Study was conducted over two years with two locations each year. Study locations each year were Spindeltop Research Farm near Lexington, KY and the Woodford County Animal Research Center near Versailles, KY. Both locations are research farms that are part of the Kentucky Agricultural Experiment Station. Burley tobacco (variety KT 210LC) was grown following recommended practices as described in the Kentucky and Tennessee Tobacco Production Guide (UK Cooperative Extension Publication ID-160). Sucker Control treatments were initiated immediately after topping. Treatments for each season are shown in tables 1 and 2 and there were 4 replications of each treatment. Shortly before harvest sucker control was evaluated by removing, counting and weighing all the suckers on 10 plants per plot. Plots were harvested by stalk cutting and the tobacco was allowed to cure in a standard burley curing barn. After curing the leaves were removed and separated by stalk position and weighed to estimate leaf yield for each plot. All data were analyzed with the GLM procedure in SAS 9.3 with means separated at the p=0.1 level. Dates of important field operations are shown in table 3.

Results: Since treatments were different between the two years of the test each year's data were analyzed and are presented separately. In 2013 follow-up applications of contact sucker control were made based on the number of days between applications as shown in table 1. In 2014 follow-up applications were made based on observations of leaf axils. At least ten plants were inspected at roughly two day intervals; when the majority of the plants had signs of lateral bud growth the next application was triggered. The statistical analysis indicated there were no significant location x treatment interactions so the data are presented below averaged across locations.

For 2013 all treatments provided good sucker control (table 4). Only the untreated check was significantly different. There were a just a limited number of sucker escapes in some treatments. The untreated check had a significantly lower leaf yield than all other treatments. There were some significant difference among the treatments for yield, but most treatments

were no different than the highest yielding treatment. One treatment for which a lower yield was recorded was the highest rate of N-TAC (15% solution). At one location in 2013 significant leaf drop of lower leaves was observed for that treatment. Other treatments that were significantly lower than the highest yielding treatments included the two flumetralin only treatments. It is possible that the flumettralin resulted in some stunting of the smaller upper leaves, thought this effect was not measured in this study.

For 2014 again all the treatments provided sucker control that was significantly better than the check (table 5). Though there was some variability among treatments in 2014, the majority of treatments were at least as good as the best treatment. Evaluations of the need for follow-up treatments revealed that the time between applications could be stretched beyond the recommended 5 to 7 days for contact sucker control. There also appeared to be a rate effect with the time between applications being longer when higher concentrations of the contact material was used (data not shown). The yields were not significantly different from the highest yield in the test except for the check plot and treatment receiving 3 applications of Fair 85. No leaf drop was observed in 2014 to explain the yield loss for that treatment.

Conclusions: Based on these trials N-Tac appears to be a viable method of sucker control for burley tobacco. Burley tobacco tolerated higher concentrations of the contact material than was previously reported. Rates up to 7% did not result in leaf drop. At the highest rates of 10 to 15% some leaf drop and possible loss of yield was observed. The time between applications could be stretched out to potentially reduce the total number of applications needed between topping and harvest. In many cases two applications of contact provided sucker control and yields that were just as good as three applications, thought it would be recommended that growers keep a close watch to determine if sucker regrowth was occurring. From these studies a recommended program for organic sucker control would be N-TAC at 5 to 7% solution applied immediately after topping and at intervals of 7 to 10 days or when sucker regrowth is visible in leaf axils.

Table 1. Sucker control treatments applied to burley tobacco during the 2013 season

TRT		Application Notes
1	Topped, but no chemical sucker control	Used to calculate % sucker control
2	Flumetralin 2.5L/ha (1qt per acre)	Single application after topping
3	Flumetralin10L/ha (1 Gallon per acre)	Single application after topping
4	N-TAC 4%: two applications	Spaced approximately 10 days apart
5	N-TAC 4%: three applications	Spaced approximately 7 days apart
6	N-TAC 5%: two applications	Spaced approximately 10 days apart
7	N-TAC 5%: three applications	Spaced approximately 7 days apart
8	N-TAC 6%: two applications	Spaced approximately 10 days apart
9	N-TAC 6%: three applications	Spaced approximately 7 days apart
10	N-TAC 10%: two applications	Spaced approximately 10 days apart
11	N-TAC 15%: two applications	Spaced approximately 10 days apart
12	1 Gallon MH plus 0.5 Gallon Flumetralin	Single application after topping

All treatments were applied by hand with a back-pack pump sprayer using a volume control nozzle calibrated to deliver 22 mls of solution to the top of each plant.

Table 2. Sucker Control treatments applied to burley tobacco during the 2014 season

TRT		Application Notes
1	Topped, but no chemical sucker control	Used to calculate % sucker control
2	Flumetralin 2.5L/ha (1qt per acre)	Single application after topping
3	N-TAC 5%: two applications	Applications "as needed"
4	N-TAC 5%: three applications	Applications "as needed"
5	N-TAC 7%: two applications	Applications "as needed"
6	N-TAC 7%: three applications	Applications "as needed"
7	N-TAC 10%: two applications	Applications "as needed"
8	N-TAC 10%: three applications	Applications "as needed"
9	N-TAC 12%: two applications	Applications "as needed"
10	N-TAC 12%: three applications	Applications "as needed"
11	Fair 85 5%: three applications	Applications "as needed"
12	Fair 85 7%: three applications	Applications "as needed"
13	Fair 85 10%: three applications	Applications "as needed"
14	1 Gallon MH plus 0.5 Gallon Flumetralin	Single application after topping

All treatments were applied by hand with a back-pack pump sprayer using a volume control nozzle calibrated to deliver 18 ml of solution to the top of the plant.
"as needed" applications were applied when close inspection of the leaf axil area revealed active sucker growth.

Table 3. Dates of important field operations.

Operation	2013		2014	
	Spindletop	Woodford	Spindletop	Woodford
Transplanting	May 24	June 21	June 4	June 17
Topping	July 26	August 29	August 13	August 25
Initial Application	July 26	August 29	August 13	August 26
Sucker Evaluation	August 22	Sept 23	Sept 15	Sept 22
Harvest	August 23	Sept 24	Sept 17	Sept 29

Table 4. Sucker control and yield data for 2013 averaged across locations.

Treatment	Suckers per plant	Sucker Control	Leaf Yield
	#/plant	%	Kg/ha
Topped, but no chemical sucker control	6.12 a	0.0 b	2678 e
Flumetralin 2.5L/ha (1qt per acre)	0.26 bc	98.0 a	3028 d
Flumetralin10L/ha (1 Gallon per acre)	0.04 c	99.8 a	3225 bcd
N-TAC 4%: two applications	0.29 bc	98.7 a	3061 cd
N-TAC 4%: three applications	0.08 bc	99.4 a	3277 abcd
N-TAC 5%: two applications	0.05 c	99.9 a	3597 a
N-TAC 5%: three applications	0.03 c	99.9 a	3358 abcd
N-TAC 6%: two applications	0.19 bc	97.3 a	3424 abc
N-TAC 6%: three applications	0.0 c	100 a	3309 abcd
N-TAC 10%: two applications	0.43 b	99.4 a	3370 abc
N-TAC 15%: two applications	0.01 c	99.7 a	3224 bcd
1 Gallon MH plus 0.5 Gallon Flumetralin	0.05 c	99.9 a	3340 abcd
LSD p=0.1	0.35	4.0	335

Table 5. Sucker control and yield data for 2014 averaged across locations.

Treatment	Suckers per plant	Sucker Control	Leaf Yield
	#/plant	%	Kg/ha
Topped, but no chemical sucker control	6.66 a	0.0 d	2491 c
Flumetralin 2.5L/ha (1qt per acre)	0.68 c	90.0 abc	3192 a
N-TAC 5%: two applications	1.79 b	85.1 bc	3142 ab
N-TAC 5%: three applications	0.49 c	94.1 ab	3052 ab
N-TAC 7%: two applications	0.40 c	97.7 a	3363 a
N-TAC 7%: three applications	0.89 c	84.3 c	3039 ab
N-TAC 10%: two applications	0.50 c	90.0 abc	3133 ab
N-TAC 10%: three applications	0.38 c	93.5 abc	3073 ab
N-TAC 12%: two applications	0.41 c	90.6 abc	3085 ab
N-TAC 12%: three applications	0.23 c	98.0 ab	3076 ab
Fair 85 5%: three applications	0.88 c	88.4 abc	3197 a
Fair 85 7%: three applications	0.63 c	91.1 abc	3179 ab
Fair 85 10%: three applications	0.53 c	93.5 abc	2841 bc
1 Gallon MH plus 0.5 Gallon Flumetralin	0.19 c	95.5 abc	3013 ab
LSD p=0.1	0.80	9.8	351

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2014 Report
to the

British American Tobacco

From The

NC TOBACCO FOUNDATION INC.

For The

Evaluation of N-Tac Organic Contact Suckercide in Flue-cured Tobacco

LEADER(S):Loren Fisher

DEPARTMENT(S):Department of Crop Science

REPORT:

Research was conducted in 2013 and 2014 to evaluate drop-line applications of N-Tac, an organically approved fatty alcohol tobacco sucker control material from Fair Products Inc. Research was conducted at the Cunningham Research Station in Kinston, NC and the Oxford Tobacco Research Station in Oxford, NC both years.

In year one, treatments were:

Product	Concentration	Total Apps No.
Flumetralin	1qt/32 gal	1
Flumetralin	2qt/50 gal	1
N-Tac	5	2
N-Tac	5	3
N-Tac	5	4
N-Tac	5	5
N-Tac	6	2
N-Tac	6	3
N-Tac	7	2
N-Tac	7	3
N-Tac	10	2
N-Tac	15	2

In year two, treatments were:

Product	Concentration	Total Apps No.
Flumetralin	1qt/32 gal	1
N-Tac	5	2
N-Tac	5	3
N-Tac	7	2
N-Tac	7	3
N-Tac	10	2
N-Tac	10	3
N-Tac	12	1
N-Tac	12	2
Fair-85	5	3
Fair-85	7	3
Fair-85	10	3
MH/Flumetralin	1 gal/2qts 50 gal	1

All treatments were applied with a drop-line except for in year two where the MH/flumetralin tank mix was applied as a broadcast spray. The dropline treatments were applied with a nozzle supplied by BAT that is commonly used in Brazil, which delivered approximately 20 ml of solution per plant. The exception was the flumetralin treatment in 2013 when the 2qt/50 gallon concentration was applied at 30 ml per plant as a comparison to a standard US application rate and method. The first application was made either just before or just after topping and subsequent applications were made at 5-7 day intervals for the first three applications. In plots receiving more than three applications of N-tac, the fourth or fifth application was made 10-14 days after the third or fourth application. The time span from topping till final harvest ranged from 9-13 weeks across years, and was dependent on rainfall.

In 2013, significant leaf drop was observed with the 15% N-tac concentration at the Kinston location and to a lesser extent at the Oxford location. Leaf drop was caused by injury to the leaf axil with the high N-tac concentration and also resulted in poor sucker control because leaves were not present to catch the spray solution at the second application timing. Therefore, the 15% concentration was not evaluated in 2014. Very minor leaf lamina injury was observed either year regardless of application concentration.

Sucker control was evaluated by counting and weighing suckers from 10 representative plants from each plot. Sucker weights were compared to a control plot where plants were topped, but no sucker control was performed, either by hand or with chemical methods. The control plot was used to determine maximum sucker pressure and the comparison allowed calculation of percent sucker control.

The Kinston location in both years had excessive rainfall and therefore limited late season sucker pressure. The Oxford location had moderate sucker pressure in 2013 and high sucker pressure in 2014.

Regardless of N-tac concentration, sucker control was improved as number of applications increased. In fact, number of applications had a greater positive impact on sucker control than concentration (Tables 1 and 2). Four or more applications of N-tac gave 95% sucker control when averaged over locations and N-tac concentrations (Table 1), but increasing N-tac concentration did not improve sucker control when averaged over number of applications (Table 2.) However, it should be noted that higher concentrations were only evaluated at a maximum of two applications when computing these averages over N-tac rates. Multiple applications at high rates were avoided to prevent leaf drop.

Tables 3-5 show sucker control from each individual treatment. The trend for improving sucker control with increased number of applications is consistent and there are few differences in sucker control across N-tac rates with a similar number of applications. Yield was directly related to level of sucker control.

The environment at the Oxford location in 2014 most represents expected sucker pressure in a normal production year for flue-cured tobacco in NC. In that environment, the positive effects of 3 or more N-tac applications and the limitations of contact-only sucker control programs were observed. In seasons where there is an extended period from topping to final harvest (more than 9 weeks) and normal rainfall, five or more applications of contact will be needed to maximize sucker control. Regardless of sucker

pressure or length of season, no advantage was seen with increasing contact rates above 5%. It is likely that one or two contact applications do not sufficiently control secondary and tertiary suckers in the leaf axils. This is likely because those suckers are not developed at the time of contact application and are difficult to reach with the contact solution. In addition, the 5% solution provided sufficient desiccation of the sucker and higher rates were not necessary.

Table 1. Sucker Control and Yield based on total number of Applications, averaged over N-tac rates.

Total Apps.	Sucker Control	Yield	N
No.	%	lbs/A	
1	49	2924	2
2	55	2926	13
3	64	3095	15
4	95	3189	2
5	100	2721	2

Table 2. Sucker Control and Yield based on Concentration of Contact, averaged over number of applications.

Concentration	Sucker Control	Yield	N
%	%	lbs/A	
5	68	3051	14
6	71	2760	4
7	63	2971	10
10	55	3060	8
12	50	3038	4
15	72	2843	2

Table 3. Sucker Control with each concentration and Number of Appplications, combined over four locations

Concentration	Total Apps.	N	Sucker Control
%	No.		%
5	2	4	48
5	3	6	60
5	4	2	95
5	5	2	100
6	2	2	56
6	3	2	87
7	2	4	59
7	3	6	66
10	2	4	51
10	3	4	59
12	1	2	49
12	2	2	51
15	2	2	72

Table 4. Sucker Control and Yield Combined Over Two Locations, 2013

Product	Concentration	Total Apps	Sucker Control	Yield
		No.	%	lbs/A
Flumetralin	1qt/32 gal	1	86	2901
Flumetralin	2qt/50 gal	1	74	3067
N-Tac	5	2	55	2922
N-Tac	5	3	83	3158
N-Tac	5	4	95	3189
N-Tac	5	5	100	2721
N-Tac	6	2	56	2610
N-Tac	6	3	87	2911
N-Tac	7	2	64	2882
N-Tac	7	3	90	3013
N-Tac	10	2	54	2845
N-Tac	15	2	81	2843

Table 5. Sucker Control and Yield Combined Over Two Locations, 2014

Product	Concentration	Total Apps No.	Sucker Control %	Yield lbs/A
Flumetralin	1qt/32 gal	1	89	3024
N-Tac	5	2	42	2985
N-Tac	5	3	50	3230
N-Tac	7	2	53	2889
N-Tac	7	3	53	2990
N-Tac	10	2	49	2943
N-Tac	10	3	59	3065
N-Tac	12	1	49	2924
N-Tac	12	2	51	3152
Fair-85	5	3	49	3048
Fair-85	7	3	55	3060
Fair-85	10	3	59	3281
MH and Flu	1 gal/2qts 50 gal	1	100	3036

North Carolina State University

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Trial ID:BATK-14 Location:Kinston, NC Trial Year:2014

Protocol ID:BATK-14 Investigator:Joseph A Priest

Project ID: Study Director:Loren Fisher

Sponsor Contact:Roger Black

Crop Code Crop Variety Description Part Rated Rating Date Number of Decimals				GREEN WT PLANT (GRAMS) 8/15/14 1	NUMBER / PLANT 8/15/14 1	GREEN WT SUCKER (GRAMS) 8/15/14	PERCENT SUCKER CONTROL 8/15/14 1
Trt No.	Treatment Name	Rate	Rate Unit	Plot	1	2	3	4
1	Topped, Not Suckered			101	590.0	4.0	148.0	0.0
				214	568.0	3.3	172.0	0.0
				301	587.0	3.5	168.0	0.0
				414	514.0	3.3	156.0	0.0
				Mean =	564.8	3.5	160.9t	0.0
2	Flumentralin (0.25 GPA) (31.7 GPA)	0.3	lb ai/a	102	23.0	0.8	28.0	96.1
				211	51.0	0.6	85.0	91.0
				313	77.0	1.4	55.0	86.9
				406	17.0	0.6	28.0	96.7
				Mean =	42.0	0.9	46.3t	92.7
3	N-Tac 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	103	204.0	1.4	146.0	65.4
	N-Tac 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	206	57.0	1.2	47.0	90.0
				302	162.0	1.2	135.0	72.4
				403	145.0	0.9	161.0	71.8
				Mean =	142.0	1.2	116.9t	74.9
4	N-Tac 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	104	60.0	0.7	85.0	89.8
	N-Tac 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	205	74.0	0.9	82.0	87.0
	N-Tac 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	307	60.0	1.2	50.0	89.8
				404	23.0	0.5	46.0	95.5
				Mean =	54.3	0.8	64.5t	90.5
5	N-Tac 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	105	23.0	0.4	58.0	96.1
	N-Tac 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	209	45.0	0.7	65.0	92.1
				311	23.0	0.2	114.0	96.1
				401	23.0	0.5	46.0	95.5
				Mean =	28.5	0.5	68.6t	95.0
6	N-Tac 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	106	77.0	1.4	55.0	86.9
	N-Tac 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	212	6.0	0.5	12.0	98.9
	N-Tac 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	305	9.0	0.4	22.0	98.5
				410	9.0	0.2	45.0	98.2
				Mean =	25.3	0.6	31.1t	95.6
7	N-Tac 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	107	79.0	1.4	57.0	86.7
	N-Tac 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	207	37.0	1.2	31.0	93.5
				314	14.0	0.4	35.0	97.6
				412	40.0	0.6	66.0	92.2
				Mean =	42.5	0.9	46.1t	92.5
8	N-Tac 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	108	45.0	0.4	114.0	92.4
	N-Tac 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	202	26.0	0.5	52.0	95.4
	N-Tac 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	304	17.0	0.5	34.0	97.1
				413	23.0	0.8	28.0	95.5
				Mean =	27.8	0.6	52.6t	95.1

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Trial ID:BATK-14 Location:Kinston, NC Trial Year:2014
Protocol ID:BATK-14 Investigator:Joseph A Priest
Project ID: Study Director:Loren Fisher
Sponsor Contact:Roger Black

Trt No.	Treatment Name	Rate	Rate Unit	Plot	GREEN WT PLANT (GRAMS) 8/15/14	NUMBER / PLANT 8/15/14 1	GREEN WT SUCKER (GRAMS) 8/15/14	PERCENT SUCKER CONTROL 8/15/14 1
					1	2	3	4
9	N-Tac 12% 3.85 GPA (31.7 GPA)	23.14	lb ai/a	109	45.0	0.7	64.0	92.4
				201	60.0	1.1	54.0	89.4
				303	79.0	0.8	99.0	86.5
				407	45.0	0.7	64.0	91.2
				Mean =	57.3	0.8	69.3t	89.9
10	N-Tac 12% 3.85 GPA (31.7 GPA)	23.14	lb ai/a	110	45.0	1.0	45.0	92.4
	N-Tac 12% 3.85 GPA (31.7 GPA)	23.14	lb ai/a	208	96.0	1.1	88.0	83.1
				308	20.0	0.9	22.0	96.6
				405	23.0	0.4	58.0	95.5
				Mean =	46.0	0.9	50.4t	91.9
11	Fair 85 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	111	102.0	1.1	93.0	82.7
	Fair 85 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	210	51.0	1.1	46.0	91.0
	Fair 85 5% 1.6 GPA (31.7 GPA)	9.62	lb ai/a	310	45.0	0.6	75.0	92.3
				408	60.0	0.8	74.0	88.3
				Mean =	64.5	0.9	70.9t	88.6
12	Fair 85 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	112	43.0	0.8	53.0	92.7
	Fair 85 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	213	23.0	0.6	38.0	95.9
	Fair 85 7% 2.25 GPA (31.7 GPA)	13.52	lb ai/a	306	3.0	0.3	10.0	99.5
				411	45.0	0.8	56.0	91.2
				Mean =	28.5	0.6	36.3t	94.8
13	Fair 85 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	113	54.0	1.3	41.0	90.8
	Fair 85 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	203	31.0	0.3	104.0	94.5
	Fair 85 10% 3.2 GPA (31.7 GPA)	19.23	lb ai/a	309	3.0	0.2	15.0	99.5
				402	6.0	0.5	12.0	98.8
				Mean =	23.5	0.6	35.9t	95.9
14	(MH 1.0 GPA &	1.5	lb ai/a	114	0.0	0.0	0.0	100.0
	Flumentralin 0.5 GPA) TM	0.6	lb ai/a	204	0.0	0.0	0.0	100.0
	(Overall Spray) (50 GPA)			312	0.0	0.0	0.0	100.0
				409	0.0	0.0	0.0	100.0
				Mean =	0.0	0.0	0.0t	100.0

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North Carolina State University

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Protocol ID:BATK-14 Investigator:Joseph A Priest
Project ID: Study Director:Loren Fisher
Sponsor Contact:Roger Black

Crop Code Crop Variety Description Part Rated Rating Date Number of Decimals			GREEN WT PLANT (GRAMS) 8/15/14	NUMBER / PLANT 8/15/14 1	GREEN WT SUCKER (GRAMS) 8/15/14	PERCENT SUCKER CONTROL 8/15/14 1
Trt No.	Treatment Name	Rate Rate Unit	1	2	3	4
1	Topped, Not Suckered		564.8a	3.5a	160.9a	0.0e
2	Flumentralin (0.25 GPA) (31.7 GPA)	0.3lb ai/a	42.0cd	0.9bcd	46.3cd	92.7bc
3	N-Tac 5% 1.6 GPA (31.7 GPA) N-Tac 5% 1.6 GPA (31.7 GPA)	9.62lb ai/a 9.62lb ai/a	142.0b	1.2b	116.9ab	74.9d
4	N-Tac 5% 1.6 GPA (31.7 GPA) N-Tac 5% 1.6 GPA (31.7 GPA) N-Tac 5% 1.6 GPA (31.7 GPA)	9.62lb ai/a 9.62lb ai/a 9.62lb ai/a	54.3cd	0.8bcd	64.5cd	90.5bc
5	N-Tac 7% 2.25 GPA (31.7 GPA) N-Tac 7% 2.25 GPA (31.7 GPA)	13.52lb ai/a 13.52lb ai/a	28.5cde	0.5d	68.6bc	95.0abc
6	N-Tac 7% 2.25 GPA (31.7 GPA) N-Tac 7% 2.25 GPA (31.7 GPA) N-Tac 7% 2.25 GPA (31.7 GPA)	13.52lb ai/a 13.52lb ai/a 13.52lb ai/a	25.3de	0.6cd	31.1d	95.6ab
7	N-Tac 10% 3.2 GPA (31.7 GPA) N-Tac 10% 3.2 GPA (31.7 GPA)	19.23lb ai/a 19.23lb ai/a	42.5cd	0.9bc	46.1cd	92.5bc
8	N-Tac 10% 3.2 GPA (31.7 GPA) N-Tac 10% 3.2 GPA (31.7 GPA) N-Tac 10% 3.2 GPA (31.7 GPA)	19.23lb ai/a 19.23lb ai/a 19.23lb ai/a	27.8cde	0.6cd	52.6cd	95.1ab
9	N-Tac 12% 3.85 GPA (31.7 GPA)	23.14lb ai/a	57.3cd	0.8bcd	69.3bc	89.9bc
10	N-Tac 12% 3.85 GPA (31.7 GPA) N-Tac 12% 3.85 GPA (31.7 GPA)	23.14lb ai/a 23.14lb ai/a	46.0cd	0.9bcd	50.4cd	91.9bc
11	Fair 85 5% 1.6 GPA (31.7 GPA) Fair 85 5% 1.6 GPA (31.7 GPA) Fair 85 5% 1.6 GPA (31.7 GPA)	9.62lb ai/a 9.62lb ai/a 9.62lb ai/a	64.5c	0.9bc	70.9bc	88.6c
12	Fair 85 7% 2.25 GPA (31.7 GPA) Fair 85 7% 2.25 GPA (31.7 GPA) Fair 85 7% 2.25 GPA (31.7 GPA)	13.52lb ai/a 13.52lb ai/a 13.52lb ai/a	28.5cde	0.6cd	36.3cd	94.8abc
13	Fair 85 10% 3.2 GPA (31.7 GPA) Fair 85 10% 3.2 GPA (31.7 GPA) Fair 85 10% 3.2 GPA (31.7 GPA)	19.23lb ai/a 19.23lb ai/a 19.23lb ai/a	23.5de	0.6cd	35.9cd	95.9ab

Means followed by same letter do not significantly differ (P=.05, LSD)
t=Mean descriptions are reported in transformed data units, and are not de-transformed.
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

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Crop Code Crop Variety Description Part Rated Rating Date Number of Decimals		GREEN WT PLANT (GRAMS) 8/15/14	NUMBER / PLANT 8/15/14 1	GREEN WT SUCKER (GRAMS) 8/15/14	PERCENT SUCKER CONTROL 8/15/14 1
Trt No.	Treatment Name / Rate / Rate Unit	1	2	3	4
14	(MH 1.0 GPA & Flumentralin 0.5 GPA) TM (Overall Spray) (50 GPA) / 1.5lb ai/a / 0.6lb ai/a	0.0e	0.0e	0.0e	100.0a
LSD (P=.05)		38.46	0.43	2.61t	6.43
Standard Deviation		26.92	0.30	1.82t	4.50
CV		32.86	32.89	24.73	5.26
Bartlett's X2		14.186	9.504	11.911	14.487
P(Bartlett's X2)		0.289	0.659	0.453	0.207
Skewness		3.021*	2.2936*	-0.2471	-3.0113*

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Protocol ID:BATK-14 Investigator:Joseph A Priest
Project ID: Study Director:Loren Fisher
Sponsor Contact:Roger Black

Randomized Complete Block (RCB) AOV For GREEN WT PLANT (GRAMS) 8/15/14 (Data Column 1)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)
Total	55	1094140.553571			
Replicate	3	6579.482143	2193.160714	3.027	0.0408
Treatment	13	1059307.803571	81485.215659	112.480	0.0001
Error	39	28253.267857	724.442766		

Randomized Complete Block (RCB) AOV For NUMBER / PLANT 8/15/14 1 (Data Column 2)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)
Total	55	37.888393			
Replicate	3	0.933393	0.311131	3.508	0.0241
Treatment	13	33.495893	2.576607	29.050	0.0001
Error	39	3.459107	0.088695		

Randomized Complete Block (RCB) AOV For GREEN WT SUCKER (GRAMS) 8/15/14 (Data Column 3)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)
Total	55	519.107977			
Replicate	3	7.187505	2.395835	0.720	0.5461
Treatment	13	382.156094	29.396623	8.835	0.0001
Error	39	129.764378	3.327292		

Randomized Complete Block (RCB) AOV For PERCENT SUCKER CONTROL 8/15/14 1 (Data Column 4)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)
Total	55	34127.281598			
Replicate	3	108.226363	36.075454	1.780	0.1669
Treatment	13	33228.790523	2556.060809	126.143	0.0001
Error	39	790.264712	20.263198		

RESEARCH NOTE

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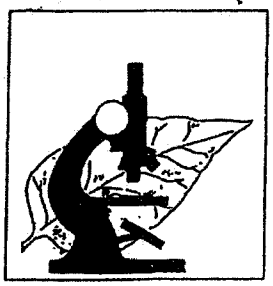

EFFECTS OF FATTY-ALCOHOL AND SYSTEMIC GROWTH REGULATOR COMBINATIONS ON SUCKER CONTROL IN FLUE-CURED TOBACCO.[1]

By W.C. SMITH, JR. and W.D. SMITH[2]

Three field experiments were conducted from 1983-1985 to compare the effects of four fatty-alcohol treatments (two applications with active ingredients concentrations of: 1.7% + 1.7%; 0 + 3.4%; 1.7% + 3.4%; and 3.4% + 3.8%) in factorial combination with four systemic treatments (maleic hydrazide; maleic hydrazide + fatty-alcohol, tank mixed; maleic hydrazide/chlorpropham, sequential; and flumetralin) on sucker number and fresh weight per plant in flue-cured tobacco. The combined analysis of variance over the three years indicated a significant interaction among fatty-alcohol and systemic treatments. Year by treatment interactions were not significant. In general, fatty-alcohol treatments of 3.4% or 3.8% concentrations improved sucker control when maleic hydrazide was used alone, in sequential combination with chlorpropham, or in simultaneous combination with a fatty-alcohol. Sucker control was generally greatest when flumetralin was used as the systemic treatment regardless of the fatty-alcohol treatment. However, sucker control with flumentralin decreased when used after two applications of a fatty-alcohol at 3.4% and 3.8% concentrations respectively as compared to two applications at concentrations of 1.7% + 1.7%, 1.7% + 3.4%, and 0 + 3.4%. These results indicate that sucker control with flumetralin can be improved by avoiding the relatively strong 3.4% + 3.8% fatty-alcohol applications.

Addition Index Words: *Nicotiana tabacum* L., Maleic Hydrazide, chlorpropham, flumetralin.

INTRODUCTION

Prior to 1983, flue-cured tobacco growers had few options for chemical control of axillary bud growth (suckers). Maleic hydrazide (MH), preceeded by two applications of a fatty-alcohol was the recommended chemical sucker control program (1). Flumetralin is a local systemic and was registered in 1983 for use as an alternative to MH. Another local systemic, chlorpropham, was also marketed for the first time in 1983 for use following MH in a fatty-alcohol, MH sequential application. Flumetralin and chlorpropham have been incorporated into recommended sucker control programs (3) and are presently used by tobacco growers.

The ad hoc Regional Tobacco Growth Regulator Committee has conducted a number of experiments to compare the sucker control obtained from the use of flumetralin and chlorpropham to the control obtained with MH (unpublished data). Additional studies investigated various mixtures of these new products with MH (4,6). However, these studies did not compare the sucker control obtained with flumetralin, chlorpropham, and MH following different fatty-alcohol concentrations and application times. Therefore, the objective of this study was to investigate the effect of various systemic and fatty-alcohol combinations on sucker control in flue-cured tobacco.

MATERIALS AND METHODS

Three field experiments were conducted on a flue-cured tobacco farm in Suwannee County, Florida from 1983-85. Treatments consisted of four combinations of a fatty-alcohol (1-octanol and

[1]Paper No. 7373 of the Journal Series of the Florida Agricultural Experiment Station, Gainesville, Florida.
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Contribution received May 2, 1986. Tob. Sci. 31:5-7, 1987.

Table 1. Effect of fatty-alcohol and systemic combinations on sucker number and fresh weight (1983-1985).

Fatty-Alcohol[a] Concentration	Systemic Chemical: Maleic Hydrazide[b] (2.7 kg/ha)	Maleic Hydrazide +Fatty-Alcohol[c] (2.4 kg/ha,2.0%)	Maleic Hydrazide / Chlorphropham[d] (2.7 + 1.2 kg/ha)	Flumetralin[e] (1.4 kg/ha)
1st Applic % — 2nd Applic %				
	Suckers,no./plant[f]			
1.7 + 1.7	5.9 a a'	5.8 a a'	4.3 a b'	1.4 a c'
0 + 3.4	3.8 a a'	3.8 b a'	3.1 b a'	1.4 a b'
1.7 + 3.4	3.9 a a'	3.9 b a'	3.1 b a'	1.4 a b'
3.4 + 3.8	4.4 a a'	3.7 b a'	3.6 b a'	2.2 b b'
	Sucker weight, gm/plant[f]			
1.7 + 1.7	581 a a'	535 a ab'	401 a b'	156 a c'
0 + 3.4	497 ab a'	421 b a'	292 a b'	100 a c'
1.7 + 3.4	507 ab a'	340 c a'	271 a b'	116 a c'
3.4 + 3.8	344 b a'	320 c ab'	311 a ab'	220 b b'

a) Concentrations are in % active ingredient obtained from a commercial formulation of fatty-alcohol (tradename Off-Shoot T, Buckeye Celluose Corp.). 1.7% = 2% formulation, 3.4% = 4% formulation, and 3.8% = 4.5% formulation.
b) Commercial formulation of a potassium salt of maleic hydrazide (tradename Royal MH-30, Uniroyal Inc.).
c) Commercial formulation of fatty-alcohol and potassium salt of maleic hydrazide (tradename FST-7, Fair Products)
d) Sequential applications of a commercial formulation of a potassium salt of maleic hydrazide (tradename Royal MH-30, Uniroyal, Inc.) and a commercial formulation of chlorpropham (tradename Budnip, PPG Industries).
e) Commercial formulation of flumetralin (tradename Prime+, Ciba-Geigy Corp.).
f) Treatment means followed by the same letter do not differ significantly at P = 0.05 according to Duncan's Multiple Range Test. The letters "a", "b", and "c" are for comparisons within columns, while the letters "a'", "b'", and "c'" are for comparisons within rows.

1-decanol mixture) and four treatments with systemic chemicals in a factorial arrangement for a total of 16 treatments (**Table 1**). Each treatment was replicated three times in a randomized complete block design. Each plot consisted of a single row of tobacco 7.6m long. *Nicotiana tobacum* L. cvs. 'Speight G-70' and 'Northrup King K-326' were used in 1983 and 1984-85, respectively.

Materials were applied with CO_2 pressurized back-pack sprayer utilizing three spray nozzles over the row. Fatty-alcohol, flumetralin, and chlorpropham applications were applied with three TG-3 nozzles at 173 kPa for a solution volume of 487 L/ha. Products containing MH were applied with three 8003 nozzles at 345 kPa for a solution volume of 542 L/ha. Rates of the chemicals used are shown in **Table 1**. The first fatty-alcohol applications were when 50% of the tobacco plants in each plot were in the button stage of floral development. The second fatty-alcohol applications were 5 days after the first. Systemic applications were 7 days after the second contact applications. Plants were topped immediately before the application of systemic treatments.

Treatments were evaluated the day following harvest completion. Suckers were counted and weighed from ten consecutive plants in each plot. Sucker number and fresh weight per plant were calculated and analyzed by analysis of variance techniques (5) for each year of the study. The combined data over the three years were also analyzed. Duncan's multiple range test was utilized to separate treatment means when the analysis of variance indicated significant ($P \leq 0.05$) treatment differences.

RESULTS

The combined analysis of variance over three years indicated a significant interaction among fatty-alcohol and systemic treatments. Year by fatty-alcohol, year by systemic, and year by fatty-alcohol by systemic effects were not significant. Significant differences among systemic treatments within fatty-alcohol treatments were observed. Fatty-alcohol treatments also differed significantly when analyzed within systemic treatments.

Systemics within fatty-alcohol

Flumetralin resulted in the lowest sucker number within all fatty-alcohol treatments (**Table 1**). MH/chlorpropham resulted in fewer suckers than MH and MH + fatty-alcohol when the relatively weak 1.7% + 1.7% fatty-alcohol treatment was used. For treatments which included a second fatty-alcohol application of 3.4% or 3.8% the sequential application of MH/chlorpropham did not significantly decrease sucker number as compared to MH and MH + fatty-alcohol. There were no differences in sucker number between plants sprayed with MH or MH + fatty-alcohol regardless of the fatty-alcohol treatment.

Flumetralin application resulted in the lowest sucker weight per plant following the 1.7% + 1.7%, O + 3.4%, and 1.7% + 3.4% fatty-alcohol treatments (*Table 1*). However, when following the relatively strong 3.4% + 3.8% fatty-alcohol treatment fluometratin resulted in less sucker weight per plant than MH but did not differ significantly from MH + fatty-alcohol and MH/chlorpropham. MH/chlorpropham resulted in less sucker weight per plant than MH following all fatty-alcohol treatments except the 3.4% + 3.8% treatment; and less sucker weight per plant than MH + fatty-alcohol following the O + 3.4% and 1.7% + 3.4% fatty-alcohol treatments. There were no differences in sucker weight per plant between MH/chlorpropham and MH + fatty-alcohol following the relatively weak 1.7% + 1.7% or strong 3.4% + 3.8% fatty-alcohol treatments. MH + fatty-alcohol did not differ significantly from MH as measured by sucker weight per plant following any fatty-alcohol treatment

Fatty-alcohols within systemics

Sucker number per plant did not differ significantly due to fatty-alcohol treatment when MH was the systemic treatment (**Table 1**). When MH + fatty-alcohol or MH/chlorpropham was the systemic treatment the O + 3.4%;, 1.7% + 3.4%, and 3.4 + 3.8% treatments resulted in fewer suckers per plant than the 1.7% + 1.7% fatty-alcohol treatment. The 3.4% + 3.8% fatty-alcohol treatment resulted in more suckers per plant than 1.7%

+ 1.7%, O + 3.4%, and 1.7% + 3.4% when flumetralin was the systemic treatment.

Sucker weight per plant was lower with 3.4% + 3.8% than with the 1.7% + 1.7% fatty-alcohol treatment when used in combination with the MH treatment. When MH + fatty alcohol was used as the systemic, 1.7% + 3.4% and 3.4% + 3.8% resulted in less sucker weight per plant than the 1.7% + 1.7% and O + 3.4% fatty-alcohol treatments. The 0 + 3.4% treatment resulted in less sucker weight per plant than 1.7% + 1.7% treatment when MH + fatty-alcohol was the systemic. The use of a relatively strong fatty-alcohol (3.4% + 3.8%) resulted in more sucker weight per plant than the other fatty-alcohol treatments when flumetralin was used as the systemic. Sucker weight did not differ significantly due to fatty-alcohol treatment when MH/chlorpropham was the systemic treatment.

DISCUSSION

In general, fatty-alcohol treatments of 3.4% or 3.8% improved sucker control when MH was used alone, in sequential combination with chlorpropham, or in simultaneous combination with a fatty-alcohol. Under these experimental conditions there was no advantage in using MH + fatty-alcohol instead of MH alone following any fatty-alcohol treatment. Sequential application of chlorpropham after MH improved sucker control as compared to MH alone when 1.7% + 1.7%, 0 + 3.4%, and 1.7% + 3.4% fatty-alcohol treatments were used; however, there were no differences in sucker number or fresh weight following the 3.4% + 3.8% contact treatment. These results indicate that the additional application of chlorpropham is not warranted when tobacco growers utilize the standard sucker control program (3) of 2 fatty-alcohol applications at 3.4% and 3.8% concentrations followed by MH application.

Flumetralin provided better sucker control than other systemics when following fatty-alcohol treatments of 1.7% + 1.7%, 0 +3.4%, and 1.7% +3.4%. Sucker control with flumetralin was decreased when used after the 3.4% + 3.8% fatty-alcohol treatment, and provided sucker control equal to MH + fatty-alcohol and MH/chlorpropham. The nature of this reduced effectiv[illegible] cannot be determined from this experiment. However, pre[illegible] research (2) has shown the leaf-axil to be the primary absorp[illegible] site for flumetralin and translocation from leaf to leaf-axil to be very limited. Physical and morphological damage to the leaf-axil by fatty-alcohol application may reduce flumetralin absorption and result in reduced sucker control. If flumetralin absorption is affected, the reduction is not complete since sucker control with flumetralin is comparable to other systemic treatments. These results do indicate the sucker control with flumetralin can be improved by advoiding the relatively strong 3.4% + 3.8% fatty-alcohol treatment.

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ATTACHMENT A

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Residue Levels of Fatty Compounds and Surfactants as Suckering Agents on Tobacco*

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INTRODUCTION

Decapitation (topping) at onset of flowering is a standard practice in the production of tobacco. Subsequently, axillary buds will grow into branches, known as suckers, because of the removal of apical dominance. The operation for the removal of these suckers is called "suckering". Materials used to inhibit the growth of axillary buds into suckers are termed as "suckering agents". The majority of the suckering agents are either lost or decomposed during the period of tobacco growth and curing, but some may remain in or on the cured leaf. This paper reports the residues of fatty ester and alcohol used as suckering agents in the field which remained in the cured leaves of Maryland, Burley, and Bright experimental tobaccos.

Many lower alkyl esters and alcohols showed various degrees of effectiveness for sucker inhibition (4). The most effective ones are saturated, 8 to 12 carbon straight chain esters and alcohols, especially those with 10 carbons (2, 3). The commonly used ester for field application is methyl caprate, and the commonly used alcohol is a mixture of 1-octanol and 1-decanol. The surfactant for ester is polyoxyethylene [20] sorbitan monolaurate (Tween 20)**, and that for alcohol is polyoxyethylene [20] sorbitan monooleate (Tween 80). Since fatty compounds are naturally occurring products in tobacco, labeled materials were used as tracers in this recovery study. ^{14}C lauric acid derivatives were used as they were readily available. The Tween surfactants with ^{14}C-labeling were supplied to us as a courtesy of ICI United States, Inc. (formerly the Atlas Chemical Industries, Inc.).

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** Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

MATERIALS AND METHODS

Tobacco Plants: Three types of tobacco (*Nicotiana tabacum* L.) were used in this study, including cv. Maryland Catterton, Burley 21, and N.C. 95. The first two represent Maryland and Burley types and were grown and air-cured at Beltsville, Maryland, and the last one represents Bright type tobacco, grown and flue-cured at Oxford, North Carolina.

These plants were field-grown under regular culture practices and cured according to type. For sucker chemical tests of Maryland and Burley types, three plants were used for each treatment. Each plant received the chemicals once and was harvested two weeks after treatment. The air-cured leaves from three plants within each treatment were combined, and grouped into three composite samples according to top, middle, and bottom stalk positions. For Bright type tobacco, five plants were used for each treatment. Each plant received the chemicals twice, the second application was applied two weeks after the first. This type of tobacco was harvested by leaf priming and then was flue-cured. The first priming was made one week after the first treatment, the second priming was three weeks after first treatment (or one week after second treatment), and the third or last priming was five weeks after the first treatment (or three weeks after second treatment). Leaves from five plants of same priming within each treatment were combined into one composite sample.

Suckering Materials and Field Treatments: Chemicals used included the following: Methyl caprate, a mixture of 1-octanol and 1-decanol (approximately 45—55), methyl laurate, lauryl alcohol, lauric acid-1-^{14}C methyl ester, lauryl-alcohol-1-^{14}C, Tween 20,** Tween 20-^{14}C (either ^{14}C-1-fatty acid, or ^{14}C-U-ethylene oxide), Tween 80, and Tween 80-^{14}C (either ^{14}C-1-fatty acid, or ^{14}C-U-ethylene oxide).

Table 1. Description of materials and dosage used for each plant.

Treatment code	Materials and combination	^{14}C-activity (CPM)	
		Maryland & Burley types	Bright type
1	830 mg methyl caprate + 320 mg Tween 20	—	—
2	636 mg mixture of 1-octanol and 1-decanol + 480 mg Tween 80	—	—
3	960 mg methyl laurate + 320 mg Tween 20	—	—
4	750 mg lauryl alcohol + 480 mg Tween 80	—	—
5	830 mg methyl caprate + 320 mg Tween 20 (^{14}C-1-fatty acid)	5.73×10^7	1.26×10^8
6	830 mg methyl caprate + 320 mg Tween 20 (^{14}C-U-ethylene oxide)	1.18×10^8	1.37×10^8
7	636 mg mixture of 1-octanol and 1-decanol + 480 mg Tween 80 (^{14}C-1-fatty acid)	6.60×10^7	1.16×10^8
8	636 mg mixture of 1-octanol and 1-decanol + 480 mg Tween 80 (^{14}C-U-ethylene oxide)	6.80×10^7	1.30×10^8
9	960 mg methyl laurate (^{14}C-1-lauric acid methyl ester) + 320 mg Tween 20	5.30×10^7	8.40×10^7
10	750 mg lauryl alcohol (^{14}C-1-lauryl alcohol) + 480 mg Tween 80	5.68×10^7	1.40×10^8

The exact combination of these active materials and surfactants, the rate of application, and the total level of ^{14}C-activity are shown in Table 1, together with the assigned code for each treatment.

Residue Determination: The combined cured leaf samples were ground and well mixed. A 10 g subsample from each treatment was extracted with 100 ml 70% ethanol in a Waring Blender for 10 minutes. Following filtration and concentration, an aliquot representing 100 mg of original tobacco sample was used for ^{14}C-counting in a toluene cocktail. Data obtained from treatments codes 1, 2, 3, and 4 were used for ^{14}C background correction of corresponding treatments.

Residue data are calculated based on ^{14}C-recovery.

RESULTS

Total yield of cured leaf from each treatment is listed in Table 2. These composite samples represented materials of three plants from Maryland and Burley types, and five plants from the Bright type. The ^{14}C-activity of composite sample from each type and the percentage of ^{14}C-recovery are listed in Tables 3, 4, and 5 for Maryland, Burley, and Bright tobaccos, respectively. Generally, the average recovery of ^{14}C-activity was low. The ^{14}C-labeled ethylene oxide moiety of Tween compounds appeared to be more stable than ^{14}C-labeled fatty acid moiety of the same compounds and thus resulted in an apparently higher ^{14}C-recovery of the former treatments.

The ^{14}C-recovery for Maryland and Burley types was the highest in top leaves where most of the chemical sprays were directly applied. As expected, the percentage of recovery was gradually reduced toward middle portion of the plant, and the lowest recovery was obtained for the bottom leaves. However, the highest ^{14}C-recovery for Bright type tobacco was usually in the second priming or at the middle position. This result may have reflected the effect of the second chemical

Table 2. Yield of composite samples from each treatment according to stalk positions or primings.

Treatment code*	Maryland Catterion				Burley 21				N. C. 85			
	Bottom g	Middle g	Top g	Total g	Bottom g	Middle g	Top g	Total g	1st priming g	2nd priming g	3rd priming g	Total g
1	49	46	86	181	84	72	85	241	202	239	173	614
2	83	76	79	238	88	84	106	278	247	250	345	842
3	103	97	97	297	109	110	83	302	188	255	257	700
4	98	95	82	275	126	123	119	368	225	237	295	759
5	66	47	72	185	105	72	100	277	163	283	252	698
6	69	74	76	219	97	80	168	345	160	187	185	542
7	62	93	88	243	92	73	116	281	201	257	304	762
8	111	100	135	346	114	119	159	392	171	290	367	828
9	107	114	98	319	126	117	120	365	148	215	214	577
10	100	86	131	317	97	95	92	274	178	233	298	707

* See Table 1.

