Attapulgite
Handling/Processing

Identification of Petitioned Substance

Chemical Name:
Attapulgite

CAS Numbers:
12174-11-7

Other Names:
Palygorskite
Aluminum Magnesium Silicate, Hydrated
Fuller's earth (CAS # 8031-18-3)

[Note: In the United States, the term "attapulgite" is used in place of palygorskite; however, the International Nomenclature Committee determined that palygorskite is the preferred name.]

Characterization of Petitioned Substance

Composition of the Substance:

Attapulgite is complex magnesium (Mg) aluminum (Al) silicates with an open-channel structure, which forms elongate (needle-shaped) crystals. Its chemical formula is $Mg_{1.5}\ Al_{0.5}\ Si_4\ O_{10}\ (OH)\ \cdot 4H_2O$. Actual composition varies because of partial replacement of magnesium (Mg) and aluminum (Al), by iron (Fe), and other elements (Harben, 2002).

Attapulgite consists of double silica tetrahedral chains linked together by octahedral oxygen and hydroxyl groups containing Al and Mg ions in a chain-like inverted structure. The inverted tetrahedral occurs regularly and causes channels through the structure, see Figure 1, (Murray, 1999). Attapulgite contains two types of water— one coordinated to the octahedral cations and other loosely bonded in the channels. The latter water is referred to as zeolitic water. The channels may also contain exchangeable cations. The elongated morphology and the presence of the channels are the most important physical attributes (Murray and Zhou, 2006).

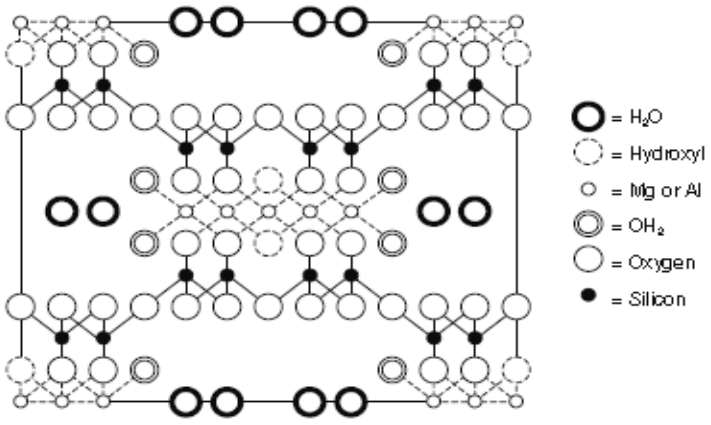

Figure 1. Attapulgite Structure

In addition, Haden (1963) indicated that there are two unusual characteristics from the structure. First, since the structure is three-dimensional, little swelling can occur. Second, cleavage will be easiest along the Si-O-Si bonds holding together the three-layer strips. Hence, it is of the needle-like rather than plate-like particle shape. The typical attapulgite needle has a length of about 1µm and a width of about 0.01µm.

Properties of the Substance:

Physical and Chemical Properties	
Color	Bluish-grey tint
Particle shape	Elongate
Mohs hardness[1]	2.0-2.5
High surface area	150 m^2/g
Specific gravity	2.0-2.3 g/cm^3
Moderate base exchange capacity	30-50 meq/100g
Charge on the lattice	Moderate
Melting point	1550°C
Sorptive capacity	High
Water absorption	Up to 100% of the weight of the clay
Oil absorption	Up to 80% of the weight of the clay
pH	7.5-8.5

Attapulgite has a strong ability to absorb water. When it is wet, attapulgite shows plastic and adhesive properties; and when it gets dry, attapulgite does not shrink much and does not show cracks. When it is soaked in water, attapulgite collapses.

Specific Uses of the Substance:

According to the petition, attapulgite will be used as a processing aid and function as a natural bleaching clay for the purification of vegetable and animal oils.

Attapulgite also has other uses. Haden (1963) divided the applications of attapulgite into two broad categories: colloidal and non-colloidal. A number of representative applications are listed in Table 1, see below:

Table 1. Some Uses of Attapulgite

Colloidal	Non-Colloidal
1. Oil-base and water-base foundry sand binders	1. Petroleum refining, decolorizing, neutralizing, brightening, desulfurization, deodorizing
2. Adhesive viscosity control	2. Vegetable oils and animal fats neutralizing, decolorizing, deodorizing
3. Oil well drilling mud	3. Carrier for granular and powdered agricultural chemicals (insecticides, herbicides, etc.)
4. Latex paint thickener and gelling agent	4. Pharmaceutical intestinal absorbent
5. Pharmaceutical thickener and adsorbent	5. Floor absorbents
6. Liquid suspension fertilizers	6. Animal bedding, pet litter
7. Polishes— suspending agent for abrasives	7. Flowability additive to dry fire extinguisher powders
8. Wax emulsion stabilizer	8. Catalytic applications (no carbon required papers, olefin polymerization, etc.)
9. Metal drawing lubricants— suspending agent	9. Anti-caking agent
10. Laundry washing powders	10. Chromatographic adsorbent
11. Bonding agent for granulation of powders	11. Drying of oils

[1] A scale used to measure the hardness of minerals, with talc at zero and diamond at 10. Each mineral on the scale is hard enough to scratch the one below it in the scale.

Approved Legal Uses of the Substance:

The U.S. Food and Drug Administration (FDA) — Attapulgite (Doc. No. 1943) is listed under Everything Added to Food in the United States (EAFUS) and referred to in 21 CFR Part 582 -- Substances Generally Recognized as Safe (GRAS), §582.99 Adjuvants for pesticide chemicals.

The U.S. Environmental Protection Agency (EPA) — Attapulgite is listed as an inert ingredient can be used in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 25(b) pesticide products applied to food use site (e.g., food crops, animals used for food) and nonfood use site (e.g., ornamental plants, highway right-of-ways, rodent control). In addition, attapulgite can be used, under 40 CFR §180.910 Inert Ingredients, during pre- and post harvest. It is exempted from the requirement of a tolerance.

Action of the Substance:

Attapulgite is classed as a 2:1 layer inverted structure (Fig. 1). Substitution of iron, magnesium, calcium, and other elements for aluminum generates an excess negative charge and a cation exchange capacity. Because of the inversions in the silica tetrahedral sheet, the structure has parallel channels or holes throughout, which along with the elongate habit and the fine particle size, give a high surface area (porous structure). The charge on the particles, the channels through the structure, and the high surface area give attapulgite a capacity to absorb and adsorb various materials. [Note: Absorption is the penetration of fluid molecules into the bulk of an absorbing clay, whereas adsorption is the interaction between the fluid molecules and the clay surface.] In addition, the elongate particles cause higher viscosity when it is added to any liquid (Murray, 1999).

The channels or holes of attapulgite are filled with zeolitic water that may be driven off by heating to 500°C and so activated to form bleaching clay. This bleaching clay derived from attapulgite can be utilized in refining animal fats and vegetable oils. Bleaching is carried out by mixing it with the oil or fat to be treated. The impurities, including color pigments, are adsorbed onto the surface of attapulgite clay. The clay combined with impurities is filtered and thus removed from the bleached oil (Harben, 2002).

Status

Domestic:

According to FDA, the Everything Added to Food in the United States (EAFUS)[2] list dated June 2009 is from a database maintained by the FDA Center for Food Safety and Applied Nutrition under the Priority-based Assessment of Food Additives program. The EAFUS list of substances contains ingredients added directly to food that FDA has either approved as food additives or listed or affirmed as GRAS. "CLAY, ATTAPULGITE" (Doc No. 1943[3], updated 11/09/2009) is found in the database and referred to FDA Regulation 582.99 (Adjuvants for pesticide chemicals) where the chemical appears.

The petitioned substance lists under *Table 87.5 Additional Special Purpose Products* in 2008 Official Publication of the Association of American Feed Control Officials. "Attapulgite Clay" is classified under Food Additives Amendment function as anti-caking agent and pelleting aid (not to exceed 2% in finished feed) and suspension aid in liquid feed supplement (not to exceed 2.5% in supplement). It contains a reference to FDA Regulation 582.1 (Substances that are generally recognized as safe).