Table 3. ^{14}C-activity of composite Maryland tobacco samples.

Treatment code*	Bottom			Middle			Top			Average recovery (%)
	100 mg	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	
1	18.2	8.9 × 10^2	—	17.4	8.0 × 10^2	—	29	2.49 × 10^3	—	—
2	19.3	1.60 × 10^3	—	21.9	1.66 × 10^3	—	18.3	1.28 × 10^3	—	—
3	21.9	2.25 × 10^3	—	23.8	2.30 × 10^3	—	23.3	2.28 × 10^3	—	—
4	27.0	2.85 × 10^3	—	27.2	2.58 × 10^3	—	20.8	1.70 × 10^3	—	—
5	133.8	8.83 × 10^3	.005	174.2	8.18 × 10^3	.004	336.7	2.42 × 10^4	.012	.007
6	422.1	2.01 × 10^4	.008	1124.2	8.31 × 10^4	.024	2552.9	1.94 × 10^4	.054	.028
7	186.7	1.22 × 10^4	.005	283.6	2.63 × 10^4	.012	315.5	2.77 × 10^3	.013	.010
8	147.7	1.64 × 10^4	.007	347.7	3.47 × 10^4	.016	518.8	6.86 × 10^3	.033	.018
9	72.2	7.72 × 10^3	.003	166.8	1.90 × 10^4	.010	600.3	5.88 × 10^3	.035	.018
10	98.6	8.96 × 10^3	.004	235.8	2.02 × 10^4	.010	607.4	7.65 × 10^4	.044	.019

Table 4. ^{14}C-activity of composite Burley tobacco samples.

Treatment code*	Bottom			Middle			Top			Average recovery (%)
	100 mg sample CPM	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	
1	20.3	1.70 × 10^3	—	21.9	1.57 × 10^3	—	16.1	1.36 × 10^3	—	—
2	22.5	1.93 × 10^3	—	20.0	1.68 × 10^3	—	16.9	1.82 × 10^3	—	—
3	22.4	2.44 × 10^3	—	3.4	3.74 × 10^3	—	14.8	1.22 × 10^3	—	—
4	23.5	2.96 × 10^3	—	19.1	2.35 × 10^3	—	16.3	1.93 × 10^3	—	—
5	49.1	4.52 × 10^3	.002	80.7	5.81 × 10^3	.002	177.1	1.77 × 10^4	.009	.004
6	152.4	1.48 × 10^4	.004	220.0	1.89 × 10^4	.005	940.3	1.57 × 10^4	.044	.017
7	51.1	4.70 × 10^3	.001	148.2	1.08 × 10^4	.005	347.4	4.02 × 10^4	.020	.009
8	75.8	8.84 × 10^3	.003	137.4	1.53 × 10^4	.007	384.1	6.10 × 10^4	.029	.013
9	74.5	9.63 × 10^3	.004	153.8	1.79 × 10^4	.009	721.8	8.66 × 10^4	.054	.022
10	102.5	9.94 × 10^3	.004	207.4	1.76 × 10^4	.009	469.7	4.32 × 10^4	.024	.012

Table 5. ^{14}C-activity of composite Bright tobacco samples.

Treatment code*	1st priming			2nd priming			3rd priming			Average recovery (%)
	100 mg sample CPM	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	100 mg sample CPM	Total CPM	Recovery (%)	
1	10.0	2.02 × 10^3	—	7.9	1.88 × 10^3	—	10.0	1.73 × 10^3	—	—
2	11.9	2.83 × 10^3	—	3.8	9.00 × 10^3	—	53.5	1.84 × 10^4	—	—
3	13.2	2.48 × 10^3	—	1.5	3.62 × 10^3	—	11.9	3.05 × 10^3	—	—
4	12.8	2.43 × 10^3	—	5.0	1.18 × 10^3	—	11.7	3.45 × 10^3	—	—
5	68.0	1.11 × 10^4	0.001	860.8	2.43 × 10^5	0.038	798.1	2.01 × 10^5	0.031	0.023
6	102.7	1.64 × 10^4	0.002	7785.7	1.45 × 10^6	0.211	7020.0	1.36 × 10^6	0.198	0.137
7	65.0	1.30 × 10^4	0.002	1685.6	4.33 × 10^5	0.074	869.7	2.64 × 10^5	0.042	0.039
8	79.5	1.35 × 10^4	0.002	1427.1	4.13 × 10^5	0.063	1603.4	5.88 × 10^5	0.087	0.050
9	48.3	7.14 × 10^3	0.001	181.3	3.89 × 10^4	0.009	366.7	7.84 × 10^4	0.018	0.009
10	87.3	1.55 × 10^4	0.002	477.5	1.11 × 10^5	0.018	864.7	2.85 × 10^5	0.040	0.019

* See Table 1.

Table 6. Calculated residual levels of test materials in tobacco leaf.

Treatment code*	^{14}C-labeled test material	Maryland Callerton		Burley 21		N. C. 95	
		Recovery of material (mg)	Residue on leaf (ppm)	Recovery of material (mg)	Residue on leaf (ppm)	Recovery of material (mg)	Residue on leaf (ppm)
5	Tween 20 ^{14}C-1-fatty acid	0.087	0.383	0.036	0.138	0.368	0.527
6	Tween 20 ^{14}C-U-ethylene oxide	0.269	1.227	0.163	0.473	2.192	4.044
7	Tween 80 ^{14}C-1-fatty acid	0.144	0.592	0.115	0.409	0.936	1.228
8	Tween 80 ^{14}C-U-ethylene oxide	0.259	0.748	0.187	0.477	1.200	1.449
9	^{14}C-1-lauric acid methyl ester	0.461	1.445	0.633	1.734	0.432	0.748
10	^{14}C-1-lauryl alcohol	0.427	1.348	0.270	0.985	0.712	1.007

* See Table 1.

treatment which was applied only one week before this priming. The average residue levels remaining on tobacco leaf were calculated, as shown in Table 6. The calculation was based on percent of ^{14}C-recovery from each treatment of each tobacco type. Lauric acid methyl ester residues were 1.45, 1.73, and 0.75 ppm, and lauryl alcohol residues were 1.35, 0.99, and 1.01 ppm for Maryland, Burley, and Bright tobacco, respectively. Calculated residue levels for the Tween materials varied widely depending on position of ^{14}C-labeling; range was between 0.24 and 4.04 ppm. The general average for the residue level of Tween compounds was approximately 0.5 ppm based on fatty acid moiety, and 1.4 ppm based on ethylene oxide moiety.

DISCUSSION AND CONCLUSION

A separate study on the fate of fatty compounds and surfactants applied on tobacco (1) revealed that there was interconversion among methyl laurate, lauryl alcohol, and lauric acid during the 16 and 144 hour sampling of fresh tobacco materials. Since results reported here were based on recovery of ^{14}C-activity which was labeled at the 1-position to carbonyl or alcoholic hydroxyl groups, the calculated fatty residues may, therefore, include the summation of acid, alcohol, and ester resulting from interconversion of the applied material. It was also found that all the Tween materials remaining on the tobacco were hydrolyzed *in situ* (1). The calculated residual data from Tweens reported here may either reflect fatty ester (laurate or oleate), or polyethoxylated polyol, depending on whether the labeling was at fatty acid or ethylene oxide moiety, respectively. The maximum calculated recovery of Tween material observed in these tests was 4 ppm; hydrolyzed fatty materials originated from Tweens would be only a small fraction of the Tweens.

In one of our preliminary tests involving Maryland and Burley tobacco types with which we used ^{14}C-labeled methyl laurate and lauryl alcohol, we found an average of 4.8 ppm residue. The present study showed an average residue of only 1.6 ppm fatty compound and approximately 1.0 ppm Tween residue. The combined total is about 2.6 ppm residue level which is much lower than earlier findings.

The naturally occurring fatty acid derivatives in cured leaf tobacco are around 7,000 ppm (4). The total lipid fraction in leaf tobacco is approximately ten times greater than the level of fatty compounds. It is apparent that the residue level of fatty compounds used as suckering agent, in the range reported in this paper, would not affect leaf quality or usability.

SUMMARY

Fatty compounds including lauryl alcohol and methyl laurate and Tween 20 surfactant (polyoxyethylene [20] sorbitan monolaurate) and Tween 80 surfactant (polyoxyethylene [20] sorbitan monooleate) with ^{14}C-labeling at various positions were used as suckering agents for Maryland, Burley, and Bright tobacco types (*Nicotiana tabacum* L.) and their residues on the tobacco determined. An average residue of 1.62 ppm of fatty compounds and 1.0 ppm of surfactants were found. The combined total of 2.6 ppm residue due to these suckering agents is far below an earlier preliminary test of 4.8 ppm of residue in comparison with 7,000 ppm naturally occurring fatty compounds in tobacco.

ZUSAMMENFASSUNG

Fettartige Verbindungen wie Laurylalkohol und Methyllaurat sowie die oberflächenaktiven Substanzen Tween 20 (Polyoxyäthylen[20]sorbitan-monolaurat) und Tween 80 (Polyoxyäthylen[20]sorbitan-monooleat) mit ^{14}C-Markierung in verschiedenen Positionen wurden als Mittel zur Kontrolle des Geizenwachstums bei Maryland-, Burley- und Bright-Tabaken (*Nicotiana tabacum* L.) benutzt und ihre Rückstände im Tabak untersucht. Der durchschnittliche Rückstandsgehalt belief sich auf 1,62 ppm bei den fettartigen Verbindungen und auf 1,0 ppm bei den oberflächenaktiven Substanzen. Der Gesamtwert von 2,6 ppm für Rückstände dieser Wachstumsregler liegt weit unter dem Ergebnis eines früheren Vorver-

suchs mit 4,8 ppm im Vergleich zu dem natürlichen Vorkommen von fettartigen Verbindungen im Tabak in Höhe von 7000 ppm.

RESUME

On a employé comme agents pour l'ébourgeonnement de tabac Maryland, Burley et Bright (*Nicotiana tabacum* L.) les composés gras suivants: alcool laurylique, laurate de méthyle, Tween 20 surfactant (polyoxyéthylène[20]monolaurate de sorbitan) et Tween 80 surfactant (polyoxyéthylène[20]mono-oléate de sorbitan) marqués au carbone 14 à différentes positions. On a déterminé leur résidu dans le tabac. Des résidus moyens de 2,61 ppm de composés gras, et 2,0 ppm de surfactants ont été retrouvés. Le résidu total combiné de 2,6 ppm dû aux agents d'ébourgeonnement en question est de beaucoup inférieur à 4,8 ppm trouvé dans des tests préliminaires, surtout si l'on compare au 7.000 ppm des corps gras se trouvant naturellement dans le tabac.

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Grower Statements on Sucker Control

The 3 acre field of tobacco NC196 was planted on 5-28-13 to be used in a flue cured wood barn for a historical demonstration at the N.C. state fair. The tobacco first went through somewhat of a drought but eventually the rain started coming regularly making the crop all uniform. Then we come in on 8-23-13 and were able to top the field 100 percent .Then the following day 8-24-13 we walked over the field to make sure that we had got 1 inch or longer suckers. Then on 8-26-13 we applied our first application of n-tac at a rate of 2.5 gal. to 48 gals. of water. Then I kept check on the burn down of the following smaller suckers weeks after the first application. We had such a great burn control of suckers from n-tac even holding the next set suckers from coming. Then I come in on 9-17 13 and made another application of n-tac 2.5 gal. to 48 gals. of water and observes the following days of control we have gotten .Then I was thinking about a MH application but the following weeks proved I didn't need it because of the control I had with 2 applications of n-tac for the tobacco to hold until 10-18-13 with great control of suckers. The burn down of the sucker and hold ability were amazing using n-tac.

Sincerely,

Carl Watson

OLD BELT TOBACCO GROWERS' PROFITS UP IN 2010

David Hartman, Walnut Cove, NC, flue-cured and burley tobacco grower says his tobacco profits were up last year compared to previous years.

Hartman and his brother grew 34 acres of flue-cured and 6 acres of burley in 2010. Their tobacco profits were greater with 40 acres than when they planted more than 100 acres of tobacco. And, the smaller tobacco crop allowed them time and resources to develop other profitable enterprises on the farm.

Hartman says they controlled production costs, produced better quality leaf with higher grades and had a year with more favorable rains. Their contract buyer increased and their growing contract for 2011 and he and his family look forward to another profitable crop in 2011.

As a result of the production practices used and good weather and the quality of his cured leaf, his contractor rewarded him for the high quality of his cured leaf and increased his contract for 2011.

All of Hartman bales received number 1 or 2 grades except that 5 in 6 bales graded 3. He found the grades received to be a big plus for profits compared to when his leaf graded much lower.

After the 2009 season one of his two contractors dropped him. After the 2010 season the remaining contractor gave him an increase for 2011. His family has about all they want to grow.

Production costs in the Hartman operation are reduced several ways to help profits. Heading the list is controlling labor costs by using only 4 or 5 local people only when needed with the remainder being family labor. He found the overhead cost of migrant workers was more than he could pay and be profitable.

The biggest reduction in costs of production was very low curing fuel costs. Hartman cures with a boiler-type system where the water is heated with wood fuel. The fuel source is scrap wood from a logger and wood from landscape companies. There is a logging operation near the Hartman farm that delivers scrap wood from as far away as 20 miles. The other big source of scrap wood is from about 15 landscape companies.

The landscape people deliver scrap free rather than pay $50 to $75 dollars when delivered to a landfill. A lot of this scrap is wooden pallets and most of the scrap is delivered in off-season when Hartman has time to organize it for the furnaces.

Hartman has adequate land for a 4-year rotation. Being able to use a long rotation saves him a lot on chemicals for soil borne diseases and, the rotation allows him to plant a range of varieties which may stay in the field different times. This year he plans to plant 15 acres of his K326 on land that has not been planted in tobacco for many years.

Hartman has had a problem with weeds in his tobacco fields and plans to use more herbicides this season. He does not like to chop morning glories and other weeds.

Fertilizer use is another big area that Hartman has relatively low costs. Fertilizer costs are about 6 cents per pound of cured leaf! First, he controls the rate nitrogen to 65 pounds per acre for the flue-cured tobacco and about double this for the burley plus a little starter fertilizer in the transplant in water.

Hartman gets the maximum use from his fertilizer by applying some of the fertilizer by hand as well as some mechanically. He drops the fertilizer on the soil close to the base of the plant. He figures out how many plants should be fertilized with a handful of the fertilizer being applied. (Many growers use fertilizer programs that cost 12-15 cents per pound of cured leaf.) Hartman reduces fertilizer rates applied if timely rains do not come. He works with his county extension agent in the fertilization program or 8-16-24 or 6-12-18 and ammonium nitrate.

Sucker control is an area that Hartman is studying for 2011. He believes his contractor will soon want to buy only MH free leaf. Hartman is trying to determine how he will respond to these buyer needs. He has been applying two applications of a contact-type chemical applied at 4 percent concentration the first application and 5 percent the second application. These applications were followed with Prime Plus and MH.

Harvesting is done by hand although he owns two second-hand harvesters. Curing is in rack bulk barns.

Supplemental income comes from Ag tourism and a wholesale and retail meat market.

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Walnut Cove, NC 27052

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Email: DavidHartman966@hotmail.com

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7

1. **A Petition Justification Statement:**

Inclusion of a Synthetic on the National List 205.601(k)(2)

- **Explain why the synthetic substance is necessary for the production of an organic product ?**

- **Sucker control on organic crops:**

The Fatty Alcohols being petitioned for use in organic crop productions, have beeen used on farms for several decades with a positive and effective use history, has an excellent record in the field, the environment, and human safety; with cultural benefits.

Proper crop use of these *Fatty Alcohols* reduces overall insect/pest pressures and chemical use, farm labor exposure, farm labor cost and energy. Through carefully timed applications as required, it reduces crop hand topping and suckering, this activity benefits the overall farm resources management, during the pre-and- post harvest peiords.

When used in conjuinction with traditional cultural practices, *Fatty Alcohols,* increases crop yield, quality and marketability and has been shown to increase gross yield by several hundreds pounds per acre, with a substandial income increase in crop value for the farmer!

Additionally, clean sucker and foliage control enables machine harvesting, once again increasing crop yield and quality, and providing major energy and labor savings. Following are a few benefits realized by the farmer when using *Fatty Alcohols:*

- **Yield increases amounting to 20-25 pounds per acre, per day.**
- **Pest/insect population reductions.**
- **Labor and chemical use reduction.**
- **Time/cost savings at critical pre-post–harvest handling.**
- **Increase crop quality and yields and gross income margins to the farmer.**

In summary, the proper use of *Fatty Alcohols* on **organic crops** increases crop quality, yield, and value-added components, at substantial labor and energy reductions, which contribures significantly to the farm gross/net income of the family farm unit!

Green Chemistry Support Documents

Up Close and Green

Here's a closer look at the terms and organizations that are impacting the global natural and organic marketplace.

Rachel Wright
Croda Europe
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THE PERSONAL care market is without doubt caught up in the global whirlwind of going green. Some in the industry may say that the trend is still in its infancy, but it is by no means insignificant. In fact, it is increasing rapidly: the global natural and organic market is growing a staggering 10-15% a year, according to Organic Monitor. The global natural and organic market was valued at $8 billion in 2008, with the most developed regions being North America and Western Europe, which accounted for a significant 65% and 28% respectively. However, growth is not as strong in Asia Pacific, which has less than 3% market share.

The Interpretation of Green

With increased media activity and consumer awareness, the term green is being used in so many scenarios and, as a result, there are many different definitions. With no official definition, translation and interpretation of the meaning of green can depend on many factors, including the industry in question and the consumer's social and environmental awareness.

In many developed markets, green claims are rising significantly, especially in Europe, a market in which Mintel data indicates that one in seven personal care products had at least one green claim, an increase from 1 in 10 during 2007. However, these claims extend beyond natural and organic to include petrochemical-free, preservative-free, locally produced, fair trade, not tested on animals, bio-degradable, sustainably sourced ingredients, recycled package and carbon neutral, to name a few.

In the Asia-Pacific region, the green market is quite diversified. Australia and New Zealand have the majority share with home grown brands such as Gaia Skin Naturals, Natures Organic and Eco Store. Natural and organic claims are less prominent in other Asian countries, as they tackle the green trend with the use of traditional natural ingredients, cold processing and recyclable and refillable packaging claims.

Green claims used across the global personal care industry can include any of the following:

Natural claims can be cited for either an individual ingredient or group of ingredients; e.g., contains 100% natural moisturizers, or for the entire formulation, especially when formulations contain between 90-100% natural ingredients. While natural claims are unregulated, formulations can also be certified natural by a number of non-government organizations, such as Germany's BDIH or France's Ecocert.

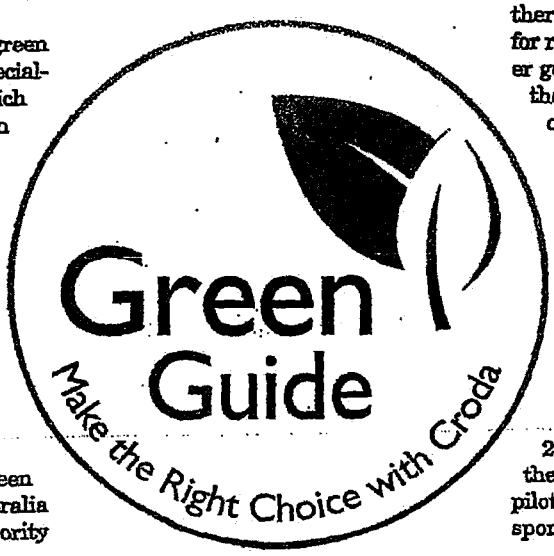
Organic claims can also be made either for a specific ingredient or for the entire formulation, and if desired, the formulation can be certified organic by non-government organizations. Yet many consumers do not realize that organic claims for cosmetics and personal care products fall outside EU legislation of organic labelling as they are not for human consumption.

"Free from" is a common food industry claim which is also increasingly used in the personal care industry. Free from claims have been criticized for their use in cosmetics, as they can sometimes be misleading. These claims can imply that the free from ingredient is in some way undesirable, but the undesirable attributes often lack technical data to justify this perception.

Social and ethical claims such as fair trade and not tested on animals can be perceived by consumers as green. Some of these claims are focused on preserving nature and the environment; others are concerned with assisting either the local economy or localized communities, often in remote areas.

Biodegradability claims are uncommon, but growing in popularity. According to GNPD Mintel, there were three times as many products launched with biodegradability claims in 2008 as there were in 2007. It is an area of focus for rinse-off formulations such as shower gels, shampoos and hand washes, as these products go more directly down our drains and into our ecosystem.

Carbon footprints measure the greenhouse gas emissions of a product throughout its lifecycle in order to identify areas for carbon reductions. In the UK, the Carbon Trust has been piloting a plan on a number of different products from several industry sectors. Boots' Botanics shampoo range was one of the first in personal care to trial the concept in 2006, resulting in 20% reduction in the range's carbon footprint.[1] Since the pilot, and at the request of the project sponsors (Carbon Trust and



Global Certification at a Glance

Natural and/or Organic Certifications

Europe: Ecocert, Soil Association, AIAB, Eco Garantie, BDIH, Cosmebio, NaTrue

North America: USDA Organic, OASIS, NSF, Natural Products Association

Asia-Pacific: National Association for Sustainable Agriculture, Australia (NASAA)

Latin America: IBD Certified Organic, IBD Natural Ingredients

Environmentally-Friendly Certifications

Europe: EU Flower, Nordic Swan

North America: US Environmental Protection Agency, Green Seal, EcoLogo

Asia-Pacific: Korea Eco-label, Environmental Choice, Australia

Latin America: IBD EcoSocial

Department for Environment, Food and Rural Affairs), the British Standards Institute developed a carbon footprint standard (PAS 2050) which, hopefully, makes carbon footprint claims more comparable and meaningful to the consumer.

In addition to carbon reduction claims, carbon neutral claims are appearing on cosmetic packs. These usually mean that the organization has offset the carbon footprint of producing the product by partaking in a project that has a positive impact on carbon emissions.

Sustainability is a keyword that is linked to being green. In general, sustainability relies on a balance between use of and replenishment of a natural resource. Qualifying exactly what constitutes sustainability is very difficult, but there are some organizations that offer raw material certification. The Forest Stewardship Council (FSC) is one of the most common certification organizations. FSC has globally certified more than 280 million acres of sustainable forest.

Packaging is another area scrutinized by green brands and there are several green options, including refillable, recyclable and biodegradable packaging.

Certification Landscape

Natural and organic content are obvious measurable parameters. Datamonitor estimates that 9% of all personal care products launched in 2008 were marketed as being natural in some way. Moreover, 5% of product launches claimed organic content, but even these claims are not regulated, and are, from a purist's point of view, sometimes subject to misuse. As a result, even in the regions where the green trend is booming, such as North America and Europe, there is still some confusion surrounding what constitutes green. To alleviate some of the confusion, various organizations have developed standards to which cosmetics can be certified natural, organic or environmentally friendly.

With a proliferation of certification bodies, Europe appears to be leading the way with both private and not-for-profit organizations exercising their own definitions and standards for natural and organic cosmetics. This landscape is now slightly improved with the European harmonization of six current certification bodies: Soil Association (UK), Ecocert (France), BDIH (Germany), AIAB/ICEA (Italy), BioForum (Belgium) and Cosmebio (France). These organizations launched harmonized standards called COSMOS Natural and Organic Cosmetic Standards in September. While they go someway to tackle the overcrowding of certifications, it will not completely eradicate the confusion.

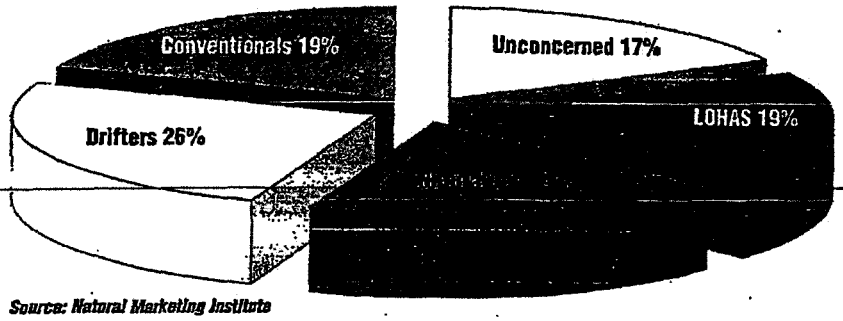
Other certifications within Europe will both coexist and compete with the COSMOS standard, including the NaTrue label, established in 2008 by a European interest group consisting of natural and organic cosmetics manufacturers. NaTrue, which is aiming for a truly global standard with complete transparency, is offering a three-star approach dependent on whether the product is made from natural, natural with organic or organic ingredients. It has signed an equivalency agreement with the National Science Foundation (NSF) in North America, which means that products certified by NaTrue are also guaranteed to gain NSF approval if the product is to be extended into North America and vice-versa.

Another group of certification bodies, referred to as eco-labels, also exist in Europe. These include the Nordic Swan and EU Flower eco-label. Both focus more heavily on detergent systems and their environmental impact, in their aim to reduce water pollution, minimize waste and prevent potential risks to the environment.

Other regions are expected to look to Europe for guidance on certification and eagerly anticipate the European harmonized COSMOS standards, especially as regions such as North America and Asia-Pacific have a growing number of certifications and accreditations of their own. North America has a number of certifications for natural and organic cosmetics, including OASIS, USDA Organic and Natural Products Association. The Asia-Pacific region has the National Association for Sustainable Agriculture Australia (NASAA) and several eco-labels including the Korea program, which aims to reduce energy and resource consump-

Fig. 1: Five Classes of Consumers

% of general population adults by segment



Source: Natural Marketing Institute

tion and minimize pollution in each production step.

Going Green

With so many different standards to choose from, key personal care ingredient suppliers and manufacturers of finished goods can have an influential role when it comes to adopting any of these standards. So far, ingredient suppliers' and cosmetic manufacturers' reactions have been mixed, especially in Europe with some manufacturers choosing not to certify with a current standard, but instead develop their own values and criteria for green.

Ingredient suppliers are also reacting in different ways; some have developed their own rating scales, while others, such as Croda, have chosen not to go down the numerous certification routes. Instead they are inviting customers to get "up close and green" with them and review their green credentials in a Green Guide that allows formulators to make selections based on the green criteria they value most. A Green Formulary also allows formulators to understand the spectrum of "greenness" that they can achieve for a variety of different formulation categories

More than Natural and Organic

While natural and organic claims are prevalent in North America and Europe, other green parameters are often considered by manufacturers, especially in Asia where going green is an energy or waste saving exercise and thoughts are more inline with the 12 Principles of Green Chemistry.[2]

When it comes to reducing energy input and processing costs, cold processable ingredients often provide a greener solution. For manufacturers trying to save in every aspect of the product life cycle, there are options for cold processable ingredients, which eliminate the need for high temperatures and unnecessary energy costs. These ingredients can range from emulsifiers such as Arlatone V-175, through to inorganic sunscreens such as Solaveil Clarus.

Below is an example of a cold process formulation:

Natural Wet Wipe Cleanser

Ingredient:	%Wt.
Crodamol IPIS (Croda) (Isopropyl isostearate)	5.00
Crodamol GTCC (Croda) (Caprylic/capric triglyceride)	5.00
Deionized water	q.s. to 100.00
Pricerine 9091 (Croda) (Glycerin)	3.00
Arlatone V-175 (Croda) (Sucrose palmitate (and) glyceryl stearate (and) glyceryl stearate citrate (and) sucrose (and) mannan (and) xanthan gum)	1.00
Naticide (Sinerga) (parfum)	1.00

Procedure: Premix Arlatone V-175 with Pricerine 9091, slowly add water with stirring and stir until fully hydrated. Separately combine Crodamol IPIS and Crodamol GTCC and add to water blend while stirring at 400rpm. Homogenize for two minutes at 10,000rpm. Stir at 400-500rpm for a further 20-30 minutes. At 40°C add Naticide. Assess pH and adjust.

Appearance: Sprayable, white emulsion; pH: 5.0-5.5; Viscosity: 900cP±10% (Spdl 21, Rpm 20, 25°C); Stability: 2 months@45-, 40-, 25-, 4°C and light.

Green claims: ≥95% natural, cold process, preservative-free, ethylene oxide-free, sulfate-free

Consumer Understanding

With so many different claims being made, it is hard for the consumer to know what to look for in order to make sure they are not being "green washed"—one of the latest buzzwords being used by the industry and media to describe how some green claims may be dishonest or mislead the consumer.

There are six sins associated with green washing:[3]

1. The hidden trade-off—emphasizing just one environmental improvement, while possibly compromising on others.
2. No proof—no official documentation to support claims.
3. Vagueness—claims not being clear enough; for example, nothing is ever "chemical-free."
4. Irrelevance—claims are not relevant; for example "CFC-free," this is a requirement, not a claim.
5. Fibbing—claims are simply untrue.
6. The lesser of two evils—where a greener alternative is not necessarily better; for example, organic cigarettes.

Green washing is a growing concern throughout all industry sectors and not without reason. A recent study showed that approximately 70-80% of North American and 23-30% of Asian products are marketed in this way.[4]

Due to the diversity of the green trend, it is important to try and understand who the green consumers are and who they are not. Many market research companies in North America have tried to understand the various consumer groups. The Natural Marketing Institute (NMI) is a very good example. It has identified five classes of consumers in North America (*Figure 1*). LOHAS (Lifestyles of Health and Sustainability) accounts for 19% of the mix. They are driven by issues surrounding their health and environment and play a big role in sustaining the trend. Naturalites also account for 19%,

-3-

but they are thought to be driven by personal health, more than the environment, and similar to LOHAS, they are avid users of green products. The largest segment, accounting for 25%, is the Drifters, those who are driven by the latest trends and are also sensitive to price and issues in the media. The fourth group (19%), is the Conventionals. They are driven by practicality and may partake in some green issues, such as recycling and energy conservation. Finally, the remaining 17% are the Unconcerned. Although not currently driven by green issues, these consumers may be targeted as products go into more mainstream retailers. As issues in the media and economic pressures take hold, the Drifters and the Unconcerned will threaten the strength and longevity of the green trend.

Along with strong health and environmental values held by LOHAS consumers, the study showed they value product efficacy, demonstrating that applications and/or clinical evidence is key to a product's success. This may explain why natural deodorants and sunscreens have not taken off as fast as other personal care sectors.

Conclusion

Despite confusion regarding accreditations and certifications, the personal care industry seems united in the belief that the green trend will continue.

In regions where the trend is well established, namely North America and Europe, double digit growth is predicted for the next five years and with the harmonization of standards, green claims are expected to become more regulated and sophisticated.

In Asia, growth is likely to be led by Australia, New Zealand, Korea, Malaysia, Hong Kong, Japan, Taiwan and Singapore. Other regions, such as India and China, have recorded strong economic growth, and this, along with recent health scares such as the chromium and neodymium contamination, are likely to have a significant impact on green consumer demands. As imported brands make their presence felt within Asia, and domestic brands provide the market with knowledge and confidence, the green trend looks set to prosper. ●

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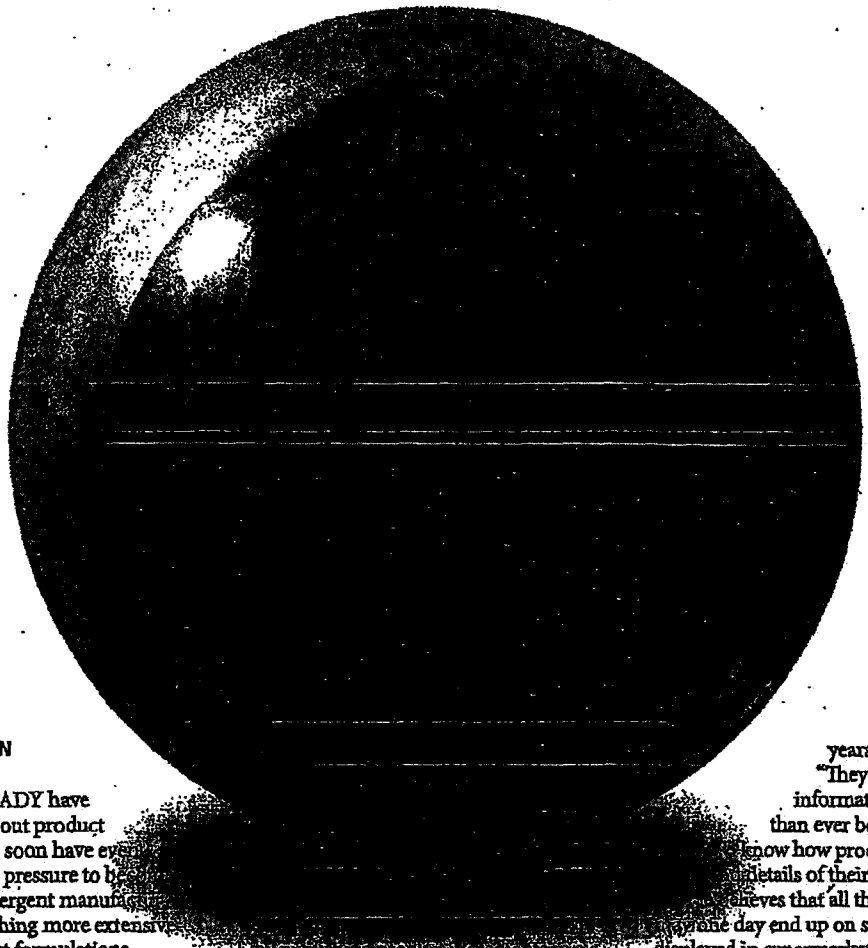
Clean and green

Despite the global downturn, consumers are still choosing detergents with a green twist



REX FEATURES/CHRIS EYLES

LOU READE/LONDON

CONSUMERS ALREADY have lots of information about product ingredients – and will soon have even more. Under growing pressure to be more transparent, detergent manufacturers have begun publishing more extensive details of their product formulations.

"You'll see companies providing much more information about what's in their products," says Brian Sansoni, a spokesman for the US-based Soap & Detergent Association.

The SDA and two other North American associations have set up the Consumer Product Industry Ingredient Communication Initiative. Participating members began to implement it on January 1, by publishing product ingredients in a number of formats – including labels on packaging, manufacturer websites and even via a free telephone line.

This desire for greater product understanding goes hand in hand with another overriding consumer concern: the environment.

"Sustainability has been the message from the major retailers for the past three to five years," says Sansoni.

"They're looking for more information and verification than ever before. They want to know how products are sourced, the details of their life-cycles."

He believes that all this information may one day end up on score cards that are displayed in supermarket aisles – as an aid to the consumer.

ECOLOGICALLY SOUND

Green attributes can take many forms, such as naturally sourced ingredients, the ability to work at lower temperatures, or the use of concentrated liquid formulations.

"Much of this has already been implemented, and is now the norm in

mass-market retail," says Sansoni.

And despite the punishing economic conditions – which have led to a surge in popularity for value brands – there is still an appetite for these higher-priced products with green credentials. "I think this segment of the market is here to stay," he says.

EUROPEAN INITIATIVES

Similar initiatives are happening in Europe. At its December-2, 2009 Information Day in Brussels, Belgium, the International Association for Soaps, Detergents and Maintenance Products (AISE) announced extensions to its own plans to encourage sustainable production and consumption – such as the launch of its consumer website, www.cleanright.eu.

The site provides information and advice on the safe, sustainable use of cleaning products. It is available in eight languages – which AISE says will help it reach up to 345m people. Further languages are planned.

AISE reports that Europeans also have a growing appetite for sustainable products. Christophe Legraverend, quality and sustainability manager for household and personal care products at French supermarket Carrefour, said 'Ecolabels' – which identify products made accoring to environmental principles – have proved to be a big selling point.

"We saw a 40% sales increase for eco-labeled products in 2008," he told delegates at the AISE event.

According to AISE, European sales of detergent products topped €29bn ($42bn) in 2008 (see pie chart) – a 1.4% increase on 2007. Figures from global market research firm Euromonitor International also show steady global growth in detergent sales from 2003 to 2008: in that time, world sales of laundry detergents swelled by nearly 50%, to top $50bn (€35bn). In the same period, dishwashing products grew at a similar rate to reach more than $13bn.

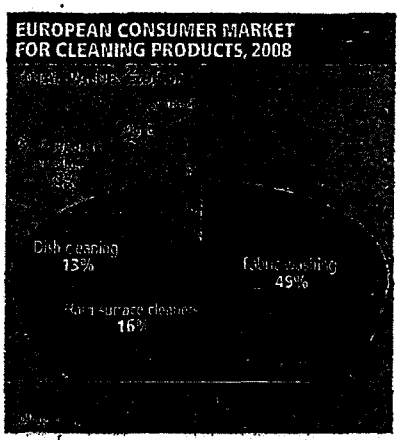
Whether consumers are choosing green brands or value brands, major manufacturers are seeing declining returns from their detergent-related business segments.

Procter & Gamble, the huge US supplier, recently posted its first-quarter (Q1) results: its Fabric Care & Home Care division, which includes laundry and dishwasher detergents and fabric softeners, reported a 5% dip in sales, to $6.1bn.

Its Anglo-Dutch rival Unilever fared little better: Q3 sales in its home care division – whose brands include *Cif* and *Domestos* – fell by 4.8% year on year to $1.75bn. Sales for the first nine months were down by nearly 4%.

Meanwhile, Henkel, of Germany, saw a Q3 dip of nearly 3% in its Laundry & Home Care division – keeping sales just above €1bn – though it claimed organic growth of 2.4%.

"In Western Europe and North America, the difficult market environment impeded sales performance to the extent that neither region was able to attain the sales level of the prior-year quarter," said Henkel at its Q3 results presentation on November 11, 2009.



Sustainability is undoubtedly the major factor driving development of new detergents. But for UK cosmetics and toiletries consultant Colin Hession, this green approach is not appropriate for personal care products such as soap and shampoo.

"I would be very cautious about 'playing green' too hard in personal care," he says. "If there's a trade-off between green and price, then price will win. Cost is very important."

He says consumers are unwilling to pay more for green personal care products. Instead, they respond to tangible product qualities – such as fragrance and lathering ability – which he calls "nice-to-use" factors.

"Beware of setting technical challenges in personal care too far towards green issues, at the expense of cost or nice-to-use," he says.

An ongoing change within personal care – certainly in developed markets – is the shift from solid soap bars to liquid products. This is partly linked to the rise in popularity of showers over baths.

"Liquid soaps have now gone beyond the kitchen, and moved upstairs to the bathroom," says Hession.

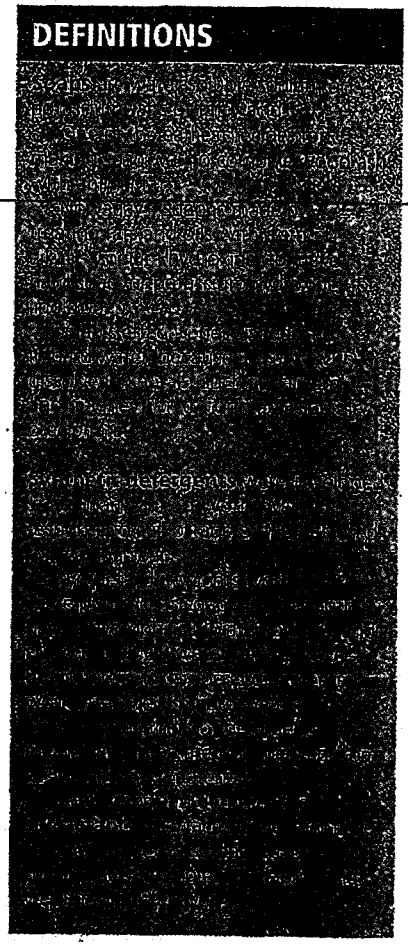
Liquid soaps also give manufacturers more chance to add value, with new formulations. Traditional bar soaps, which are based on natural products, are still common in developing markets, but falling out of favor in Western ones.

Traditional soaps cannot demand high prices, says Hession, but the new breed of synthetic detergents – or 'syndets' – have a perceived added value that produces better margins. "Consumers want more interesting soaps, with fragrance and better lathering qualities," says Hession.

These products are also good for manufacturers, which can more accurately predict the cost of ingredients and chemicals, rather than animal fats and palm oil.

"The market is driven to an extent by consumers – but also by raw material variability and by manufacturers' desire to increase margins," he says. ■

DEFINITIONS



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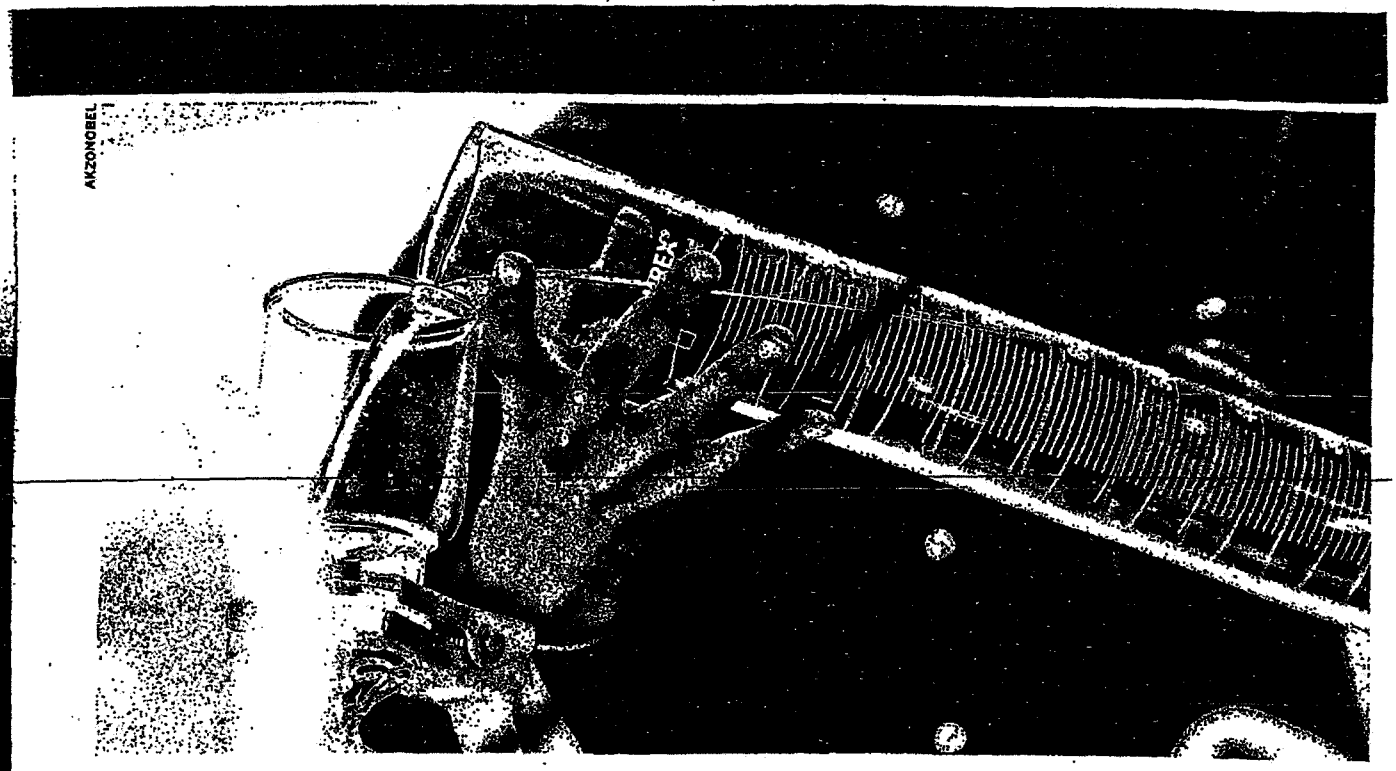


THE GREENING GAME

Makers of **CLEANING PRODUCTS AND DETERGENTS** seek the sweet spot between products that are green and products that clean

MICHAEL MCCOY, C&EN NORTHEAST NEWS BUREAU

TAKE A WALK down the aisles at WalMart or a neighborhood supermarket and it becomes clear that the cleaning product landscape is changing. Laundry detergents, dishwashing detergents, and spray cleaners have always promised to rid the home of dirt and grime. But now many products vow to protect the environment as well.

Niche marketers such as Seventh Generation and Method Home have for several years offered products formulated to be more environmentally sustainable. During 2008, the major cleaning product companies also got into the act. With the help of their raw material suppliers, they introduced a range of goods that demonstrate the diverse ways they are responding to consumer demand for greener cleaners.

After shaking up the market for hard-surface cleaners early in 2008 with the launch of its Green Works brand, Clorox expanded the line to include hand dishwashing liquids and cleaning wipes. And on bottles of some Shout and Scrubbing Bubbles products, SC Johnson started touting that its ingredients are cleared by the Environmental Protection Agency's Design for the Environment program.

Church & Dwight took its Arm & Hammer Essentials brand beyond just a laundry detergent with plant-based surfactants to include spray cleaners with an environmentally friendly twist: Rather than buy a fresh container that is mostly plastic and water, consumers needing more cleaner can purchase a small capsule of concentrate and, using tap water, refill their old bottle at home.

Henkel launched the Terra Activ line of cleaners in Germany, while its Dial subsidiary added a fabric softener to its Purex Natural Elements laundry detergent in the U.S. And Colgate-Palmolive debuted Palmolive Eco automatic dishwashing detergent, which claims to be the first mass-marketed automatic dishwashing detergent brand to eliminate phosphates.

"For us what was significant in 2008 is that the sustainable elements of this market became structural in the U.S.," says Francois Scheffler, industry marketing manager for care chemicals at BASF, a major supplier of ingredients to the cleaning product industry. "Before 2008, the evidence was anecdotal."

THE NEW OFFERINGS target consumers who, more and more, want to know what's in the cleaners they buy. In response to public pressure, the Soap & Detergent Association (SDA) and two other consumer product groups recently launched an initiative to provide more information about what's in the box or bottle. Starting in January 2010, association members will voluntarily post ingredients on product labels or on company websites.

"The consumer is becoming more educated, and the Internet is doing a lot to make that happen," says Andrew Douglass, market innovation director with Novecare, the home and personal care ingredients division of specialty chemical maker Rhodia.

MORE ONLINE To see how cleaning product ingredient makers are weathering the economic crisis, click on this story at www.cen-online.org.

Marketers of household goods are certainly aware that the public wants environmentally sound products. Earlier this month, more than 12 of them formed a partnership with the American Chemical Society's Green Chemistry Institute aimed at sharing knowledge and experience in green chemistry and engineering (C&EN, Jan. 5, page 12).

YET COMPANIES and their ingredient suppliers are taking a surprisingly diverse range of approaches to the sustainability challenge. Some are emphasizing more compact packages, and others are pushing ingredients derived from renewable resources. Still others say formulas that lower the temperature of water required for cleaning are the way to go.

Procter & Gamble, the 800-lb gorilla in the laundry detergent aisle with its Tide line, is noticeably missing from those promoting cleaners based on natural ingredients. Lauren Thaman, a public affairs specialist who handles sustainability issues for P&G's fabric care business, explains that this is because the company wants to see science behind its sustainability claims.

"We're committed to having a science-based approach to sustainability," Thaman says. "Just because it's natural doesn't mean it's sustainable. We have taken a life-cycle analysis approach to ensure we are making claims that are meaningful and measureable."

In laundry products, P&G's main sustainability efforts have been in concentrating its detergents to save on transportation and packaging costs and in launching detergents such as Tide Coldwater and Ariel Cool Clean that save energy by cleaning well at lower wash temperatures. In both cases, P&G says it can quantify its new products' reduced environmental footprint.

"I'm not going to comment on whether or not our competitors are doing that," Thaman says, "but I will tell you that until being able to say something is 'natural' means it is more sustainable, we will not do that."

BASF's Scheffler makes a similar point regarding the cleaning product raw materials BASF makes. "Using a synthetic product that reduces water or energy use by the consumer is as equally sustainable as a product based on a renewable vegetable source," he says.

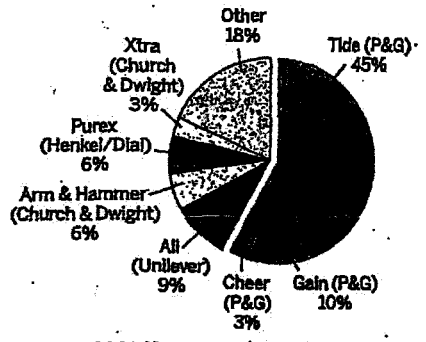
Scheffler points to Lutensol M, a new BASF surfactant made by ethoxylating 2-propylheptanol, a branched alcohol. The company says it conducted an "eco-efficiency analysis" that concluded Lutensol M production causes fewer emissions into wastewater and consumes less energy than other surfactants. Moreover, because of its good emulsifying properties, the new surfactant allows the formulation of laundry detergents that work well at low wash temperatures, BASF says.

Likewise, Pascal Juery, president of Rhodia's Novecare division, cites products such as his firm's Mirapol Surf S, an acrylic-based polymer that makes surfaces more hydrophilic. When added to automatic dishwashing detergent formulas to provide better rinsing, Mirapol Surf S can replace surfactants at just 1% or even 0.1% of the original quantity, Juery says.

"Using a synthetic material to reduce a product's overall chemical content is a valid approach to sustainability," he maintains. Rhodia is also developing "natural-synthetic" hybrid ingredients such as

TIDAL FORCES

P&G dominates the U.S. laundry detergent market



2008 U.S. sales = $3.6 billion

NOTE: Sales in food, drug, and mass merchandise stores, excluding WalMart, for the 52-week period ending Dec. 28, 2008. P&G = Procter & Gamble. SOURCE: Information Resources

"Just because it's natural doesn't mean it's sustainable."

Rhodoclean, a surfactant that links ethylene oxide or propylene oxide to β-pinene extracted from pine oil.

ALTHOUGH COMPANIES such as P&G may have sound scientific reasons to stay off the "all-natural" bandwagon, they have image-based motives as well. Anders Lund, marketing director for detergents at Novozymes, the world's largest manufacturer of enzymes, notes that large corporations have built up a lot of consumer trust in their brands, and they are loathe to put it at risk.

"Some of the bigger brands are worried that their brand equity can get diluted if they focus solely on sustainability," Lund says. "The ones with the most to lose are the most conservative. That doesn't mean they aren't doing anything, but they may not be as aggressive in communicating it." Rather, it's the companies with a smaller market share that tend to trumpet their natural or sustainable products.

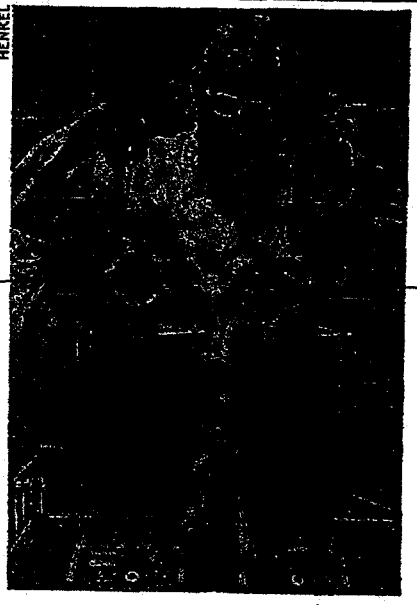
Lund's observation bears out at Henkel, a leading European detergent manufacturer. Henkel has taken a chance in the U.S. with the Purex Natural Elements line, but Purex is a second-tier brand that doesn't have the same reputation as Tide does. In Europe, where Henkel's Persil is the gold standard, the company hasn't launched a green version.

Going all-natural would compromise the performance of Henkel's brands, according to Thomas Müller-Kirschbaum, senior vice president for R&D, technology, and supply chain with Henkel's laundry and home care business. Still, he says, the company is committed to improving the sustainability of its products, particularly in the realm of low-temperature performance.

Europe has a history of using high wash temperatures, and in the 1970s, close to half of all laundering was done in near-boiling water. This figure is only 8% today, Henkel says, but cool-water washing is still rare there. As of 2006, the company says, less than 5% of laundry was washed at 20 °C. It expects that figure to rise to at least 20% by 2020.

Last April, Henkel launched a reformulated Persil line designed to "clean better than ever" at 20 °C. According to Müller-Kirschbaum, the new Persil formula was made possible with an enzyme system developed under a four-year partnership between Henkel and Brain, a German firm that discovers enzymes and other bioactive compounds. The result was a new mixture of proteases and other enzymes specifically evolved to work at lower temperatures.

HENKEL



APRÈS COFFEE Henkel scientists use rigorous tests to ensure new cleaning formulas live up to expectations.

Similarly, Henkel is improving the low-temperature performance of its best-selling Somat automatic dishwashing detergent brand. In 2008, the firm launched Somat 7, a detergent with seven distinct functions, including performance at 40 °C that was previously obtainable only at 60 °C.

For Somat 7, Henkel looked twice to outside technology partners. It developed a new enzyme in an exclusive cooperation with an unnamed collaborator. And it turned to a competitor to license an activator that helps the detergent's sodium percarbonate bleach work well at the lower temperature. Under its open innovation policy, Müller-Kirschbaum says, Henkel not only cooperates with raw material suppliers and research institutes but also licenses innovations from its rivals.

While Henkel used low-temperature effectiveness to improve the sustainability of its marquee European brands, the company also created a new brand aimed at consumers with what it calls lifestyles of health and sustainability, or LOHAS. Terra Activ, a line of hard-surface and hand dishwashing products, was launched in October. On average, the company says,

85% of each formula in the Terra Activ line is based on renewable raw materials.

LOHAS consumers are willing to pay extra for sustainability, but they won't sacrifice performance, according to Müller-Kirschbaum. This is why Henkel chose the 85% target rather than the 99% all-natural claim that Clorox makes for its Green Works line in the U.S. "What we saw in our development work was that if we went in the direction of 99%, we would come to areas where we sacrificed performance," he says.

So far, Müller-Kirschbaum adds, consumers are receptive to Henkel's products with high natural-ingredient content. He says the company plans to launch a Terra Activ laundry detergent in the first half of 2009 and also broaden the Natural Elements brand in the U.S.

SUCH PLANS are good news for chemical companies that have been expanding their arsenals of cleaning ingredients that are partially or wholly based on natural raw materials. Seeing a trend that isn't likely to go away, chemical makers are both increasing their use of renewable feedstocks and developing new ingredients that overcome the environmental shortcomings of some stalwart cleaning chemicals.

It was one year ago that Dow Chemical made its foray into renewable raw materials for cleaning products with the Ecosurf line of surfactants based on chemically modified seed oils. Carlos Silva Lopes, global marketing director for Dow's fabric and surface care business, says Dow will launch a second-generation Ecosurf line at SDA's annual conference, held this week in Boca Raton, Fla.

The new surfactants will offer an improvement in performance and formulation flexibility over the original Ecosurf, according to Lopes. He says they are tailored for hard-surface products such as bath, tub, and kitchen cleaners.

CLOROX

Evonik Industries, the world's largest supplier of fabric softener active ingredients, has long manufactured a naturally derived product. Its softener actives are based on tallow or, increasingly, vegetable oil. Although consumer goods companies have no desire to highlight tallow, an animal fat, on their labels, they are interested in the "renewable carbon" content of the ingredients they buy.

David Del Guercio, Evonik's household care business director for North America, says the company has responded to the clamor for renewable carbon content by developing a dossier that categorizes its products by, among other things, their renewable carbon index (RCI). These indexes are obtained by dividing the number of carbons derived from renewable sources by the total number of carbons. For example, Evonik's Varisoft DS 350 VEG, a vegetable-based softener active, has an RCI of 0.9. In other words, 90% of the product's carbons are renewable.

Customer interest in enzymes, another renewable cleaning ingredient, has surged over the past two years, if Novozymes' results are any guide. Although detergents are the Danish firm's biggest market, for much of this decade, the market wasn't

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growing very fast. Then, in 2007, detergent enzyme sales shot up 10%. Last year, sales were on track for 14% growth—impressive for the detergent industry, which typically expands by only 1 or 2% per year.

"Novozymes has always believed in detergents," says Lund, the marketing director, "but only in the past two years has it paid off." He attributes the growth mostly to customers who turned to enzymes as a safe harbor when prices for conventional ingredients started becoming highly volatile.

But customer demand for more sustainable ingredients has also been a driver, Lund says. In recent years, Novozymes has developed new enzymes such as Stainzyme, Polarzyme, and Liquanase that are specifically designed to work in cold water. "We can prove that compared with other ingredients, enzymes work better at low temperature," he says. Moreover, although laundry detergent makers traditionally add enzymes for their stain-removal capabilities, Lund says his customers are discovering that enzymes impart basic detergency as well.

Novozymes sees enzymes as potential replacements for phosphates, which are being banned from laundry detergents in several European countries and will be phased out of automatic dishwasher detergents in the U.S. by mid-2010 under an industry agreement. According to Lund, detergent makers can replace phosphates and surfactants with a multienzyme mixture without loss of performance.

Also exploring phosphate replacement is AkzoNobel, which became a bigger player in cleaning chemistry after its 2008 acquisition of ICI. Soon after the deal, company managers combined Akzo's surface chemistry business with ICI's Alco Chemical specialty polymers subsidiary to create a major supplier of cleaning product ingredients.

The combined company can supply 75% of the active ingredients in most cleaning formulas, according to John Cate, global business director for fabric and cleaning applications at AkzoNobel Surface Chemistry. "No one else can do that," he says.

Researchers from the two halves of the business are now joining forces to tackle the phosphate phaseout. Today, the firms' specialty polymers are added to phosphate-containing automatic dishwashing products to disperse calcium phosphate and other salts. For tomorrow's phosphate-free formulas, Cate says, scientists are developing dispersing agents based on polymers and AkzoNobel chelating agents such as glutamic acid diacetic acid, which is derived primarily from corn or other renewable resources.

Some automatic dishwashing detergent makers don't worry about phosphates because they don't use them in the first place. Case in point is the household goods maker Seventh Generation, which is in the vanguard in trying to create products with renewable, sustainable ingredients.

Seventh Generation launched its automatic dishwashing detergent in 2001, using citric acid to play the buffering and hard-water softening role of phosphates. The company has since moved on to a new challenge: going more natural by weaning itself from the effective, but nonbiodegradable, acrylic polymer dispersing agents that it now buys from Rohm and Haas and replacing them with plant-based substitutes.

For the past few years, Martin H. Wolf, Seventh Generation's director of product and environmental technology, has been working with the Dutch chemical company Thermphos on carboxymethylinulin, a dispersing agent based on chicory root. Wolf had hoped to launch a reformulated automatic dishwashing detergent in 2008, but he is now targeting 2009.

LIKEWISE, some companies believe they've gone natural if they reformulate their laundry detergents with surfactants made by reacting coconut-based alcohols with ethylene oxide. Seventh Generation did that a while ago. It's now working to move beyond ethylene oxide—both because it is a petrochemical and because ethoxylation yields minute amounts of the possible carcinogen 1,4-dioxane as a by-product.

Wolf and his colleagues have been working with specialty surfactant suppliers such as Cognis, Croda, McIntyre Group, Stepan, and Win Chemical to replace the ethoxylated alcohols with sodium cocosulfate, an alkyl sulfate based on coconut oil. It hasn't been easy, Wolf acknowledges. Alkyl sulfates are less soluble than ethoxylates, must be used at higher concentration to achieve the same degree of cleaning, and can irritate the skin, he explains.

Still, Wolf hopes to launch new versions of Seventh Generation's laundry detergents and hand dishwashing liquids later this year. In addition to eliminating 1,4-dioxane, the company will have switched to a surfactant with an RCI of 1, versus only 0.75 with an ethoxylated natural alcohol.

Seventh Generation is also eliminating a chlorine-containing preservative from its liquid cleaning products. Although Wolf has a long-term goal to move to a substitute derived from renewable raw materials, for now he is content to switch from a triazine

5

EVONIK

WASH CYCLE Evonik and its competitors put new cleaning chemistries through real-life tests.

to a blend of methyl and benzyl isothiazolinones.

Without a doubt, the product improvements Wolf is pursuing matter only to a small group of people who are very concerned about the environmental impact of the products they buy. Yet there's also no doubt that a growing group of consumers is aware that the pleasantly colored cleaners under their sinks are actually mixtures of potent chemicals with varying degrees of impact on Earth.

Consumers are becoming more savvy about the products they buy, according to Lauren G. Heine, a consultant and senior science adviser to Clean Production Action, an advocacy group. "I think our definition of 'safe' has changed," she says. "What may be safe for occasional use in the home isn't necessarily safe when the entire life cycle is considered and when a lot of homes are using it and discharging it to the environment."

While at the nonprofit GreenBlue, Heine initiated the development of CleanGredients, an Internet database of environmentally friendly surfactants. Launched with the backing of EPA's Design for the Environment program, the database today contains surfactants from all major chemical companies. CleanGredients is now debuting a companion database for solvents and is readying one for fragrances.

"At first some people thought it would be a blacklist," Heine recalls of industry reaction to the surfactants database when it first came out. "But after awhile they realized it was a way to identify greener chemicals and open market opportunities."

Indeed, a market opportunity is how most players in the cleaning product industry see sustainability these days. Pointing to the spate of new spray cleaners on store shelves, Rhodia's Douglass marvels at how environmentally friendlier products are shaking the industry up. "Hard-surface cleaners was probably the least interesting market out there, and look at what Clorox has done to it," he says.

"Fabric and home care companies see an opportunity to bring innovation to market based on the sustainability initiative," Douglass adds. "They are reinventing the industry and making it exciting again." ■

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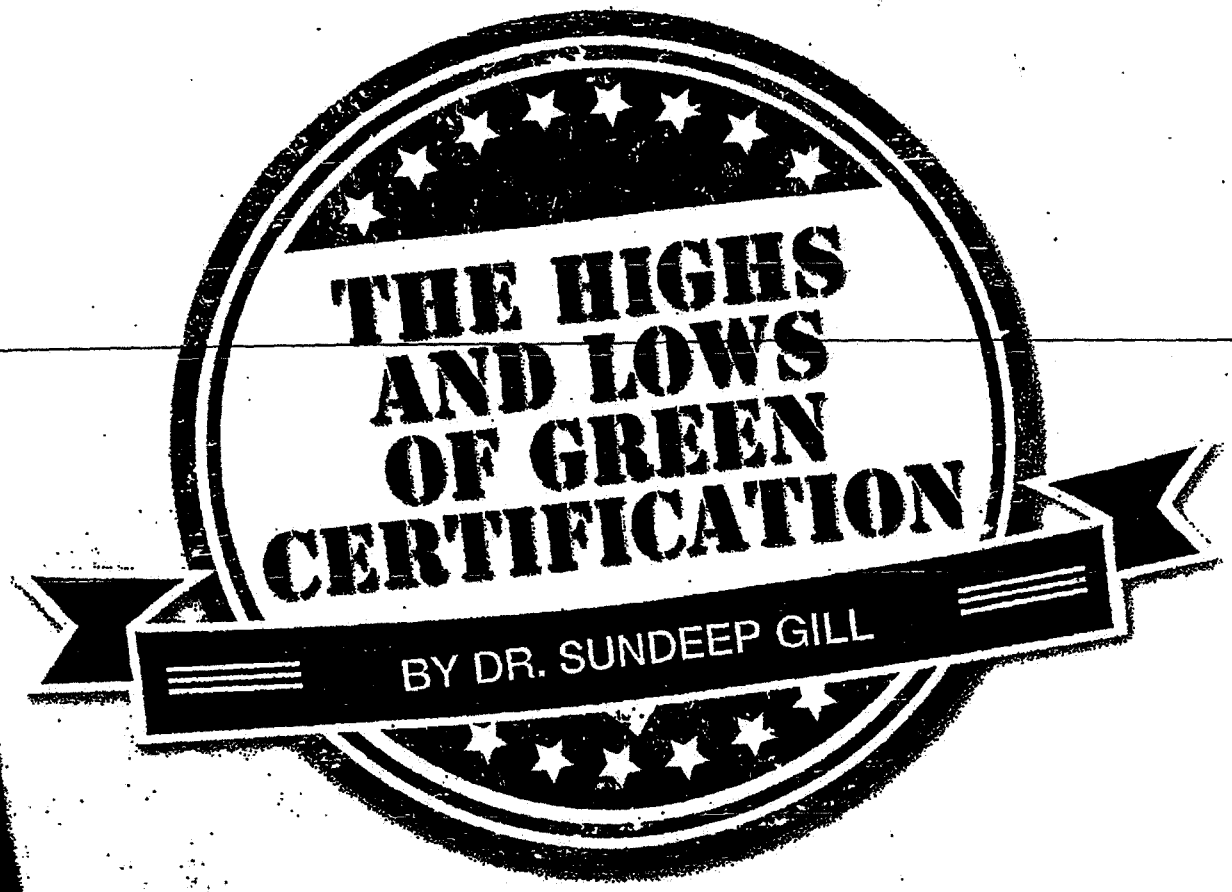


A beauty industry insider shares his thoughts on some of the trendiest of today's green certifications and what makes them good—as well as what can make them difficult to achieve and sustain.

IMPACT POINTS

- Beauty brands that position themselves as "natural" can opt for an alphabet soup of available green certifications. However, the bottom line is that certification should help the brand's marketability.
- Certifications such as the USDA NOP certification, while a well-known organic industry standard, can be problematic as they weren't developed with the beauty industry in mind and often require expensive manufacturing restructuring and upgrading.

The need to differentiate one product from another predates the organic and natural movement in the beauty industry. But during the last two decades, consumers have been inundated by an alphabet soup of green, organic and natural standards. Although the path to certification can be very different in dealing with multiple standards, the ultimate goal is the same—solidifying your brand as more natural than the rest.

What's Best

When choosing which standard is best suited for your brand, it comes down to one simple fact: the value of any and all certification is marketability. Designing a product using natural ingredients, avoiding hot button problematic ingredients and utilizing a generally favorable ingredient profile is a noble cause, and, in many cases, sales will do just fine. But often the question arises, "What will a certification add to the value of the brand?"

Editor's note: For additional information on green certifications and labeling, check out "Labeling for Legitimacy: Certifications for Natural and Organic Personal Care" by Darrin C. Duber-Smith on *www.GCImagazine.com*.

And it is simple—the more heavily marketed the standard is, the more it will add value to your brand. So far, most natural and organic standards have been beyond reproach due to their well-written nature. So choosing the "wrong" standard based on lack of strictness is relatively unheard of. However, there are multiple options that beauty brands pursue in green certifications.

Setting Standards

Touching on a few standards I have been intimately involved with, I can offer a firsthand perspective.

The U.S. Department of Agriculture's National Organic Program (USDA NOP) is what many consider to be the pinnacle of any green/organic standard. This is likely due to it being the most heavily recognized and branded of any standard—and not because it is suited and designed for personal care. Using USDA-certified organic ingredients in place of conventional ingredients will generally increase a product's stature, but, in some cases, turning your product into a full USDA organic certified product is a challenge due to the many limitations of this standard and applying it to produce a quality, stable product meant for retail.

A product that is allowed to carry the USDA seal of an organic product has at least 95% of its solids derived from organic ingredients, excluding water and salt. The certification process also involves a detailed label and formula review, as well as ensuring the product is made in a USDA organic certified facility. The certification process for a USDA facility involves many policies and procedures to comply with the complex tracking systems required by the USDA, and, in many cases, manufacturers must weigh if certification is a viable equity to their facility, as it can be very costly to upgrade to the necessary standards.

The NSF International organic certification is another green certification standard that has seen recent success, and typically is more feasible for the production of a functional and stable product. This standard saw most of its success when, in 2010, Whole Foods enforced that personal care products sold on its shelves and making a "contains organic ingredients" claim must be certified to the NSF 305 ANSI Standard for Organic Personal Care products, a consensus-based industry standard accepted by the American National Standards Institute and managed by NSF International. (Whole Foods' guidelines also state "all products making an 'organic' product claim must be certified to the USDA NOP standard, the same standard to which organic food must be certified under U.S. law.")

The fascinating part of the NSF International standard is its approval approach. Rather than have a fixed list of acceptable ingredients to work with, this standard has an acceptable list of processes of how these ingredients are made—i.e. you can have two ingredients from the same source and within the same end product but one could be approved and the other not simply due to its allowable process.

With this standard, certain original ingredients such as sulfate-based surfactants became allowable over newer, novel surfactants because the process to make the original surfactant was far more natural than some newer ones. However, the success of the NSF certification is not all in its originality. It is far more marketed and recognized than many other standards of its caliber thanks to its retail support.

The GMO Debate

Another growing area of the green movement is genetically modified organisms, or GMOs. GMO awareness has gained momentum in recent years, partially due to the narrow loss of California Proposition 37—a statute voted down in November 2012 that would have required labeling of genetically engineered food, with exceptions. It also would have disallowed the practice of labeling genetically engineered food with the word "natural."

GMO verification in beauty products relies on simply not using feedstock from plants that have been genetically modified or crossbred with other species in the product's ingredients. Although no clear difference has ever been substantiated between an ingredient derived from non-GMO ingredients versus ingredients derived from GMOs, this standard has become increasingly popular due to widespread awareness of GMO foods.

During the non-GMO verification process, beauty brand owners need to assess both the ingredients used in their products *and* the ingredients of an ingredient—leading all the way back to the source material—in order to do a proper audit. In some cases, this can be a difficult task, as source material suppliers can be closely guarded or can change often enough for them to be difficult to track.

Weighing Your Options

Overall, beauty brand owners will continue to find new ways to differentiate themselves from all other product lines. The use of green-certified standards has been an invaluable tool to verify and lend definition to natural products, but many barriers remain to certification. These barriers include cost, recognizability of the certification standard and the formulation constrains of using a green certification standard that may not have a wide selection of cosmetic ingredients or ingredient synthesis processes available yet.

Brand owners must carefully weigh their choices to make sure that adhering to any green certification standard will be giving their brand the advantages and positioning that they are looking for without hurting overall quality. ■ GCI

DR. SUNDEEP GILL has been involved with the beauty and cosmetic industry for many years, first working for Carme Cosmetics in Novato, California, in 1987, where he started out in the quality control lab. He soon worked his way up to a research chemist, and in this position, he learned the possibilities of creating natural products based on science-driven ingredients. A few years later Sun Deep Cosmetics opened its first manufacturing plant in Hayward, California. Here Dr. Gill was able to put his creative skills into motion, developing popular personal care products in the natural products industry. Dr. Gill attended the University of the Pacific, where he attained his bachelors degree and ultimately his doctor of pharmacy degree. Soon after, he completed an internship and residency at Stanford University Lucile Packard Children's Hospital and the Veterans Hospital. Through this work Dr. Gill published several articles on pharmacotherapy and drug delivery and assisted in several clinical studies involving topical drug delivery and chemotherapy. Dr. Gill is a registered pharmacist and still practices as a clinical pharmacologist when he is not working as a personal care research chemist. And an avid educator, Dr. Gill still preceptors to doctor of pharmacy candidates around the country. He currently lives in San Ramon, California, with his wife and three daughters.

MAKE YOUR GREEN CLAIMS MEAN SOMETHING

To ensure your brand's green claims have meaning for consumers, the claims should be authentic, clear and relevant.

IMPACT POINTS

- The green trend isn't going away, but consumers are becoming more and more skeptical of brand-promoted "green" claims—and what's more, "green" isn't a huge factor in consumers' decision to actually purchase. If being eco-friendly is something you want equated with your brand, make sure you are doing it in a way that is meaningful to consumers.
- Green claims need to be specific. Vague promises of natural ingredients and giving back aren't enough anymore.
- Green claims need to be developed in support of a product's primary benefit.

BY SOURABH SHARMA AND SCOTT GARRISON

Three billion Google search results for the phrase "going green" easily validate that sustainability is a vital area for marketers. But hidden in this volume is also the undoing of the phenomenon, for despite its apparent importance, it has reached a stage of being overwhelming and cliché. Furthermore, consumers are becoming savvy to disingenuous attempts to "greenwash" a brand or product.

Through a meta-analysis of claims across a plethora of categories, including beauty and personal care, marketing research consultancy SKIM found the majority of consumers find green concepts appealing—*but not to the extent of driving purchases.* Although many of us like to believe we care more about the earth than our own self-interests, marketing messages that focus solely on the green aspect of a product are significantly less effective at driving purchase than those that highlight product benefits.

A claim is a concise statement that promises value to the consumer and is designed to influence consumer choice. There is only a split second to convince shoppers to buy a product, and this green push means marketers now have the additional responsibility of communicating shoppers that a brand is environmentally friendly—as well as able to successfully deliver on the promise of what the product is designed to do.

Green brands have succeeded in creating a large following based on their promise of being natural. Burt's Bees and Aveda are known for their comforting, low sensitivity and low allergen formulas, which are purposefully natural, for example. However, do consumers seek out companies and products that are sustainable or is it merely a perceived benefit?

Problem Areas With Claims

Claims that emphasize being environmentally friendly are commonly used in relation to product development. Packaging and recycling related measures such as biodegradability or compostability are related to product usage and disposal, and are common in cosmetics and beauty products. Further, the blurred distinction between natural, organic and sustainably made products risks pushing consumers into information overload. Consumers are unsure of the difference between, say, a natural versus an organic lotion, let alone understanding the complex story of how the brand supports scarce ingredient harvesters and farmers in partnering nations. What happens when consumers simply want an effective moisturizing lotion but that benefit is effectively downplayed in comparison to green claims?

Additionally, green products, unlike their synthetically derived counterparts, tend to be perceived as less effective. Past experience, as well as general knowledge, has shown that "non-natural" products can deliver excellent results and resonate with consumers, for various reasons. Women may love the fact that a lipstick manufacturer has utilized natural pigments, for example, but the resulting limited shade palette may mean they are likely to switch to a product that offers synthetic but vibrant hues and more color options.

Shoppers also often find green benefits irrelevant at the point of purchase. Saying your foundation will donate to environmental protection is nice to hear, but consumers will ultimately prefer a foundation that works best. Consumers like to feel as though they are doing their part in contributing to the environment, but brands [illegible] make it unclear how this is possible. [illegible] lack of clarity can lead to [illegible] and combining this with [illegible] can lead to distrust. In [illegible] of consumers trust a [illegible] claims.

[illegible] consumers still expect [illegible] to the environment. [illegible] look to product [illegible] environmentally friendly [illegible] growing number (expected [illegible] exhibit a strong [illegible] lifestyles. How are [illegible] these seemingly

> Ideally, a brand should not convolute the meaning by aiming for an all-encompassing message.

Making Claims Meaningful

Be specific. Distinguish what the green claim applies to—the product via its natural ingredients, the company's practices of sustainable processing, or the packaging made with effective recycling or decomposition? Something else? Relaying this message specifically is critical to engaging consumers. Saying something like "100% natural ingredients and 50% post-consumer recycled packaging that reduces global warming gases" may sound direct and specific, but it has shown to be a weaker driver of purchase than focusing on one strong message.

Ideally, a brand should not convolute the meaning by aiming for an all-encompassing message. Rather, leveraging natural ingredients works well (e.g., Kiehl's and Burt's Bees) as does building a strong, clear image of a brand identity (e.g., The Body Shop). It also is important to keep in mind that mentioning names of impactful rainforest or animal protection alliances may be nice for a media campaign or as a sticker on packaging, but consumers would rather be informed of specific product benefits in an on-pack claim.

Make it relevant. Ultimately, consumers want a product that works. Even for something as simple as an anti-dandruff shampoo, the consumer is more likely to be driven to purchase a product that claims to prevent flakes than one that emphasizes less split-ends, as it better addresses the consumer's core concern. This simple principle can also be applied to green claims. Clearly articulating the benefit is necessary as statements must be prominent and understandable, leaving no room for alternative interpretation.

Take the example of a body wash. Instead of saying, "Good for the planet and made with vegetable oils that are better for your skin," a message such as "Non-irritating for the skin because it is made with vegetable oils" will resonate better. The latter statement more clearly articulates how the natural element will functionally benefit the consumer, thus making it more relevant.

Put the key benefit first, then tie "green" to it. A claim must be centered on something important to consumers and make a clear value promise that will drive purchase. An emphasis on sustainability may not be as motivating to consumers, but green claims are not generally rejected

nt. This provides an opportunity for marketers to make green claims more meaningful by tying the green element in with a key benefit of the product.

Rather than saying "All of our ingredients are naturally sourced to ensure a better tomorrow," a corrective skin care product can more effective layer this message into a clear value promise. Something along the lines of "Reduce skin blemishes using only naturally sourced ingredients" is more effective because it messages around the element of being environmentally friendly while still addressing the core concern of the consumer: reducing skin blemishes.

In this manner, a marketer can promise the consumer a key benefit while ensuring the brand is seen as environmentally friendly.

Avoid jargon. Especially with regard to green claims, it is important to avoid using jargon in a marketing claim. On such a sensitive issue, the use of jargon can alienate consumers and lead to the feeling of distrust that is so prevalent with these types of claims.

Sustainability, in particular, is often cited as a reason to like a green claim, but only when the word itself is implied rather than explicitly stated. Consumers hear the word "sustainable" so frequently, often with few results from the companies promising it, that it has become a cliché. Including it in a claim is neither unique nor is it motivating. Saying that a toner can provide "Hydrated, enriched skin with natural minerals and rosewater" can be interpreted as the brand doing something right in the direction of sustainability.

With this in mind, marketers should do their best to avoid jargon that leads to feelings of distrust. It is more effective to allude to being environmentally friendly by describing how a product's green elements support product benefits.

True Green

The process of writing brand or product claims can be tricky because there are many messages to relay to consumers, and typically there is very little space in which to do it. While it is always recommended to focus a claim on a key benefit or value promise, there also are situations in which being environmentally friendly, given its growing importance in the world, is useful.

Ultimately, a brand must be true to its roots and consistent with its brand legacy in order to make green claims work to its benefit. ■ GCI

SOURABH SHARMA comes to SKIM with a keen eye for understanding consumer behavior. He adds perspective to marketing research from his years in brand management and product development at L'Oréal, where he launched hair color and makeup products for brands in Asia and North America. With a multifaceted background, Sharma enables the firms he works with to acquire a stronger understanding of their end users. Furthermore, he strives to extract value from the evolving brand-to-consumer interface through his social media research.

SCOTT GARRISON is a manager at SKIM. He is experienced in conducting marketing communication development projects for consumer products, beauty and technology brands. He oversees SKIM's claim development methods with a focus on emotional claims.

8

NOP Communications, TAP Review
NOSB Committee Actions & Vote

TAB 8

Response Letter to original petition that was submitted; resubmission of the petition and response to this letter are included in the cover letter of this updated petition.

USDA Agricultural Marketing Service

1400 Independence Avenue, SW.
Room 2648-S, STOP 0268
Washington, DC 20250-0268

September 25, 2015

Mr. Thomas Harding
On behalf of Green Ag Supply, LLC
Lehigh Valley Organic Growers, Inc.
125 West 7th Street
Wind Gap, PA 18091

Sent by email [agrisys1@aol.com]

Dear Mr. Harding:

Thank you for your petition of June 24, 2015 which requests the inclusion of natural fatty alcohols in section 205.601 of the National Organic Program's (NOP) National List of Allowed and Prohibited Substances (National List).

We have reviewed your petition for natural fatty alcohols and determined that it cannot proceed in the petition process because it does not provide sufficient information to address each item specified in 72 FR 2167 "National Organic Program – Submission of Petitions of Substances for Inclusion on or Removal from the National List of Substances Allowed and Prohibited in Organic Production and Handling." This notice provides information such as what can be petitioned, how substances should be petitioned, and what information should be addressed in a petition.

To assist you in the development of your petition, we recommend that you modify your current petition to address the following items:

Item A – Section of the National List

We noted that the petition requests addition of natural fatty alcohols, specifically, octanol and decanol, to section 205.601(a) of the National List.

Based on the requested uses of these substances as growth regulators, we anticipate that they will be considered by the National Organic Standards Board under section 205.601(**k**) rather than section 205.601(**a**).

A final determination will be made by the NOSB during the course of review. However, if an alternative listing at section 205.601(k) does not meet the intent of the petition, you may wish to provide additional information on why paragraph (a) of 205.601 if preferred. We noted that paragraph (a) includes other alcohols; however, it also includes the following text: "As algicide, disinfectants, and sanitizer, including irrigation system cleaning systems." Paragraph (k) includes growth regulations that are allowed for organic crop production.

Item B.1 The Substance's Chemical or Material Common Name

We noted multiple names used for the petitioned substance, including the following: natural fatty alcohols, fatty alcohols, octanol, and decanol. In addition, the citation provided to FDA regulations at 21 CFR 172.864 uses the term "synthetic fatty alcohols."

Based on our review of the product labels provided, the active ingredients included on the EPA approved labels are identified as "octanol" and "decanol." To facilitate the review and reduce potential confusion, we suggest providing additional clarification on the names used within the petition.

The petition should also clearly indicate why a single petition is needed for the fatty alcohols mixture (i.e., blend of octanol and decanol) instead of separate petitions for octanol and decanol as individual active ingredients.

Please also note that natural substances are allowed for use in organic crop production, unless prohibited at section 205.602 of the National List. The classification for octanol and decanol as natural or synthetic will be determined by the National Organic Standards Board during the review of the petition.

Item B.6 Previous Reviews

We noted that information regarding previous reviews of fatty alcohols by OMRI and other organizations was included in the supplemental tabs. Thank you for this information. For the response to Item B6 provided at **Page 3** of the petition, you may want to provide a brief summary of this information.

Item B.7. Information Regarding EPA Registrations
Item B.8. Product Labels

We have reviewed the intended use of the substance against the product labels provide in the petition. We have noted that the products O-Tac Plant Contact Agent and N-Tac are labeled only for use on tobacco. We have also noted the inclusion of email correspondence from EPA staff regarding the registration of these products for other crops.

From the information provided, we have been unable to verify that the following petitioned uses of fatty alcohols are currently permitted by the EPA:

- Sucker control on tomatoes
- Meristematic regrowth on vegetable grafts
- Desiccant/defoliant on cotton

For the revised petition, please provide additional information, such as EPA approved product labels, and/or citations to EPA regulations that confirm that these intended uses of octanol and decanol fatty alcohols are permitted by EPA. If the intended uses are not currently permitted by EPA, you will

need to amend the petition to remove these uses or wait until EPA registration is granted before resubmission.

Resubmission:

Please note that electronic submission (by disk or email) is preferred to facilitate posting of petitions on the NOP website.

If only part(s) of the original hard copy petition need to be updated, submission of only those parts may be sufficient. If submitting in part, please clearly indicate which section(s) are replaced and which section(s) can be retained as originally submitted.

Additional information on the petition process is available on the NOP website at How to File a Petition.

If you have any questions, please contact me by phone at (202) 821-9683 or email lisa.brines@ams.usda.gov.

Sincerely,

Lisa M. Brines, Ph.D.
National List Manager
National Organic Program

TAB 9

PENDING PETITION INFORMATION (CORRESPONDENCE) PERTAINING TO OTHER PROPOSED USES

Pesticide Registration Improvement Act - PRIA 3: Proposed petition for adding Cotton to product labels (N-TAC, EPA Reg. No. 51873-20, O-TAC PLANT CONTACT AGENT, EPA Reg. No. 51873-18 and FAIR 85, PA Reg. No. 51873-7)

Fair Products, Inc.

March 5, 2015

Shaja Joyner Product Manager, Team-20
Fungicide Herbicide Branch, Registration Division
Document Processing Desk
Office of Pesticide Programs (7504P)
U.S Environmental Protection Agency
Room S-4900 One Potomac Yard
2777 South Crystal Drive
Arlington, VA 22202-4501

Subject: Pesticide Registration Improvement Act - PRIA 3: Proposed petition for adding Cotton to product labels (N-TAC, EPA Reg. No. 51873-20, O-TAC PLANT CONTACT AGENT, EPA Reg. No. 51873-18 and FAIR 85, EPA Reg. No. 51873-7),

Dear Ms. Joyner,

Confirming our communications with you we are providing the following information pertaining to the subject:

1. Proposed Use: Use of Fatty Alcohols to assist with defoliation and desiccation of Cotton prior to harvest.

2. Intended Crops: Cotton

3. Field Test Data: 2013 and 2014 North Carolina University Trials (see attachment 1).

4. Proposed Directions for Use: Proposed new use for the Fatty Alcohol Products, (N-TAC, EPA Reg. No. 51873-20, O-TAC PLANT CONTACT AGENT, EPA Reg. No. 51873-18 and FAIR 85, EPA Reg. No. 51873-7) consists of application to cotton prior to harvest as a defoliant and desiccant. The spray solution should be applied as a broadcast spray 12 inches over the top of plants using 2 flat fan nozzles per row approximately 19 inches apart that delivers 20 gallons of spray solution per acre. The spray solution consists of 15 to 25% volume/volume (3 to 5 gallons of N-TAC, Fair 85 and O-TAC PLANT CONTACT AGENT) per acre will aid in providing desiccation and defoliation of cotton leaves when used alone or a tank mix combination with sodium chlorate (6 lbai/a).

Fair Products, Inc. ◦ Agri-Specialties Division ◦ Post Office Box 386 ◦ Cary North Carolina 27512-0386
Telephone: (919) 467-8352 ◦ Fax (919) 467-9142

5. Documentation / Communications per Lindsay Rowe and Tony Kish indicating that cotton is classified as a non-food crop that this use would be exempt from tolerance (See attachment 2 email dated 2/19/15).

6. Proposed Risk Assessment document (See attachment 3).

We appreciate your review and comments regarding this information for adding this use to our Fatty Alcohol Product Labels. Let us know if any further information is required at this time.

Sincerely,

Carla Hull

Carla Hull
Administrative Assistant
Product Registration

cc: Roland Cargill

Carla Hull

From: Stewart, Alexander <Sandy.Stewart@ncagr.gov>
Sent: Tuesday, March 17, 2015 3:32 PM
To: Carla Hull
Subject: RE: need

Carla,

The 2012 test turned out to be just a strip trial because of space that was available. I figured out that was why I had so much trouble finding the info on the 2012 test. Unfortunately, there is very little, if any, information from the 2012 trial. I think we'll need to go with the 2013 and 2014 replicated trials.

Please let me know if you or Roland have any questions.

Thanks,
Sandy

Sandy Stewart
Research Stations Division Director
NCDA and NC State University

(O) 919-707-3237
(M) 919-414-4863
2 West Edenton Street, Raleigh, NC 27601
1001 Mail Service Center, Raleigh, NC 27699-10001

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Tuesday, March 17, 2015 3:28 PM
To: Stewart, Alexander
Subject: need

Sandy,

Need test results for 2012 cotton for our book.

Need ASAP!

Thanks,

Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX
Carla@fairproductsinc.com

Alexander M. "Sandy" Stewart, Ph.D.
228 McLeod's Corner
Carthage, NC 28327

Mr. Frank Grainger, President
Fair Products, Inc.
Cary, NC

Dear Mr. Grainger,

Over the past three years, I have evaluated O-TAC fatty alcohol for its activity as a cotton defoliant in organic systems. I have experience in doing so for many products as a cotton researcher and former Extension Cotton Specialist for the LSU AgCenter. My evaluations of O-TAC have taken place in field trials in North Carolina cotton from 2011 through 2014.

O-TAC has some activity and utility as a cotton defoliant. Although the exact mode of action is not known, it can be reasonably expected that the fatty alcohol in O-TAC desiccates the leaf, thereby rupturing cell walls and stimulating the cotton plant's natural production of ethylene. Ethylene production is important for forming the abscission layer at the base of the leaf petiole, resulting in leaf drop. This is a very similar mode of action to commercially available cotton defoliants in conventional cotton production.

Results from three field trials over three years in North Carolina have shown O-TAC to have activity as a defoliant for cotton production. O-TAC applied in a single application at in a 15% solution generally resulted in about 30-40% leaf drop in field grown cotton. Sequential applications do enhance leaf drop, although results are variable. Tank-mixtures of O-TAC and ammonium sulfate have typically enhanced defoliation. However, it should be noted that the optimum rate for application of O-TAC as a cotton defoliant, either alone or in combination with ammonium sulfate, is not known at this time. Research is ongoing and additional field trials are needed.

Cotton defoliation is critical to facilitating mechanical harvest with a spindle picker. The removal of green foliage on a mature cotton crop reduces stain from green leaf and harvest losses with a mechanical picker. In organic cotton production, the preparation of the crop for mechanical harvest has always been a barrier to production. Although the overall activity of O-TAC as a cotton defoliant and harvest aide is less than conventional products, it does show promise for organic production. The value of organic cotton dictates that even a small increase in the efficiency of mechanical harvest is worthwhile. Continuing research with O-TAC will focus on refining the appropriate rate as well as exploring appropriate organic tank-mix partners for cotton defoliation.

I look forward to continuing to work with you and Fair Products in the investigation of O-TAC as a cotton defoliant and harvest aide. Please let me know if I can be of any assistance.

Best Regards,

Alexander M. "Sandy" Stewart, Ph.D.

Application Info.
Cotton Trials - 2013

Crop Stage at Application	65% Open Bolls
Application Equipment	Backpack sprayer with CO2 for propellant
Carrier	Water
Boom Configuration	Two rows, two nozzles per row
Nozzle Type	Tee-Jet 110-03 Flat Fan
Nozzle Spacing	19-inches for two nozzles per row in 38-inch rows
Application Volume	20 Gallons per acre
Height Above Canopy	12 inches
Plot Size	4 rows, 40 feet long, 38-inch rows
Treated Area	Inside two rows in order to utilize a "running check" for each plot
Replications	4 replications
Experimental Design	Randomized complete block

3/3/2015

Treatment List
Cotton Trials - 2013

TRT	Product	Rate	Timing	Rep 1	Rep 2	Rep 3	Rep 4
1	OTAC	10% v/v	Initial	101	202	305	403
2	OTAC	10% v/v	Initial	102	204	303	402
2	Sodium Chlorate 7.5L	100 oz/a	Initial				
3	OTAC	15% v/v	Initial	103	205	304	404
4	OTAC	15% v/v	Initial	104	203	301	405
4	Sodium Chlorate 7.5L	100 oz/a	Initial				
5	Sodium Chlorate 7.5L	100 oz/a	Initial	105	201	302	401

All applied at 14 GPA with flat fan nozzles on 10/17/13.