[2] http://www.fda.gov/Food/FoodIngredientsPackaging/ucm115326.htm
[3] http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=eafusListing&id=683

According to the EPA document 'Inert Ingredients Eligible for FIFRA 25(b) Pesticide Products', last updated March 3, 2009[4], attapulgite is an inert ingredient. It is eligible for inclusion in pesticide products under EPA the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)'s Section 25(b). The residues of the attapulgite 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. See, e-CFR dated December 8, 2009, 40 CFR §180.910 Inert Ingredients used pre- and post harvest; Exemptions from the requirement of a tolerance.

"Palygorskite fibers (>5 µm in length)" is also on the California Proposition 65 List[5] (updated September 11, 2009) as a chemical known to the State to cause cancer. The initial appearance of the chemical on the list was dated December 28, 1999. State of California, Environmental Protection Agency, Office of Environmental Health Hazard Assessment, the Safe Drinking Water and Toxic Enforcement Act of 1986 requires that the Governor revise and republish at least once per year the list of chemicals known to the State to cause cancer or reproductive toxicity.

International:

Regulation (EC) 1831/2003— "Attapulgite (clay) CAS No. 12174-11-7", under silage additives functional group, listed in Community Register of Feed Additives. The date of first entry in the Register is July 11, 2005.

Canadian Food Inspection Agency, Feed Program— Schedule IV of the Feeds Regulations, 1983, lists ingredients approved for use as livestock feed. Attapulgite clay (Schedule IV Number 8.111) is listed under *Class 8. Miscellaneous Product of the Feeds Regulations*. It stated, "Attapulgite clay (IFN[6] 8-14-008) is hydrated aluminum-magnesium silica, a naturally occurring mineral mined in Attapulgus, Georgia… It shall be labeled with the following statement: This product is for use in non-medicated feeds only as an anticaking agent or pelleting aid in an amount not to exceed 0.25% of the finished feed or as an emulsifier in liquid feed supplements at a level not to exceed 2.5% of the supplement."

Evaluation Questions for Substances to be used in Organic Handling

Evaluation Question #1: Is the petitioned substance formulated or manufactured by a chemical process? (From 7 U.S.C. § 6502 (21).)

Attapulgite is the principal mineral of attapulgus clay, which is surface mined by open-pit method with stripping by scrapers, draglines, or bulldozers and extraction by shovels, backhoes, small draglines, or front-end loaders. The clay is then loaded onto trucks and transported to the processing plant. They are then dried, milled, and sieved to obtain a desired range of particle sizes (Patterson, 1992).

Occasionally, special processes are also used to enhance certain properties, such as adding 1% or 2% MgO to improve the viscosity; drying with high heat to remove the zeolitic water from the channels in the structure to increase the sorbent properties; and pulverizing to ultrafine particles for improving suspension properties and increasing the surface area (Murray and Zhou, 2006). In addition, some attapulgites are acid activated, which is treated with sulfuric or hydrochloric acid, to enhance its bleaching activation for using in clarifying edible and non-edible oils. Murray (2007) reported that sulfuric acid is preferred because it is less expensive and is not as harsh as hydrochloric acid. This acid treatment can be a dry or wet process. The dry process involves crushing, drying, pulverization, acid treatment, and packaging. The

[4] http://docs.google.com/gview?a=v&q=cache:IlDC-2lWGQ8J:www.epa.gov/opprd001/inerts/section25b_inerts.pdf+EPA+CAS+12174-11-7&hl=en&gl=us
[5] http://www.oehha.ca.gov/prop65/prop65_list/files/P65single091009.pdf
[6] International Feed Number

wet process involves blunging (mixing clay with water), heating (around the boiling point), adding acid (sulfuric or hydrochloric), dewatering, drying, and then formed into a powder or granules.

The difference between natural and acid activated bleaching clay is that natural bleaching clay in aqueous suspension is slightly acid or neutral, whereas that of acid activated bleaching clay is highly acidic.