3/3/2015

Raw Data
Cotton Trials - 2013

TRT	Treatment Name	Plot	10/24/2013 Defoliation Defol 7DAT	10/24/2013 Desiccation Dess 7DAT	10/31/2013 Defoliation Defol 14DAT	10/31/2013 Desiccation Dess 14DAT
1	OTAC 10%	101	21	15	25	15
2	OTAC 10% + Sodium Chlorate	102	50	25	65	20
3	OTAC 15%	103	20	25	25	20
4	OTAC 15% + Sodium Chlorate	104	65	20	65	15
5	Sodium Chlorate	105	50	20	55	25
5	Sodium Chlorate	201	55	25	65	25
1	OTAC 10%	202	20	10	25	12
4	OTAC 15% + Sodium Chlorate	203	55	25	65	25
2	OTAC 10% + Sodium Chlorate	204	45	20	55	20
3	OTAC 15%	205	25	15	25	25
4	OTAC 15% + Sodium Chlorate	301	50	25	65	20
5	Sodium Chlorate	302	55	25	65	20
2	OTAC 10% + Sodium Chlorate	303	35	20	45	25
3	OTAC 15%	304	30	15	40	20
1	OTAC 10%	305	15	10	20	10
5	Sodium Chlorate	401	55	25	65	25
2	OTAC 10% + Sodium Chlorate	402	35	15	50	20
1	OTAC 10%	403	20	10	20	15
3	OTAC 15%	404	35	20	40	10
4	OTAC 15% + Sodium Chlorate	405	65	25	65	20

3/3/2015

Summary
Cotton Trials - 2013

TRT (All)

Treatment Name	Average of Defol 7DAT	Average of Dess 7DAT	Average of Defol 14DAT	Average of Dess 14DAT
OTAC 15%	27.5	18.8	32.5	18.8
OTAC 15% + Sodium Chlorate	58.8	23.8	65.0	20.0
Sodium Chlorate	53.8	23.8	62.5	23.8
OTAC 10%	19.0	11.3	22.5	13.0
OTAC 10% + Sodium Chlorate	41.3	20.0	53.8	21.3
Mean	40.1	19.5	47.3	19.4

Application Info
Cotton Trials - 2014

Crop Stage at Application	65% Open Bolls
Application Equipment	Backpack sprayer with CO2 for propellant
Carrier	Water
Boom Configuration	Two rows, two nozzles per row
Nozzle Type	Tee-Jet 110-03 Flat Fan
Nozzle Spacing	19-inches for two nozzles per row in 38-inch rows
Application Volume	20 Gallons per acre
Height Above Canopy	12 inches
Plot Size	4 rows, 40 feet long, 38-inch rows
Treated Area	Inside two rows in order to utilize a "running check" for each plot
Replications	4 replications
Experimental Design	Randomized complete block

3/3/2015

Summary
Cotton Trials - 2014

TRT (All)

Treatment Name	Average of Defol 7DAT	Average of Dess 7DAT	Average of Defol 16DAT	Average of Dess 16DAT
NTAC 15%	16.3	10.0	20.0	6.3
NTAC 15% + Sodium Chlorate	56.3	17.5	75.0	5.5
NTAC 25%	36.0	15.0	49.0	7.4
NTAC 25% +Sodium Chlorate	60.0	28.3	78.3	15.0
NTAC 25% fb Sodium Chlorate 7DAT	22.5	13.8	81.3	13.8
OTAC 15%	26.3	11.3	35.0	6.3
OTAC 15% + Sodium Chlorate	43.8	23.8	61.3	11.3
OTAC 25%	23.8	16.3	53.8	5.5
OTAC 25% + Sodium Chlorate	63.8	21.3	83.3	10.0
OTAC 25% fb Sodium Chlorate 7DAT	31.3	11.3	82.5	8.8
Sodium Chlorate	53.8	25.0	84.3	7.5
Mean	**38.9**	**17.3**	**63.3**	**8.7**

3/3/2015

Carla Hull

From: Balan, Aswathy <Balan.Aswathy@epa.gov>
Sent: Thursday, February 19, 2015 8:09 AM
To: carla@fairproductsinc.com
Subject: RE: Pre-application 51873PA1 - 493158

Dear Roland Cargill/ Carla Hull,

Thanks for your email and I apologize for not getting back to you sooner. We were having some internal discussions to determine the best way to move forward. Before getting into the specifics of the PRIA category, we would like to obtain some more information.

I understand you would like to come in with one submission for the vegetable rootstalk and another one for the cotton use. Could you send me a draft proposal of your petition for both uses. The one for rootstock use should list out all the use sites (right now I know of tomatoes and cucurbits) that you would like to have for that use. Including all the applicable sites in the initial application itself will be advantageous for you. Also provide the widest range of application rates that would be used.

If you have any questions or concerns please do not hesitate to contact me.

Thanks,
Aswathy

Aswathy Balan, Biologist
Fungicide and Herbicide Branch
OCSPP/OPP/RD
Environmental Protection Agency
Ph: 703-347-0510

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Thursday, February 05, 2015 2:45 PM
To: Joyner, Shaja
Cc: Balan, Aswathy; Roe, Lindsay; Kish, Tony
Subject: RE: Pre-application 51873PA1 - 493158

Shaya Joyner and Aswathy Balan,

Lindsay Roe had briefed you on the recent activity involving the proposed use of fatty alcohol for control of meristematic regrowth on vegetable rootstock, as well as a proposed use as a defoliant/dessicant on cotton. As we proceed, Lindsay has informed us that further action will require separate submissions for these.

In EPA's review report (Decision 493158) that proposed use on vegetable rootstock is exempt from the requirements for tolerance; therefore, the use is exempt from the residue chemistry data requirements associated with a petition for tolerance. Likewise, as Lindsay pointed out in her 12/19/14 correspondence, "since cotton use is classified as non-food, the tolerance exemption will not have any bearing on that use."

Thus, we are ready to proceed with preparing for two separate submissions (vegetable rootstock and cotton) with a separate risk assessment for each. Based on the conference call we

had with Lindsay and Tony Kish on 12/11/14, it appears that a R-170 submission is the approach for us to take.

Can you please provide us the detailed steps and documentation requirements in preparing the R-170 submission. We are currently preparing risk assessment documentation for each

of the proposed new uses.

Thanks you for your assistance on this matter and we look forward to working with you in the furfure.

Roland Cargill

By:
Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX
Carla@fairproductsinc.com
www.fairproductsinc.com

From: Roe, Lindsay [mailto:Roe.Lindsay@epa.gov]
Sent: Friday, January 30, 2015 11:26 AM
To: Carla Hull
Cc: Balan, Aswathy; Joyner, Shaja; Kish, Tony
Subject: Re: Pre-application 51873PA1 - 493158

Hi, Carla.

I just had a handover meeting with the team that will be taking over 1-octanol and 1-decanol. Aswathy Balan is the risk manager in the Fungicide/Herbicide Branch that you will be working with, and her product manager is Shaja Joyner. I have cc'ed them on this email, so you have their contact information. I briefed both of them on the recent activity with Fair's proposed product, so feel free to go to them with any questions that you have.

It's been a pleasure working with you!

Best regards,
Lindsay

From: Roe, Lindsay
Sent: Friday, January 23, 2015 3:25 PM
To: 'Carla Hull'
Subject: RE: Pre-application 51873PA1 - 493158

Carla-

The Registration Division reorganized in October. Many products and people stayed in the same branches as always, but a couple of new branches were added and a couple were consolidated, shifting some people and chemicals around. The Fungicide/Herbicide Branch (one of the new branches) now handles the fatty alcohols but not all plant growth regulators. Rachel Holloman is the branch chief. I have already contacted her to find out which specific reviewer, or at least which team, has been assigned to these chemicals.

-Lindsay

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Friday, January 23, 2015 3:12 PM
To: Roe, Lindsay
Subject: RE: Pre-application 51873PA1 - 493158

Lindsay,

Thank you for your prompt response. We were not aware of the reorganization of the Registration Division. Who is the head of the branch that handles PGR's (ie fatty alcohols)?

Thanks again,

Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX
Carla@fairproductsinc.com
www.fairproductsinc.com

From: Roe, Lindsay [mailto:Roe.Lindsay@epa.gov]
Sent: Friday, January 23, 2015 9:25 AM
To: Carla Hull
Subject: RE: Pre-application 51873PA1 - 493158

Hi, Carla.

I talked to Tony about your proposed approach to the no hazard rationale, and before we came to a clear decision (it might be alright but I honestly don't know- this is the first no hazard rationale I have ever dealt with), Tony realized that aliphatic alcohols are no longer handled in our branch as of the reorganization in the Registration Division that took place several months ago. I am going to have to coordinate a hand-off to another team. I will talk to the branch chief of the Fungicide/Herbicide Branch and find out who the new risk manager will be. Once I've done that I will talk to the new risk manager about where we stand regarding this product and put the two of you in contact.

Sorry to be giving you the run-around on this. I should be back to you within a couple of days with information on who you will be dealing with now.

Best regards,
Lindsay

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Wednesday, January 21, 2015 10:08 AM
To: Roe, Lindsay
Subject: RE: Pre-application 51873PA1 - 493158

Hello Lindsay,

We hope that you has a relaxing Holiday. After further thought on the preparation of the Risk Assessment document, we have decided to take the following approach. As you may be aware, the EPA produced and published risk assessment documentation (human health, environmental, ecotoxicological) in its Reregistration Eligibility Decision

(RED) for aliphatic alcohols; Case No. 4004, March 2007. We see no need to "reinvent the wheel", so much of the documentation that we are providing comes directly from EPA's already published documentation. Of course, we explicitly note this in tour documentation at the very start of the document, as well as including the appropriate citations in our document.
Do you have any comments on our approach?

Have a great day,

Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX
Carla@fairproductsinc.com
www.fairproductsinc.com

From: Roe, Lindsay [mailto:Roe.Lindsay@epa.gov]
Sent: Wednesday, December 31, 2014 10:15 AM
To: Carla Hull
Subject: RE: Pre-application 51873PA1 - 493158

Hi Carla and Roland. There is no template available, but I will ask around to see if there is an example that we can release to you. There's quite a shortage of people in the office right now, so I'll get back to you in the next week or so.

Happy New Year!

Lindsay

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Tuesday, December 23, 2014 2:17 PM
To: Roe, Lindsay
Subject: RE: Pre-application 51873PA1 - 493158

Lindsay,

Thanks for your prompt reply.

We have a question about preparing a risk assessment. Since we have no experience to date in preparing a risk assessment, can you please provide to us the rationale, requirements, format, etc. for this documentation so that we can determine if we have the capability of preparing one ourselves. Thanks once again for your assistance.

Have a great Holiday,

Roland Cargill

By

Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX

Carla@fairproductsinc.com
www.fairproductsinc.com

From: Roe, Lindsay [mailto:Roe.Lindsay@epa.gov]
Sent: Friday, December 19, 2014 11:04 AM
To: Carla Hull
Subject: RE: Pre-application 51873PA1 - 493158

Hi, Carla.

I have emailed one of our contacts at TSG to see if they would mind us referring you to them and if there is anyone in particular that you should contact. I will let you know about that once we hear back from TSG. Expect to hear from us in the next few weeks (but not TOO quickly with the holidays coming up).

Cotton could not be included in the list of crops because the list of crops will only apply to one use- application to rootstock of grafted plants. Since in the cotton use, product will be applied to growing plants, it will need to undergo a separate risk assessment, and would thus be charged a separate PRIA fee. These new uses could still be submitted at the same time, but they should be submitted as two distinct new uses. In addition, since cotton use is classified as non-food, the tolerance exemption will not have any bearing on that use.

Hope that you and yours have a great holiday. I'm sure we'll be back in touch soon, and don't hesitate to contact us if you have any more questions.

Best regards,
Lindsay

From: Carla Hull [mailto:carla@fairproductsinc.com]
Sent: Wednesday, December 17, 2014 2:26 PM
To: Roe, Lindsay
Cc: Kish, Tony
Subject: RE: Pre-application 51873PA1 - 493158

Lindsay and Tony,

We thank you both for spending the time with us last Friday to discuss the results of the pre-application (R-124) evaluation for use of fatty alcohols to control meristematic regrowth of vegetable rootstock, post-grafting. We have received the EPA review on this subject. Thank you.

Our current thinking on this subject leans towards taking option 2 that you presented, i.e. the Food Route. We understand that a rationale for no hazard finding should be developed. You mentioned that TSG has done such a study/report. Is this something that could be shared with us and/or do you have any contact information for TSG?

In the meantime, another question has surfaced regarding the use of fatty alcohol on cotton as a desiccant/control of vegetative growth prior to harvest. Field trials were conducted in Arizona many years ago (by yours truly) and showed good activity. More recently, field trials have been conducted in North Carolina the last two years and we are currently awaiting the North Carolina State University Agronomist's report. Could this crop be included in the broad scope of crops in option 2 (Food Route) without having to conduct residue studies because of the tolerance exemption?

We look forward to your feedback as we proceed in deciding the best approach for these added uses for fatty alcohol products.

Thank you and Happy Holidays,

Roland Cargill

by

Carla Hull
FAIR PRODUCTS, INC.
919-467-1599
919-467-9142 FAX
Carla@fairproductsinc.com
www.fairproductsinc.com

From: Roe, Lindsay [mailto:Roe.Lindsay@epa.gov]
Sent: Friday, December 12, 2014 4:05 PM
To: Carla@FairProductsInc.com
Subject: Pre-application 51873PA1 - 493158

Good afternoon, Carla.

As we discussed in our meeting this morning, I am sending you the Health Effects Division's evaluation of pre-application 51873PA1 submitted 7/2/2014.

If you would like a hard copy mailed to you or if you have any questions, let me know.

Have a great weekend!

Best regards,
Lindsay

Lindsay Roe
EPA/OCSPP
Office of Pesticide Programs
Registration Division, Fungicide Branch
Roe.lindsay@epa.gov
(703) 347-0506

RISK ASSESSMENT DOCUMENT – FATTY ALCOHOLS/ COTTON

I Introduction

This risk assessment document is prepared to support the proposed new use of fatty alcohol products to aid in providing defoliation and desiccation of cotton prior to harvest. The only currently registered use of fatty alcohols is for contact tobacco sucker control. There are no residential uses. Most of the risk assessment information contained in this document was prepared by EPA in the following documents:

1. Reregistration Eligibility Decision for Aliphatic Alcohols; EPA 738 –R-07- 004; March 2007; 23pp.

2. Human Health Risk Assessment; Aliphatic Alcohols; Human Health Chapter of the Reregistration Eligibility Decision (RED) Document. Reregistration Case Number 4004. June 30, 2006.

3. Ecological Risk Assessment: Reregistration Eligibility Decision (RED), Reregistration Case 4004: Aliphatic Alcohols C-8, C-10 and C-12. September 8, 2006.

4. Aliphatic Alcohols (1-octanol; 1-decanol): Tier 2 Aquatic Exposure Model (PRZM and EXAMS) Estimates and Characterization. November 28, 2006.

5. Aliphatic Alcohols (1-octanol; 1-decanol): Addendum to PRZM and EXAMS refinement of environmental concentrations in surface water (DPBarcode D334066; 11/28/2006). Recalculation of EEC's considering volatilization from soil as a dissipation route; Recalculation of Risk Quotients. December 11, 2006.

6. Aliphatic Alcohols (1-octanol; 1-decanol) Addendum to Ecological Risk Assessment in Support of RED: Reconsideration of Ecological Toxicity Data Gaps in Light of Surface Water EEC Refinements. February 9, 2007.

This document summarizes EPA's human health and ecological risk assessments and consists of an overview of the fatty alcohols (aliphatic alcohol) and profile of its intended use and current uses, as well as the human health and ecological risk assessments.

II Chemical Overview

A. Regulatory History

Reregistration case number 4004 consists of straight chain aliphatic alcohols with 6 to 16 carbon atoms in the chain, which has been abbreviated in previous documents as aliphatic alcohols (Cx-Cxx) or (C6-C16). Currently, case 4004 consists of four active ingredients. Three of these active ingredients are used as plant growth regulators on tobacco. These are described as fatty alcohol blend (PC code 079029), 1-octanol (079037) and 1-decanol (079038). The fatty alcohol blend under PC code 079029 is predominantly a mixture of 1-octanol and 1-decanol, although some labels list 0.5% 1-hexanol (C6) and 1.5 % dodecanol (C12) among the active ingredients. The single product listed under PC code 079037, although listed as 1-octanol, is also in fact a mixture of 1-octanol and 1-decanol. The earliest registered label for use of aliphatic alcohols for tobacco sucker control included in the Agency's Pesticide Product Label System (PPLS) was issued to Uniroyal in 1964.

B. Chemical Identification

The aliphatic alcohols are considered primary alcohols (i.e., the –OH group in the C-1 position). The aliphatic alcohols 1-octanol (PC code 079037) and 1-decanol (PC code 079038) are also known by many other common names, and the fatty alcohol blend (PC code 079029) is a generic term meaning that the compound is obtained by the hydrolysis of fatty acid esters. The registrations under the name fatty alcohol blend (PC code 079029) are considered a mixture of the linear, straight chain chemicals 1-octanol and 1-decanol. Tables 1 - 3 provide the chemical identification for 1-octanol, 1-decanol, and 1-dodecanol, respectively.

Table 1. Chemical Identification of 1-Octanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Octanol**
CAS Reg. No.	111-87-5
Other Names	Octyl alcohol; n-Octan-1-ol; n-Octanol; n-Octyl alcohol; Caprylic alcohol; Heptyl carbinol; Octanol; Alcohol C-8; Capryl alcohol; n-Heptyl carbinol; Octan-1-ol; Prim-n-octyl alcohol; Octanol-(1); Octyl alcohol, normal-primary; Primary octyl alcohol; Hydroxyoctane
Empirical Formula	$C_8H_{18}O$
Molecular Weight Number of Carbons	130.23 The number of carbons is 8
Chemical Structure	C-C-C-C-C-C-C-COH

Table 2. Chemical Identification of 1-Decanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Decanol**
CAS Reg. No.	112-30-1
Other Names	Decyl alcohol; n-Decan-1-ol; n-Decanol; n-Decyl alcohol; Alcohol C10; Capric alcohol; Caprinic alcohol; Decanol; Nonylcarbinol; Decylic Alcohol; Decan-1-ol; Decanol-(1); Decyl, n- alcohol 22; Primary decyl alcohol; Nonyl carbinol
Empirical Formula	$C_{10}H_{22}O$
Molecular Weight Number of Carbons	158.28 The number of carbons is 10
Chemical Structure	C-C-C-C-C-C-C-C-C-COH

Table 3. Chemical Identification of 1-Dodecanol

Type of Information	Information for this Chemical
IUPAC Name	**1-Dodecanol**
CAS Reg. No.	112-53-8
Other Names	Dodecyl alcohol; *n*-Dodecan-1-ol; *n*-Dodecyl alcohol; Alcohol C-12; Dodecanol-1; Lauric Alcohol; Laurinic alcohol; Lauryl alcohol; 1-Dodecyl alcohol; Duodecyl alcohol; *n*-Lauryl alcohol; *n*-Lauric alcohol, primary; Dodecanol; 1-Hydroxydodecane; Hydroxydodecane
Empirical Formula	$C_{12}H_{26}O$
Molecular Weight Number of Carbons	186.33 The number of carbons is 12
Chemical Structure	C-C-C-C-C-C-C-C-C-C-C-COH

The aliphatic alcohols 1-octanol and 1-decanol are applied as water-based sprays to burley, flue cured and dark tobacco by hand using a back pack sprayer, or to tobacco plants by a boom. The aliphatic alcohols are applied to tobacco at the button or early flower stage and act as chemical pinching agents to control sucker shoots. The aliphatic alcohols dissolve the layer of waxy cuticle on the plant, causing dehydration of the young sucker. Because these aliphatic alcohols are applied solely on tobacco, its use is limited to the tobacco growing states, mainly on the east coast (Connecticut, Pennsylvania, Virginia, North Carolina, South Carolina, Georgia, and Florida), but also in Kentucky and Tennessee. Between 1.5 and 2 million pounds of aliphatic alcohols are applied annually.

Recommended application rates range from approximately 8.5 lbs ai/acre up to approximately 21 lbs active ingredient/acre, at 1 to 3 applications per year. However, 1-octanol and 1-decanol have estimated volatilization half-lives of 3.5 and 1.0 minutes, respectively. Therefore, the amount of the aliphatic alcohol available for runoff or for chronic exposure to terrestrial animals is likely to be lower than the maximum label rates. As described below, the ecological risk assessment took this into account when estimating potential exposure.

Proposed Directions for Use: Proposed new use for the Fatty Alcohol Products, (N-TAC, EPA Reg. No. 51873-20, O-TAC PLANT CONTACT AGENT, EPA Reg. No. 51873-18 and FAIR 85, EPA Reg. No. 51873-7) consists of application to cotton prior to harvest as a defoliant and desiccant. The spray solution should be applied as a broadcast spray 12 inches over the top of plants using 2 flat fan nozzles per row approximately 19 inches apart that delivers 20 gallons of spray solution per acre. The spray solution consists of 15 to 25% volume/volume (3 to 5 gallons of N-TAC, Fair 85 and O-TAC PLANT CONTACT AGENT) per acre will aid in providing desiccation and defoliation of cotton leaves when used alone or a tank mix combination with sodium chlorate (6 lbai/a).

The aliphatic alcohols are used in, or can be naturally found in various food items. The Food and Drug Administration permits the use of aliphatic alcohols as a food additive, under certain conditions. The aliphatic alcohols have been found to be natural components of apples and oranges, and have been reported as a component of edible seeds, oils and fermented beverages.

III Human Health Risk Assessment

EPA has conducted a risk assessment of the tobacco plant growth inhibitor use of the aliphatic alcohols. EPA's screening level assessment was conducted using data submitted by the registrants and published in the open literature.

A. Executive Summary

This document represents the human health risk assessment chapter of the Reregistration Eligibility Decision (RED) document for the aliphatic alcohols, which include N-decanol, Cx-Cxx alcohols, and fatty alcohols. Aliphatic alcohols are contact sucker control agents used primarily on tobacco. There are no tolerances or tolerance exemptions established for residues of aliphatic alcohols on food.

Based on the supported tobacco use, there are no residential uses for the aliphatic alcohols. In addition, the pesticidal uses of the aliphatic alcohols do not involve use on food and, therefore, are not subject to the Food Quality Protection Act (1996).

The available acute toxicity studies indicate the aliphatic alcohols are of low oral and dermal toxicity. Acute inhalation studies with the rat resulted in LDso estimates above the limit concentration of 2 mgIL. Eye irritation studies, however, resulted in severe and sometimes non-reversible eye irritation. Dermal irritation studies revealed slight to moderate irritation in rabbits. The aliphatic alcohols generally did not produce sensitization in tests with guinea pigs.

A 90-day dermal rat study (fatty alcohol blend) resulted in irritation at lower concentrations and before the development of any marginal systemic effects. Slight changes in hematology, clinical chemistry, and organ weights were noted at the limit dose of 1000 mg/kg/day. Severe irritation including fissuring of the skin occurred in 40% of the animals at 100 mg/kg/day and in 80% of the animals at the limit dose. Available developmental toxicity studies (rat) via the inhalation (I-decanol) and oral (fatty alcohol blend) routes of exposure resulted in no adverse effects when examined at the maximum attainable vapor concentration (100 mg/m)) and oral limit dose (1000

mg/kg/day) based on fetal and maternal parameters. Genotoxicity and mutagenicity studies available were negative and long-term rodent studies to inform the carcinogenic potential of the aliphatic alcohols are not available. However, as a class, the straight chain aliphatic alcohols are generally not carcinogenic. Neurotoxicity information is currently not available, however, there were no clinical signs in any of the acute, subchronic, or developmental toxicity studies to suggest the aliphatic alcohols elicit a neurotoxic effect. Currently there is insufficient hazard concern to warrant a dose response evaluation or endpoint selection for quantitative risk estimates. Therefore, no acute or chronic endpoints have been identified.

An exposure assessment considers the different pathways (food, water, occupational, and residential) through which exposure to the aliphatic alcohols may occur. Oral exposure through food is not expected since the aliphatic alcohols have no food uses and there are no residential uses. Drinking water is not of concern due to: a) the high vapor pressure and likely volatilization in air; b) atmospheric degradation by reaction with photochemically produced hydroxyl radicals; c) lack of hazard for the oral route of exposure; and d) lack of systemic endpoints based on the available studies. Acute and chronic dietary endpoints have not been selected. Therefore, based on the low hazard concern, lack of food uses, along with no quantitative toxicological endpoints, a dietary (food and water) risk assessment is not required.

Since a quantitative dermal endpoint was not identified, no quantitative post application dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) was established. The REI was based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational handler exposure of aliphatic alcohols-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use of Personal Protective Equipment (PPE). Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Based on the lack of food and residential uses and low hazard via the oral, dermal, and inhalation routes of exposure, **quantitative dietary (food and water) and occupational/residential exposure assessments have not been conducted.**

Additionally, the aliphatic alcohols are 'non-food use' chemicals and are not subject to the amendments to the Federal Food, Drug, and Cosmetic Act (FFDCA) promulgated under the Food Quality Protection Act (FQPA) of 1996, and **an aggregate risk assessment is not required.**

B. Introduction

1. Scope of Risk Assessment

This risk assessment evaluates the aliphatic alcohols that are comprised of decanol, alcohols Cx-Cxx, and fatty alcohols. Because of the low hazard concern of the aliphatic alcohols, no toxicological endpoints have been selected for dietary or exposure risk assessment purposes.

2. Ingredient Profile

The review of the product chemistry for the aliphatic alcohols was not based on a single chemical or pc code but rather based on the collective nature of the aliphatic alcohols.

Table 1 Nomenclature for Aliphatic Alcohols		
Chemical structure	C-C-C-C-C-C-C-C-C-C-COH n-Decyl Alcohol	
Common name	Simple Aliphatic Alcohol: Ethanol	1-Decanol
Molecular formula	C_2H_5OH	$CH_3(CH_2)_9-OH$
Molecular weight	46.068 g/mol	*158.29 g/mol*
IUPAC name (denotation)	InChI=IIC2H60/c1-2-3/h3H,2H2,1 H3	Not Reported
CAS name	Ethyl Alcohol	n-Decyl Alcohol
CAS number	64-17-5	112-30-1
PC Code	001501	079038

ii. Physical and Chemical Properties

Table 2. Physicochemical Properties Aliphatic Alcohols		
Parameter	Simple Aliphatic Alcohol Value/Reference	Aliphatic Alcohol : 1-Deconol Value/Reference
Melting point/range	-114.1 to -1 17 degrees Celsius Merck 12th - Edition; MSDS	6.9 degrees Celsius MSDS
Vapor Density at 20 degrees Celsius	1.59 ChemFinder	4.5 MSDS
Water solubility	Fully miscible; >=10 g/100 mL at 23° C Riddick, J.A. et al. (1996); ChemFinder	37 mg/L ; Insoluble; poor Barton, AFM (1984)
Solvent solubility at 20 degrees Celsius	Organic solids of low molecular weight are usually soluble in ethanol. --Among ionic compounds, many mono-valent salts are at least somewhat soluble in ethanol, with salts of large, polarizable ions being more soluble than salts of smaller ions. – Most salts of polyvalent ions are practically insoluble in ethanol. 1) Valja, et al., *Appl Biochem. Biotechno/.*, 7, 51, 1982. 2) J. M. Lee and J. Woodward, *Biotech. Bioeng., 25*, 2441 ,1983. 3) Encyclopedia	Not reported
Vapor pressure	40 mmHg at 19°C 44 mmHg at 20°C	0.00851 mmHg at 25°C

	59.3 mmHg at 25°C Daubert, TE & Danner, RP (1985); MSDS	Daubert, TE & Danner, RP (1989)
	15.9 (H^+ from OH group)	Not reported

Table 2. Physicochemical Properties Aliphatic Alcohols

Parameter	Simple Aliphatic Alcohol Value/Reference	Aliphatic Alcohol: 1-Deconol Value/Reference
Dissociation constant, pK_a	Hansch, c et al. (1995)	
Octanol/water partition coefficient	Log Kow Log P= -0.14 Hansch, c et al. (1995)	Log Kow Log P - 3.79 Hansch, c et al. (1995)
UV/visible absorption spectrum	Data Gap	Data Gap

Refer to http://www.epa.gov/athens/researchiregsupport/properties,html for further details relating to physical and chemical chemistry

3. Summary of Pesticidal Uses

All three chemicals that comprise the reregistration case for the aliphatic alcohols serve as plant regulators. N-Decanol, alcohols (Cx-Cxx), and fatty alcohols are formulated as liquids and are applied via the following methods: groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands. For the new proposed use on cotton the method of application is by ground sprayer as a broadcast spray over the top of the cotton plants.

4. Tolerances

I. Established Tolerances & Tolerance Exemptions

As the aliphatic alcohols are not registered for use on food crops, there are no tolerances established for residues on food. Similarly, there are currently no tolerance exemptions for the aliphatic alcohols.

C. Hazard Characterization and Assessment

The available toxicity database for the aliphatic alcohols consists of acute toxicity, irritation, and sensitization studies. In addition, there are developmental rat (oral and inhalation) toxicity studies and a 90-day rat (dermal) study. Mutagenicity studies available include the Ames, micronucleus, and gene mutation assays. Sources from the published literature are also included in this hazard assessment. The combination of the published literature and submitted toxicity studies are sufficient to assess the pesticidal nonfood uses of the aliphatic alcohols. Based on the low hazard concern via the oral, dermal, and inhalation routes of exposure, a qualitative hazard assessment is appropriate for the aliphatic alcohols.

1-Decanol has been found as a natural component in apples and oranges and has been reported in essential oils of ambrette seeds, almond flowers, citrus oils and fermented

beverages (as cited in HSDB, 2005). I-Decanol is also a permitted food additive for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the following FDA conditions: 1) the quantity added to food does not exceed the amount reasonably required to accomplish its intended physical, nutritive, or other technical effect in food, and 2) when intended for use in or on food it is of appropriate food grade and is prepared and handled as a food ingredient (21 CFR 172.515). There is currently no known mode of action for the aliphatic alcohols. There are currently no guideline metabolism studies in rats available for the aliphatic alcohols.

The acute toxicity studies available for all three of the aliphatic alcohols (PC Codes 079038, 079029, 079059) are listed in Table AI. The available acute toxicity studies indicate the aliphatic alcohols are of low oral and dermal toxicity (Toxicity Categories III and IV). Acute inhalation studies with the rat resulted in LD50 estimates above the limit concentration of 2 mg/L. However, eye irritation studies resulted in severe and sometimes non-reversible eye irritation (Toxicity Category I, II, and III). Dermal irritation studies revealed slight to moderate irritation in rabbits (Toxicity Category III and IV). The aliphatic alcohols generally did not produce sensitization in tests with guinea pigs. More recent acute toxicity data are presented in Table B1 for the fatty alcohol blend Active Substance (Alfol 810) and the end use product (N-TAC).

Oral subchronic toxicity studies are not available for the aliphatic alcohols. However, a 90-day dermal toxicity study in the rat is available (MRID 43701201). Results of the dermal exposure to a fatty alcohol blend (56.7% decanol, 42.7% octanol) at 0, 100,300, or 1000 mg/kg for 5 days/week for 13 weeks included erythema, edema, desquamation, eschar formation and exfoliation of all treated animals. The irritation occurred early (within two weeks of the application process) with irritation apparent in a dose-response fashion. Fissuring of the skin occurred in 40% of animals at 100 mg/kg/day while in 80% of animals at the limit dose of 1000 mg/kg/day. Decreased body weight was also observed at the limit dose (-19% M, -13% F). Slight changes in hematological parameters, clinical chemistry, and organ weight changes were apparent at the limit dose. No other gross or histopathological organ pathology was associated with the skin application of the fatty alcohol blend. The dermal irritation NOAEL was not established with an irritation LOAEL of 100 mg/kg based on severe irritation. The systemic NOAEL was 300 mg/kg/day with systemic LOAEL of 1000 mg/kg/day, based on hematological, clinical chemistry, and organ weight changes.

Developmental toxicity studies via the inhalation (l-decanol) and oral (fatty alcohol blend) routes of exposure resulted in no adverse effects based on fetal and maternal parameters. A developmental inhalation study exposed Sprague-Dawley rats (15) to 15 3 ppm (100 *mglm*) 1-decanol for 7 hours per day on GD 1-19 (Nelson *et al.*. 1990a; Nelson *et al.* . 1990b). The concentration of 1-decanol selected was based on the highest concentration that could be generated as a vapor at an average daily chamber temperature of70-80°F. No treatment-related effects were observed in pregnant females or fetuses including frequency of resorptions, fetal weights, or skeletal/visceral malformations. An oral developmental study exposed 25 female Sprague-Dawley rats/dose at 0, 125,375. or 1000 mg/kg/day to a fatty alcohol blend (55% decanol; 40.7% octanol) on GD 6-16 (MRID 42609301). The maternal NOAEL was 375 mg/k/day and LOAEL was 1000 Mg/kg/day (limit dose), based on increased incidence of salivation (67%). No adverse effects were observed in the offspring. The developmental NOAEL was 1000 mg/kg/day (HDT) with no LOAEL being established.

Genotoxicity and mutagenicity studies available were negative for reverse gene mutations in *Salmonella typhimurium*, not mutagenic in 2 independent assays with/without activation at levels ranging from 9.4 µg/ml to 37.5 µ/ml, and negative for micronucleus induction in bone marrow cells of male and female CD-I mice harvested 24 or 48 hrs post-administration of3 daily doses of SOD, 1000, or 2000 mg/kg/day. There is currently no long-term rodent information regarding the carcinogenic potential for the aliphatic alcohols.

Neurotoxicity information is currently not available. However, there were no clinical signs in any of the acute, subchronic, or developmental toxicity studies to suggest the aliphatic alcohols elicit a neurotoxic effect.

D. Endpoint Selection

Based on the available data, there is no evidence to suggest that the aliphatic alcohols cause increased susceptibility in infants and children. Furthermore, based on the low hazard concern from the available studies, no endpoints of toxicological concern have been identified for risk assessment purposes.

E. Exposure Assessment

1. Dietary Exposure (food and drinking water)

An exposure assessment considers the different pathways (food, water, occupational, and residential) through which exposure to the aliphatic alcohols may occur. Drinking water is not of concern due to: a) the high vapor pressure and likely volatilization in air; b) atmospheric degradation by reaction with photochemically produced hydroxyl radicals (HSDB, 2005); c) lack of hazard for the oral route of exposure; and d) lack of systemic endpoints based on the available studies. Acute and chronic dietary endpoints have not been selected. Therefore, based on the lack of food uses and the low hazard concern of the aliphatic alcohols along with no acute or chronic dietary endpoints being identified, a dietary (food and water) risk assessment is not appropriate.

2. Occupational and Residential Exposure

Aliphatic alcohols are contact sucker control agents used primarily on tobacco [N - decanol, alcohols (Cx-Cxx), fatty alcohols]. Currently there are no residential uses for the aliphatic alcohols. There is potential for exposure of occupational mixers, loaders, applicators, and post-application workers to aliphatic alcohol formulations . However, due to the low hazard concern of the aliphatic alcohols, no dermal, oral, or inhalation endpoints of toxicological concern have been identified for the aliphatic alcohols. Therefore, an **occupational/residential exposure assessment is not required.**

N-Decanol, alcohols (Cx-Cxx), and fatty alcohols are formulated as liquids and are applied via the following methods: groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands.

Available dermal studies indicate that aliphatic alcohols are acutely irritating with any possible stress related changes systemically occurring at higher concentrations and over repeated dermal exposure. Mammals are, therefore, more sensitive to irritation than to any systemic effects and so dermal exposure should be avoided. Available inhalation toxicity studies indicate that aliphatic alcohols are oflow toxicity via the inhalation route. Due to the low hazard profile and lack of endpoint selection for the dermal route of exposure, no post application dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) was established. The REI was based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational uses of aliphatic alcohol-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use of Personal Protective Equipment (PPE). Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Table 3 Summary of Maximum Application Rates for Registered Aliphatic Alcohol Products

Chemical	Crop	Target	Formulation	Maximum Application Rate	Max # of applications	Application Equipment
N-Decanol	Tobacco	Foliar	EC	21.5 lbs ai/acre for hand sprayer 18.9lbs ai/acre for groundboom	2	Groundboom sprayer, backpack sprayer, handgun sprayer, high pressure handwands and low pressure handwands
Alcohols (Cx-Cxx)	Tobacco	Foliar	Liquid (EC,SC)	21.7 lbs ai/arcre	3	
Fatty Alcohols	Tobacco	Foliar	EC	14.19 lbs ai/acre	2	

Table 4: Summary of Maximum application for Proposed uses of Fatty Alcohol Products						
CHEMICAL	**CROP**	**TARGET**	**FORMULATION**	**MAXIMUM APPLICATION RATE %**	**MAXIMUM OF APPLICATION**	**METHOD**
Fatty Alcohol Blend (N-TAC)	Cotton	Broadcast application	EC	25% (5 gal / A product)	1	Ground boom sprayer using 20 gallons of spray solution per acre

F. Cumulative Exposure

As the aliphatic alcohols are not registered for use on food crops, the requirements of FQPA are not applicable and a cumulative risk assessment is not appropriate.

G. Summary

l-Decanol has been found as a natural component in apples and oranges and has been reported in essential oils of ambrette seeds, almond flowers, citrus oils and fermented beverages. l-Decanol is also a permitted food additive for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the FDA. Aliphatic alcohols are contact sucker control agents used primarily on tobacco [N-decanol, alcohols (Cx-Cxx), fatty alcohols]. Currently there are no residential uses for the aliphatic alcohols.

There is potential for exposure of occupational mixers, loaders, and applicators to aliphatic alcohol formulations . However, endpoint selection was not warranted based on the available toxicity data. Therefore, occupational handler risk assessments cannot be conducted and are not appropriate for the aliphatic alcohols.

Based on the hazard profile for dermal exposure to aliphatic alcohols, no post-application dermal risk was assessed. For uses within the scope of the Worker Protection Standard for Agricultural Pesticides (40 CFR 170), a restricted entry interval (REI) was established. The REI was based on the category assigned to the acute dermal toxicity, skin irritation potential, and eye irritation potential of the active ingredient. The appropriate REI is 48 hours if any of the three categories are classified as toxicity category one.

For occupational uses of aliphatic alcohol-containing products, dermal, eye and respiratory irritation effects are addressed through precautionary labeling requirements for use ofPPE. Most of the current labels for N-decanol, alcohols (Cx-Cxx), and fatty alcohols require long pants, chemical resistant gloves, shoes plus socks, and protective eyewear.

Due to the toxicity profile of the aliphatic alcohols, toxicological endpoints of concern were not warranted for risk assessment purposes. **Quantitative dietary (food and water) and occupational/residential exposure assessments, therefore, have not been** conducted. Additionally, as the aliphatic alcohols are 'nonfood use' chemicals and are not ubject to FQPA, **an aggregate risk assessment is not required.**

Appendix 1: Toxicological Profile Tables for the Aliphatic Alcohols

Table A1: Acute Toxicity Data for Aliphatic Alcohols

GUIDELINE NO.	STUDY TYPE	PC CODE	MRID	RESULTS	TOXICITY CATEGORY
870.1100 81-1	Acute oral (rat)	079029 Fatty Alcohols	00142279	85% fatty alcohols, LD50 - 29.3 mg/ml (95% CI of 26.5 to 32.5) (approximately 25 g/kg)	IV
870.1100 81-1	Acute oral (rat)	079038 1-decanol	44460401	79% decanol No deaths at 2000 mg/kg LD50>2000 mg/kg	III
870.1100 81-1	Acute oral (rat)	079038 1-decanol	46004601	79% decanol No deaths at 2000 mg/kg LD50>2000 mg/kg	III
870.1100 81-1	Acute oral (rat)	079038 1-decanol	45507901	37.98% decanol No deaths LD50>3000 mg/kg	III
870.1100 81-1	Acute oral (rat)	079038 1-decanol	0060309 0064859	78.4% decanol, LD50 = 5000 mg/kg	IV
870.1200 81-2	Acute dermal (rat)	079038 1-decanol	44460402	79.2% decanol No systemic clinical signs, no deaths, very slight erythema at 2000 and 4000 mg/kg LD50>4000 mg/kg	III
870.1200 81-2	Acute dermal (rat)	079038 1-decanol	46004602	79% decanol No deaths, no systemic clinical signs. LD50> 2000 mg/kg	III
870.1200 81-2	Acute dermal (rat)	079038 1-decanol	45507902	37.98% decanol No deaths, no clinical signs LD50>4000 mg/kg	III
870.1200 81-2	Acute dermal (rabbit)	079038 1-decanol	0046993 0046994	78.4% decanol. LD50=5000 mg/kg	IV
870.1300 81-3	Acute inhalation (rat)	079038 1-decanol	44460403	79.2% decanol (4 hr nose only) 1 male died Day 2 post-exposure. survivors recovered from 7 to 10 post-exposure LC50>5.07 mg/L.	IV
870.1300 81-3	Acute inhalation (rat)	079038 1-decanol	46004603	79% decanol No deaths. LC50>3.35 mg/L	IV
870.1300 81-3	Acute inhalation (rat)	079038 1-decanol	45517901	37.98% decanol (4 hr nose only) No deaths LC50>7.08 mg/L	IV
870.2400 81-4	Acute eye irritation	079038 1-decanol	44460404 44578801	79.2% decanol Corneal opacity in all treated eye at 7 days.	I

	(rabbit)			Conjunctive irritation until 7 and 14 days. Irreversible vascularisation in one eye until Day 21.	
Table A1: Acute Toxicity Data for Aliphatic Alcohols					
GUIDELINE NO.	**STUDY TYPE**	**PC CODE**	**MRID**	**RESULTS**	**TOXICITY CATEGORY**
870.2400 81-4	Acute eye irritation (rabbit)	079038 1-decanol	46004604	79% decanol Corneal opacity, irritation cleared by 6 days. Conjunctive irritation, redness, chemosis cleared by 6 days. Moderately irritating.	III
870.2400 81-4	Acute eye irritation (rabbit)	079038 1-decanol	45517902	37.98% decanol Corneal involvement or irritation clearing in 7 days or less	III
870.2400 81-4	Acute eye irritation (rabbit)	079029 Fatty Alcohols	44340701	100% fatty alcohols, All 6 rabbits showed moderate to severe irritation. Opacity up to 7 days. Slight iritis with conjunctival redness to Day 6, slight chemosis to Day 7 and slight to severe discharge to Day 8.	II-III
870.2400 81-4	Acute eye irritation (rabbit)	079038 1-decanol	--	78.4% decanol, irreversible corneal opacity in all 6 animals. Severe eye irritation.	I
870.2500 81-5	Acute dermal irritation (rabbit)	079038 1-decanol	44407601 44460405	79.2% decanol Primary irritation index 4.0. Moderate irritation.	III
870.2500 81-5	Acute dermal irritation (rabbit)	079038 1-decanol	46004605	79% decanol Primary irritation index 0.0	iv
870.2500 81-5	Acute dermal irritation (rabbit)	079038 1-decanol	45517903	37.98% decanol Primary irritation index 0.0. Non-irritant.	IV
870.2500 81-5	Acute dermal irritation (rabbit)	079038 1-decanol	--	PIS 2.04. Erythema, eschar formation and edema evident at72 hrs. Mild irritant.	III
870.2600 81-6	Skin Sensitization (guinea pig)	079029 Fatty Alcohols	43386201	Fatty alcohol blend C6-C12 (99%) All animals survived. No adverse effect on body weight. Not a dermal sensitizer	NA
870.2600 81-6	Skin Sensitization (guinea pig)	079038 1-decanol	44407602 44460406	79.2% decanol No change in body weight. *55% (11 / 20)* sensitization rate.	NA
870.2600 81-6	Skin Sensitization	079038 1-decanol	46004606	79% decanol Not a dermal sensitizer	NA

	(guinea pig)				
870.2600 81-6	Skin Sensitization (guinea pig)	079038 1-decanol	45507903	37.98% decanol Not a dermal sensitizer	NA

Table B1:
TOXICOLOGICAL PROFILE FOR FATTY ALCOHOL BLEND END USE PRODUCT (N-TAC) AND TECHNICAL SUBSTANCE (ALFOL 810)

GUIDELINE NO.	STUDY TYPE	PRODUCT	MRID	RESULTS
870.1100	Acute Oral (rat)	N–TAC*	49218303	LD_{50}= >5000 mg/kg
		ALFOL 810**	47589902	LD_{50} = >5000 mg/kg
870.1200	Acute Dermal (rat)	N-TAC	49218304	LD_{50}= >2000 mg/kg
		ALFOL 810	47589903	LD_{50}= >5000 mg/kg
870.1300	Acute inhalation (rat)	N-TAC	49218305	LC_{50}= >2.09 mg/L
		ALFOL 810	47777501	LC_{50} = >2.07 mg/L
870.2400	Primary eye irritation (rabbit)	N-TAC	49218306	Extremely irritating to the eyes
		ALFOL 810	47589904	Moderately irritating
870.2500	Primary dermal irritation (rabbit)	N-TAC	49218307	Slightly irritating to the skin.
		ALFOL 810	47589905	Moderately irritating
870.2600	Dermal sensitization (mice)	N-TAC	49218308	Contact dermal Sensitizer at concentration > 25%
	(guinea pig)	ALFOL 810	47380201	Not a Sensitizer

*N-TAC
FATTY ALCOHOL BLEND (END USE PRODUCT)
Octanol – 36.2%
Decanol - 48.2%
Related compounds (dodecanol) – 0.3%
Other ingredients (Tween 80) – 15.3%

** FATTY ALCOHOL BLEND (TECHNICAL SUBSTANCE) PC CODE 079029
Octanol – 42.6%
Decanol – 56.7%
Dodecanol – 0.3%
Water – 0.1%
Other – 0.3% (hexanol, decanol, 2 ethyl hexanol, dodecane, 3-decanol)

Table A2: Subchronic, Chronic, Developmental, Reproductive and Other Toxicity Profile on the Fatty Alcohols				
Guideline No.	Study Type	MRID	Classification (Doses)	Results
870.3250 82-3	90-day dermal toxicity	43701201 (1995)	10-Spraque-Dawley rats/sex/dose of 0, 100, 300 or 1000 mg/kg for 5 days/week for 13 weeks	Fatty alcohol blend (56.7% decanol, 42.7% octanol) Primary adverse clinical signs included erythema, edema, desquamation, eschar formation and exfoliation of all toxicity treated animals. Irritation apparent within 2 weeks after dermal application. Fissuring of skin observed in 40% of animals in low dose while 80% of animals in high dose. High doses animals exhibited vocalization and hypersensitivity to touch. Body weight was reduced in high dose (-19% M, -13% F) animals. Marginally increased adrenal glands in high-dose animals, slightly reduced RBC counts, hematocrit, and increased WBC and platelet counts in high-dose animals. No gross or histological alterations other than severe irritation. **Dermal irritation NOAEL not established,** LOAEL 100 mg/kg based on severe irritation. **Systemic NOAEL 300 mg/kg/day,** LOAEL 1000 mg/kg/day (LTD), based on slight changes in hematological and clinical chemistry parameters, and decreased bodyweight.
	Develop-mental Range finding	42634201 (1991)	Rats	Fatty Alcohol Blend: 96.6%. Dose levels tested: 125,375,750, and 1000 mg/kg/day. No treatment-related effects were seen in the dams or in the fetuses of dams given the highest dose. Based on this study, does level selected for the main study were: 0, 125, 375 or 1000 mg/kg/day.
870.3700a 83-3a	Develop-mental Toxicity (rat)	42609301 (1992)	Acceptable/Guideline 25 F Sprague-Dawley /dose at 0, 125, 375, 1000 mg/kg/day on GD 6-16	Fatty alcohol blend (55% decanol; 40.7% octanol) Maternal NOAEL 375 mg/kg/day Maternal LOAEL 1000 mg/kg/day, based on increased incidence of salivation (67%). Developmental NOAEL 1000 mg/kg/day Developmental LOAEL not established

Table A2: Subchronic, Chronic, Developmental, Reproductive and Other Toxicity Profile on the Fatty Alcohols				
Guideline No.	Study Type	MRID	Classification (Doses)	Results
	Develop-mental Toxicity (rat)		Nelson et al., 1990a, 1990b 100 mg/m^3 (max vapor achievable 15° F Sprague-Dawley/7 hrs/day on GD 1-19	Dams weighed daily for first week and weekly thereafter. Rats sacrificed on GD 20. No treatment related effects observed in pregnant females, frequency of resorptions, fetal weights, or skeletal/visceral malformations.
870.5100 84-2	Gene Mutation *(Salmonella typhimurium)*	42372002 (1992)	Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Negative for reverse gene mutations in *Salmonella typhimurium* TA 1535, TA 1537, TA 1538, TA98, and TA 100 in presence or absence of S9 activation to 6 doses from 1.5 µg/plate to 500 µg/plate (2 independent trials). Cytotoxicity was apparent for all strains at 500 µg/plate +/- S9.
870.5300 84-2	Gene Mutation (mouse lymphoma cells)	42372003 (1992)	Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Not mutagenic in 2 independent assays with/without activation. Initial assay non-activated & S9 levels ranged from 9.4 µg/ml to 37.5 µg/ml; doses of 37.5 µg/ml severely cytotoxic. Confirmatory assay with 10-50 µg/ml - S9 and 30-70 µg/ml +S9 were evaluated with severe cytotoxicity observed at non-activated levels (60 µg/ml and at S9 activation 80 µg/ml).
870.5395 84-2	Micronucleus (mouse)	42372001 (1992)	Acceptable/Guideline (55.3% decanol, 40.7% octanol)	Negative for micronucleus induction in bone marrow cells of Male and Female CD-1 mice harvested 24 or 48 hrs post-administration of 3 daily doses of 500, 1000, or 2000 mg/kg/day. No overt toxicity in any treated animal or target organ in any treatment group.