Evaluation Question #2: Is the petitioned substance formulated or manufactured by a process that chemically changes the substance extracted from naturally occurring plant, animal, or mineral sources? (From 7 U.S.C. § 6502 (21).)

According to the petitioner, the petitioned substance is a fine powder (<325 mesh) and produced by the following steps:

- The shredded clay from the crude clay shed is dried in a rotary dryer and is pulverized in a Raymond mill. As an optional method, the shredded clay from the crude clay shed can be dried and pulverized simultaneously in a heated hammer mill such as Williams mill.
- The dried, pulverized clay is packaged into bulk containers for transport.

Evaluation Question #3: Is the petitioned substance created by naturally occurring biological processes? (From 7 U.S.C. § 6502 (21).)

Attapulgite deposits were formed in various geological environments. Formation in soils, lakes, or shallow seas, was associated with the Mediterranean-type climate (i.e., dry summer subtropical climate), prevalent during certain geological times. Formation in inland seas and lakes was as chemical sediments or from the constitution of clays during diagenesis[7], in open oceans by hydrothermal alteration of basaltic glass, volcanic sediments or clays, in marine deposits by slumping and turbidity currents transporting near-shore materials. Generation may also be by direct crystallization in calcareous soils or the weathering of serpentinite[8] and magnesite[9].

Evaluation Question #4: Is there a natural source of the petitioned substance? (From 7 CFR § 205.600 (b) (1).)

Bleaching clay (earth) is made from naturally occurring minerals, such as palygorskite (also known as attapulgite), sepiolite, and bentonite (Zschau, 2000). They have some common properties such as a medium to high surface area, sorptive abilities, and decolorizing, binding, and thickening power.

The natural deposits of palygorskite can be found in Unite States, China, Senegal, Spain, and Ukraine. All of these major deposits were formed during geologic time of Eocene or Miocene. In the US, the palygorskite rich deposits in south Georgia and north Florida dominate the world's production. The deposits extend from Quincy, Florida, on the south to the Meigs, Georgia, area on the north, about 80 km. The deposition of the palygorskite took place in a shallow water trough that connected the Gulf of Mexico with the Southeast Georgia Embayment on the Atlantic Ocean. The seawater in this trough was characterized by fluctuating salinities, and at times the lagoons were closed off from normal circulation. There was sufficient magnesium present to precipitate palygorskite. The mineralogical content changes from dominantly palygorskite in the Quincy-Attapulgus District to a mixture of smectite and palygorskite in the northern area around Ochlocknee and Meigs. Smectite is transformed to palygorskite and sepiolite in a saline, alkaline water environment. Murray (2007) stated "Both attapulgite and sepiolite are natural bleaching earths. They are used to clarify automotive oil and many edible oils which are used in cooking." Attapulgite and sepiolite are hydrated magnesium aluminum silicates with thin elongate chain type structures. Sepiolite has higher magnesium content than attapulgite and has a slightly larger unit cell size.

[7] Recombination or rearrangement of constituents (as of a chemical or mineral) resulting in a new product.
[8] A metamorphic rock consisting almost entirely of minerals in the serpentine group. Serpentinite forms from the alteration of ferromagnesian silicate materials, such as olivine and pyroxene, during metamorphism.
[9] A white, colorless, or lightly tinted mineral consisting of naturally occurring magnesium carbonate in hexagonal crystalline form: a source of magnesium.

In addition, Pickering and Heivilin (2006) have reported that bleaching earths, with or without acid activation, need a particular pore size and porosity to clean and decolorize edible oils. There are only two such actively mined fuller's earth clay deposits in the US — In northeastern Mississippi, where acid activation (the clay treated with sulfuric or hydrochloric acid) is necessary, and in the south Georgia district near Meigs, where clays can be a natural bleaching earth or acid activated bleaching earth.

Evaluation Question #5: Is there an organic agricultural product that could be substituted for the petitioned substance? (From 7 CFR § 205.600 (b) (1).)

No information was identified to suggest that an organic agricultural product can be used as a bleaching earth for processing vegetable and animal oils.