References:

Nelson BK, Brightwell WS, and Krieg EF Jr (1990a). Developmental toxicology of industrial alcohols: A summary of 13 alcohols administered by inhalation to rats. Toxicology and Industrial Health. Vol 6 (3/4): 373-387.

Nelson BK, Brightwell WS, Khan A, Krieg EF Jr, and Hobennan AM (1990b). Developmental toxicology assessment of 1 -octanol, 1-nonanol, and 1-decanol administered by inhalation to rats. Journal of the American College of Toxicology. Vol 9(1): 93-97.

HSDB, 2005. Hazardous Substances Data Bank. National Library of Medicine. Search Tenn: 1-Decanol. http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f? /temp/~fK9c0q: 1

Reaves, Elissa and Recore, US EPA Memorandum: Aliphatic Alcohols; Human Health

Chapter of the Reregistration Eligibility Decision (RED) Document. Reregistration Case Number 4004. June 30, 2006; 13 pp.

IV. Conclusion

The proposed addition for the use of fatty alcohol products is as a defoliant/dessicant on cotton prior to harvest. The proposed use rates of 15-25% volume/volume or 3 to 5 gallon of product/ A (18-30 lbasi /A) are similar to the use pattern in tobacco and thus the risk assessment documentation should apply to this proposed use pattern; i.e. this new use represents no added risk to humans or the environment..

Subject: Pesticide Registration Improvement Act (PRIA 3): Action Code R124; Conditional Ruling on Pre-application Study Waivers: Product: N-TAC (EPA Reg. No. 51873-20), O-TAC PLANT CONTACT AGENT (EPA Reg. No. 51873-18), Fair 85 (EPA Reg. No. 51873-7)
(C_8-C_{10} fatty alcohol)

FAIR PRODUCTS, INC.
PO BOX 386
CARY, NC 27512

Fair Products, Inc.

March 2, 2015

Shaja Joyner Product Manager, Team-20
Fungicide Herbicide Branch, Registration Division
Document Processing Desk
Office of Pesticide Programs (7504P)
U.S Environmental Protection Agency
Room S-4900 One Potomac Yard
2777 South Crystal Drive
Arlington, VA 22202-4501

Dear Ms. Joyner,
The purpose of this communication is to follow-up with you pertaining to your February 19, 2015 email. This communication is a draft proposal of the petition to add vegetables grown from rootstock to our fatty alcohol labels (N-TAC, EPA Reg. No. 51873-20, O-TAC PLANT CONTACT AGENT, EPA Reg. No. 51873-18 and FAIR 85, EPA Reg. No. 51873-7), respectively. A separate proposal/petition for adding cotton is being prepared.

During our original discussions with Tony Kish and Lindsay Roe, we provided the following information (see March 26, 2015 letter to Tony Kish) pertaining to the use of Fatty Alcohols to control Meristematic Regrowth on Vegetable Rootstock.

A. List of articles pertaining to this subject.
B. Fair Products, Inc.'s rationale and proposal that this would not require residue studies.
C. Listing of references cited supporting the rationale proposed.
D. Overall Grafting Trials Conclusions.
E. Our initial proposed wording for the label instructions.

Subsequently, we prepared our R-124 Reapplication proposal. In this current draft petition proposal we are providing the same documentation as provided in the R-124 application. We have added the following information:

A. Copy of the EPA's Decision Report on the Pre-application of 51873PA1-493158 (see Tab 17);

B. Risk Assessment Document for Fatty Alcohols (see Tab 18);

Fair Products, Inc. ◦ Agri-Specialties Division ◦ Post Office Box 386 ◦ Cary North Carolina 27512-0386
Telephone: (919) 467-8352 ◦ Fax (919) 467-9142

C. Updated proposed wording for the label that broadens the vegetable crops covered as follows:

A proposed new use for the fatty alcohol products Fair 85, N-TAC and O-TAC PLANT CONTACT AGENT consists of application to control meristematic regrowth on vegetable rootstocks used for grafting other vegetable crops that are members of the following plant families; Solanaceae (e.g. tomato, eggplant, peppers, potato), Cucurbitaceae (e.g. watermelon, cucumbers, melons, squash, cantaloupe), Brassicaceae (e.g. broccoli, cauliflower, cabbage and turnips).

We appreciate your review and comments regarding this information for adding this use to our Fatty Alcohol Product Labels.

Sincerely,

Carla Hull

Carla Hull
Administrative Assistant
Product Registration

cc: Roland Cargill

Fair Products, Inc.

July 2, 2014

Tony Kish Product Manager, Team-22
Fungicide Branch, Registration Division
Document Processing Desk (AMEND)
Office of Pesticide Programs (7504P)
U.S Environmental Protection Agency
Room S-4900 One Potomac Yard
2777 South Crystal Drive
Arlington, VA 22202-4501

Subject: Pesticide Registration Improvement Act (PRIA 3): Action Code R124; Conditional Ruling on Pre-application Study Waivers: Product: N-TAC (EPA Reg. No. 51873-20), O-TAC PLANT CONTACT AGENT (EPA Reg. No. 51873-18), Fair 85 (EPA Reg. No. 51873-7) (C_8-C_{10} fatty alcohol)

A. **Proposed Use: Use of Fatty Alcohol Product to control Meristematic Regrowth of Vegetable Rootstock.**

Grafting Trial Conclusions:

- Fatty Alcohol treatments are effective in controlling meristematic regrowth on vegetable rootstocks.
- Fatty Alcohol treatments improve success and efficiency by increasing graft survival and increasing the rootstock grafting window.
- Fatty alcohol treatment allows for successful use of the hypocotyl-only grafting method.
    - Decreases chances of disease
    - Increases production efficiency (Can use smaller cell size tray)

References

1. Grafting Methods for Watermelon Production-Richard L Hassell and Frederic Memmott; HortScience Vol. 43 (6) October 2008.

2. Watermelon (Citrullas lanatus) Grafting Method to Reduce Labor cost by Eliminating Rootstock Side Shoots - F. D. Memmott and R. L. Hassell; Acta Hort. 871, ISHS 2010.

3. Methods and compositions for the Inhibition of Meristematic Growth on Cucurbit Rootstock – Hassell, et. Al. United States Patent 8,629330B2 Jan. 14, 2014.

Fair Products, Inc. ◦ Agri-Specialties Division ◦ Post Office Box 386 ◦ Cary North Carolina 27512-0386
Telephone: (919) 467-8352 ◦ Fax (919) 467-9142

4. Improvement of Grafted Watermelon Transplant Survival over Time by Rootstock Fatty Alcohol Treatment – Shawna Daley, Jeffrey Adelberg, Richard L. Hassell (22pp).

5. Fatty Alcohol Application to Control Meristematic Regrowth in Bottle Gourd and Interspecific Hybrid Squash Rootstocks used for Grafting Watermelon – Shawna L. Daley and Richard L. Hassell, HortScience 49 (3): 1-5. 2014

6. Fatty Alcohol Blinding Causes Watermelon Rootstock Seedlings to Accumulate Carbohydrates and Increase in Size – Manuscript in review for HortScience.

7. The Effect of Rootstock Age on Grafting Ability, Re-rooting and Field Performance of Grafted Watermelon Transplants – Abstract.

8. Watermelon Grafting: Progress Update- Shawna Daley and Richard Hassell, Clemson University CREC, 3/24/14; 9pp.

B. Intended Crops and Rootstocks Contemplated:

Rootstocks: Gourds, Squash
Crops: Watermelon, Melons, Cucumbers, Cantaloupe, Squash, Tomato

C. Rationale as to why Fair Products, Inc. believes that this use should be classified as a <u>non-food</u> use:

1. The fatty alcohol product is applied to the meristematic tissue on the rootstock before the graft of the scion is made to the rootstock; thus, the fatty alcohol does not come in contact with the scion/ grafted plant tissue.

2. The fatty alcohol is not systemic (contact only) and thus would not translocate to the scion from the rootstock application. (see page 14 of EPA-HD-OPP-2007-0134-005, Ecological Risk Assessment: Aliphatic Alcohols Considered in Registration Case 4004; by Colleen M. Flaherty and Silvia C. Termes, September 8, 2006 which states regarding the mode of action of fatty alcohols: "As non-systemic growth regulators, the alcohols are not translocated in the plant."

3. Fatty alcohols are natural component of plants and studies conducted in tobacco show no increased residue (see attached article by Tso and Chu.)

<u>Reference:</u>
Residue Levels of Fatty Compounds and Surfactants as Suckering Agents on Tobacco – T.C. Tso, H. Chu. and D.W. DeJong; Beiträge zur Tabakforschung Band 8. Heft 4. December 1975, 241-245.

Studies of residue levels of fatty alcohols showed that they could not be detected 26 days after treatment. Tancogne [I] indicates that C_8 and C_{10} alcohols rapidly decreased even in the absence of rainfall and high temperatures. Tso et. al. [II, III] report that residues of ^{14}C labeled fatty alcohol were about 1 ppm compared to a 7000 ppm natural fatty acid fraction.

References:

I. Tancogne, J. (1974). Evolution of the residues of aliphatic alcohols used as sucker control agents on topped dark tobacco. LeTabac Annales, Section 2. 11: 213-238.

II. Tso, T.C, Chu, H. and DeJong, D.W. (1975). Residue levels of fatty compounds and surfactants as suckering agents on tobacco. Beitr. Zur Tabakforschung 8: 241-245

III. Tso, T.C. and Chu, H. (1977). The fate of fatty compounds and surfactants used as sucker control agents on field tobacco. Beitr. Zur Tabakforschung 9: 58-62.

4. Fatty alcohols are generally accepted as biodegradable under both aerobic and anaerobic conditions (Steber et. al., 1988) [IV] and the breakdown or assimilation by microbial organisms is rapid and complete. Dissipation of C_6-C_{12} fatty alcohols under field rates and conditions is rapid and complete. Half-lives as short as a matter of hours could be possible and would not be expected to exceed 3 to 5 days. (MRID 42135801)

References

IV. Steber, J., P. Gode, W. Guhl. 1988. Fatty alcohol sulfates: The ecological evaluation of a group of important detergent surfactants. Fett Wissenschaft Technologie. 90(1): 32-38.

MRID 42135801- Literature review on Fatty alcohol compounds: Lab Project number: FATF-9101. Unpublished study prepared by compliance Services International. 60pp; 12/18/1991.

Additional information contained on page 8 in the reference EPA-HD-OPP-2007-0134-005, Ecological Risk Assessment: Aliphatic Alcohols Considered in Registration Case 4004; by Colleen M. Flaherty and Silvia C. Termes, September 8, 2006 states "The vapor pressure and Henry's Law constant suggest a potential to volatilize from soil (or other solid surfaces) and water. However, the atmospheric persistence (as half-lives) of the volatilized alcohols is less than 10 hours. The mobility in the soil is high to moderate, but rapid biotransformation and volatility reduces mobility in soils." And on page 29

further discloses "Because in general, the biodegradation half-life in aerobic soil is one-half (1/2) of the half-life in water, the half- life of biodegradation of the three alcohols (i.e. C8, C10, C12) in aerobic soils is estimated as 4.33 days for ultimate biodegradation. The primary biodegradation (I.e. biodegradation to the minimum extent necessary to change the identity of the compound) half-life is estimated at 2.33 days (aerobic soil) for 1-octanol and 1-decanol, but longer for dodecanol (7.5 days) (EPI Suite User Guide)."

In addition, the following reference (page 2), the Volatilization from Surface of Soil Data that the half-life for 1-octanol and 1-decanol is estimated at 3.45 minutes and 1 minute, respectively, using the Dow Method.

Reference:

USEPA Memorandum;
Subject: Aliphatic Alcohols (1-octanol; 1-decanol)
Addendum to PRZM and EXAMS refinement of environmental concentrations in surface water (DP Barcode D334066; 11/28/2006).

Recalculation of EE's considering Volatilization from soil as a dissipation route; Recalculation of Risk Quotients; by Colleen Flaherty and Sylvia Termes. 11 December 2006.

Thus, with the grafts being made to the rootstocks 5 to 21 days after the fatty alcohol was applied to control meristematic growth of the rootstock, the fatty alcohol would be volatilized or biodegraded by the time grafting takes place.

5. It is important to note that both the active ingredient (fatty alcohol)[V] and the inert ingredient (polyoxyethyene sorbitan monooleate)- (polysorbate 80)[VI] are both approved as food additives by the US FDA.

Reference

V. Code of Federal Regulations, Title 21, Volume 3; Revised as of April 1, 2011, 21CFR172.864, 6pp.

VI. Code of Federal Regulations, Title 21,Volume 3; Revised as of April 1, 2011; 21CFR172.840, 4pp.

D. Application Locations:
Greenhouse, headhouse for greenhouse operations

E. Proposed directions for use:

Our initial proposed wording for the label instructions could be as follows

(Fatty Alcohol Product Name eg. Fair 85, N-TAC, O-TAC PLANT CONTACT AGENT) Application to Control Meristematic Regrowth on Vegetable Rootstocks Used for Grafting other Vegetable Crops Such as, Watermelon, Cucumbers, Melon, Squash, Cantaloupe and Tomato.

Vegetable grafting is an alternative approach to reduce crop damage resulting from soil borne pathogens and increase plant abiotic stress tolerance, which increases crop production – and fruit quality.

Application of (Fatty Alcohol Product Name eg. Fair 85, N-TAC, O-TAC PLANT CONTACT AGENT) to rootstock meristems can control rootstock meristematic regrowth, thus decreasing the cost of producing grafted vegetable transplants by reducing the labor to remove the meristematic growth by hand.

Apply (Fatty Alcohol Product Name eg. Fair 85, N-TAC, O-TAC PLANT CONTACT AGENT) solution (5.0 - 6.25% concentration) to the rootstock by dipping or direct application when the rootstock seeding cotyledons unfold (5.0%) or when completely unfolded and the first true leaf is visible (6.25%) - (generally 5 to 8 days after seeding).

Listing of Attachments (References)

1. Grafting Methods for Watermelon Production-Richard L Hassell and Frederic Memmott; HortScience Vol. 43 (6) October 2008.

2. Watermelon (Citrullas lanatus) Grafting Method to Reduce Labor cost by Eliminating Rootstock Side Shoots - F. D. Memmott and R. L. Hassell; Acta Hort. 871, ISHS 2010.

3. Methods and Compositions for the Inhibition of Meristematic Growth on Cucurbit Rootstock – Hassell, et. Al. United States Patent 8,629,330B2 Jan. 14, 2014.

4. Improvement of Grafted Watermelon Transplant Survival over Time by Rootstock Fatty Alcohol Treatment – Shawna Daley, Jeffrey Adelberg, Richard L. Hassell (22pp).

5. Fatty Alcohol Application to Control Meristematic Regrowth in Bottle Gourd and Interspecific Hybrid Squash Rootstocks used for Grafting Watermelon – Shawna L. Daley and Richard L. Hassell, HortScience 49 (3): 1-5. 2014

6. Fatty Alcohol Blinding Causes Watermelon Rootstock Seedlings to Accumulate Carbohydrates and Increase in Size – Manuscript in review for HortScience.

7. The Effect of Rootstock Age on Grafting Ability, Re-rooting and Field Performance of Grafted Watermelon Transplants – Abstract.

8. Watermelon Grafting: Progress Update- Shawna Daley and Richard Hassell, Clemson University CREC, 3/24/14; 9pp.

9. Residue Levels of Fatty Compounds and Surfactants as Suckering Agents on Tobacco – T.C. Tso, H. Chu. and D.W. DeJong; Beiträge zur Tabakforschung Band 8. Heft 4. December 1975, 241-245.

10. Tso, T.C. and Chu, H. (1977). The fate of fatty compounds and surfactants used as sucker control agents on field tobacco. Beitr. Zur Tabakforschung 9: 58-62.

11. MRID 42135801 - Literature review on Fatty alcohol compounds: Lab Project number: FATF-9101. Unpublished study prepared by compliance Services International. 60p; 12/18/1991.

12. EPA-HD-OPP-2007-0134-005, Ecological Risk Assessment: Aliphatic Alcohols Considered in Registration Case 4004; by Colleen M. Flaherty and Silvia C. Termes, September 8, 2006.

13. USEPA Memorandum;
Subject: Aliphatic Alcohols (1-octanol; 1-decanol)
Addendum to PRZM and EXAMS refinement of environmental concentrations in surface water (DP Barcode D334066; 11/28/2006).

14. Recalculation of EE's considering Volatilization from soil as a dissipation route; Recalculation of Risk Quotients; by Colleen Flaherty and Sylvia Termes. 11 December 2006.

15. Code of Federal Regulations, Title 21, Volume 3; Revised as of April 1, 2011, 21CFR172.864, 6pp.

16. Code of Federal Regulations, Title 21,Volume 3; Revised as of April 1, 2011; 21CFR172.840, 4pp.

Sincerely,

R. L. Cargill

Roland L. Cargill
Product Registration Specialist

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY
AND POLLUTION PREVENTION

December 12, 2014

Roland L. Cargill
Product Registration Specialist
Agri-Specialties Division
Fair Products, Inc.
PO Box 386
Cary, NC 27512

Subject: Pre-application evaluation for – use of fatty alcohols to control meristematic regrowth of vegetable rootstock, post-grafting

Pre-Application Number: 51873PA1
Application Date: 7/2/2014
Decision Number: 493158

Dear Mr. Cargill:

The EPA has completed an evaluation of your proposal to apply 1-Decanol and 1-Octanol to cucurbit vegetables and tomato during the grafting process to control meristematic regrowth. This evaluation is not an official registration decision but may be used as a tool in planning further actions associated with these chemicals. You will find the review attached.

If you have any questions, please contact Lindsay Roe by phone at 703-347-0506, or via email at roe.lindsay@epa.gov.

Sincerely,

Tony Kish, Product Manager 22
Fungicide Branch
Registration Division (7505P)
Office of Pesticide Programs

[Attachment]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

MEMORANDUM

Date: 10/07/2014

SUBJECT: 1-Decanol and 1-Octanol. Evaluation of Proposal to Apply to Cucurbit Vegetables and Tomato in the Grafting Process.

PC Code: 079037; 079038
Decision No.: 493158
Petition No.: None
Risk Assessment Type: NA
TXR No.: NA
MRID No.: None

DP Barcode: D421961
Registration Nos.: 51873PA1
Regulatory Action: R124: Pre-application Study
Case No.: NA
CAS No.: 112-30-1; 111-87-5
40 CFR: None

Ver.Apr.08

FROM: Stephen Funk, Senior Chemist
Risk Assessment Branch III (RAB III)
Health Effects Division (HED) (7509P)

THROUGH: Christine Olinger, Branch Chief
Risk Assessment Branch III (RAB III)
Health Effects Division (HED) (7509P)

TO: Lindsay Roe and Tony Kish, RM Team #22
Fungicide Branch
Registration Division (7505P)

Background

Fair Products Inc. has proposed the use of n-octanol (capryl alcohol) and n-decanol (capric alcohol) in the grafting process for cucurbit vegetables and tomato. The root stock is treated with a 2 - 6% (v/v) aqueous solution of the fatty alcohols 1 – 21 days prior to grafting the watermelon or other cucurbit scion. The use is also proposed for tomato, although details are not provided. The plants are maintained initially under greenhouse conditions and then transplanted to the field.

HED has been requested to evaluate the process and specifically to determine if the use is food/feed (requiring tolerance) or non-food/non-feed (exempt from the data requirements for food and feed use).

Conclusions and Recommendation

The use of n-octanol and n-decanol in the grafting process for cucurbits and tomatoes is a food use. The information supplied is insufficient to ascertain that no residues will result in the raw agricultural commodities. However, the use is exempt from the requirements for tolerance. A tolerance and the requirements associated with the tolerance petition are not needed. Therefore, the use is exempt from the residue chemistry data requirements associated with a petition for tolerance. Note that this decision applies only to the two fatty alcohols when used for the grafting procedure described and does not apply to the general process of treating root stock (with unspecified chemicals) for grafting. The reasons for the classification as exempt from tolerance and not non-food use are as follows:

(1) N-octanol and n-decanol are approved *inerts* (solvent or co-solvent) for pesticide formulations, and therefore exempt from the requirements for a tolerance (40CFR§180.910). This exemption specifically notes that the inerts may on occasion be used as an active ingredient, as in this situation.
(2) N-octanol and n-decanol are approved *food additives* (20CFR§172.864 – synthetic fatty alcohols) for direct addition to food for human consumption.
(3) N-octanol and N-decanol (or their ester derivatives) are *naturally occurring chemicals.*
(4) The 6% solution is applied by dip or spray to each root stock. Dilution upon growth and development of the plants would lead to very low levels in the cucurbits. However, it is not possible to conclude with certainty that the residues would be non-quantifiable, a criterion for non-food use designation.

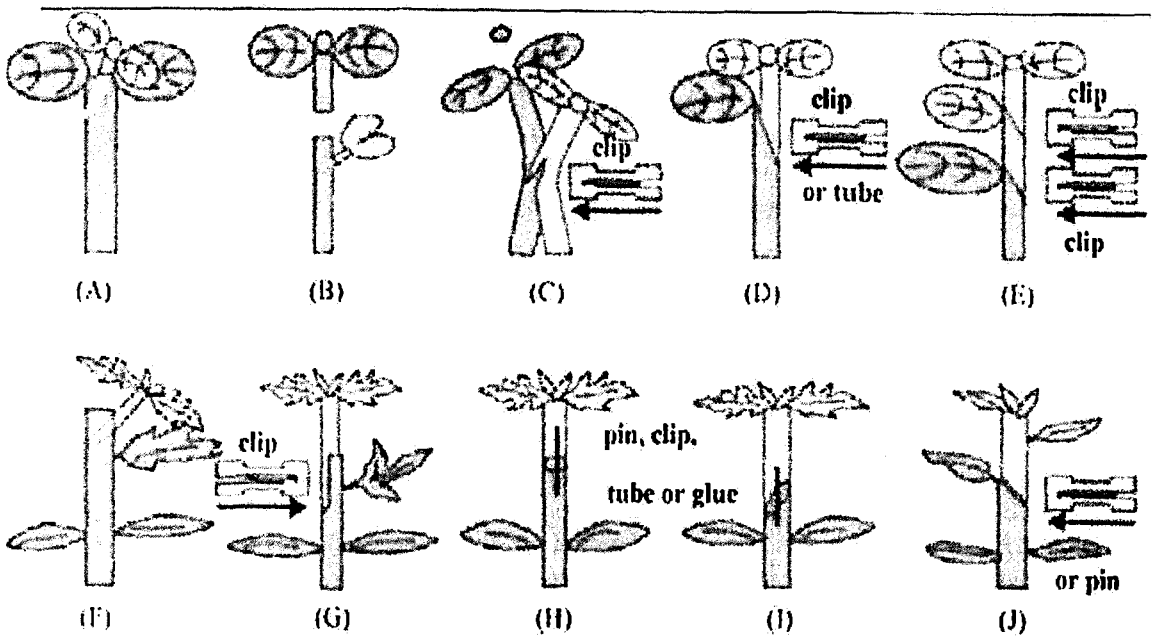
If the petitioner prefers to pursue a non-food designation, further information and/or studies will be needed. A calculation of the residue level on the cucumber raw agricultural commodity (RAC) should be presented based on the proposed label GAP, verifiable data on the translocation of n-octanol/n-decanol, and horticultural and production conditions for cucurbits. Should the calculation be equivocal, a radiolabeled study conducted under GAP conditions would be needed to clearly demonstrate the total radioactive concentrations in the cucumber RAC. If significant levels are found (>5 ppb), it would be necessary to identify the residue as either the fatty alcohols or as incorporation of the radioactivity into naturally occurring compounds or degradates of no toxicological concern.

Details

Process-

Watermelon (and other cucurbit) grafting is an important technique for cucurbit production to avoid soil-borne diseases and as an alternative to soil fumigation. Cucurbit grafting is claimed to promote plant vigor, to provide increased yield in the presence of disease, and to impart a tolerance to abiotic stresses (North Carolina State University). For example, hybrid squash or

bottle gourd rootstock is grafted with seedless watermelon scion. Typical spicing techniques are as follows:



(A and B) hole insertion grafting **(C) tongue approach grafting**

(D, E and J) splice grafting **(F, G) cleft grafting**

(H and I) pin grafting

(Jung-Myung Lee, C Kubota, S.J. Tsao, et al.Current status of vegetable grafting: Diffusion, grafting techniques, automation. Science Horticulturae, 2010. V(127) Iss. 2, P93-105).

Technique J, splice grafting, is used in the current proposal with the alcohols. There is an alteration from one cotyledon to zero cotyledon (cotyledon devoid method). Only the hypocotyl stem is used. After the grafting is completed, the new plants (with old roots cut) typically are placed in a fresh soil medium in a healing chamber with 95% relative humidity and temperatures of 28 – 29°C for about seven days. Healing chambers are typically in greenhouse settings.

Fair Products Inc. has obtained a patent (US 8,629,330 B2, 01/14/2014) for the use of the alcohols on cucurbit rootstock. The alcohols inhibit meristematic growth on the rootstock (growth of shoot apical meristem) and also encourage the accumulation of carbohydrates in the rootstock. Meristematic growth of the rootstock is undesirable, as this leads to competition of the rootstock growth with the desirable growth from the scion. The accumulation of carbohydrates helps promote the survival and vitality of the grafted plant.

The proposed directions for grafting with the fatty alcohols include use on watermelon, cucumbers, squash, cantaloupe, and tomato. The Fair 85 formulation, 5.0 – 6.25% concentration, is to be applied to root stock by dipping or direct application (spraying, misting, and painting) when the rootstock seeding cotyledons unfold (5.0%) or when completely unfolded and the first true leaf is visible (6.25%), which is generally 5 – 8 days after seeding.

While no other specifics are provided in the proposed directions, the results of the experiments (Clemson University) demonstrate that the optimal fatty alcohol concentration is around 6%. This controls regrowth from the root stock with no adverse effect on grafting success. Higher application rates do not significantly increase regrowth suppression but do lead to grafting failures. Also, rootstock seedlings develop up to 21 days after treatment, suggesting that the grafting process should be conducted within 3 weeks of treatment.

N-Octanol and N-Decanol –

Some fatty alcohol derivatives are classified as fungicides. An example is potassium oleate (C_{18} unsaturated acid), registration number 53219-6. Octanol and decanol are registered as growth regulators for tobacco, for example, registration number 400-451.

The Reregistration Eligibility Decision for Aliphatic Alcohols was issued in March 2007. 1-Octanol and 1-Dexanol are registered as growth regulators for tobacco. It was concluded that "...there is no known mode of toxicological action for the aliphatic alcohols. Based on the low hazard concern via the oral, dermal, and inhalation routes of exposure, a quantitative risk assessment for the aliphatic alcohols is not appropriate."

N-decyl alcohol (1-decanol) and N-octyl alcohol (1-octanol) are "exempted from the requirement of a tolerance when used in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest" (40CFR§180.910; *Federal Register*, 76 (24), 02/04/2011, p 6342). Both are listed as solvents for pesticide formulations. The Decision Document (Petition 9E7671, A. Debesai, 01/14/2010) included a human health risk assessment which concluded that there is a reasonable certainty that no harm will result to the general population or to infants and children from aggregate exposure to n-octyl and n-decyl alcohol inert ingredients.

Concentrations of the alcohols in the final spray mixture from use as an inert solvent would be in a similar range as that of the proposed use. For example, a formulation that is 50% alcohol and used at 4 fl oz per gallon of water, would have a 1.5% alcohol concentration is the spray mix. Moreover, the spray mix might be applied to the entire plant, including edible parts, whereas the grafting use (6% v/v) involves application to the root stock very early season long before flowering and formation of the edible commodities.

N-Octanol and N-Decanol are also approved by FDA as additives for foods consumed by humans. 21CFR§172.864 Synthetic Fatty Alcohols may be safely used in food. 1-Octanol and 1-Decanol are specifically named components of synthetic fatty alcohols. They may be used as substitutes for the corresponding *naturally* derived fatty alcohols permitted in food in parts 172 or 173.

Both alcohols occur as esters in essential oils. The longer chain lauric acid (C_{12}) and caprylic acid, the oxidation product of octanol, occur naturally in some food commodities, including milk, coconut, palm kernel, plum, and watermelon. N-decanol and/or n-ocatanol is found in apples and oranges. For example, in citrus oil 1-octanol is up to 0.3% and 1-decanol is up to 0.08% (*Citrus Essential Oils: Flavor and Fragrance*, M. Sawamura, John Wiley & Sons, Inc., 2010). It is ubiquitous in the environment (EFSA, DAR, 2010).

The registered use of 1-decanol/1-octanol as a pesticide (growth regulator) is for foliar application to tobacco. Several products are registered for use on tobacco to prevent or retard sucker development. One such formulation is Kleen-Tac 85 EC, 50% 1-decanol and 36% 1-octanol, with 6.01 lbs ai/gallon. The directions allow 2 applications, each at 0.0013 lb ai/plant or 14.4 lbs ai/acre. Such uses were reviewed in the RED, which concluded that only a qualitative risk assessment was needed.

N-octanol and n-decanol are reputed to be non-systemic when used as plant growth regulators on tobacco (EPA-HD-OPP-2007-0134-005, C. Flaherty, EFED, 08/08/2006). EFSA has concluded that 1-decanol is non-systemic based on its chemical nature (EFSA Journal 2010; 8(9): 1715). It can be speculated that significant translocation into the scion and new growth is not anticipated. Application is very early season, within days of seeding and long before flowering and/or the formation of edible parts. From the patent application and Clemson University report, each root stock is treated with 20 µL of 6% (v/v) solution, or about 1 mg fatty alcohol. Transfer of 100% of the alcohols to one cucumber of 0.2 kg weight (from the many cucumbers on the plant; average weight of English cucumber is 0.3 kg) would give an alcohol concentration of about 5 ppm. Transfer (100%) to all cucumbers over the growing season would yield about 0.14 ppm alcohol concentration in the cucumbers. This assumes 2 lbs of cucumber production per plant per week over a 8 week season per plant, or 16 lbs (7.3 kg) total (University of Florida, IFAS Extension). The 0.14 ppm is an exaggeration, as the alcohols (1) would not 100% translocate; and (2) would distribute throughout the plant and would not locate only in the cucumbers fruits. The degree of exaggeration cannot be quantitated with the available information.

References

PC Code: 879037 and 879038; Decision Document for Inert Ingredients Petition number 9E7671; n-Octyl alcohol (CAS Reg. No. 111-87-5) and n-Decyl alcohol (CAS Reg. No. 112-30-1) to Support the Proposed Exemption from the Requirement of a Tolerance under 40 CFR 180.910. A. Debesai, Petition 9E7671, 11/14/2010.

n-Octyl Alcohol and n-Decyl Alcohol;Exemption From the Requirement of a Tolerance. Federal Register, 76 (24), 02/04/2011, 6342 – 6346.

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Draft Assessment Report (DAR): 1-Decanol. RMS Italy for EFSA. 2008.

Citrus Essential Oils: Flavor and Fragrance, M. Sawamura, John Wiley & Sons, Inc., 2010

Ecological Risk Assessment: Aliphatic Alcohols Considered in Registration Case 4004. EPA-HD-OPP-2007-0134-005, C. Flaherty, EFED, 08/08/2006.

Conclusion of the peer review of the pesticide risk assessment of the active substance 1-decanol. European Food Safety Authority, Parma, Italy, 2010 [EFSA Journal 2010:8(9):1715]

Row Crop Research and Production

Using Fatty alcohols as Active

The Effect of Rootstock Age on Grafting Ability, Re-rooting, and Field Performance of Grafted Watermelon Transplants

Fatty alcohol treatment is a useful technology that prevents rootstock regrowth in Bottle Gourd (*Lagenaria siceraria*) and Interspecific Hybrid Squash (*Cucurbita maxima x C. moschata)* rootstocks. During a three-week period after treatment, rootstock carbohydrates have been shown to increase. This increase could provide energy to improve graft healing and rootstock re-rooting. This positive effect on transplant quality could lead to an eventual improvement in overall fruit quality and yields. A greenhouse grafting experiment and an open-field trial were conducted to characterize this effect. Bottle Gourd (cv. 'Macis') and Interspecific Hybrid Squash (cv. 'Carnivor') rootstock seed were sown in subsequent weekly plantings to achieve rootstock ages of 1, 7, 14, and 21 days after fatty alcohol application. All rootstocks were grafted using Tri-X 313 scion. The age of the scion was the same for all rootstock types, and the grafting was done on the same day using the one-cotyledon grafting method. Two weeks after grafting, the percentage of healed grafts was calculated and scion fresh and dry weights were recorded. Percent rooting, root length density (RLD) and surface area (SA) were also measured. Increases for both cultivars were observed as rootstock age increased. Grafted plants were also planted in a field at the Clemson University Coastal Research Station in Charleston, SC. Transplant survival was recorded and aerial tissue fresh and dry weights from two plants per plot were measured. Yield data, including number and weight of fruit produced per plot and number of harvests per plot, was also collected. Significant effects in both plant growth and fruit yields were observed depending on the age of the rootstock treatments.

Poster:

Rootstock Age Affects Grafting Ability and Rootstock Re-rooting of Grafted Watermelon Transplants

Shawna Daley* and Richard L. Hassell

Clemson University Coastal Research and Education Center, Charleston, SC 29414

Regrowth from the rootstock of a grafted watermelon competes with the scion for nutrients and sunlight, and could cause yield loss and scion abortion. Control of regrowth is costly and labor-intensive. Fatty alcohol treatment of the meristem is a useful technology that prevents rootstock regrowth, thus reducing overall transplant costs. During a three-week period after treatment, rootstock carbohydrates increase while plant growth is prevented. This increase could provide needed energy to improve graft healing of the scion and encourage rootstock re-rooting. A greenhouse grafting experiment was conducted to determine the effect of rootstock age after fatty alcohol treatment on graft healing and re-rooting. Bottle Gourd (*Lagenaria siceraria* cv. 'Macis') and Interspecific Hybrid Squash (*Cucurbita maxima* x *C. moschata* cv. 'Carnivor') rootstock seed were sown in subsequent weekly plantings to achieve rootstock ages of 1, 7, 14, and 21 days after fatty alcohol application. All rootstocks were grafted using Tri-X 313 scion. The age of the scion was the same for all rootstock types, and the grafting was done on the same day using the one-cotyledon grafting method. Two weeks after grafting, the percentage of healed grafts, scion fresh and dry weights, percent rooting, root length density (RLD), surface area (SA), and number of forks were measured. Significant effects of scion and rooting characteristics were observed over changes in rootstock age after fatty alcohol treatment.

Watermelon Grafting: Progress Update

Shawna Daley & Dr. Richard Hassell
Clemson University CREC
Charleston, South Carolina USA

Our Concentration

Control of rootstock regrowth

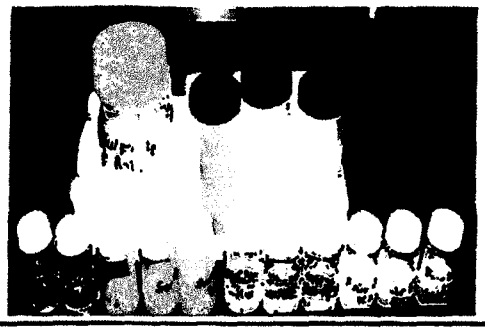
^Competes for space in the field.

<Stunts scion growth

Chemical Control

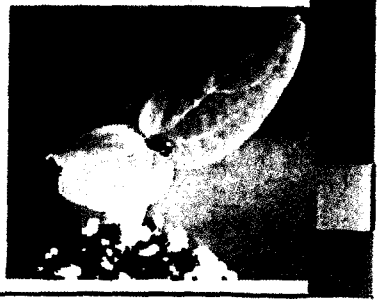
Preliminary Research

1:Surflan	100 mM, 50 mM, 25mM
2:Fair 85(Fatty alcohol)	10x, 5x, 1x (based on 2 gal into 50 gal of water)
3:MH 30	10x, 5x,1x (2 gal into 40 gal of water)
4:Sulfuric Acid	1x, .5x (1x = full strength)
5:Control	



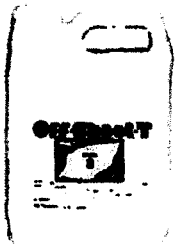
Fatty Alcohol Treatment

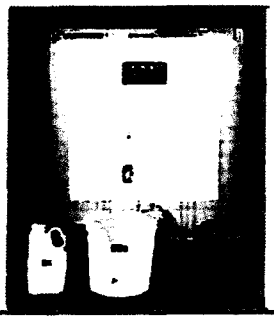
- Dilute fatty alcohol solution (C6-0.5%, C8-42%, C10-56%, C12-1.5%)
- Plasmolyzes tissue and 'burns out' the meristem.
- Method patent granted Jan 14, 2014
  - Plant patent and international patent applications pending.



Fatty Alcohol Rate Trial

- What rate will best control regrowth while causing the least amount of damage?
- 2 products, 9 rates





RATE TRIAL RESULTS: DAMAGE

Table 2. Effects of fatty alcohol concentration on mean percent damage[a] using two C_8-0.5%, C_8-42%, C_{10}-56%, C_{12}-1.5%) fatty alcohol compounds, pooled over three consecutive experiments

Fatty Alcohol Concentration (%)	'Emphasis' Damage		'Carnivor' Damage	
	Fair 85[by] (%)	Off-Shoot T[bx] (%)	Fair 85[b] (%)	Off-Shoot T[b] (%)
0.00	0.0 g[w]	0.0 g	0.0 g	0.0 g
3.75	0.0 g	3.1 fg	0.0 g	1.4 g
5.00	9.8 efg	13.1 ef	4.9 fg	8.7 efg
6.25	17.2 e	43.2 cd	5.4 fg	19.0 cde
7.50	33.3 d	49.3 c	13.6 def	25.8 c
8.75	34.4 d	78.3 b	17.3 cde	43.6 b
10.00	78.4 b	91.8 a	23.7 cd	49.3 b
12.50	84.8 ab	76.6 b	48.9 b	51.2 b
15.00	92.3 ab	94.2 a	69.1 a	55.1 b

[a] 18 seedlings per replication
[y] Fair Products, Inc., USA Cary, NC.
[x] Chemtura Corporation Middlebury, CT.
[w] Values within the two rootstock columns (across compound type) that are not followed by the same letter are significantly different according to Fisher's Protected least Significant Difference test at $P \leq 0.05$.

RATE TRIAL RESULTS: REGROWTH

Table 3. Effects of fatty alcohol concentration on rootstock seedling mean percent regrowth[a] using two C_8-0.5%, C_8-42%, C_{10}-56%, C_{12}-1.5%) fatty alcohol compounds, pooled over three consecutive experiments

Fatty Alcohol Concentration (%)	'Emphasis' Regrowth		'Carnivor' Regrowth	
	Fair 85[by] (%)	Off-Shoot T[bx] (%)	Fair 85[b] (%)	Off-Shoot T[b] (%)
0.00	100.0 a[w]	100.0 a	100.0 a	100.0 a
3.75	32.7 b	14.9 c	47.1 b	35.9 c
5.00	16.2 c	7.7 d	26.6 d	8.1 e
6.25	2.0 de	2.1 d	6.8 e	0.7 e
7.50	1.3 de	0.0 e	1.4 e	0.0 e
8.75	0.0 e	0.0 e	1.4 e	0.0 e
10.00	0.0 e	0.0 e	0.7 e	0.0 e
12.50	0.0 e	0.0 e	0.0 e	0.1 e
15.00	0.0 e	0.0 e	0.0 e	

[a] 18 seedlings per replication
[y] Fair Products, Inc., USA Cary, NC
[x] Chemtura Corporation Middlebury, CT
[w] Values within the two rootstock columns (across compound type) that are not followed by the same letter are

Rate Trial: Conclusions

Optimal treatment rate, (95% control of regrowth with less than 10% damage, between a 5.00% (Off-Shoot T®) and 6.25% (Fair 85®) fatty alcohol application.

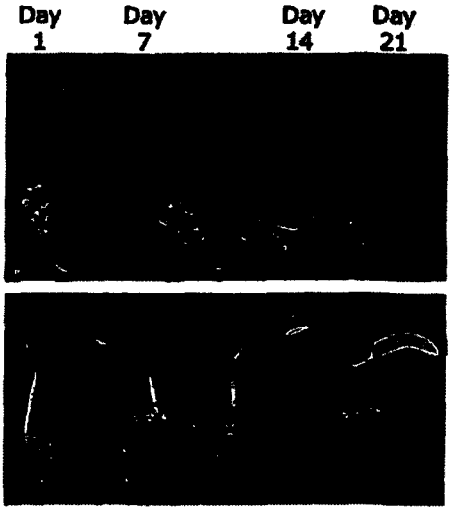
At the optimal treatment rate, no adverse effects to grafting success were observed

Regrowth can be controlled

Observations

Rootstock seedlings increase in size over time after treatment.

Hypothesize an increase in stored carbohydrates.



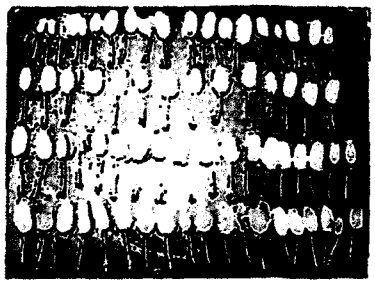
Rootstock Analysis

1, 7, 14, and 21 days.

2 rootstocks

Verify Size Changes

Analyze hypocotyl and cotyledons for Total Soluble Sugars and Starch



Zhao et al. 2010. Rapid Analysis of Nonstructural Carbohydrate Components in Grass Forage Using Microplate Enzymatic Assays. Crop Sci. 50(4):1537-1545

Results: Hypocotyl Development

Table 3. Effect of time after fatty alcohol treatment[x] on 'Emphasis' and 'Carnivor' rootstock hypocotyl[y] development

		Hypocotyl			
Rootstock	Days After Treatment	Fresh Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
Emphasis	1 (Water)	0.2949 e[z]	0.0127 d	36.97 a	2.63 c
	1	0.2278 e	0.0131 d	36.41 a	2.53 c
	7	0.2958 c	0.0284 c	34.97 a	3.06 c
	14	0.4805 b	0.0569 b	35.82 a	4.18 b
	21	0.6181 a	0.0585 a	37.48 a	4.89 a
Carnivor	1 (Water)	0.3723 c	0.0253 c	34.20 a	2.80 c
	1	0.8493 c	0.0294 c	51.65 a	2.94 c
	7	0.4873 bc	0.0649 c	42.95 b	3.53 b
	14	0.5888 ab	0.0896 b	41.55 b	4.22 a
	21	0.7515 a	0.1345 a	41.39 b	4.48 a

[x] All rootstocks, except the water control treatments, were treated with a 0.25% fatty alcohol emulsion

[y] Single hypocotyl measurements

[z] Different letters within each column represent significantly different means based on Fisher's Protected Least Significant Difference test ($P \leq 0.05$)

Results: Cotyledon Development

Table 4. Effect of time after fatty alcohol treatment[x] on 'Emphasis' and 'Carnivor' rootstock cotyledon[y] development

		Cotyledon				
Rootstock	DAT	Fresh Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)	Thickness (cm^2/g)
Emphasis	1 (Water)	0.2969 b[z]	0.0218 b	37.39 ab	30.16 a	0.059 a
	1	0.2771 b	0.0225 b	35.42 b	28.72 a	0.067 a
	7	0.3539 b	0.0595 a	37.19 b	21.41 a	0.065 a
	14	0.4712 a	0.0606 a	42.49 ab	22.92 a	0.062 a
	21	0.5335 a	0.0791 a	44.55 a	24.75 a	0.070 a
Carnivor	1 (Water)	0.5144 b	0.0362 d	46.42 ab	27.69 b	0.064 ab
	1	0.4874 b	0.0417 d	42.53 b	26.67 b	0.065 ab
	7	0.6001 b	0.0745 c	46.35 ab	32.17 a	0.059 b
	14	0.6666 ab	0.0985 b	48.54 ab	32.66 a	0.060 ab
	21	0.8180 a	0.1274 a	51.77 a	33.77 a	0.069 a

[x] All rootstocks, except the water control treatments, were treated with a 6.25% fatty alcohol emulsion

[y] Single cotyledon measurements

[z] Different letters within each column represent significantly different means based on Fisher's Protected Least Significant Difference test ($P \leq 0.05$)

RESULTS: CARBOHYDRATES

Table 5. Effect of time after fatty alcohol treatment[x] on 'Emphasis' and 'Carnivor' rootstock Total Soluble Sugar[y] (TSS) and Starch[z] content per Hypocotyl and Cotyledon

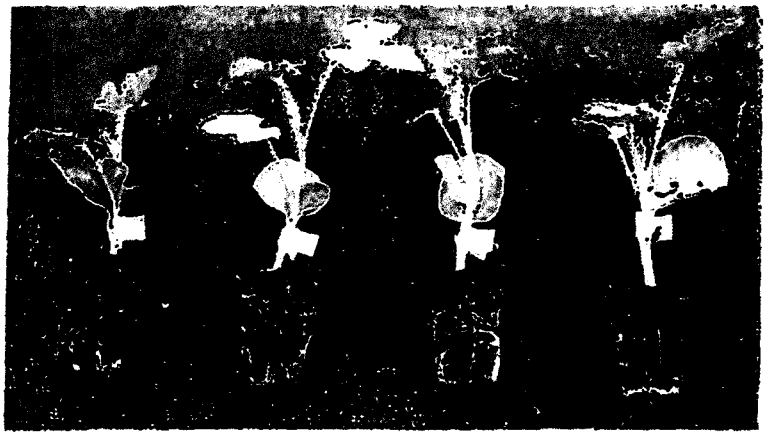
		Hypocotyl[w]		Cotyledon[v]	
Rootstock	Days After Treatment	TSS (µg)	Starch (µg)	TSS (µg/g)	Starch (µg/g)
Emphasis	1 (Water)	1.017 bc[u]	0.023 b	0.663 b	0.032 c
	1				
	7	3	32	9	109
	14	1.932 ab	0.469 ab	4.530 a	2.266 b
	21	2.521 a	0.724 a	5.930 a	3.487 a
Carnivor	1 (Water)	1.625 c	0.040 d	1.323 c	0.061 c
	1				
	7	7	194	6	68
	14				
	21	10.824 a	7.742 a	7.620 a	4.140 a

Analysis Conclusions

- Rootstock seedlings continue to develop and expand over 21 days after fatty alcohol treatment.
- Seedlings increase in carbohydrate content, most notably starch.

Energy is being stored in the rootstock

How does carbohydrate increase affect Graftability?

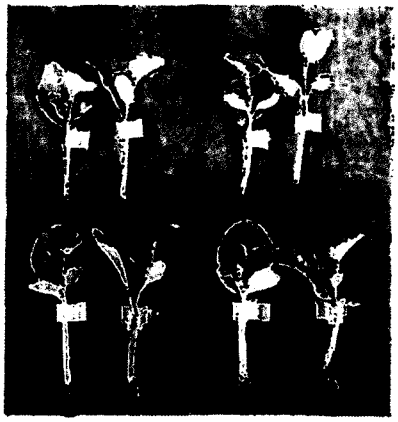


Grafting Trial

Determine effect of increased starch on grafting success and rootstock re-rooting

Experiment 1
- One-Cotyledon Method

Experiment 2
- Hypocoyti-Only Method



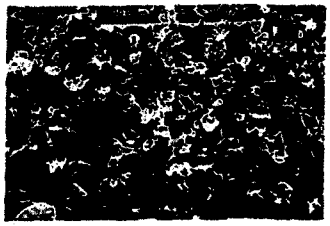
Grafting Trial Conclusions

- Fatty alcohol treatments improve success and efficiency by increasing graft survival and increasing the rootstock grafting window.

- Fatty alcohol treatment allows for successful use of the hypocotyl-only grafting method.
  - Decreases chances of disease,
  - Increases production efficiency
    - Can use smaller cell size tray

Applications

- Expanded grafting window
  - **from 2-3 days to 2-3 weeks**
- New grafting method is successful



Acknowledgements

Grafting Methods for Watermelon Production

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Additional index words. cucurbit, rootstock, scion

Abstract. **Vegetable grafting is most common in European and Asian countries where crop rotation is no longer an option and available land is under intense use. Grafting is an alternative approach to reduce crop damage resulting from soilborne pathogens and increase plant abiotic stress tolerance, which increases crop production. We discuss and outline four grafting methods that are available for vegetable production in cucurbits: tongue approach grafting, hole insertion grafting, one cotyledon grafting, and side grafting.**

The initial grafting method used for melon was cleft grafting (Ishibashi, 1959), but after the introduction of the tongue approach grafting method, its use diminished greatly. The tongue approach method became widespread in Asia because of its higher success rate and the uniform growth of grafted seedlings. In Italy, the most common have been the approach and cleft methods (Bianco, 1990; Buzi et al., 2002; Morra, 1997), but currently the one cotyledon method and the hole insertion method are used (Amadio, 2004). In Spain, a high proportion (more than 90%) of watermelon plants are grafted using the one cotyledon method (Miguel and Maroto, 2000). In France, both the side insertion and the tongue approach have been used in cucurbits (Brajeul and Letard, 1998). Top insertion grafting is the most popular method used in China, because it is suitable for Lagenaria and interspecific squash as rootstocks and requires few materials, has a high efficiency, 1500+ plants/day/worker, and simpler management requirements (Lee and Oda, 2003).

GRAFTING TECHNIQUES

There are two techniques used in grafting, manual and machine (robotic grafting). In manual grafting, the grafting and postgrafting operations require three to four people, each assigned to a specific step in the process (Lee and Oda, 2003). Cucurbits are usually grafted once the first true leaf appears but before it reaches full development both in the rootstock and scion seedlings. To reach this stage for both the scion and the rootstock, planting dates will vary depending on the rootstock and scion chosen, greenhouse temperatures, and seed germination criteria. Different grafting approaches have been adapted depending on scion and rootstock purpose, grafting technique, grower experience, and postgrafting management condition. The tongue approach, hole insertion, and one cotyledon grafting are the currently preferred methods. Modifications to these methods have been done by growers adapting to their particular operation. The tongue approach technique, which has a high survivor rate in general, is chosen by nonexperienced farmers who are looking into grafting for the first time and have plenty of space and adequate labor. One cotyledon and hole insertion grafts require specialized tools and a healing chamber for a high survivor rate and require time to learn. In addition, the graft junction needs to be aboveground during grafting and healing to avoid the direct contact between the scion and soil because adventitious root are easily stimulated, which will defeat the purpose of the graft.

In automatic (machine-driven) grafting, the requirements for the growth of the rootstock and scion are just as critical as in manual grafting. Uniformity in both germination and growth of the rootstock and scion are more critical for the robotic-driven machines. Machine grafting is done using a simple machine or a grafting robot, which is expensive. New machines are currently being developed in Japan and Korea that are much more forgiving and require less labor to operate. The grafting method generally used by these machines is the one cotyledon graft. It is well adapted for machine operation and has a high rate of success. However, there are constant adjustments being made to the machine at the cutting arm to adjust for the variation in hypocotyl thickness or lack thereof. Removal of one of the cotyledons from the hypocotyl at just the right depth and angle is critical for the take of the graft and also for preventing shoot development from the rootstock. The first semiautomatic grafting system for cucumber was commercialized in 1993 and numerous others have been developed since then. A simple grafting machine can produce 600 grafts per hour with two operators as compared with manual grafting making ≈1000 grafts per person per day (Lee and Oda, 2003; Masanao and Hisaya, 1996; Suzuki et al., 1998). In Spain, the automated methods represent less than the 5% of the total cucurbits but may be as high as 10% in Japan and China. At present, 40% of watermelon grafting in Japan is done by the automated method (Lee and Oda, 2003; Masanao and Hisaya, 1996; Suzuki et al., 1998).

MATERIAL AND GRAFTING METHODS

Quality seed and proper plant growth procedures of both rootstocks and scion material are critical for grafting to be successful. High-quality seed with a uniform germination is a must. If primed seed is available, take advantage of it. This seed germinates sooner and with greater uniformity. If seedless watermelon seed is used as the scion material, use the methods for uniform seed germination described by Hassell and Schulthesis (2002). Rootstock seed is generally sown 5 to 7 d before scion seed regardless if they are grown in cell trays or germination beds. The cotyledon of rootstocks should be fully expanded when the scion emerges, keeping the scion at low relative humidity before grafting can minimize pathogen diseases. Watermelon scion are harvested (1 or 2 d) after they emerge, rinsed with clean water, and then treated with fungicides or disinfectant, e.g., Physan 20 or peroxyacetic acid/hydrogen peroxide, to minimize the microorganism damage to the graft. The rootstock should have good tolerance to abiotic stress, resistance to soilborne diseases, and not negatively affect fruit quality. The compatibility between rootstock and scion should be high and stable. In general, grafting compatibility is related to taxonomic affinity. For example, luffa and melon have higher compatibility with nettle melon compared with chinese pumpkin and wax gourd (Wei et al., 2006). Grafting incompatibility can occur at an early stage because vascular connection cannot form properly after grafting. Grafting incompatibility can also be delayed until fruiting stage when massive amounts of nutrition and water are needed. Grafted plants then decline early and successful harvesting is impossible. There is a positive correlation between the vigor of grafted watermelon and the similarity of protective isozymes, e.g., peroxidase and superoxide dismutase, between grafted and regular seedlings (Zhang et al., 2006). The age of the rootstock and scion also plays an important role in compatibility. Optimal seedling age varies for species and different grafting methods. If seedlings are too young, they are too tender to handle during the grafting process and if they

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are too old, it can cause unwanted meristematic growth on the rootstock.

Once grafting has taken place and the necessary procedures followed, the proper healing chamber is critical to ensure that complete union has formed. With the case of the tongue approach grafting, this means only an adequate greenhouse with temperatures controls. However, for the other three methods described, a special healing chamber with light, humidity, and temperature controls are required. Some nurseries, producing grafted plants, have chambers (growth chambers or healing chambers) to maintain temperature above 20 °C to ≈25 °C with relative humidity (RH) controls maintained between 85% and 100% (Miguel, 1997). Other nurseries acclimate in small plastic tunnels (healing chamber) inside the greenhouses where it is possible to maintain a high RH (above 85%). Shading is often required during summer months when using a healing chamber. After 6 to 8 d, grafted plants are acclimated to the natural conditions of the greenhouse by slowly dropping the humidity and increasing light. The best conditions for grafting are: temperatures of ≈22 to 28 °C, RH close to 100%, and very low light intensity for the first 5 to 7 d (Miguel, 1997). Humidifiers can be purchased; however, remember that too much free water can lead to disease pressure and loss of graft union. A fog or mist system is the preferred method.

Listed subsequently are the current methods and figures of each being tested for grafting watermelon transplants. In all the methods described subsequently, the scion seed should be sown at different intervals from the rootstock seed depending on greenhouse conditions, germination temperatures, and rootstock seed chosen. As a general rule, the rootstock seed germinates quicker that the scion seed. This procedure is followed to ensure that the physiological development of the scion and rootstock is as close to the same as possible.

Tongue approach grafting. Cell size for growing the transplants for both the scion and rootstock is 2.5 cm square and 5 cm deep. After rootstock has fully developed cotyledons and scion has cotyledon and first true leaf, plants are pulled out from the tray and laid on a table (Note: 1 d before doing the grafting, trays should be watered heavily.). Do an angle (35° to 45° angle) cut into the hypocotyl of rootstock approximately halfway with a razor blade and make an oppositely angled cut on the hypocotyl of the scion (Fig. 1A). These cuts need to be made so that the scion will be on top of the rootstock when completed (Fig. 1C). Two cut hypocotyls are placed together, then sealed with aluminum foil to help healing and prevent the graft from drying out (Fig. 1D). The two plants are then transplanted into a bigger cell that will accommodate the two root balls (5 cm square × 7.5 cm deep). Trays are then watered heavily until soil is completely wet. Trays should then be moved into a greenhouse (Note: After trays have been placed in the greenhouse, water only as needed.). The top of the rootstock is cut off 5 d after grafting (Fig. 1D), and the bottom of the scion is cut off 7 d after the top of the rootstock is removed (Fig. 1E). After the bottom of the scion is cut off, you must wait 2 d for the plants to be ready to transplant. Grafted plants are maintained in the greenhouse until the plants are ready for transplanting. Grafted plants need not be maintained in high humidity after grafting; plants should not be older than 33 d before transplanting.

Hole insertion grafting. Rootstock seeds are sown in a 3- to 4-cm square cell 5 cm deep. Scion seeds are sown in a much smaller cell tray (1- to 2-cm cell 5 cm deep) with multiple seeds per cell. Trays for rootstock should be watered very well and trays for triploid scion should be watered to the best moisture for germination (Hassell and Shulthesis, 2002). Trays are maintained at 30 °C for germination. When both cotyledons and first true leaf start to develop, the rootstock plant is ready to graft (≈7 to 10 d after sowing), depending on greenhouse conditions. Remove the growing point with a sharp probe, and then open a hole on the upper portion of the rootstock hypocotyl (Fig. 2B–C). A bamboo needle or 1.4-mm drill bit works best. The scion is then cut on a 35° to 45° angle, both sides, on the hypocotyls (Fig. 2A). The scion is then inserted into the hole made in the rootstock (Fig. 2D). The cut surfaces are matched together and held with or without a grafting clip (Fig. 2E). Grafted plants should then be transferred to a humidity chamber or healing room. After the healing process is complete, grafted plants are then transferred and maintained at 21 to 36 °C in the greenhouse until the scion is connected well with the rootstock; plants should not be older than 33 d before transplanting.

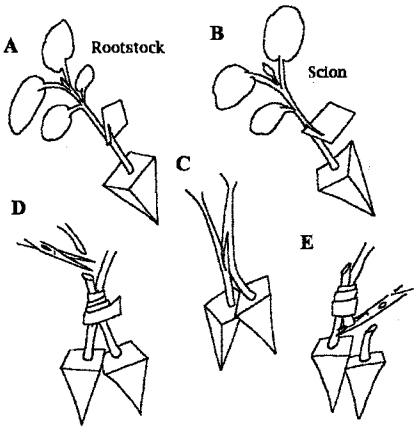

Fig. 1. Tongue approach grafting.

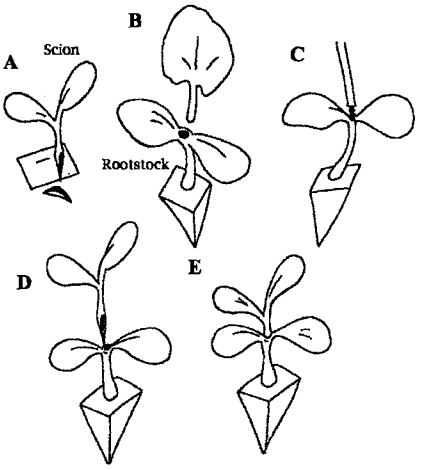

Fig. 2. Hole insertion grafting.

One cotyledon grafting. Production of rootstocks and scions is the same as described for hole insertion grafting. When both cotyledons and first true leaf start to develop, the rootstock plant is ready to graft (≈7 to 10 d after sowing). One cotyledon, along with the visible growing point, is cut with a razor blade following the angle of the leaf petiole (Fig. 3B). The hypocotyl of the scion is cut on a 35° to 45° angle (Fig. 3A) on one side only. The two cut surfaces are matched and held together with a grafting clip or a silicone sleeve (Fig. 3C–D). Grafted plants should then be transferred to a humidity chamber or healing room. Postgrafting care is the same as that described for hole insertion grafting.

Side grafting. Production of rootstocks and scions is the same as that described for hole insertion grafting. When both cotyledons and first true leaf start to develop, the rootstock plant is ready to graft (≈7 to 10 d after sowing). A slit is cut on the hypocotyl of the rootstock with a razor blade and held open with a toothpick (Fig. 4B–C). An angle cut, 35° to 45° angle, on both sides is done on the hypocotyl of the scion (Fig. 4A). The scion is then inserted into the slit in the hypocotyl of the rootstock and the toothpick is removed (Fig. 4D). Two cut surfaces are matched together and held with a grafting clip or silicone sleeve (Fig. 4D). Grafted plants should then be transferred to a humidity chamber or healing room. The top of the rootstock is cut off 5 d after grafted plants are moved from the high-humidity growth chamber (Fig. 4E). Plants are maintained in the greenhouse until the scion is connected well

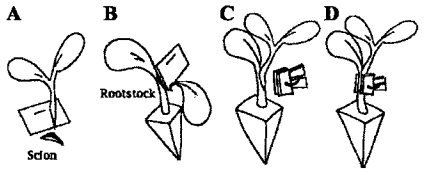

Fig. 3. One cotyledon grafting.

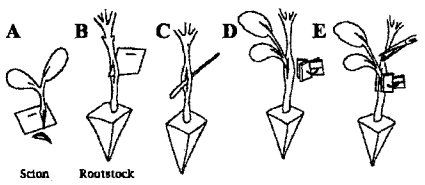

Fig. 4. Side grafting.

to the rootstock; plants should not be older than 33 d before transplanting.

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Watermelon (*Citrullus lanatus*) Grafting Method to Reduce Labor Cost by Eliminating Rootstock Side Shoots

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Keywords: transplants, leaf stage, re-growth, cotyledon devoid, healing chamber

Abstract

Watermelon grafting methods vary from Europe and Asia and are based on efficiency, skill and needs. China mainly practices the whole insertion grafting method where as Europe and Japan employs the splice/slant-cut grafting method. These methods are not suitable for grafting production in the U.S. due to the intense amount of labor cost necessary to successfully produce grafted watermelon transplants. This paper introduces a modified grafting technique called the "cotyledon devoid" method. Both rootstock cotyledons are removed at time of grafting to eliminate any potential rootstock regeneration. By allowing the rootstock and scion material to develop, to the appearance of the second or third true leaf before grafting, (employing the complete removal of both cotyledons) grafting success greatly increase. Furthermore by removing the need to maintain an active root system by excising the root, hypocotyl energy reserves can be conserved to initially heal the graft union and then generate new roots as needed. Grafting was performed on ten plants in five replications using four different rootstocks: *Lagenaria siceraria* 'Emphasis', *Citrullus lanatus* var. *citroides* 'Ojakkyo', *Cucurbita moschata* × *Cucurbita maxima* 'Strongtosa', and *Citrullus lanatus* var. *lanatus* 'Tri-X 313'. All scion material was *Citrullus lanatus* var. *lanatus* 'Tri-X 313'. Rootstocks and scion material was allowed to develop conjointly to the appearance of the first, second and third true leaf whereupon both cotyledons were removed and grafting was performed at each respective developmental stage. A 65° angle was cut below and half an inch below the rootstock and scion cotyledons respectively. Opposing cuts were matched together and secured with a plastic clip. Roots were subsequently excised from the rootstock at soil base and inserted into fresh media for rooting. Grafts were randomly placed inside a healing chamber for 7 days.

INTRODUCTION

Watermelon grafting is an important part of watermelon production to avoid soil-borne diseases and/or chemical fumigation in areas where land rotation is not feasible. Current commercial grafting practices depend on maintaining at least one rootstock cotyledon during the healing period following grafting for high survival (Cushman, 2006; Lee, 1994; Lee and Oda, 2003; Oda, 1995). Rootstock re-growth originating from meristematic tissue next to the remaining cotyledon is one main contributing barrier preventing affordable costs which prevent its introduction into the United States agricultural system (Edelstein, 2004). With the phase-out of methyl bromide fumigant new interests are being reviewed for potential alternatives (Cohen et al., 2007; Davis et al., 2008). For many years grafting in watermelons has been viewed as an option solely in areas where labor costs are minimal. This benefit has great potential to have a very positive effect for commercial production in the United States by improving the plants overall environmental efficiency and overcoming soil-borne pathogens. An alternative grafting method which eliminates potential re-growth is needed in order for grafting technology and benefits to progress into the United States. Removal of both cotyledons in a one step fashion at time of grafting eliminates all potential re-growth and greatly reduces overall grafting costs. Observations indicate however that the rootstock hypocotyl begins to yellow and declines until death when grafted at the 1st leaf stage or younger

which is customary for current commercial grafting techniques. The yellowing and steady decline of the hypocotyl, which results in rootstock death, simulates leaf senescence and suggests that insufficient nutrient reserves were available to the hypocotyl prior to grafting. Without sufficient stored carbohydrates, the hypocotyl cannot sustain itself long enough before receiving photosynthates from the newly grafted vegetative tissue. When plants are allowed to mature to the appearance of the 2nd or 3rd leaf, hypocotyl deterioration is not observed, suggesting perhaps that more reserves are available with maturity to maintain the rootstock until graft healing is complete.

MATERIALS AND METHODS

Material for Growing Seedlings

For this experiment four rootstocks were tested: *Lagenaria siceraria* '*Emphasis*' (bottle gourd), *Citrulus lanatus* var. *citroides* '*Ojakkyo*' (wild watermelon), *Cucurbita mochata* × *Cucurbita maxima* '*Strongtosa*' (inter-specific squash hybrid), and *Citrulus lanatus* var. *lanatus* 'Tri-X 313' (triploid seedless watermelon). Scion material was *Citrulus lanatus* var. *lanatus* 'Tri-X 313'. All seeds were obtained through Syngenta Seeds, Inc. (Boise, Idaho). The soilless mix used for this research has the following composition: 75% NB nursery peat, 25% coarse perlite, 198 g/yd of dolomitic limestone, and 454 g/yd of gypsum, (Conrad Fafard, Inc., Agawam, MA). No premix (nutrient charge) was added to the soilless mix. Rootstocks were grown in 72 square vented plug trays with cell depths of 5.71 cm and top and bottom cell diameters of 3.96 and 2.54 cm respectively (TLC Polyform, Inc. Morrow, GA). Scion was seeded in 288 square plug trays with cell depths of 3.81 cm inches and top and bottom cell diameters of 2.05 and 1.14 cm respectively (TLC Polyform, Inc. Morrow, GA). All fertilizer applications consisted of 100 ppm of 15-5-15 Peters Excel water soluble fertilizer (Scotts-Sierra Horticultural Products Company, Marysville, OH) using the Anderson Injector Series S (H.E. Anderson Company, Muskogee, OK).

Material for Grafting

Rootstocks species were seeded in 72 cell flats and divided into ten plant subsamples replicated five times for grafting and tissue analysis. Rootstocks were grafted at separate times starting with interspecific squash hybrid, followed by the bottle gourd, wild watermelon, and the seedless hybrid watermelon. The 1st leaf stage in this study is defined as visibly seeing the first unexpanded true leaf. The 2nd leaf stage is defined as seeing the fully expanded 1st true leaf and the unexpanded 2nd true leaf. The 3rd leaf stage is defined as seeing the 1st and 2nd expanded true leaves and the unexpanded 3rd true leaf. Prior to grafting separate plants samples were then severed from the roots at the cell line and divided into cotyledons, leaves, and hypocotyls for area measurements of the vegetative tissue which was calculated by LI-3100 area meter (Li-Cor, Inc., Lincoln, Nebraska). At each leaf stage all the rootstock plants were grafted using the cotyledon devoid grafting method (Fig. 1). The "cotyledon devoid" grafting technique is a new method aimed at eliminating rootstock re-growth and is the method under investigation. The cotyledon devoid graft is described as follows: using sterile single edge kobalt blade (Warner Manufacturing Company, Minneapolis, MN) rootstocks were first cut just below both the cotyledons at a 90° angle. This was performed to increase accessibility and precision for the grafting slant cut. An approximate 65° slant cut was then made at the tip of the hypocotyl. The scion was cut at the base from the roots in large quantities and set on sterile paper towels. It was then individually cut at approximately 1.9 cm below the cotyledons with an opposing 65° angle to the rootstock slice and preserved in a 3.8 L size zip-lock bag to help prevent wilting until it was used. Finally the scion was matched together to align the vascular bundles with the rootstock and secured with a spring loaded clip (Syngenta Seeds Inc., Boise, Idaho) (Fig. 1). Grafting treatments consisted of ten plants replicated five times. Following grafting, the newly grafted plants were immediately placed randomly inside a custom made healing chamber for seven days

which was located inside the greenhouse. The healing chamber was constructed with a rectangular wooden box with the following dimensions: width of 86 cm, a length of 300 cm, and a depth of 14 cm and covered with polyethylene sheet. The humidity was maintained using the 707U-duct mount centrifugal atomizer humidifier (Herrmidifier, Effingham, Illinois).

RESULTS AND DISCUSSION

There was a significant rootstock by leaf stage interaction suggesting that the four rootstocks responded differently at each of the leaf stages (Table 1). The seedless watermelon type did not significantly increase in hypocotyl length with each leaf stage but the diameter did increase significant with growing time. This then was reflected on the overall hypocotyl area with a decrease at the third leaf stage. However an increase in grafting success was not seen until the rootstock had reaches the third leaf stage. The wild watermelon type did significantly increase at both the hypocotyl length and diameter at each of the leaf stages which resulted in an overall increase in the hypocotyls area. However grafting success was fully achieved at the second leaf stage of plant development. Both the interspecific hybrid and the bottled gourd rootstock significantly increased in both hypocotyl diameter and length with each increase of leaf stage resulting in a significant increase in hypocotyl area and grafting success. There was a strong correlation with grafting success and hypocotyl growth (Table 2). As hypocotyls increased in both lengths, diameter and area grafting success also increased. The weakest correlations seemed to be with the wild and seedless watermelon rootstock types in the hypocotyl length. However, the strongest correlation came with the interspecific hybrid rootstock with the hypocotyl length. These results suggest that as the rootstock increases in size and development the greater grafting success can be seen in the absence of the cotyledon leaf.

CONCLUSION

Larger hypocotyls suggest an increase in storage capacity or an overall increased carbohydrate reserves from the 1st leaf stage to the 2nd and 3rd due to larger hypocotyl size. Results indicate that this new method could be used to reduce costs by eliminated rootstock side shoots only if performed when the rootstock has developed to the 2nd or 3rd true leaf stage. We also found that using scion material at the 3 rd leaf stage may be another contributing factor to increase grafting success.

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Tables

Table 1. Grafting success and hypocotyl growth of seedless watermelon grafted on various rootstocks at different leaf stages of development.

Rootstock		Leaf stage[x]	Hypocotyl[w]			Grafting success (%)[y]
Cultivar	Type		Area (cm^2)	Diameter (mm)	Length (mm)	
Ojakkyo	Wild watermelon	1	0.56 g[z]	2.53 f[z]	28.98 e[z]	57.60 d[z]
		2	1.10 e	2.70 e	37.85 d	100.00 a
		3	1.80 b	3.25 cd	55.00 b	100.00 a
Strong Tosa	Interspecific hyb.	1	1.30 d	3.59 b	39.00 d	15.00 f
		2	1.50 c	3.30 c	48.61 c	60.00 d
		3	4.30 a	5.30 a	73.72 a	84.00 bc
Emphasis	Bottled gourd	1	0.72 f	2.72 ef	27.40 e	39.12 e
		2	1.10 e	3.30 c	30.15 e	84.70 bc
		3	1.80 b	3.09 d	57.29 b	98.33 a
Tri-X 313	Seedless watermelon	1	0.66 fg	2.25 g	28.18 e	75.00 c
		2	1.76 f	2.80 e	31.63 e	83.18 c
		3	1.00 e	3.22 cd	30.16 e	95.00 ab

[z]Means within columns followed by the same lowercase letter are not significant at the $P \leq 0.05$.
[y]Analysis was performed after arcsin transformation of the percentage data.
[x]The 1st leaf stage in this study is defined as visibly seeing the first unexpanded true leaf. The 2nd leaf stage is defined as seeing the fully expanded 1st true leaf and the unexpanded 2nd true leaf. The 3rd leaf stage is defined as seeing the 1st and 2nd expanded true leaves and the unexpanded 3rd true leaf.
[w]Hypocotyl measurements represent a total of a ten plant sample replicated five times.

Table 2. Pearson correlation coefficients (R^2) between rootstock hypocotyl area, diameter or length and grafting success.

Rootstock		Hypocotyl[y]		
Cultivar	Type	Area (cm^2)	Diameter (mm)	Length (mm)
Ojakkyo	Wild watermelon	0.781[z]	0.681	0.565
Strong Tosa	Interspecific hyb.	0.784	0.655	0.828
Emphasis	Bottled gourd	0.825	0.655	0.676
Tri-X 313	Seedless watermelon	0.721	0.874	0.630

[y]Hypocotyl measurements represent a total of a ten plant sample replicated five times.
[z]Values are significant at P=0.05.

Figures

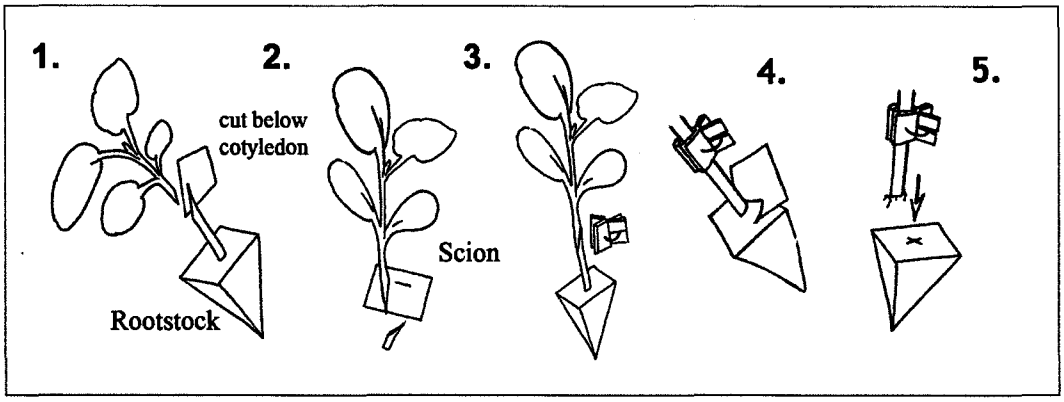

Fig. 1. Cotyledon devoid method described as a five step process (Hassell et al., 2008). 1) Both cotyledons are cut from the rootstock at an approximate 65° angle; 2) The scion is cut at an approximate 65° opposing slant to the rootstock; 3) The scion and rootstock wounded regions are joined and secured with a clip; 4) The rootstock hypocotyl is cut just below the baseline; and 5) The grafted seedling is then re-stuck in a new cell with fresh soil media.

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Fatty Alcohol Application to Control Meristematic Regrowth in Bottle Gourd and Interspecific Hybrid Squash Rootstocks Used for Grafting Watermelon

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Additional index words. cucurbit grafting, sucker control, shoot apical meristem, *Citrullus lanatus*, *Lagenaria sicereria*, *Cucurbita maxima* × *Cucurbita moschata*

Abstract. **Application of fatty alcohol compounds to rootstock meristems can control rootstock meristematic regrowth, thus decreasing the cost of producing grafted watermelon transplants by reducing the labor. Eight rates of Fair 85® and Off-Shoot T®, two commercially available fatty alcohol compounds, were applied to the meristem region of bottle gourd (*Lagenaria sicereria* cv. Emphasis) and interspecific hybrid squash (*Cucurbita maxima* × *Cucurbita moschata* cv. Carnivor) rootstocks to determine the optimal application rate to control regrowth without damaging the remaining plant parts. A water-only control treatment was also included. Rootstock seedlings were rated for damage and regrowth on Days 1, 7, 14, and 21 after treatment. Damage increased and regrowth decreased with increasing rates of fatty alcohol compound. In addition, a significant compound-by-rate interaction indicated that inert ingredients in the fatty alcohol formulation have an effect on both damage and regrowth. The optimal treatment rate, e.g., providing at least 95% control of regrowth with less than 10% damage, was found to be between a 5% (Off-Shoot T®) and 6.25% (Fair 85®) fatty alcohol application. At the optimal treatment rate, no adverse effects to grafting success were observed in the grafting procedure.**

Grafted watermelon transplants are an important part of worldwide watermelon production because they confer resistance to soilborne diseases such as fusarium wilt (*Fusarium oxysporum* f. sp. *niveum*) and Monosporascus root rot (*Monosporascus cannonballus*) (Beltran et al., 2008; Guan et al., 2012; Louws et al., 2010). Grafting can also control root-knot nematode (*Meloidogyne* spp.) using wild watermelon (*Citrullus lanatus* var. *citroides*) or *Cucumis metuliferus* as a rootstock (Sigüenza et al., 2005; Thies et al., 2010). In addition to disease resistance, grafting watermelon onto vigorous rootstocks provides various other benefits, including increased yield and fruit quality (Ozlem et al., 2007), increased resistance to abiotic stresses (Savvas et al., 2010), decreased planting densities (Cushman and Huan, 2008), and increased nutritional components (Davis and Perkins-Veazie, 2005). Currently, the United States is one of the few countries worldwide that does not use grafted cucurbit transplants in commercial production. A key reason for this is that soil fumigants have been available at modest costs, whereas there is high cost associated with grafted transplants (Edelstein, 2004). However, the loss of the widely used and inexpensive soil fumigant methyl bromide as a result of the *Montreal Protocol* and the Clean Air Act (EPA, 2012) has made the use of grafted watermelon transplants a more attractive option for producers looking for a solution to soilborne diseases and pests. Of the 105,000 acres of seedless watermelon planted in the United States in 2012 (U.S. Department of Agriculture, National Agricultural Statistics Service, 2012) 5% (5250 acres) was reported to be affected by fusarium wilt (Dean Liere, Syngenta Corporation, personal communication). As arable land for rotation decreases, the percentage of fusarium-infested soils will continue to rise. Currently, no control options are available other than grafted transplants; however, their increased cost remains the major impediment to adoption in U.S. production.

The two most common commercially used grafting methods (over 90%) are the hole-insertion and the one-cotyledon method (Hassell et al., 2008). These methods require at least one cotyledon to remain intact to ensure graft success (Bisognin et al., 2005; Hassell et al., 2008), and both require manual meristem removal with a blade during grafting. This method often removes the meristem only partially, and meristem regeneration occurs. The extent of meristem regeneration varies widely and is dependent on the method used, timing of grafting, and the experience of the individual doing the grafting.

Rootstock meristem regrowth also contributes greatly to the cost associated with grafted watermelon transplant production (Choi et al., 2002; Memmott and Hassell, 2010) because it decreases graft success and requires additional labor to control. If the regrowth is not removed manually during production, it will outcompete the watermelon plants (the scion) for light, space, and nutrients, preventing effective healing. In the field, unremoved regrowth can also affect yields by competing with the scion. Even if the regrowth is removed at the transplant stage, additional labor is required to scout and remove regrowth in the field. The labor required for manual regrowth control makes grafted transplants economically impractical for commercial production in the United States. Because grafted transplant production is not currently taking place in the United States, it is unclear what the specific production costs would be. Regardless, a labor-free method of eliminating meristematic regrowth should significantly reduce the overall cost of grafted watermelon transplant production and might help to increase the adoption of grafted cucurbit transplants in the United States.

Chemical inhibition of the meristem region of rootstocks would not only decrease the labor required for grafted transplant maintenance, but would address the variance in regrowth based on grafter skill, timing, and method. However, acceptable removal of the meristem without damaging the rootstock cotyledons has been a challenge. Preserving the quality of the cotyledons is essential, because cucurbit seedlings rely heavily on at least one cotyledon to supply energy for growth and establishment (Bisognin et al., 2005). A chemical treatment would be acceptable for use only if it could destroy the meristem without damaging the cotyledons, which would provide the energy required for rootstock health and graft healing. AU1

Previous studies (Choi et al., 2002) have examined silver nitrate and hydrogen peroxide applications to the meristem region of cucurbit rootstocks, but the application resulted in unacceptably low rootstock survival. Other preliminary research of chemicals including maleic hydrazide, oryzalin, sulfuric acid, and fatty alcohols indicated that only the fatty alcohol successfully destroys the rootstock meristem without damaging the rootstock cotyledons (Hassell, unpublished data). This promising method of regrowth control (U.S. Provisional Application No. 61/647,312) involves applying a dilute C_6, C_8, C_{10}, C_{12} fatty alcohol solution to the meristem area of a rootstock seedling, where it destroys only the rapidly dividing meristem tissue (Steffens et al., 1967) to prevent regrowth while the rootstock seedling remains viable for AU2

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grafting. Commercially available fatty alcohol products are used on tobacco to control axillary meristem growth (suckers) after topping. The compound acts by disrupting the cell's plasma membrane, causing plasmolysis of the cells and desiccation of the tissue (Wheeler et al., 1991). Although the mode of action on tobacco is understood, the specifics of fatty alcohol applications on cucurbit rootstock tissues have not been characterized. The first objective of this experiment was to determine the optimal application rate of commercially available fatty alcohol compounds that would control rootstock regrowth without damaging the rootstock cotyledons and, thus, their potential for grafting. The second objective was to determine whether the fatty alcohol treatment affected the graft success of the rootstocks.

Materials and Methods

Plant material. Seeds of two rootstocks commonly used in Asia and Europe, bottle gourd (*Lagenaria sicereria* cv. Emphasis) (Syngenta Seeds, Boise, ID) and interspecific hybrid squash (*Cucurbita maxima* × *Cucurbita moschata* cv. Carnivor) (Syngenta Seeds), were sown in 72-cell, TLC polyform plug flats (cell depth: 5.72 cm, top cell diameter: 3.96 cm, bottom cell diameter: 2.54 cm) (TLC Polyform Inc., Minneapolis, MN) using a nutrient-free, soilless mix (75% sphagnum peat, 25% perlite) (Sun Gro Horticulture, Agawam, MA). Seeds were sown on four planting dates, once each week of Aug. 2012, following standard greenhouse production practices (Rutledge, 2009). Seedlings were grown in a standard, double-layer polyethylene greenhouse covered with 6 mm Klerk's K50 clear plastic (Klerks Hyplast, Inc., Chester, SC). The greenhouse contained a gas heating system to supply heat and exhaust fans to remove heat. Minimum temperatures were set at 15 °C and the exhaust fans were set to power on when greenhouse temperatures reached 21 °C.

Experimental design and data collection. A split-split plot design was used with the four planting dates as the whole plot factor, compounds applied to half-trays (compound type being the subplot factor), and rates randomized within compound (rates being the sub-subplot factor). Three trays total were used to complete each replication. Each planting date consisted of three replications of 18 individual plants per compound type and rate treatment combination, resulting in a total of 54 plants (observations) per planting date.

Seedling treatment. Two commercially available, concentrated fatty alcohol stock solutions, Fair 85® (Fair Products, Inc., Cary, NC) and Off-Shoot T® (Chemtura Corporation, Lawrenceville, GA), were used in the experiment. Both products contain identical active ingredients (C_6 0.5%, C_8 42%, C_{10} 56%, and C_{12} 1.5%) according to the labels. Emulsions were prepared by diluting fatty alcohol in distilled water according to the dilutions presented in Table 1. Rates were based on a 20-mL total volume.

Fatty alcohol treatment began when rootstock seedling cotyledons were completely unfolded and the first true leaf was visible (6 to 8 d after seeding for bottle gourd and 5 to 7 d after seeding for the interspecific hybrid). This is the standard rootstock age for grafting (Hassell et al., 2008). Twelve h before treatment, trays of plants were removed from the greenhouse and transferred to a climate-controlled room to acclimatize seedlings to a standard environment. Temperatures were maintained at a constant 23 °C, and relative humidity was maintained at a range of 50% to 70%. Single-channel pipettes (VWR International LLC, Radnor, PA) were used to apply 20 µL of the emulsion to the meristematic region between the cotyledons. In previous experiments, this volume was found to be the amount that covered the meristematic region of the rootstock without the compound overflowing the area and dripping down the hypocotyl. Seedlings remained in the controlled environment 5 h after treatment, 2.5 times greater than the 2-h timeframe reported by Wheeler et al. (1991) to be required for the fatty alcohol to penetrate leaf tissue.

Because at least one cotyledon is required for grafting success (Bisognin et al., 2005; Memmott, 2010), it was necessary to determine the effect of the fatty alcohol application on cotyledon damage as well as on regrowth control to ensure rootstock quality for grafting. For cotyledon damage, a rating of 0 was assigned to seedlings with no visible damage (Fig. 1A), whereas seedlings with damaged cotyledons were assigned a rating of 1 (Fig. 1C). For regrowth response, rootstock seedlings with no meristematic regrowth were assigned a regrowth rating of 0 (Fig. 1A), and a rating of 1 was assigned to seedlings with visible meristematic regrowth (Fig. 1B).

Preliminary research revealed that some cotyledons recover from damage incurred by the fatty alcohol and are able to be successfully grafted (Hassell, unpublished data). The rootstock regrowth also occurs over varied amounts of time. To determine the rating day that would most accurately reflect true damage and regrowth after fatty alcohol application, a series of ratings were conducted on Days 1, 7, 14, and 21 after fatty alcohol application.

Grafting experiment. The same rootstock material as described previously was used in the grafting experiment. 'Tri-X 313' (*Citrullus lanatus* var. *lanatus*) (Syngenta Seeds) was used as the scion. Scion seeds were sown according to guidelines outlined by Hassell and Schultheis (2002). The experiment was a randomized complete block design with three replications and 12 grafted plants per treatment and was repeated twice on 26 and 28 Aug. 2013. Three different treatments were applied: 6.25% Off-Shoot T®, 6.25% Fair 85®, and a water control. Fatty alcohol treatments were chosen based on the results of the previously described rate trial experiment. One day after fatty alcohol treatment, seedlings were grafted using the one-cotyledon grafting method, according to the procedure described by Hassell et al. (2008). Graft success was recorded as a percentage of total grafts attempted.

Data analysis. Damage and regrowth data were separated by rootstock type and analyzed separately with an approximate generalized linear mixed model. The model was a complete factorial model of all combinations and interactions between and among the following fixed effects: planting date, compound, rate, and day of evaluation. Random effects included replication and the interactions among replications and the three fixed factors. Planting date was nested within the factors. In both responses, means were multiplied by 100 and are presented as a percent incidence.

The main effect of day of evaluation appeared to reach an asymptote; thus, a series

Table 1. Dilutions used to create fatty alcohol emulsions[z] with Fair 85® and Off-Shoot T®.

Water added (mL)	Compound added (mL)	Final volume (mL)	Final emulsion percent
20.00	0.00	20.00	0.00
19.25	0.75	20.00	3.75
19.00	1.00	20.00	5.00
18.75	1.25	20.00	6.25
18.50	1.50	20.00	7.50
18.25	1.75	20.00	8.75
18.00	2.00	20.00	10.00
17.50	2.50	20.00	12.50
17.00	3.00	20.00	15.00

[z]Emulsions were created by measuring desired volume of fatty alcohol compound and bringing to 20 mL final volume with diH_2O.

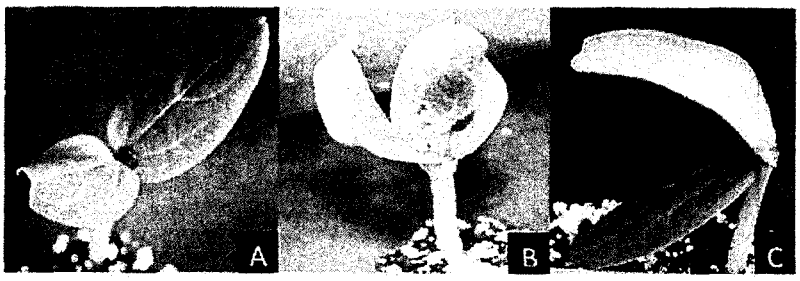

Fig. 1. Rating system for treated seedlings. (A) Treated seedlings with no damage or regrowth were given a rating of 0 in both categories. (B) Treated seedlings with regrowth and no damage were given a rating of 0 for damage and 1 for regrowth. (C) Treated seedlings exhibiting damaged cotyledons were given a rating of 1 for damage and 0 for regrowth.

of contrasts were used to determine at which day the damage and regrowth responses became constant. Day 14 was used for the final linear mixed model analysis, excluding the data from Days 1, 7, and 21. Effects used in this model included all of these factors with the exception of any factor including day. Multiple means comparisons were performed using Fisher's protected least significant difference test with a P value ≤ 0.05 considered significant throughout. The choice of Fisher's protected least significant difference test was to reduce the overall probability of Type II errors.

All calculations were performed using the fit model platform of JMP Pro 10® Software (SAS Institute Inc., 1989–2010). The reason for a generalized linear mixed model was that both damage and regrowth were binomial random variables. The reason it was an approximate generalized linear mixed model was that the complex nature of the statistical design, including random effects, led to some approximations (using general linear mixed models) to overcome some convergence and estimation issues.

Graft success data were also analyzed with a linear mixed model using the fit model platform of JMP Pro 10® Software (SAS Institute Inc., 1989–2010). Similar to the damage and regrowth data, means are presented as percent incidence. The model for grafting success was a complete factorial model including all combinations and interactions between and among the following fixed effects: planting date, compound, and treatment. Random effects included replication and the interactions among replication and the three fixed factors with planting date nested within the remaining factors.

Results

Damage response. A significant compound-by-rate interaction existed for damage incidence in both 'Emphasis' and 'Carnivor' ($P < 0.0001$), indicating that the two compounds reacted differently as their concentrations increased (Tables 2 and 3). There were no significant differences in damage incidence in 'Emphasis' seedlings treated with 0%, 3.75%, and 5% of either Fair 85® or with 0% and 3.75% of Off-Shoot T® (Table 2). 'Emphasis' rootstock damage incidence increased significantly between 6.25% and 7.5% Fair 85® and the damage incidences at 10%, 12.50%, and 15% Fair 85® were not significantly different (Table 2). Damage incidence increased significantly between 5% and 6.25% Off-Shoot T® as well as among 7.5%, 8.75%, and 10% Off-Shoot T®. Damage incidence at 12.5% Off-Shoot T® decreased significantly, but damage at 15.00% was not statistically significant from damage incidence at 10% Off-Shoot T® (Table 2).