As mentioned above, Evaluation Question #4, attapulgite, sepiolite, and bentonite have common properties and they all can be used as bleaching earth. However, attapulgite and sepiolite may be used as a natural bleaching earth, which does not require acid activation. Bentonite is an acid activated bleaching earth because the necessary surface area and porosity have to be created by an acid treatment (Murray, 2007). On the NOP National List, bentonite is a nonsynthetic allowed substance listed under 7 CFR §206.605.

Acid activation enhances properties already present in the clay. Sulfuric acid is most commonly used in the activation process but hydrochloric acid is also effective. The acid treatment increases the surface area and pore volume thus improving the clays performance in removing color pigments and impurities from vegetable oil and animal fat. Although acid activated bleaching earth is often more effective, it is also more costly.

Evaluation Question #6: Are there adverse effects on the environment from the petitioned substance's manufacture, use, or disposal? (From 7 CFR § 205.600 (b) (2).)

Attapulgite is surface mined and, in most countries, the mining company is required by law to reclaim the land. Common practice is to open a cut, mine the clay, and then spoil the overburden from the next cut into the mined-out area. The spoil is leveled or sloped to meet the standards prescribed by the government, and grasses and/or trees are planted. Sometimes the topsoil is put back on top of the spoil and is used for agriculture (Murray and Zhou, 2006).

The major environmental issue is air quality, because the dust during manufacture, use, or disposal. Repeated or prolonged inhalation of dust may cause delayed lung injury. The employees should wear proper personal protective equipment and a NIOSH[10] approved (or equivalent) respirator to prevent inhaling the dust. For occupational exposures, attapulgite is regulated by US Occupational Safety and Health Administration (OSHA) with the inert or nuisance dust standard: permissible exposure limits, 15.0 mg/m^3 total dust and 5.0 mg/m^3 respirable dust (29 CFR §1910.1000).

Manufacture

In the processing plant, air quality is maintained by using dust collectors on dryers, pulverizers, baggers, and belt-transfer points. Dust collectors, facemasks, and other devices should be provided to protect the workers from inhaling and contacting the dust.

Use

The petitioned substance should be placed in adequate ventilation and good housekeeping storage and work areas to minimize dust. To handle this product, employees should wear protective gloves, coveralls and/or an apron to minimize skin contact, if necessary; wear goggles or safety glasses with side-shields; and wear appropriate NIOSH approved respirators to prevent inhaling the dust.

[10] National Institute for Occupational Safety and Health

Misuse

Prevent dispersion of dust and avoid all contact in accidental spills of attapulgite. Person needs to ware proper personal protective equipment. Contain the spill. Scoop up or vacuum the spilled material into a sealable container for reclamation or disposal; if appropriate, moisten first to prevent dusting.

Disposal

According to the petition's MSDS, unused material is suitable for disposal in sanitary landfills. The spent bleaching earth, or spent filter cake is discarded in a land field. Zschau (2000) has reported that for each ton of bleaching earth added to the bleaching process, the oil processor has to dispose of 1.25–1.50 ton of spent bleaching earth. A typical range of oil retention, which is defined as the amount of oil retained in the spent bleaching earth, is 35–40%. Therefore, self combustion or self-ignition of spent bleaching earth is a very important consideration for storage and transportation before disposal in a land field. [Note: Generally, the danger of self combustion rises as the unsaturated fatty acids increase in the retained oil. This means that spent bleaching earths containing fish and linseed oil, but also soybean, sunflower seed and rapeseed oil, have a relatively high risk for self combustion, whereas the risk is much lower for bleaching earths that contain hydrogenated fats, palm oil, or animal fats.]

Evaluation Question #7: Does the petitioned substance have an adverse effect on human health as defined by applicable Federal regulations? (From 7 CFR § 205.600 (b) (3).)

The petitioned substance is a hydrated magnesium aluminum silicate that occurs as a fibrous chain-structure mineral in clay deposits in several areas of the world. Attapulgite fiber characteristics vary with the source, but fiber lengths in commercial sample are general less than 5 µm. Attapulgite has been mined since the 1930s and is used mainly as an absorbent for pet wastes and oils and greases and as a component of drilling muds. Occupational exposure to the petitioned substance occurs during its mining, milling, production and use. General population exposures also may occur in its use as pet waste absorbent, in fertilizers and pesticides, and by ingestion of anti-diarrheal preparations. Attapulgite is listed as an inert ingredient can be used in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 25(b) pesticide products applied to food use site (e.g., food crops, animals used for food) and nonfood use site (e.g., ornamental plants, highway right-of-ways, rodent control). In addition, attapulgite is under 40 CFR §180.910 Inert Ingredients used pre- and post harvest; Exemptions from the requirement of a tolerance. In the US, typically, an adult dose of 1.2 g is prescribed at the onset of diarrhea with repeated use up to a maximum daily dose of 8.4 g (Engle, 1994).

In the report of International Agency for Research on Cancer (IARC) Monographs (Volume 68, 1997), a single cohort study of palygorskite (attapulgite) miners and millers was available for human carcinogenicity data. In the summary stated "It showed small excesses of mortality from lung cancer and stomach cancer, but no indications of any exposure-response for either cancer."

Wilbourn et al. (1997) and the working group of IARC (1997) have reported that epidemiological studies on palygorskite (attapulgite), where available, were considered to be inadequate or of insufficient quality to allow an evaluation of its carcinogenicity in humans. There was sufficient evidence in experimental animals for the carcinogenicity of long palygorskite fibers (>5 µm) based upon studies in rats by inhalation and intrapleural and intraperitoneal administration. There was inadequate evidence in experimental animals for the carcinogenicity of short palygorskite fibers (<5 µm). Consequently, long palygorskite fibers (>5 µm) were classified as possibly carcinogenic to humans (Group 2B), while short palygorskite fibers (<5 µm) could not be classified as to their carcinogenicity to humans (Group 3).

Evaluation Question #8: Is the nutritional quality of the food maintained when the petitioned substance is used? (From 7 CFR § 205.600 (b) (3).)

According to the petition, attapulgite is used as a natural bleaching clay in the purification of vegetable and animal oils. This purification step is often referred to as bleaching process, which is used for the removal of impunities from the edible oils. During the process, the bleaching clay not only adsorbs impunities but also a certain amount of oil. Zschau (2000) has stated "for each 100 kg of fresh bleaching earth, about 25–45

kg of oil is lost." According to Brooks' study (1999), the bleaching process can have a significant effect on oil loss and production costs. There is no information sources reviewed specifically addressing the issue of the impact on the nutritional value (such as Vitamins A &D and minerals) of the vegetable and/or animal oils when attapulgite is used.

Evaluation Question #9: Is the petitioned substance to be used primarily as a preservative? (From 7 CFR § 205.600 (b) (4).)

By definition, bleaching is the physical and chemical interaction of a sorbent (bleaching clay) with oil or fat to improve its quality in the edible oil processing. It refers to removing impurities from a given oil through the addition and subsequent removal of bleaching sorbents (such as attapulgite). The impurities, in the spent bleaching earth, may contain oxidation products, color pigments, phospholipids and glycolipids, metal traces, soaps, and contaminants (such as pesticides). No information was identified to suggest that attapulgite is used primarily as a preservative.

Evaluation Question #10: Is the petitioned substance to be used primarily to recreate or improve flavors, colors, textures, or nutritive values lost in processing (except when required by law, e.g., vitamin D in milk)? (From 7 CFR § 205.600 (b) (4).)

The function of a bleaching clay is to remove undesirable by-products (impurities) for the vegetable oil and animal fat, thus improving the appearance, flavor, taste, and stability of the final product (Zschau, 2000).

Duff (1991) has reported that adsorptive bleaching removes all gross impurities such as meals, metal contaminants (e.g. iron or copper), and any soaps left over from alkali refining. In addition, it removes peroxides and some of the secondary products of oxidation. But it does a poor job for removing pigments (e.g. chlorophyll, gossypol, and carotene) and gums. Hastert (1991) has indicated that attapulgite is not ordinarily used for vegetable oil adsorption because of its limited decolorizing ability. It is more likely to be used in treating meat fats which require little color removal.