Damage incidence on 'Carnivor' seedlings also increased with increasing concentrations of fatty alcohol. Seedlings treated with 0%, 3.75%, 5%, and 6.25% Fair 85® had the lowest amount of damage with no significant differences; however, damage significantly increased from 5.4% to 13.6% as rates increased from 6.25% to 7.50%, respectively, of Fair 85® (Table 2). There was no significant increase in damage between 7.50% and 8.75%, but a significant increase from 23.7% incidence at 10.00% to 48.9% incidence at 12.50% Fair 85® (Table 2). Damage was highest at 15% Fair 85® with 69.1% incidence (Table 2). Similarly, the Off-Shoot T® treatment showed no significant differences between rates of 0%, 3.75%, and 5% (Table 2). Damage increased significantly in seedlings treated with 8.75% Off-Shoot T® and increased, but not significantly, at the four greatest rates of Off-Shoot T® (Table 2).

Regrowth response. The compound-by-rate interaction was significant in both 'Emphasis' ($P = 0.0019$) and 'Carnivor' ($P = 0.0089$), indicating that regrowth is unequally controlled by the two fatty alcohol compounds (Table 3). 'Emphasis' control seedlings (treated with water) exhibited 100% regrowth, and seedlings treated with 3.75% Fair 85® resulted in 32.7% regrowth. Regeneration continued to decrease significantly at both 5% Fair 85® (16.2% regrowth) and 6.25% Fair 85® (2% regrowth). There was no further significant reduction in regrowth at rates above 6.25% Fair 85® (Table 3). At 3.75% Off-Shoot T® treatments, regrowth was significantly reduced to 14.9%. Regrowth again significantly decreased to 7.7% at 5% Off-Shoot T®. Regrowth incidence at 6.25% Off-Shoot T® caused a decrease to 2.1% regrowth, which was not significant. However, regrowth at all treatment rates above 7.5% Off-Shoot T® were significantly lower than those at 6.25% Off-Shoot T® (Table 3). In 'Carnivor' seedlings treated with Fair 85®, regrowth decreased significantly from the 0% control (100% regrowth) to 47.1% regrowth at the rate of 3.75% Fair 85®. Regrowth also decreased significantly between 5% and 6.25% Fair 85® (26.6% and 6.8%, respectively) (Table 3). There was no significant decrease in regrowth at rates above 6.25% (Table 3). Regrowth was problematic when Fair 85® was applied at 3.75% to 5% (greater than 20%), whereas regrowth incidence was less than 10% at rates above 6.25% Fair 85®. In Off-Shoot T® application rates lower than 6.25%, regrowth was unacceptably high and decreased to less than 1% incidence above rates of 5% Off-Shoot T® (Table 3).

Grafting experiment. There was no significant effect of fatty alcohol treatment ($P =$

Table 2. Effects of fatty alcohol concentration on 'Emphasis' seedling mean percent damage[z] using two (C_6 0.5%, C_8 42%, C_{10} 56%, C_{12} 1.5%) fatty alcohol compounds pooled over three consecutive experiments.

Fatty alcohol	'Emphasis' damage		'Carnivor' damage	
concn (%)	Fair 85®[y] (%)	Off-Shoot T®[x] (%)	Fair 85® (%)	Off-Shoot T® (%)
0.00	0.0 g[w]	0.0 g	0.0 g	0.0 g
3.75	0.0 g	3.1 fg	0.0 g	1.4 g
5.00	9.8 efg	13.1 ef	4.9 fg	8.7 efg
6.25	17.2 e	43.2 cd	5.4 fg	19.0 cde
7.50	33.3 d	49.3 c	13.6 def	25.8 c
8.75	34.4 d	78.3 b	17.3 cde	43.6 b
10.00	78.4 b	91.8 a	23.7 cd	49.3 b
12.50	84.8 ab	76.6 b	48.9 b	51.2 b
15.00	92.3 ab	94.2 a	69.1 a	55.1 b

[z]Eighteen seedlings per replication.
[y]Fair Products, Inc., Cary, NC.
[x]Chemtura Corporation, Middlebury, CT.
[w]Values within the two rootstock columns (across compound type) that are not followed by the same letter are significantly different according to Fisher's protected least significant difference test at $P \leq 0.05$.

Table 3. Effects of fatty alcohol concentration on rootstock seedling mean percent regrowth[z] using two (C_6 0.5%, C_8 42%, C_{10} 56%, C_{12} 1.5%) fatty alcohol compounds pooled over three consecutive experiments.

Fatty alcohol	'Emphasis' regrowth		'Carnivor' regrowth	
concn (%)	Fair 85®[y] (%)	Off-Shoot T®[x] (%)	Fair 85® (%)	Off-Shoot T® (%)
0.00	100.0 a[w]	100.0 a	100.0 a	100.0 a
3.75	32.7 b	14.9 c	47.1 b	35.9 c
5.00	16.2 c	7.7 d	26.6 d	8.1 e
6.25	2.0 de	2.1 d	6.8 e	0.7 e
7.50	1.3 de	0.0 e	1.4 e	0.0 e
8.75	0.0 e	0.0 e	1.4 e	0.0 e
10.00	0.0 e	0.0 e	0.7 e	0.0 e
12.50	0.0 e	0.0 e	0.0 e	0.1 e
15.00	0.0 e	0.0 e	0.0 e	0.0 e

[z]Eighteen seedlings per replication.
[y]Fair Products, Inc., Cary, NC.
[x]Chemtura Corporation Middlebury, CT.
[w]Values within the two rootstock columns (across compound type) that are not followed by the same letter are significantly different according to Fisher's protected least significant difference test at $P \leq 0.05$.

Table 4. Effect of fatty alcohol treatment[z] on grafting success of two rootstocks pooled over two consecutive experiments.

Rootstock treatment	Grafting success[y]	
	'Carnivor'	'Emphasis'
Fair 85®[x]	79.2 a[v]	81.9 a
Off-Shoot T®[w]	80.6 a	80.6 a
Water	70.8 a	75.0 a

[z]Rootstocks treated with 6.25% fatty alcohol emulsion.
[y]Graft success recorded 1 week after removal from healing chamber.
[x]Fair Products, Inc., Cary, NC.
[w]Chemtura Corporation, Middlebury, CT.
[v]Values within the same column not followed by the same letter are significantly different according to Fisher's least significant difference test at $P \leq 0.05$.

0.3608) on graft success. In both 'Carnivor' and 'Emphasis' rootstocks, grafting success was greater in the fatty alcohol-treated rootstocks than the water-treated control; however, the difference was not statistically significant (Table 4). There was also no significant effect of rootstock ($P = 0.4199$). 'Carnivor' rootstocks treated with Fair 85® resulted in 79.2% success, and those treated with Off-Shoot T® resulted in 80.6% success (Table 4). The water-treated control rootstocks resulted in grafting success of 70.8%. 'Emphasis' rootstocks treated with Fair 85® and Off-Shoot T® fatty alcohol compounds resulted in 81.94% and 80.56%, respectively, whereas the control rootstocks resulted in 75% grafting success (Table 4).

Discussion

The significance of the compound-by-rate interactions was surprising, because the labels of both Fair 85® and Off-Shoot T® indicate identical amounts (85%) of active (C_6 0.5%, C_8 42%, C_{10} 56%, and C_{12} 1.5%) and inert ingredients (15%). Although the amount and type of active ingredient in each compound was the same, the alcohol sources may have differed, and this difference could be the source of the observed interaction. On communication with a company representative, we learned that alcohol purity (based on the original alcohol source) is a determining factor in the depth and uniformity of fatty alcohol tissue penetration and resulting chemical burn (Frank Grainger, Fair Products, Inc., personal communication). Steffens and Cathey (1969) reported similar variability in tissue penetration and chemical burn resulting from using surfactants of different hydrophilicities. Because sources of fatty alcohols vary in availability (Frank Grainger, Fair Products, Inc., personal communication), variations in product purity and quality within and between commercially available compounds is highly probable. Thus, it would be essential in commercial applications of this technique to understand the fatty alcohol type and source as well as the resulting effect on rootstocks. Further studies on these aspects would be required to determine these factors.

The general trend of increased damage and decreased regrowth as fatty alcohol concentrations increase was expected, because fatty alcohols are used in the tobacco industry to prevent regrowth of axillary meristems in topped tobacco. In the bottle gourd and interspecific hybrid squash rootstocks, Fair 85® and Off-Shoot T® fatty alcohol solutions at concentrations above 6.25% eliminated rootstock regrowth in at least 93% of all seedlings tested; however, the resulting damage incurred by the rootstocks at concentrations above 6.25% was unacceptably high, especially when Off-Shoot T® was applied. Choi et al. (2002) reported rootstock similar survival rates of 80% and 73% using rootstock applications of 58.8 mM silver nitrate and 5.48 M hydrogen peroxide, respectively. These data agree with our findings, indicating that complete chemical control of rootstock regrowth requires a level of acceptable damage to the rootstock.

The two rootstocks responded differently to the fatty alcohol treatments. Although damage incidence in both rootstocks followed the same increasing trend, 'Emphasis' rootstocks exhibited higher incidences of damage than 'Carnivor'. As would be expected, regrowth incidence was lower in 'Emphasis' rootstocks as well. This may be the result of physiological differences between the two species. Steffens and Cathey (1969) reported that the extent of fatty acid kill of plant tissue depends on many physiological factors such as leaf type, degree of succulence, and ease of wetting. 'Carnivor' cotyledons are thicker, less succulent, and more pubescent than 'Emphasis' cotyledons. The physiological differences in the rootstock could explain the higher incidence of damage and greater regrowth control observed in 'Emphasis' rootstocks.

The results of the grafting experiment indicate that fatty alcohol applications do not affect rootstocks' ability to be grafted and may have the potential to increase grafting success by eliminating the rootstock meristem. Because the fatty alcohol compounds damage only rapidly dividing tissue (Steffens et al., 1967), only the dividing meristem tissue is damaged by the treatment, and the remaining tissue is still able to produce callus tissue to heal the graft. Although the slight increase in grafting success was statistically insignificant, the increase we observed may be the result of the lack of competition from the rootstock meristem tissue. Because treated rootstocks do not contain active meristems, the rootstock may more readily accept the scion and more easily heal the graft. Because treated rootstocks are not supplying energy to a growing meristem, there may have been slightly more energy available to heal the graft, resulting in a faster healing process.

Fatty alcohol applications can successfully control rootstock meristem growth and by decreasing the labor required would alleviate the high cost of grafted transplant production. Based on our findings, we conclude that a fatty alcohol concentration of 5% using Off-Shoot T® and 6.25% using Fair 85® will achieve at least 95% control of meristematic regrowth with no more than 10% damage to rootstocks.

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Improvement of Grafted Watermelon Transplant Survival over Time by Rootstock Fatty Alcohol Treatment

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Summary. Rootstock fatty alcohol treatments have been shown to increase the efficiency of producing grafted transplants by controlling cucurbit rootstock meristematic regrowth and by allowing the rootstocks to accumulate carbohydrates, especially starch, over time in the hypocotyl and cotyledon. A grafting experiment was conducted to determine the effect of increased carbohydrates over time on transplant quality of watermelon grafts using standard grafting procedures. Interspecific hybrid squash (*Cucurbita maxima* x *C. moschata* 'Carnivor') and bottle gourd (*Lagenaria sicereria* 'Macis') rootstocks at 1, 7, 14, and 21 days after fatty alcohol treatment were grafted with seedless watermelon cultivar Tri-X 313 (*Citrullus lanatus* var. *lanatus*) using the one-cotyledon method. Graft quality on 'Carnivor' rootstocks was acceptable or significantly increased up to day 14, with a slight decrease at day 21. Graft quality on 'Macis' rootstock was also acceptable up to day 21, with a significant increase between days 1 and 7. The second experiment was conducted to determine whether the increased carbohydrates provide sufficient energy to successfully graft without the rootstock cotyledon, a method that has previously shown inconsistent results. Graft survival was improved by 90% using treated 'Carnivor' rootstock 7 days after fatty alcohol treatment and 'Macis' rootstock 14 days after fatty alcohol treatment. Adoption of the hypocotyl-only graft method in commercial production may increase

efficiency by better-utilizing greenhouse space, and could decrease disease probability by removing the cotyledons before grafting.

Grafting watermelon [*Citrullus lanatus* (Thunb) Matsum and Nakai] onto disease-resistant rootstocks can confer resistance to soil borne diseases such as Fusarium wilt (*Fusarium oxysporum* f. sp. *niveum*) and Monosporascus root rot (*Monosporascus cannonballus*), (Beltran et al., 2008, Guan et al., 2012, Louws et al., 2010). With the loss of methyl bromide as part of the Clean Air Act (U.S. Department of Agriculture (USDA), National Agricultural Statistics Service, 2012), watermelon grafting is currently the most promising method of Fusarium wilt control (Louws et al., 2010). While only five percent of watermelon acreage in the U.S. is currently reported to be affected by this disease (D. Liere, personal communication), arable land for rotation is decreasing, and the cost of traveling to disease-free soil is difficult for growers to overcome. Although the demand for commercially-produced grafted plants is apparent, high production cost remains a major impediment to grafted transplant adoption in United States production.

The two most common commercially-used grafting methods (over 90%) are the hole-insertion and the one-cotyledon method (Hassell et al., 2008). These methods require at least one cotyledon to remain intact to ensure graft success (Hassell et al., 2008), and both require manual meristem removal with a blade during grafting and even prior to transplanting of grafted plants. Manual meristem removal often removes the meristem only partially, allowing meristem regeneration to occur. Our previous studies have demonstrated the success of fatty alcohol rootstock treatments in controlling meristematic regrowth (Daley and Hassell, In press). Fatty alcohol products are traditionally used in tobacco (*Nicotiana tabacum* L.) production to remove axillary meristems and promote growth of remaining leaves. When fatty alcohol products are applied to rootstocks used for grafting watermelon, the

60 rootstock meristematic tissue is destroyed and the rootstocks remain viable for grafting (Daley and
61 Hassell, In press).

62 In addition to regrowth control, rootstocks treated with fatty alcohol continue to live and
63 photosynthesize, as the cotyledons are also functional leaves (Bisognin et al., 2005). Rather than putting
64 energy into new growth, carbohydrates are stored in the hypocotyl and cotyledons of the rootstocks
65 (Daley and Hassell, 2014). Previous experiments have revealed a starch increase of 100- and 200-fold in
66 hypocotyls of bottle gourd (*Lagenaria sicereria)* and interspecific hybrid squash (*Cucurbita maxima* × *C.*
67 *moschata*) rootstocks, respectively, over 21 d after fatty alcohol treatment (Daley et al., 2014). We
68 hypothesize that this increase of stored energy in the rootstock could be harnessed by the plant to
69 improve current grafting methods by providing sufficient energy to increase graft survival, rootstock
70 rooting, and overall grafted transplant quality. The first experiment outlined in this paper was designed
71 to determine the effect of increased rootstock carbohydrate content on graft survival and rootstock re-
72 rooting using the one-cotyledon grafting method (Hassell et al., 2008).

73 With current grafting methods, at least one cotyledon is left on the rootstock during grafting. Because
74 the rootstock cotyledons are larger than the cotyledons of watermelon seedlings, the rootstocks require
75 an increase in individual tray cell size over standard cell size for grafted watermelon transplant
76 production. This larger cell size is needed to accommodate the rootstock cotyledon when grafting. In
77 addition to requiring a greater cell size, the large rootstock cotyledons can also harbor foliar disease
78 such as powdery mildew (*Podosphaera xanthii*) (Kousik et al., 2008) that can prevent successful graft
79 healing or infect successfully-grafted transplants.

80 Decreasing the tray cell size and preventing the spread of disease via the rootstock cotyledon is an
81 important objective in improving the efficiency of grafted transplant production. The development of a
82 successful grafting method that removes both cotyledons would be advantageous to commercial

production; however, results of previous studies on this type of method proved to be rather inconsistent for commercial application (Memmott, 2010). Because the cotyledon has been shown to provide energy to the developing rootstock seedling (Bisognin et al., 2005), we hypothesize that the inconsistencies in previous attempts to graft without the cotyledons were a result of a lack of energy in the hypocotyl to support the graft healing and re-rooting of the transplant. The increased starch reserves in rootstocks treated with fatty alcohol over time may provide the required energy to overcome the reliance on the cotyledon and make grafting to the rootstock hypocotyl without the cotyledons feasible, (Daley et al., 2014). Thus, a second experiment was conducted to test this hypothesis and demonstrate the effect of rootstock age after fatty alcohol treatment on graft survival and rootstock re-rooting using the hypocotyl-only grafting method.

Materials and Methods

Experiment 1. The first experiment consisted of 2 rootstocks: bottle gourd 'Macis' (*Lagenaria sicereria*) (Nunhems USA, Parma, ID) and interspecific hybrid squash 'Carnivor' (*Cucurbita maxima* × *C. moschata*) (Syngenta Seeds, Boise, ID). When the cotyledons had unfolded but not expanded (approximately 6-8 d and 8-10 d after seeding for 'Carnivor' and 'Macis' rootstock, respectively) seedlings were individually treated with 20 µL 6.25% fatty alcohol (Fair 85; Fair Products, Cary, NC) applied to the meristem of the rootstock, as described by Daley and Hassell (in press). Rootstocks were held in the greenhouse for 1, 7, 14, or 21 days after treatment (DAT) before grafting. Rootstock seeding and treatment dates were scheduled weekly such that grafting for all treatments occurred on the same date. Seedless watermelon cultivar Tri-X 313 (*Citrullus lanatus* var. *lanatus*) (Syngenta Seeds Boise, ID) was used as scion, and seeds were sown, following growing procedures outlined by Hassell and Schultheis (personal communication), on the same day as the 14-day rootstocks. This timing ensured that the scion age (2 weeks after seeding) was the same for all treatments. Each rootstock treatment consisted of 10 plants, and was

replicated 4 times. The entire experiment was repeated twice, with grafting occurring in April and July of 2013. Grafting was performed using the one-cotyledon method as described by Hassell et al. (2008). Because roots require energy to maintain and continue growth (Esau, 1953), rootstock hypocotyl was separated from roots and re-rooted in soilless mix to maintain energy reserves to heal the graft before re-rooting.

Experiment 2. The second experiment also utilized both 'Macis' and 'Carnivor' rootstock cultivars, which were treated with fatty alcohol in the same manner as experiment one. Prior to grafting, all rootstocks remained in the greenhouse for 1, 7, 14, or 21 DAT. Rootstocks were sequentially seeded to provide rootstocks of each time after fatty alcohol treatment to graft on the same day. An additional rootstock treatment was also seeded on the same day as the 1 DAT rootstocks, omitting the fatty alcohol treatment to provide an untreated control. Seedless watermelon cultivar Tri-X 313 was also used as scion material, and was sown on the same day as the 14-day rootstock to ensure that scion was the same age for each treatment. Each rootstock treatment consisted of 12 plants, and was replicated 5 times. The entire experiment was repeated twice, with grafting occurring in October and December of 2013. Grafting was performed using the hypocotyl-only method, consisting of removing both cotyledons from the hypocotyl, making a 30 degree angled cut down the side of the hypocotyl, and securing the scion to the hypocotyl using a silicone grafting clip (Hydro-Gardens, Colorado Springs, CO). Rootstock hypocotyls roots were removed in the same manner as experiment one to conserve hypocotyl energy (Esau, 1953).

Growing Conditions. Rootstock seeds were sown in 72-cell plug trays with a 1 inch diameter (TLC Polyform, Minneapolis, MN) using a nutrient-free, soilless mix (75% sphagnum peat, 25% perlite) (Sun Gro Horticulture, Agawam, MA). Seeds were sown following standard greenhouse production practices (Rutledge, 2009). Scion seeds were sown according to guidelines outlined by Hassell and Schultheis

(personal communication). All seedlings were grown in a standard, double-layer polyethylene greenhouse covered with a double layer of 6 mil clear plastic (K50 Clear; Klerks Hyplast, Chester SC). The greenhouse contained a gas heating system to supply heat and exhaust fans to remove heat. Minimum temperatures were set at 60 °C and the exhaust fans were set to power on when greenhouse temperatures reached 70 °C.

Data Collection. All grafted plants remained in the healing chamber for 7 d following grafting, at which time the plants were removed to the greenhouse for a final week of growth and development. Healing chamber was a 36 × 122 inch wooden tray enclosed with 6 mil plastic on hoop frames. A duct-mount centrifugal atomizer humidifier (707U, Herrmidifier, Sanford, NC) was used to maintain humidity in the healing chamber. At the end of the final week in the greenhouse, graft survival data was recorded. Healed transplants that had re-rooted successfully (i.e., root balls were adequately developed to prevent smooth removal of the hypocotyl from the tray) were considered surviving transplants. The mix was washed from the roots, which were then separated from the hypocotyl and weighed using an analytical scale (Sartorius A 120 S; Data Weighing Systems, Elk Grove, IL). Root tissue was dried for 5-7 d at 21 °C using an incubator (320-6 1000 Series; Napco Industrial Partner, Richardson, TX). Following the drying, roots were individually weighed to determine the root dry weight.

Data Analysis. For both experiments, a randomized complete block design was used, with replication as the blocking factor. Graft survival and root fresh and dry weights were analyzed with a linear mixed model using the fit model platform of JMP Pro 10® Software (SAS Institute, Cary, NC). The percentage of surviving plants was calculated and used in data analysis. Because statistically significant differences were observed between the two rootstock types, rootstock data was analyzed separately. The model was a complete factorial model including all combinations and interactions between and among the

fixed effects of rootstock age (in DAT) and planting date. Random effects included replication and the interactions among rep and the fixed factors, with planting date nested within the remaining factors.

Results and Discussion

Experiment 1

ANOVA Analysis. There were significant effects of rootstock age, as well as some significant effects of planting date and two-way interactions, on graft survival and root growth for rootstocks grafted using the one-cotyledon method (Table 1).

Graft Survival. Using 'Carnivor' rootstock, we observed no significant differences in graft survival between 1, 7, and 14 DAT (Figure 1). In both planting dates, there were significant decreases in graft survival at 21 DAT. In past experiments, a similar decrease in rootstock vigor and carbohydrate content was observed in rootstock 21 DAT (Daley & Hassell, 2013), indicating that 'Carnivor' rootstock carbohydrate storage reaches a peak near 14 DAT.

In 'Macis' rootstocks, starch accumulation increased significantly up to 14 DAT (Figure 1). However, there were no significant differences in starch between rootstocks at 14 and 21 DAT, which paralleled a similar pattern of starch accumulation in previous research (Daley & Hassell, 2013). This data indicates that that 'Macis' rootstocks are more able to maintain their carbohydrate reserves than 'Carnivor'. The trend of increasing graft survival as time after fatty alcohol treatment progresses illustrates the benefits of the fatty alcohol treatment in improving the efficiency of standard grafting methods by increasing the grafting window of rootstocks from just a few days (Hassell et al., 2008) to at least two weeks.

There was no significant effect of planting date on graft survival in 'Carnivor'rootstock, but we observed significantly lower graft survival in the August planting of 'Macis' rootstock (Figure 1). Lagenaria rootstock is, in our experience, a more variable rootstock that is sensitive to excessive moisture. The

173 decreased grafting success observed on 1 and 7 DAT in the August planting may be due to the increased
174 amount of watering that occurred within the greenhouse to maintain live plants.

175 *Rootstock Re-rooting.* There was no effect of DAT observed in 'Carnivor' rootstock root fresh and dry
176 weights (Figures 2). Because the cotyledon remained attached to the rootstock and provided the
177 required energy to heal the grafts and produce new roots, the effect of the increased carbohydrates in
178 the hypocotyl may have been masked in this rootstock. There was a significant DAT effect on root fresh
179 and dry weights in 'Macis' rootstocks. There was a significant increase on 7 DAT in both planting dates
180 (Figures 2A and 2B), and no significant differences on 7, 14, and 21 DAT in the May planting. Root fresh
181 weight was significantly lower on 21 DAT in the August planting of 'Macis' rootstocks (Figure 2A).

182 *Experiment 2.*

183 *ANOVA Analysis* There was a significant effect of rootstock age on graft success of both 'Carnivor' and
184 'Macis' rootstocks, and significant two-way interactions of rootstock age and grafting date on root fresh
185 and dry weights for 'Macis' graft survival. There was also a significant effect of day on root fresh and dry
186 weights of both rootstock cultivars (Table 2).

187 *Graft Survival.* Using the hypocotyl only graft, we observed no significant difference in graft survival
188 between the untreated control rootstocks and the treated rootstocks that were 1 DAT with both
189 cultivars, indicating that there was no detrimental effect of the fatty alcohol treatment on graft survival.
190 All cultivars increased significantly in graft success from 1 to 7 DAT, with 'Carnivor' rootstocks increasing
191 to about 90% survival, and 'Macis' rootstocks increasing to over 45% and 70% in the August and
192 December plantings, respectively (Figure 3). There were no significant changes in graft survival for
193 'Carnivor' rootstocks at 14 and 21 DAT, with the exception of day 21 of the October planting, where
194 graft survival decreased to about 70%. This decrease follows the pattern of starch decrease at 21 DAT in
195 'Carnivor' rootstocks observed in previous experiments (Daley et al., 2014). 'Macis' rootstock graft

196 survival percentages continued to increase significantly to about 90% survival at 14 DAT in both planting
197 dates. This also parallels the pattern of starch accumulation observed previously (Daley et al., 2014).
198 No significant differences were observed in 'Macis' rootstock between 14 and 21 DAT in the October
199 planting, but survival increased significantly to 98% at 21 DAT during the December experiment. This
200 pattern of survival indicates that 'Carnivor rootstock increases in graft survival earlier than 'Macis'
201 rootstock.

202 *Rootstock Re-rooting.* For both rootstock cultivars, there were no significant differences between the
203 root fresh and dry weights of the untreated control and the rootstocks 1 DAT, indicating that there are
204 no effects of the fatty alcohol treatment on the rootstocks, and illustrating the inability of the rootstocks
205 to successfully heal the graft and re-root without taking the time to accumulate energy reserves
206 following the fatty alcohol treatment (Figures 4A and 4B). With both 'Carnivor' and 'Macis' rootstocks,
207 we observed a significant increase in root fresh and dry weight at 7 DAT, with the greatest increase
208 observed in 'Carnivor' rootstocks planted in October (Figures 4A and 4B). 'Macis' rootstocks in the
209 December planting increased the least, from 0.0 g to nearly 0.2 g fresh weight at 7 DAT (Figure 4A). In
210 both cultivars, root fresh weight did not significantly change 7 and 14 DAT, with the exception of 'Macis'
211 rootstocks planted in December. In this planting, root fresh weight increased by 0.1 g at 14 DAT. Root
212 fresh weight of 'Carnivor' rootstocks from the October planting increased significantly to nearly 0.9 g at
213 21 DAT. 'Macis' rootstock from the December planting also significantly increased from 0.3 g at 14 DAT
214 to almost 0.5 g at 21 DAT. Both rootstock cultivars produced significantly lower root fresh weights in the
215 December plantings, suggesting that lower temperatures in the winter months decrease re-rooting
216 efficiency of both rootstocks.

217 Similar trends were observed in root dry weights of both cultivars. In each cultivar, there was a
218 significant increase in root dry weight using 7 DAT rootstocks (Figure 4B). 'Carnivor' rootstocks from the

October planting exhibited the greatest increase, reaching 0.08 g 7 DAT. The least amount of increase 7 DAT was in 'Macis' rootstock from the December planting. Root dry weights of both rootstock cultivars on both planting dates, with the exception of 'Carnivor' in the October planting, also significantly increased at 14 DAT (Figure 4B). Root dry weights of both 'Macis' and 'Carnivor' rootstocks did not significantly change on 21 DAT in October, but each rootstock cultivar increased significantly on the same day of the December planting. One possible explanation for this was that the more optimal weather in the October planting allowed the rootstocks to reach their peak starch storage by day 14, but since the weather in December was cooler than optimal, the rootstocks required a greater amount of growing time to accumulate the required energy, and did not have the reserves necessary to produce as much root tissue.

The hypocotyl-only grafting method has not, until now, been successfully performed with consistent success. Based on our data, we conclude that the fatty alcohol treatment overcomes the need for a cotyledon in cucurbit grafting by increasing the amount of energy reserves in the rootstock hypocotyl. After a fatty alcohol treatment, the increased carbohydrate reserves in the rootstock overcome the reliance on the cotyledon to produce energy sufficient for graft survival and re-rooting, and make grafting with the hypocotyl possible at 7 DAT for interspecific hybrid rootstocks, or at 14 DAT for bottle gourd rootstocks.

Conclusions. The physiological differences between the two rootstocks support their differing responses to the fatty alcohol treatment in graft survival. As a hybrid, 'Carnivor' rootstock is typically more vigorous, with a deeper root system, and has recently become a more preferred rootstock in the grafting industry (King et al., 2010). The increased vigor of this rootstock continues to be evident in the rootstock's response to fatty alcohol treatment: compared to bottle gourd rootstocks, 'Carnivor' rootstock requires a greater concentration of fatty alcohol to destroy the meristem (Daley and Hassell,

242 in press), and also accumulates a greater amount of starch in the hypocotyl (almost 300-fold compared
243 to 30-fold) than 'Macis' rootstocks (Daley et al., 2014). As the rootstocks are from two separate genera
244 within the *Cucurbitaceae* family, it is expected that their respective responses to fatty alcohol treatment
245 and performance as rootstocks will differ significantly.

246 Matching hypocotyl diameter is essential to graft success (Davis et al., 2008). We observed that graft
247 survival decreased at 21 DAT with 'Carnivor' rootstock, possibly because of a cambial mismatch once
248 rootstocks reached that age. 'Carnivor' hypocotyls have previously been shown to double in diameter
249 over 21 DAT (Daley and Hassell, 2014). The difference in hypocotyl diameter between the watermelon
250 scion and the 'Carnivor' rootstock may have prevented graft survival.

251 Fatty alcohol rootstock treatments can improve success and efficiency of current methods by increasing
252 graft survival and increasing the time period that rootstocks remain suitable for grafting. Grafting in
253 ideal conditions and seasons could further increase the success of the one-cotyledon grafting method.
254 In addition, fatty alcohol treatment allows for successful use of the hypocotyl-only grafting method.
255 Removal of the cotyledons with the hypocotyl-only method may decrease chances of disease, because
256 the cotyledon could become a harbor for disease as it ages. Complete cotyledon removal also increases
257 production efficiency by decreasing the space requirement of each grafted plant. Doing so will increase
258 the number of grafted plants that can be produced utilizing finite greenhouse spaces, and thus decrease
259 overall cost of production.

260

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TABLES AND FIGURES

Table 1: ANOVA analysis[z] of the effects of rootstock age[y] after fatty alcohol treatment[x] on graft survival[w] and root weights of transplants grafted using the one-cotyledon grafting method

			Carnivor		Macis	
Response	Effect	Degrees of Freedom	F Ratio	P Value	F Ratio	P Value
Graft Survival[v]	Rootstock Age	3	8.8365	0.0044*	43.2486	<0.0001*
	Planting Date	1	4.8805	0.0547	27.9409	0.0002*
	Planting Date by Planting Date	3	3.8706	0.0490*	6.3383	0.0076*
Root Fresh	Rootstock Age	3	88.4718	<0.0001*	52.2324	<0.0001*
	Planting Date	1	26.6894	<0.0001*	5.7128	0.0178*
	Planting Date by Planting Date	3	1.5528	0.1885	20.8728	<0.0001*
Root Dry Weight	Rootstock Age	3	314.6308	<0.0001*	90.3396	<0.0001*
	Planting Date	1	2.6405	0.1058	12.9713	0.0004*
	Planting Date by Planting Date	3	3.6716	0.0066*	17.5340	<0.0001*

[z] $P \leq 0.05$ considered significant

[y] Grafting was performed at 1, 7, 14, and 21 days following rootstock fatty alcohol treatment

[x] Rootstocks treated with 20 µL 6.25% Fair 85® emulsion

[w] Percent of grafts that surviving grafting, healing, and re-rooting

Table 2: Results of ANOVA analysis[z] of the effects of rootstock age[y] after fatty alcohol treatment[x] on graft survival[w] and root weights of transplants grafted using the hypocotyl-only grafting method

			Carnivor		Macis	
Response	Effect	Degrees of	F Ratio	P Value	F Ratio	P Value
Graft Success	Rootstock Age[w]	4	294.6396	<0.0001*	354.4546	<0.0001*
	Planting Date[v]	1	0.7680	0.3912	6.7477	0.0172*
	Planting Date by Rootstock Age	4	1.6211	0.2080	3.9440	0.0161*
Root Fresh	Rootstock Age	4	240.2385	<0.0001*	239.1051	<0.0001*
	Planting Date	1	42.9908	<0.0001*	95.2659	<0.0001*
	Planting Date by Rootstock Age	4	8.3786	0.0009*	15.4225	<0.0001*
Root Dry Weight	Rootstock Age	4	168.5139	<0.0001*	213.6674	<0.0001*
	Planting Date	1	117.9220	<0.0001*	297.0647	<0.0001*
	Planting Date by Rootstock Age	4	20.0910	<0.0001*	47.1811	<0.0001*

[z] $P \leq 0.05$ considered significant

[y] Grafting was performed at 1, 7, 14, and 21 days following rootstock fatty alcohol treatment.

[x] Rootstocks treated with 20 µL 6.25% Fair 85® emulsion

[w] Percent of grafts surviving grafting, healing, and re-rooting

[v] The experiment was repeated on two planting dates in 2013

FIGURE CAPTIONS

Figure 1. Graft survival using the one-cotyledon method evaluated as a percent graft healing and rootstock re-rooting. 'Carnivor' and 'Macis' rootstocks were grafted at 1, 7, 14, and 21 days after fatty alcohol treatment in May (solid lines) and August (broken lines) of 2013. For 'Carnivor' rootstock cultivars, graft survival significantly ($P \leq 0.05$) decreased on day 21, while 'Macis' rootstock increased significantly on days 7 and 14.

Figures 2A and 2B. Root fresh (A) and dry (B) weights of 'Carnivor' and 'Macis' rootstocks grafted at 1, 7, 14, and 21 days after fatty alcohol treatment using the one-cotyledon grafting method in May (solid lines) and August (broken lines) of 2013. Statistically significant ($P \leq 0.05$) increases were observed between day 1 and day 7 of 'Macis' rootstock root fresh weight (A) in both plantings. Significant increases in root dry weight were also observed between days 1 and 7 in all rootstocks except 'Carnivor' planted in August.

Figure 3. Graft survival using the hypocotyl only method evaluated as percent graft healing and rootstock re-rooting. Untreated 'Carnivor' and 'Macis' rootstocks (day 0) are used as a control to determine whether deleterious effects of the treatment exist. In addition to the controls, 'Carnivor' and 'Macis' rootstocks were grafted at ages of 1, 7, 14, and 21 days after fatty alcohol treatment. The experiment was conducted twice in October (solid lines) and December (brokenlines) of 2013. 'Carnivor' graft success significantly increased ($P \leq 0.05$) on day 7 and decreased significantly on day 21, while 'Macis' rootstock increased significantly on day 7 and day 14

Figures 4A and 4B. Root fresh (A) and dry (B) weights of 'Carnivor' and 'Macis' rootstocks grafted at 0 (untreated), 1, 7, 14, and 21 days of fatty alcohol treatment using the hypocotyl-only grafting method in October (solid lines) and December (broken lines) of 2013. There were no stastically significant ($P \leq 0.05$) differences observed between untreated control rootstock and 1-day rootstock. Significant

increases were observed in fresh weights of both cultivars day 7, and 'Macis' at day 14. Significant dry weight increases were also observed for both cultivars on days 7 and 14, with the exception of 'Carnivor' grafted in October.

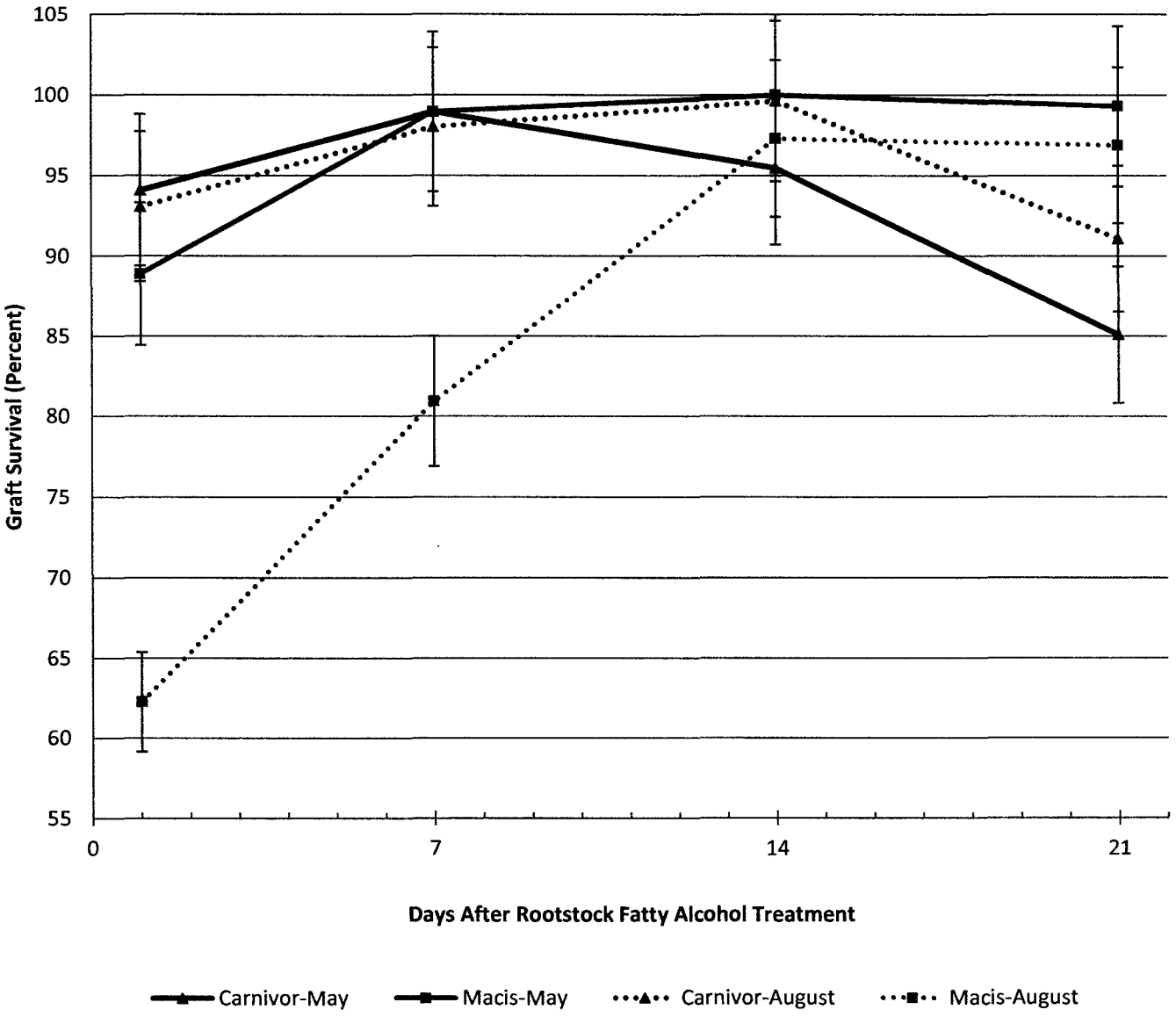
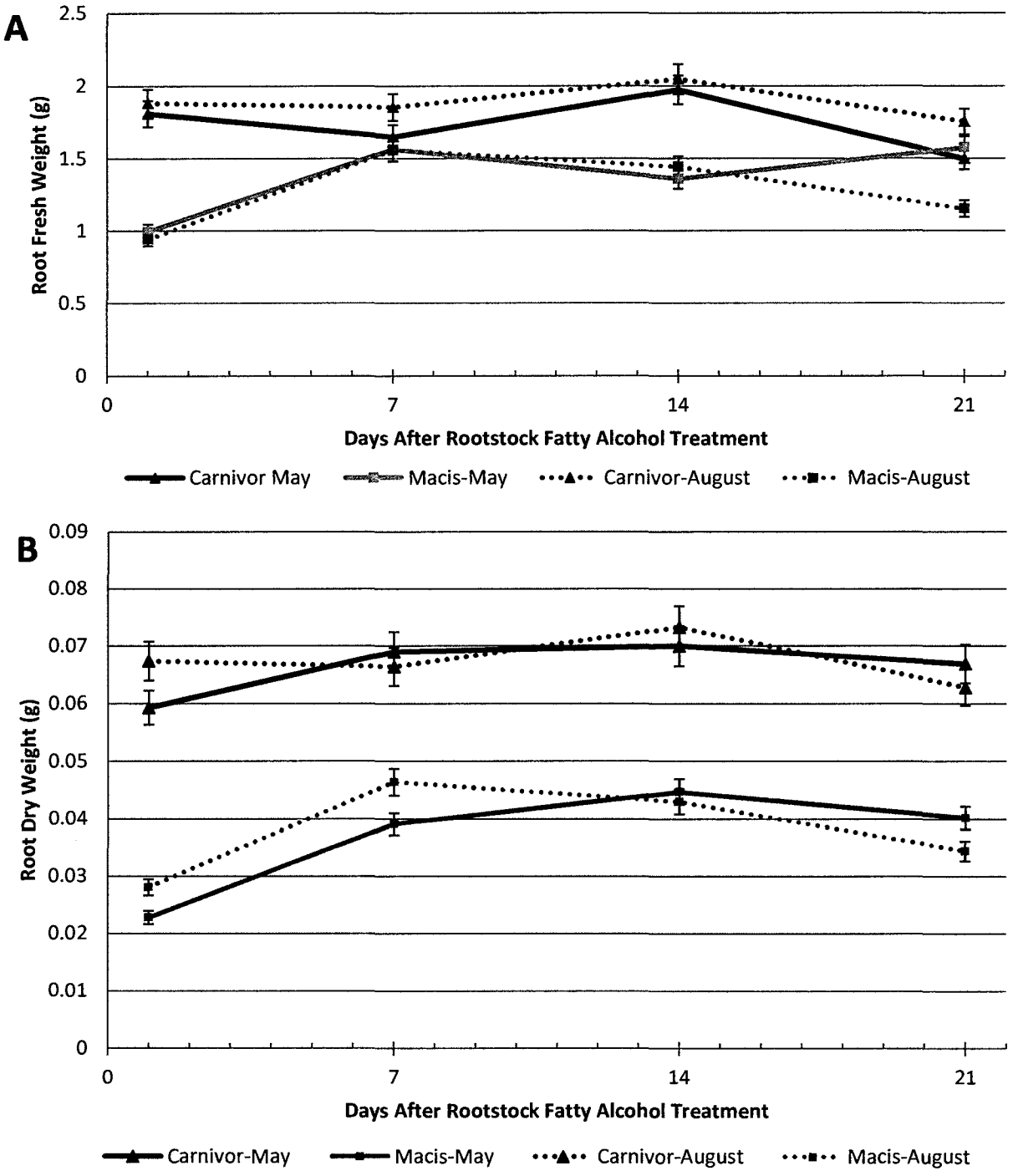


Figure 1. Graft survival using the one-cotyledon method evaluated as a percent graft healing and rootstock re-rooting. 'Carnivor' and 'Macis' rootstocks were grafted at 1, 7, 14, and 21 days after fatty alcohol treatment in May (solid lines) and August (broken lines) of 2013. For 'Carnivor' rootstock cultivars, graft survival significantly ($P \leq 0.05$) decreased on day 21, while 'Macis' rootstock increased significantly on days 7 and 14.



Figures 2A and 2B. Root fresh (A) and dry (B) weights of 'Carnivor' and 'Macis' rootstocks grafted at 1, 7, 14, and 21 days after fatty alcohol treatment using the one-cotyledon grafting method in May (solid lines) and August (broken lines) of 2013. Statistically significant ($P \leq 0.05$) increases were observed between day 1 and day 7 of 'Macis' rootstock root fresh weight (A) in both plantings. Significant increases in root dry weight were also observed between days 1 and 7 in all rootstocks except 'Carnivor' planted in August.

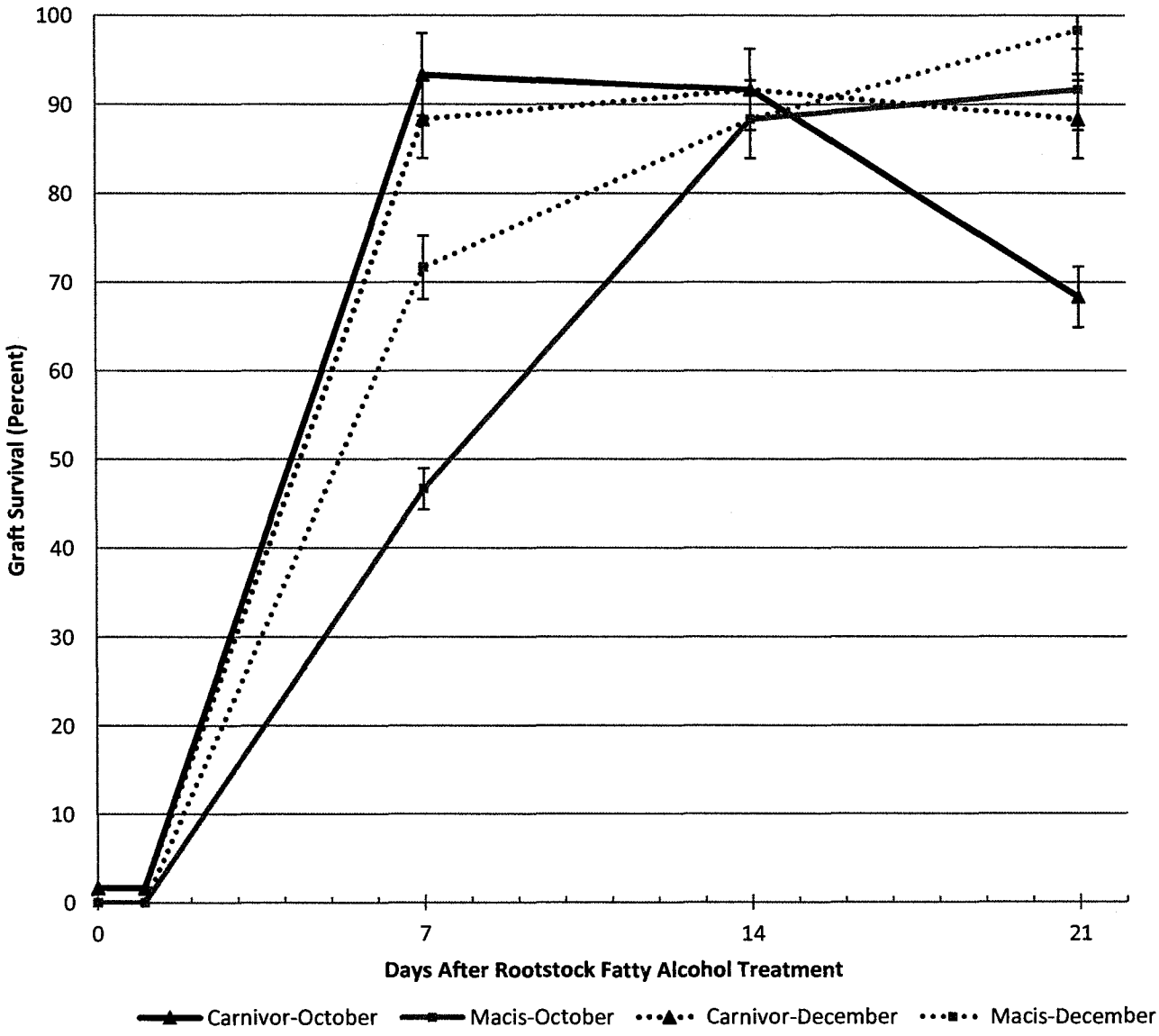
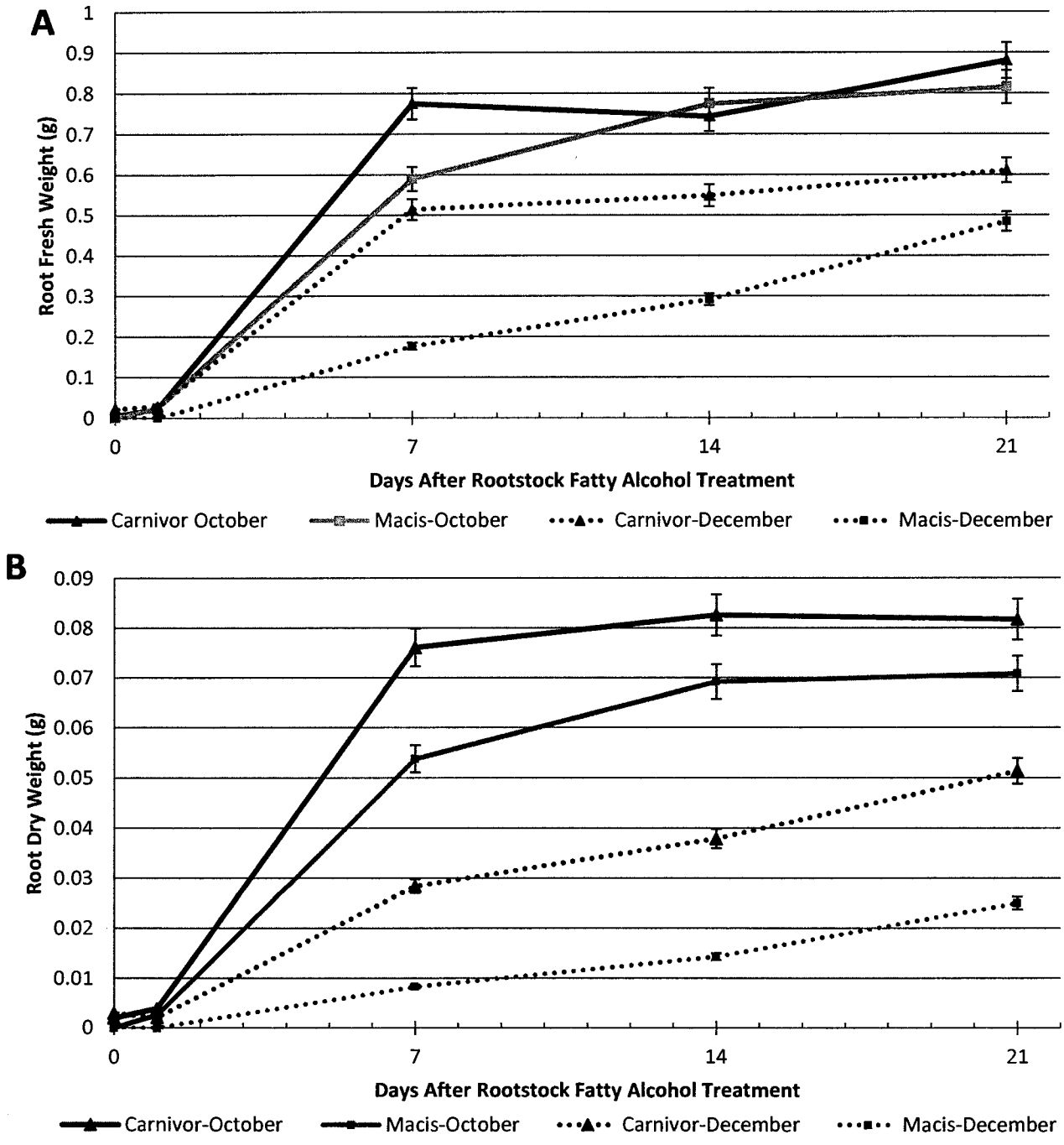


Figure 3. Graft survival using the hypocotyl only method evaluated as percent graft healing and rootstock re-rooting. Untreated 'Carnivor' and 'Macis' rootstocks (day 0) are used as a control to determine whether deleterious effects of the treatment exist. In addition to the controls, 'Carnivor' and 'Macis' rootstocks were grafted at ages of 1, 7, 14, and 21 days after fatty alcohol treatment. The experiment was conducted twice in October (solid lines) and December (brokenlines) of 2013. 'Carnivor' graft success significantly increased ($P \leq 0.05$) on day 7 and decreased significantly on day 21, while 'Macis' rootstock increased significantly on day 7 and day 14.



Figures 4A and 4B. Root fresh (A) and dry (B) weights of 'Carnivor' and 'Macis' rootstocks grafted at 0 (untreated), 1, 7, 14, and 21 days of fatty alcohol treatment using the hypocotyl-only grafting method in October (solid lines) and December (broken lines) of 2013. There were no stastically significant ($P \leq 0.05$) differences observed between untreated control rootstock and 1-day rootstock. Significant increases were observed in fresh weights of both cultivars day 7, and 'Macis' at day 14. Significant dry weight increases were also observed for both cultivars on days 7 and 14, with the exception of 'Carnivor' grafted in October.

Use of Fatty Alcohol in Tomato Production

Carla Hull

From: Renee Allen <Renee@fairproductsinc.com>
Sent: Monday, October 19, 2015 2:03 PM
To: 'Carla Hull'
Subject: FW: images of tomato root plugs
Attachments: photo.jpg

Renee' Allen
FAIR PRODUCTS, INC
www.fairproductsinc.com
(919) 467-1599

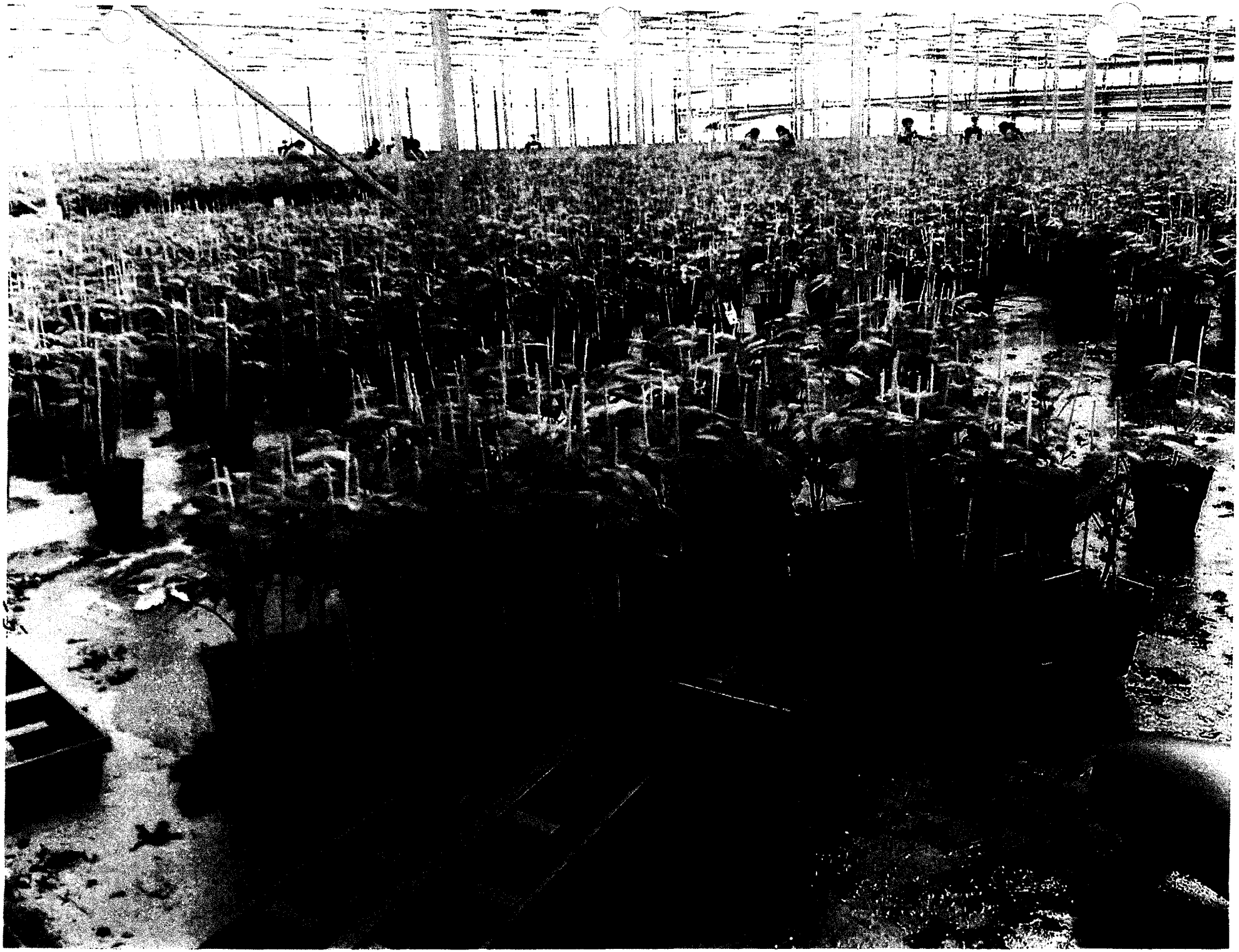
-----Original Message-----
From: Grant Ohman [mailto:grant@bevofarms.com]
Sent: Tuesday, March 18, 2014 7:09 PM
To: 'Renee Allen'
Subject: images of tomato root plugs

Hi Frank,

This is a small representation of the 1.2 million plugs of the grafted proprietary tomato seed we propagated for a customer in California.
It probably appears to be a lot to anyone but when you consider there are over 1 billion tomato plants rooted in soil it gives you an idea of the size of the market.
We've been doing R & D on this for three years and hit the nail on the head as far as success rate goes. Now all that is left to do is see how well it takes in the fields of California,

More photos to follow.

Grant



Carla Hull

From: Renee Allen <Renee@fairproductsinc.com>
Sent: Monday, October 19, 2015 2:20 PM
To: 'Carla Hull'
Subject: FW: shipping boxes
Attachments: photo (5).jpg

Renee' Allen
FAIR PRODUCTS, INC
www.fairproductsinc.com
(919) 467-1599

-----Original Message-----
From: Grant Ohman [mailto:grant@bevofarms.com]
Sent: Tuesday, March 18, 2014 7:22 PM
To: 'Renee Allen'
Subject: shipping boxes

This is how we ship the grafted tomato plants


LIVE PLANTS
LIVE PLANTS

Cotyledonary Axillary Shoot Control by Fatty Alcohol Application for Grafting Tomato

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Subject Category: Crop Production

Cotyledonary Axillary Shoot Control by Fatty Alcohol Application for Grafting Tomato

Additional index words. sucker control, chemical control, axillary buds, meristems, *Solanum lycopersicum*

Abstract. In tomato (*Solanum lycopersicum*), grafting position is recommended to be below rootstock cotyledons to avoid undesirable axillary shoots growing out from the rootstock cotyledons. In contrast, grafting above the rootstock cotyledons is desired to assure adequate distance between grafted union and soil line, only if there is no potential grow-out of axillary shoots from rootstock cotyledons. A commercially available fatty alcohol compound was tested as a potential chemical control means against cotyledonary axillary shoot growth of tomato rootstock seedlings. Solution containing various concentrations of fatty alcohol was applied to tomato seedlings grown in a greenhouse using various application methods. When fatty alcohol was applied directly to cotyledonary axillary buds, the seedlings were then pinched to force-induce the cotyledonary axillary shoot extension in order to assure the efficacy of the fatty alcohol treatment. High concentrations (10 and 15 %) of fatty alcohol killed the buds and suppressed axillary shoot extension at level lower than 7 %. However, when applied over the extended axillary shoots, application with 2 % or higher concentrations of fatty alcohol caused plant collapse because the excess fatty alcohol trickled down the stem and presumably damaged the root system. When fatty alcohol was applied over true leaves

using a sprayer, 1 % or higher concentrations of fatty alcohol caused some phytotoxic damage on true leaves. Therefore, we concluded that application of fatty alcohol to control cotyledonary axillary shoots of tomato rootstock could be a possible only if effective concentrations of fatty alcohol is applied exclusively to the target buds (10-15 % fatty alcohol concentration) or young shoots (>5 % concentration) without causing undesirable damage on stems and true leaves.

Since use of methyl bromide for soil fumigation has been limited by the Montreal Protocol, there is an increasing need to find an alternative method to manage soil borne pathogens and pests in open-field vegetable production. One of the proposed alternative methods is the use of grafting rootstock that is resistant to soil borne diseases (Kubota et al., 2008). Although vegetable grafting has been widely used in many countries such as Asia and Europe to manage soil borne diseases, the use of vegetable grafting is still limited in the United States (Lee et al., 2010, Louws et al., 2010). One issue limiting the use is the large number of seedlings needed for large-scale, open-field production systems, and another issue is the high cost of grafted seedlings compared to conventional seeds or seedlings. However, vegetable grafting as an alternative means to soil fumigation with methyl bromide is now attracting growing interest in the United States (Colla, 2010).

In vegetable grafting, the position of the graft union must be high enough to prevent the vulnerable scion from coming into direct contact and exposure with the soil, especially when the grafted plants are transplanted by machines in large-scale, open-field production system. For tomato (*Solanum lycopersicum*), while grafting above the rootstock cotyledons could be a solution to assure adequate distance between grafted union and soil line, potential grow-out of axillary shoots from rootstock cotyledons can be problematic because it requires additional labor cost to manually prune the axillary shoots in the field as well as at the propagation stage (Bausher, 2011). Therefore, the use of chemical to inhibit the cotyledonary axillary shoot growth from rootstock could allow grafting above cotyledons and reduce the additional management cost of grafted tomato production in the field.

Fatty alcohol and fatty acid methyl ester with chain lengths from C_8 to C_{12}, emulsified with appropriate surfactants, have been reported to kill the rapidly dividing meristematic tissues such as apical and axillary buds without damaging mature leaf or stem tissues in variety of plants (Cathey et al., 1966; Maw, 1977; Steffens et al., 1967; Tso, 1964; Tso et al., 1965; Tucker and Maw, 1975). The mechanism of selective killing of the meristematic tissue in tobacco (*Nicotiana tabacum*) is reportedly due to the property of the well-developed cuticlar layer over mature tissue that acts a penetration barrier to these chemicals compared with young tissue (Nelson and Reid, 1971). Once penetrating thorough the meristematic tissue, these chemicals disrupt the plasma membranes and cause desiccation of the tissue (Wheeler et al. 1991). In tobacco production, commercially available fatty alcohols, usually mixtures of C_8 and C_{10} fatty alcohols, formulated with surfactants, have been used to control axillary shoot (sucker) growth after decapitation (Steffens, 1979). Decapitation and sucker control of tobacco improves yield and the concentration of nicotine of leaf to be harvested, by reducing the competition of nutrient (Moore, 2012). Also recently a commercial fatty alcohol compound used on tobacco was demonstrated to be a part of new grafting method for watermelon (*Citrullus lanatus*), controlling rootstock shoot regrowth while preparing grafted seedlings (Daley, 2014; Daley and Hassell, 2014). For tomato, Maw (1977) demonstrated effective use of fatty alcohol for controlling axillary shoot on young tomato plants grown in greenhouse, although the fatty alcohol had to be applied exclusively to the axillary shoots otherwise it caused chemical damages on leaves and stems. These studies suggest that fatty alcohol could control growth of cotyledonary axillary shoot for tomato rootstocks; however, as far as we know, there is no information on the effective

76 concentration and application methods of fatty alcohol for tomato rootstock seedlings
77 during grafting propagation.

78 In present study, in order to discuss the possibility of using fatty alcohol to control
79 cotyledonary axillary shoot from rootstock in tomato grafting, three independent
80 experiments were conducted. Experiment 1 and 2 were to examine the effects of fatty
81 alcohol treatment at various concentrations on cotyledonary axillary shoot growth of
82 tomato seedlings at three-true-leaf stage. In these experiments, fatty alcohol was applied
83 with a pipette exclusively to non-extended axillary buds (Expt. 1) or extended axillary
84 shoots (in length from 1.8 to 3.2 cm) from cotyledons (Expt. 2). To test a more practical
85 application method, a conventional spray bottle was employed in Experiment 3 and the
86 phytotoxic effects of fatty alcohol applied on true leaves and stems were studied.

87

88 Materials and Methods

89 *Plant Materials and Growth Conditions.*

90 'Roma VF' tomato (Westar Seeds International, Inc., CA) was used in this study.
91 'Roma VF' is not a commercial rootstock but we employed this cultivar for our study as a
92 model system due to the availability of seeds. Seeds were sown into 98- cell seedling
93 trays (tray size; 28 cm × 55 cm; one seed per cell) filled with moist commercial substrate
94 (SunGro Sunshine Professional Mix 3, Bellevue, WA) covered with a thin layer of
95 vermiculite. The seeded trays were then covered with a thin plastic film and placed for
96 two days under darkness in a growth chamber (Model 2015; VWR International,
97 Cornelius, OR) controlled at 29 ± 1 °C air temperature. Two days after seeding, the trays
98 were placed in the greenhouse and irrigated every two days with tap water. After the 11th

day, the plants were irrigated daily with tap water and twice weekly with nutrient solution (electrical conductivity 2.0 to 2.4 $dS \cdot m^{-1}$, pH 5.9 to 6.3) containing 90 nitrogen (all in nitrate form) 47 phosphorus, 144 potassium, 160 calcium, 60 magnesium and 113 sulfur ($mg \cdot L^{-1}$) as well as micronutrients. The greenhouse used in the present experiments was located in Tucson, AZ, covered by double-layered acrylic roof and walls, and equipped with pad-and-fan cooling and overhead gas heating systems. The daytime and nighttime set points of air temperature were 28 and 21 °C, respectively using a commercial greenhouse controller (Wadsworth Control Systems Inc., Arvada, CO). After 17 to 19 days from seeding, when seedlings were at the three-true-leaf stage, 10-15 uniform seedlings per treatment were selected for the experiments.

Fatty Alcohol.

A commercially available fatty alcohol compound, N-TAC® (Fair Products, Inc., Cary, NC), consisting of 36.2 % C_8, 48.2 % C_{10}, 0.3 % C_{12} fatty alcohol and 15.3 % other ingredients, was used in this study. Fatty alcohol was diluted with ion-exchanged water to prepare emulsions having product concentrations from 0.5 to 15 % (V/V) for the experiments described below.

Fatty Alcohol Treatment to Axillary Buds (Experiment 1).

After 17 days of seeding (May 5th, 2014), plants were treated with 0, 2, 5, 10 or 15 % (V/V) concentration of fatty alcohol emulsions. Using a pipette, 5 µL of the emulsion was applied carefully to each cotyledonary axil area of all the seedlings. The application volume was selected so that it thoroughly covers the axillary bud without overflowing to trickle down the stem. To assess the effectiveness of the fatty alcohol treatment, plants were pinched 1 cm above cotyledons one day after the treatment to

force undamaged axillary buds to develop shoots. Plants were visually inspected for any sign of chemical damage or axillary shoot extension 1, 7, 14 and 22 days after treatment. In order to examine the degree of damage on the axillary buds caused by fatty alcohol treatment, the axillary buds of three to five representative plants per treatment were observed under stereomicroscope (Vista Vision; VWR International, Cornelius, OR).

Fatty Alcohol Treatment to Extended Axillary Shoots (Experiment 2).

After 18 days of seeding (May 6th, 2014), plants were pinched about 1 cm above cotyledons to force cotyledonary axillary shoots to develop. Seven days after pinching, axillary shoots in length from 1.8 to 3.2 cm were treated with 0, 0.5, 1, 2, 4 or 5 % (V/V) concentration of fatty alcohol emulsions. These concentrations examined in this experiment were selected based on the phytotoxicity observed in the Experiment 1. Using a pipette, 250 µL of the emulsion was applied to each axillary shoot. The application volume was selected so that the axillary shoot was covered thoroughly with emulsion. Plants were visually inspected for any sign of chemical damage and axillary shoot growth 1, 7, 15, and 21 days after treatment.

Phytotoxicity Evaluation over True Leaves and Stems (Experiment 3).

A fully unfolded true leaf and a 1-2 cm section of stem close to cotyledonary axils of each plant were subject to the spraying treatment with 0, 0.5, 1, 2, 4 or 5 % (V/V) concentration of fatty alcohol emulsions after 19 days of seeding (May 7th, 2014). Approximately 1 mL of the emulsion was applied to each of the true leaf and the stem section using an ordinary 16 oz. (473 mL) sprayer. Plants were visually inspected for damage on the true leaves and the stem sections 1, 7, 14, and 21 days after treatment.

Experimental Design.

This study was conducted during April 18 – June 3, 2014. For Expt. 1 and 2, the treatments were repeated three times using seedling tray (98 cells) as a replication. Each treatment consisted of 10-15 plants. For Expt. 3, each treatment was replicated once with 10 plants per treatment. Positions of treatment within each tray as well as positions of three trays over the bench inside the greenhouse were randomized. JMP Pro (version 9.0, SAS Institute) was used to analyze data. Percent data were arcsine-transformed and their means were separated by Tukey's honest significant difference test at $P \leq 0.05$.

Results and Discussion

Greenhouse environments.

Average day/night air temperatures in the greenhouse were 24.6 ± 2.4/18.5 ± 2.1 °C in Expt. 1, 25.2 ± 2.7/19.0 ± 2.4 °C in Expt. 2 and 24.8 ± 2.5/18.6 ± 2.2 °C in Expt. 3. Average DLIs in the greenhouse were estimated from the solar radiation recorded in the weather station (The Arizona Meteorological Network; http://ag.arizona.edu/azmet) and the predetermined greenhouse light transmission of 42 %: 25.2 ± 2.6 $mol \cdot m^{-2} \cdot d^{-1}$ in Expt. 1, 25.0 ± 3.2 $mol \cdot m^{-2} \cdot d^{-1}$ in Expt. 2 and 25.3 ± 2.6 $mol \cdot m^{-2} \cdot d^{-1}$ in Expt. 3.

Expt. 1.

Seven days after fatty alcohol treatment, the control plants (treated with 0 % fatty alcohol) had 100 % of plants with axillary shoot extension, induced by pinching (Table 1; Fig. 1A). The high concentrations (10 and 15%) of fatty alcohol treatment maintained the percentage of plants with axillary shoot extension below 7% throughout the experiment (Table 1). At 2 and 5% concentrations, the percentage of plants with axillary shoot extension increased over the first 14 days but remained the same after 22 days (Table 1).

168 The percentage of plants with axillary shoot extension at 2% fatty alcohol concentration
169 was non-significantly different from that in the control and it was significantly lower at
170 5% than that in the control but unacceptable level (23.3% after 22 days). Under the
171 stereomicroscope, the plants with no axillary shoot extension had the necrotic and
172 desiccated buds in the cotyledonary axils (Fig. 1B).

173 In contrast, 14 days after treatment, adventitious secondary shoots were observed
174 in some plants with no axillary shoot extension (data not shown). Those adventitious
175 shoots appeared to develop at either the pinched surface or the stem between the cut stem
176 end and cotyledons, and usually they grew in clumps (Fig. 1C), unlike the axillary shoots
177 developed from cotyledons (Fig. 1A). At day 22, the number of plants with adventitious
178 shoots increased, and almost all plants with no axillary shoot extension had these
179 adventitious shoots (data not shown). The adventitious shoot development observed in
180 this experiment was presumably due to the lack of active apical and axillary meristems
181 that produce auxin. Tomato seems to produce many adventitious shoots from cut surfaces
182 of stems when apical and axillary meristems were removed. For example, tomato in-vitro
183 explants grown on solid tissue culture medium without growth regulators regenerated
184 2.9-5.3 shoots on the cut surface after removing the apical and axillary meristems
185 (Pozueta-Romero et al., 2001). Also tomato plants grown in a greenhouse reportedly
186 regenerated many adventitious shoots from the cut surface of the stem and axillary shoots
187 after the plants were decapitated and the axillary shoots emerged after decapitation were
188 excised (Harada et al., 2005; Johkan et al., 2008). For rootstock plants, adventitious
189 shoots could be avoidable when grafted successfully to the scion which could continue to
190 grow and provide the source of auxin to prevent adventitious shoot development. Tezuka

191 et al. (2011) showed that adventitious shoot regeneration after decapitation was inhibited
192 by the presence of axillary shoots or by application of 1-naphthaleneacetic acid in
193 decapitated tomato plants grown in a greenhouse. However, Bausher (2011) found that
194 rootstock shoot regrowth from cotyledons recurred even after original axillary shoots
195 were pruned in grafted tomato plants when grafted above the rootstock cotyledons.
196 Therefore, adventitious shoots might occur even in successfully grafted plants treated
197 with high concentration of fatty alcohol. Multiple applications of fatty alcohol or
198 alternative methods might be required to control axillary shoot and adventitious shoot
199 growth from rootstock. Further study is needed to investigate possible development of
200 rootstock adventitious shoots long after fatty alcohol treatment using grafted tomato
201 plants.

202 The chemical damages on the plants other than the axillary buds by fatty alcohol
203 treatment, such as the stem scar and the cotyledon damage (Fig. 1D), were observed one
204 day after treatment. After 22 days of treatment, the plants treated with 2, 5, 10, and 15 %
205 fatty alcohol had 30.0, 76.7, 100 and 100 % incidence of the plants exhibiting stem scar,
206 respectively (Table 1). For the 5, 10 and 15 % fatty alcohol treatments, 10.0, 33.3 and
207 50.0 % of the plants had cotyledon damage, respectively. However, retaining cotyledons
208 is not needed for tomato grafting. Also stem scar and cotyledon damage did not seem to
209 affect the ability to grow of plants after the fatty alcohol treatment in our experiment,
210 suggesting that the damages observed in this experiment may not affect grafting success
211 and therefore may be acceptable. Even with cotyledons being damaged by fatty alcohol,
212 bottle gourd (*Lagenaria sicereria*) and interspecific hybrid squash (*Cucurbita maxima* x
213 *Cucurbita moschata*) rootstocks could be used successfully for grafting watermelon.

214 Further study is needed to confirm the influence of the damages observed in the present
215 experiment on grafting success for tomato.

216 In Expt. 1, axil-targeted application of fatty alcohol at relatively high
217 concentrations (10 and 15 %) killed cotyledonary axillary buds and suppressed the
218 percentage of plants with cotyledonary axillary shoot extension at a level lower than 7 %
219 and therefore, might be a useful chemical tool to control cotyledonary axillary shoot from
220 tomato rootstock.

221 *Expt. 2.*

222 After seven days of fatty alcohol treatment, the control plants (treated with 0 %
223 fatty alcohol) had 100 % of plants with surviving cotyledonary axillary shoots (Table 2;
224 Fig. 2A). Nearly 100% of plants treated with 2 % or lower concentration fatty alcohol
225 had surviving axillary shoots, suggesting that the concentrations or dose of fatty alcohol
226 was not enough to kill extended axillary shoot (Table 2). Fatty alcohol treatments at 4 and
227 5 % concentrations significantly reduced axillary shoot survival and suppressed axillary
228 shoot growth during 21 days after treatment, and the percentage of plants with surviving
229 axillary shoots were 40.0 and 20.0 %, respectively, 21 days after treatment (Table 2; Fig
230 2B). However, these percentages are unacceptably high for controlling cotyledonary
231 axillary shoot from rootstock. This result indicates that fatty alcohol concentration needs
232 to be higher than 5 % to sufficiently eliminate extended cotyledonary axillary shoots. It
233 was observed that the axillary shoots with no growth had necrotic shoot tip, leaves, and
234 petioles (Fig. 2C).

235 However, at 2% or greater concentrations, some plants collapsed after the
236 treatment (Figure 2D). The plants treated with 0, 0.5 and 1 % fatty alcohol had no plants

237 that collapsed during 21 days of observation (Table 2). For the 2, 4 and 5 % fatty alcohol
238 treatments, 16.7, 30.0, and 43.3 % of the plants collapsed after 21 days (Table 2). These
239 levels of damage are unacceptably high even though they were non-significantly different
240 from that of the control except for 5% treatment. These plants collapsed at the base of the
241 stem, likely due to that excessive amount of fatty alcohol trickled down the stem to the
242 substrate, causing catastrophic damage of the base of stem or the roots.

243 This collapse was observed in Expt. 2 but not in Expt. 1, despite that higher
244 concentrations were applied in Expt. 1. This is probably because the amount of fatty
245 alcohol applied to the plants in Expt. 2 was greater than that in Expt. 1. In Expt. 2, 250
246 μL of fatty alcohol emulsion was applied to cover the axillary shoot thoroughly and it
247 was observed that fatty alcohol emulsion trickled down the stem, which was not observed
248 in the Expt. 1 where only 5 μL was applied to the target axil. From these experiments, it
249 is suggested that the degree of chemical damage may differ depending on the dose and
250 application method of fatty alcohol. Two percent and higher concentration fatty alcohol
251 could cause collapse at a higher than 10 % chance when fatty alcohol spills from the
252 target shoot and trickle down stem.

253 This experiment demonstrates the challenge of controlling already extended
254 axillary shoots with fatty alcohol, because effective concentration in this type of
255 application seems to be higher than 5%, what examined in this experiment, yet enough to
256 kill the whole plants due to the amount of fatty alcohol required to cover the axillary
257 shoots. The effective concentration of fatty alcohol has to be applied exclusively target
258 axillary buds or shoots to prevent undesirable damage.

259 *Expt. 3.*

260 The damages on true leaves by fatty alcohol spray treatment were observed one
261 day after treatment. After 14 days of treatment, slightly yellowish and necrotic tissues
262 were observed even in the leaves of control plants (treated with 0 % fatty alcohol) most
263 likely due to leaf senescence. For this reason, true leaf damage was evaluated after seven
264 days of treatment instead of 14 or 21 days. Seven days after treatment, the true leaf
265 damages were visually assessed and classified into four levels. These were 1) no visible
266 damage (Figure 3A), 2) minor leaf mottling (Figure 3B), 3) marginal necrosis (Figure
267 3C) and 4) withering (severest, Figure 3D). The leaves treated with 0 or 0.5 % fatty
268 alcohol had no visible damage (Figure 4). In 1 % and higher concentration fatty alcohol
269 treatment, all leaves treated with fatty alcohol had some level of visual damages (Figure
270 4). For 1 or 2 % fatty alcohol treatment, most leaves had minor mottling (Figure 4). Most
271 leaves treated with 4 or 5 % fatty alcohol had marginal necrosis (Figure 4). For 5 % fatty
272 alcohol treatment, a small percent of plants exhibited severe withering leaf. This result
273 indicates that true leaves in contact with 1 % or higher concentration of fatty alcohol can
274 get some damage and 5 % and higher concentration of fatty alcohol can cause withering.
275 Maw (1977) reported that the mature leaves treated with 1 % (W/V) Off-Shoot-T, another
276 commercial fatty alcohol compound with similar components (26.5 % C_8 and 35.3 % C_{10}
277 fatty alcohol) as the compound employed in our experiment, had minor damage (a few
278 small necrotic patches per leaf) in tomato seedlings at age of five or six weeks, which
279 generally agree with our findings.
280 For stem damage, the stems treated with 1% or lower concentrations of fatty
281 alcohol had no visible damage during 21 days of observation (Figure 5). For 2 % and
282 higher concentration fatty alcohol treatments, the damages on stems were found one day

283 after treatment and more than half of plants collapsed by day 21 (Figure 5). The
284 remaining plants had either stem scar or cotyledon damage (Figure 5). The collapse
285 occurred at the base of stems, similarly to Expt. 2. In this experiment, overflow of
286 excessive fatty alcohol was observed similarly as in Expt. 2, likely damaging the stem
287 base or the roots. This result indicates that spraying fatty alcohol to stems at 2 % or
288 higher concentration can cause some damage on stems or roots and more than half plants
289 can collapse.

290 Steffens et al. (1967) showed that fatty alcohol effectively damaged meristematic
291 tissues, but caused little or no visible injury to more mature tissues in tobacco with the
292 aid of surfactants. In tobacco production, commercially available fatty alcohol
293 compounds at about 3 to 6 % (V/V) product concentration have been used to control
294 sucker growth after decapitation. The tobacco decapitation and sucker control are applied
295 conventionally after the production of 18 to 22 leaves (after three or four months of
296 seeding). For young tomato seedlings at three-true-leaf stage (after 17 to 19 days of
297 seeding), 5 % and lower concentration of fatty alcohol did not suppress cotyledonary
298 axillary shoot growth sufficiently in pinched plants but caused true leaf damages and
299 significant percent plant collapse despite of the inclusion of surfactant in the fatty alcohol
300 product. This indicates that the controlling cotyledonary axillary shoot growth by fatty
301 alcohol treatment without damaging true leaves and stems is difficult possibly due to the
302 relatively young stage of plants upon application. However, the previous reports showed
303 that fatty alcohol must be applied exclusively to leaf axils, to control axillary shoot
304 growth without injury to mature leaves in tomatoes at age of five or six weeks, suggesting
305 that tomato plants are susceptible to this type of chemical regardless of physiological age

306 of tissue, or that surfactants used in fatty alcohol products for tobacco do not work for
307 protecting mature tissue of tomato. Steffen and Cathey (1969) reported that the selective
308 action of fatty acid methyl ester and fatty alcohol as chemical pruning agents and tobacco
309 sucker control agents depends on the class and amount of surfactant used to emulsify
310 these chemicals. The appropriate ratio of fatty ester or alcohol to surfactants, emulsion
311 concentration and surfactant type may be different among plant species or even cultivars.
312 To protect mature tissues, Maw (1977) used a small brush and a felt tip marker to
313 apply fatty alcohol only to the axillary shoots in five to six weeks of tomatoes without
314 injury to other parts of plant. Logendra et al. (2004) used a syringe attached to a pipette to
315 apply fatty acid methyl ester or fatty acid only to leaf axils of tomato plants after 45 or 55
316 days of seeding. For controlling axillary shoot growth from tomato rootstock cotyledon in
317 commercial propagation setting, an innovative, rapid and effective application method
318 targeting the cotyledonary axils or young axillary shoots without excessive fatty alcohol
319 overflow needs to be developed alternative to ordinary sprayers to avoid undesirable
320 damage to other parts of plant.
321
322 Conclusion
323 The present experiments demonstrated that target application of 10 and 15 % fatty
324 alcohol effectively killed cotyledonary axillary buds and effectively suppressed
325 cotyledonary axillary shoot extension in pinched tomato seedlings. Therefore fatty
326 alcohol might be a useful means to control axillary shoot growth from tomato rootstock
327 cotyledons. However, to avoid undesirable damage on stems and true leaves that could
328 occur even at a concentration as low as 1%, high concentration of fatty alcohol has to be

329 applied exclusively to the target buds or young shoots. Innovative application method
330 targeting the cotyledonary axillary buds or young cotyledonary axillary shoots needs to
331 be developed to use fatty alcohol for controlling axillary shoot from rootstock cotyledons.
332 Further studies are required to evaluate the influence of fatty alcohol application on
333 grafting success as well as recurring rootstock adventitious shoot growth for the course of
334 production time.
335
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Table 1. Effects of fatty alcohol treatment to cotyledonary axillary buds on the percentage of plants with cotyledonary axillary shoot extension (7, 14 or 22 days after treatment) and the percentage of plants with chemical damage (22 days after treatment) (Expt. 1).

Fatty alcohol concentration (%)	Axillary shoot extension (%)			Chemical damage (%)	
	7 days	14 days	22 days	Stem scar	Cotyledon damage
0 (control)	100.0 a [zy]	100.0 a	100.0 a	0.0 d	0.0 c
2	36.7 b	56.7 ab	56.7 ab	30.0 c	0.0 c
5	10.0 bc	23.3 bc	23.3 bc	76.7 b	10.0 bc
10	3.3 bc	6.7 c	6.7 c	100.0 a	33.3 ab
15	0.0 c	0.0 c	0.0 c	100.0 a	50.0 a

[z] Percent data were arcsine-transformed before the statistical analysis.

[y] Mean values in columns followed by different letters are significantly different by Tukey's honest significant test at $P \leq 0.05$.

Table 2. Effects of fatty alcohol treatment to extended cotyledonary axillary shoots on the percentage of plants with surviving axillary shoot (after 7, 15 or 21 days after treatment) and the percentage of plants collapsed (21 days aftertreatment) (Expt. 2).

Fatty alcohol concentration (%)	Axillary shoot survival (%)			Collapse (%)
	7 days	15 days	21 days	
0 (control)	100.0 a [zy]	100.0 a	100.0 a	0.0 b
0.5	100.0 a	100.0 a	100.0 a	0.0 b
1	100.0 a	100.0 a	100.0 a	0.0 b
2	96.7 a	100.0 a	100.0 a	16.7 ab
4	26.7 b	36.7 b	40.0 b	30.0 ab
5	16.7 b	20.0 b	20.0 b	43.3 a

[z] Percent data were arcsine-transformed before the statistical analysis.

[y] Mean values in columns followed by different letters are significantly different by Tukey's honest significant test at $P \leq 0.05$.

Figure 1. Tomato plants applied with fatty alcohol to cotyledonary axillary bus and pinched (Expt. 1). (A) A plant with axillary shoot extension from cotyledons. (B) A plant with no axillary shoot extension from cotyledons and with necrotic axillary buds. (C) A plant with adventitious shoots. (D) A plant with cotyledon damage.

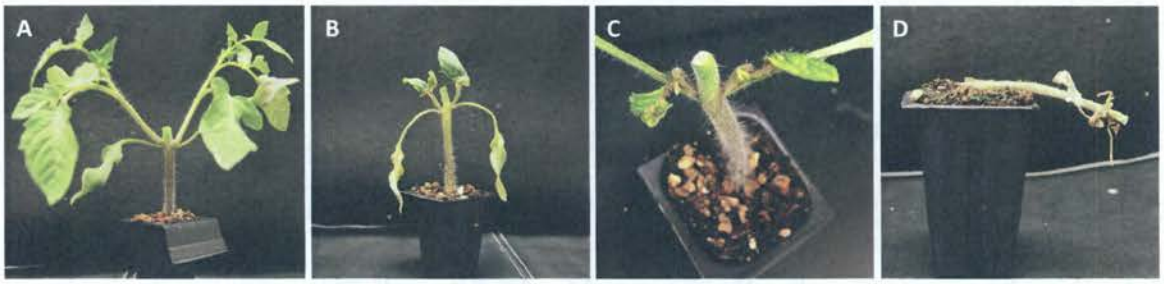

Figure 2. Tomato plants applied with fatty alcohol over extended cotyledonary axillary shoots (Expt. 2). (A) A plant with surviving cotyledonary axillary shoots, showing growth. (B) A plant with damaged cotyledonary axillary shoots, showing no growth. (C) Cotyledonary axillary shoots with necrotic shoot tip, leaves and petioles. (D) A plant collapsed.

Figure 3. Tomato true leaves sprayed with fatty alcohol (Expt. 3). (A) A leaf with no visible damage. (B) A leaf with minor mottling. (C) A leaf with marginal necrosis. (D) A leaf with withering.

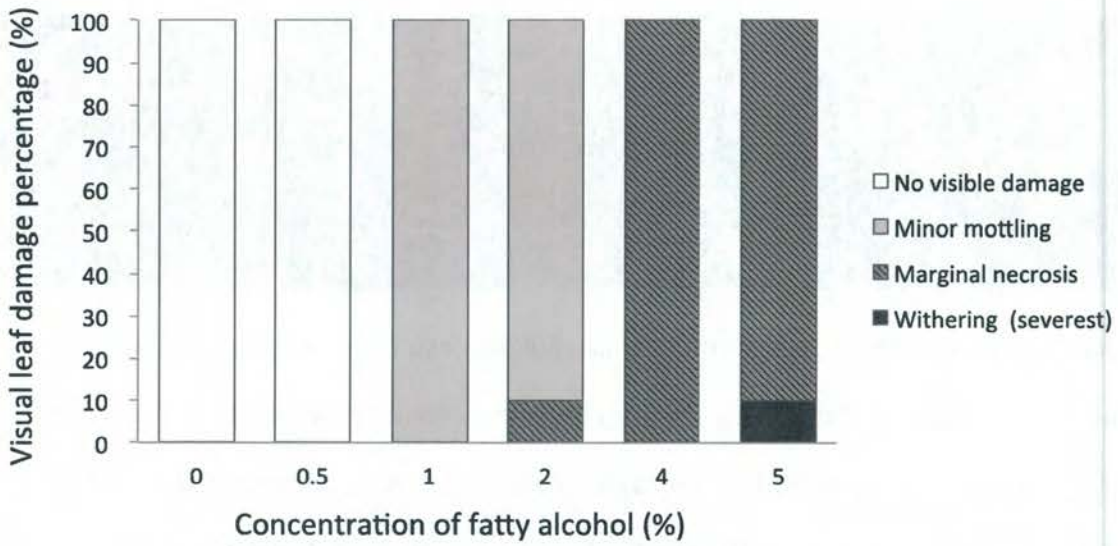

Figure 4. Effects of spraying fatty alcohol to true leaves on leaf damage seven days after treatment (Expt. 3).

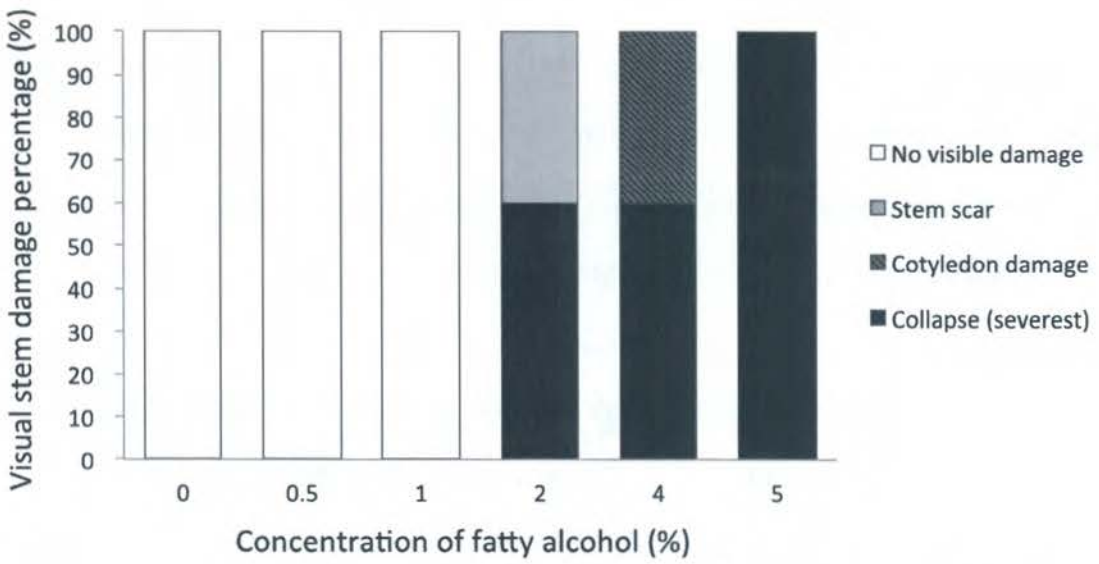

Figure 5. Effects of spraying fatty alcohol to stem sections on stem damage 21 days after treatment (Expt. 3).

Figure Captions

Figure 1. Tomato plants applied with fatty alcohol to cotyledonary axillary bus and pinched (Expt. 1). (A) A plant with axillary shoot extension from cotyledons. (B) A plant with no axillary shoot extension from cotyledons and with necrotic axillary buds. (C) A plant with adventitious shoots. (D) A plant with cotyledon damage.

Figure 2. Tomato plants applied with fatty alcohol over extended cotyledonary axillary shoots (Expt. 2). (A) A plant with surviving cotyledonary axillary shoots, showing growth. (B) A plant with damaged cotyledonary axillary shoots, showing no growth. (C) Cotyledonary axillary shoots with necrotic shoot tip, leaves and petioles. (D) A plant collapsed.

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