Evaluation Question #11: Is the petitioned substance generally recognized as safe (GRAS) when used according to FDA's good manufacturing practices? (From 7 CFR § 205.600 (b) (5).)

Attapulgite (Doc. No. 1943) is listed under Everything Added to Food in the United States (EAFUS) and referred to in 21 CFR Part 582 – Substances Generally Recognized as Safe (GRAS), §582.99 Adjuvants for pesticide chemicals. Adjuvants, identified and used in accordance with EPA Regulations (40 CFR §180.1001(c) and (b)), which are added to pesticide use dilutions by a grower or applicator prior to application to the raw agricultural commodity, are exempt from the requirement of tolerances.

Evaluation Question #12: Does the petitioned substance contain residues of heavy metals or other contaminants in excess of FDA tolerances? (From 7 CFR § 205.600 (b) (5).)47

No information sources in the public domain specifically address that attapulgite contains residues of heavy metal or other contaminants in excess of FDA tolerances. It is not listed as a commodity (the applicable human food and animal feed products) under FDA's "*Guidance for Industry: Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed*". However, according to Shenzhen Aoheng Science & Technology Co., Ltd. in China, its 'Fuller's Earth' product, which is made from the attapulgite clay, contains arsenic ≤ 0.5 mg/kg, lead ≤ 1 mg/kg, and mercury ≤ 0.3 mg/kg.

References

Attapulgite, International Chemical Safety Cards. http://www.cdc.gov/niosh/ipcsneng/neng1321.html

Brooks, D. Bleaching Considerations for "Organic" Oils. International Conference and Exhibition on Nutraceuticals and Functional Foods, San Diego, CA, Nov 17-20, 2002.

Boyer, M. J. Chapter 17 Environmental Considerations in Fats and Oils Technologies in Introduction to Fats and Oils Technology. Edited by Wan, P. J. 1991. American Oil Chemists' Society, Champaign, Illinois.

California Proposition 65 List. September 11, 2009. http://www.oehha.ca.gov/prop65/prop65_list/files/P65single091009.pdf

Canadian Food Inspection Agency, Foods Regulations, 1983, Schedule IV Part 1, 8.111 Attapulgite clay. September 19, 2007.

Chen, A. H. Chapter 3 Principles in Fats and Oils Technology in Introduction to Fats and Oils Technology. Edited by Wan, P. J., 1991. American Oil Chemists' Society, Champaign, Illinois.

Community Register of Feed Additives, pursuant to Regulation (EC) No 1831/2003. Edition 65. Released Dec. 7, 2009. http://ec.europa.eu/food/food/animalnutrition/feedadditives/comm_register_feed_additives_1831-03.pdf

Duff, H. G. Chapter 5 Refining in Introduction to Fats and Oils Technology. Edited by Wan, P. J. 1991. American Oil Chemists' Society, Champaign, Illinois.

Engle, J. P., OCT advisory: antidiarrheal products. Am. Druggist, 8, 48-50, 1994.

EPA, 40 CFR §180.910 Inert Ingredients used pre- and post harvest; Exemptions from the requirement of a tolerance. December 8, 2009. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3548f04ef55258e14615d56bda77ccb7&rgn=div8&view=text&node=40:23.0.1.1.28.4.19.3&idno=40

EPA, Inert Ingredients Eligible for FIFRA 25(b) Pesticide Products, updated March 3, 2009. http://docs.google.com/gview?a=v&q=cache:IlDC-2lWGQ8J:www.epa.gov/opprd001/inerts/section25b_inerts.pdf+EPA+CAS+12174-11-7&hl=en&gl=us

FDA, 21 CFR §582.99 Adjuvants for pesticide chemical. http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=77ec462ddcc6e77785320a1d888f767d&rgn=div8&view=text&node=21:6.0.1.1.24.1.1.9&idno=21

FDA, Attapulgite, Doc. No. 1943. EAFUS http://www.accessdata.fda.gov/scripts/fcn/fcnNavigation.cfm?rpt=eafusListing&displayAll=true

FDA, Everything Added to Food in the United State (EAFUS), June 2009. http://www.fda.gov/Food/FoodIngredientsPackaging/ucm115326.htm

FDA, Guidance for Industry: Action Level for Poisonous or Deleterious Substances in Human Food and Animal Feed, August 2000. http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ChemicalContaminantsandPesticides/ucm077969.htm

Fuller's Earth, Shenzhen Aoheng Science & Technology Co., Ltd. http://www.atb.com.cn/cpy.htm

Haden, W. L. Jr. Attapulgite: Properties and Uses. 10th National Conference on Clays and Clay Minerals. NRC-NAS Monograph No. 12, 1963, p. 284-290.

Harben, P. W. Attapulgite and Sepiolite in The Industrial Minerals HandyBook, 4th ed., 2002, p. 22-26.

Harvey, C. C. and Murray, H. H. Clays: An Overview in Industrial Minerals & Rocks, edited by Kogel, J. E., Trivedi, N. C., Barker, J. M., and Krukowski, S.T. 7th edition, 2006, p. 335-342.

Hastert, R. C. Chapter 6 Adsorptive Treatment of Edible Oils in Introduction to Fats and Oils Technology. Edited by Wan, P. J. 1991. American Oil Chemists' Society, Champaign, Illinois.

IARC. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 68 (1997), Silica, Some Silicates, Coal Dust and para-Aramid Fibrils, Lyno, France. p. 245-266.

Murray, H. H. Applied clay mineralogy today and tomorrow. Clay Minerals (1999) 34, p. 39-49.

Murray, H. H. Applied Clay Mineralogy: occurrences, processing and application of kaolins, bentonites, palygorskite-sepiolite, and common clays. First edition, 2007.

Murray, H. H. and Zhou, H. Clays: Palygorskite and Sepiolite (Hormites) in Industrial Minerals & Rocks, edited by Kogel, J. E., Trivedi, N. C., Barker, J. M., and Krukowski, S.T. 7th edition, 2006, p. 401-406.

Palygorskite (Attapulgite), International Agency for Research on Cancer- Summaries & Evaluations. http://www.inchem.org/documents/iarc/vol68/palygor.html

Palygorskite, CAS Registry Number: 12174-11-7
http://www.commonchemistry.org/ChemicalDetail.aspx?ref=12174-11-7&terms=attapulgite

Patterson, H.B.W. Chapter 3, Adsorbents in Bleaching and Purifying Fats and Oils. Theory and Practice, American Oil Chemists' Society, Champaign, Illinois. 1992.

Pickering, S. M. Jr., and Heivilin, F. G. Fuller's Earth, Industrial Minerals & Rocks, 7th edition, 2006, p. 373-381.

Sawyer, E. W. Jr. Attapulgite — The Relationship Between Its Physical/Chemical Properties and Current Commercial Applications, Presentation at the SME Annual Meeting, September 7-10, 1986.

US Occupational Safety and Health Administration. 29 CFR §1910.1000 Air contaminants, Table Z-3 —Mineral Dusts http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=fb291e932dcdf5862736a40212546ce9&rgn=div8&view=text&node=29:6.1.1.1.1.1.1.1&idno=29

US National Library of Medicine, Hazardous Substances Data Bank, Toxicology Data Network (TOXNET). http://toxnet.nlm.nih.gov/

WHO Workshop on Mechanisms of Fiber Carcinogenesis and Assessment of Chrysotile Asbestos Substitutes, Summary Consensus Report, 8-12 November 2005, Lyon, France.

Weiss, T. J. Chapter 3, Basic Processing of Fats and Oils. Food Oils and Their Uses, 2nd edition, 1983, p.65-101. Avi Publishing Company, Inc.

Wilbourn, J. D., McGregor, D. B., Partensky, C., and Rice, J. M. Meeting Report. IARC Revaluates Silica and Related Substances. Environmental Health Perspectives, Volume 105, Number 7, July 1997.

Zschau, W. Chapter 9 Bleaching in Introduction to Fats and Oils Technology, Second Edition. Edited by O'brien, R. D., Farr, W. E., and Wan, P. J., 2000. AOCS Press, Champaign, ILL.