Phosphoric acid

Processing

Identification

Chemical Names	phosphoric acid	**CAS Numbers:**	7664-38-2
Other Names:	Orthophosphoric acid; also metaphosphoric acid and pyrophosphoric acid.	**Other Codes:**	

Recommendation

Synthetic / Non-Synthetic:	**National List:**	**Suggested Annotation:**
Synthetic (consensus)	*95%+=Not allowed* *50%+=Not allowed* *Cleanser, Sanitizer, Disinfectant=Allowed (Consensus)*	*ACS or USP grade orthophosphoric acid may be used to clean food-contact surfaces and equipment. (Consensus)*

Characterization

Composition H_3PO_4

Properties:
Phosphoric acid is a colorless, odorless solution that is about 85-87% by weight in all commercial strengths with an approximate Molarity of 14.7 to 15.2. It is further diluted to different concentrations depending upon usage applications. Strongly acidic. Corrosive to concrete, most metals, and fabrics.

How Made:
Phosphoric acid can be made in two ways, either the wet process or the thermal (furnace) process. In the wet process, mined phosphate ore is treated with sulfuric acid and then the resulting phosphoric acid is separated from the calcium sulfate crystals produced. The chemical reaction is the following:

$$(PO_4)_2Ca_3 + 3H_2SO_4 + 6H_2O \dashrightarrow 3SO_4\,Ca \cdot 2H_2O + PO_4\,H_3$$

This process conserves most of the impurities found in the ore (and is therefore mostly used for fertilizer production), but the product can then be purified further for technical and food-grade phosphoric acid. Thermal acid is made from elemental phosphorus and is considerably more expensive and purer than the wet process acid. The pure phosphorus is burned in excess air and the resulting phosphorus pentoxide is then hydrated, cooled, and the acid mist is collected.

Specific Uses:
Used in cleaning operations to remove encrusted surface matter and mineral scale found on metal equipment such as boilers and steam producing equipment. Orthophosphoric acid is routinely used as a cleaning compound in its dilute form to remove oxidation from non-stainless steel surfaces, staining of stainless steel, lime and scale from heat exchangers and in Clean-in-Place (CIP) cleaning operations especially in dairy processing to remove build up of calcium and phosphate salts from processing equipment. It is also used to brighten metals and remove rust.

Additionally, orthophosphoric acid can be mixed with other detergents for process cleaning operations. It is used as an acidulent and flavoring in soft drinks--mainly colas--jellies, frozen dairy products, bakery products, candy, cheese products and in the brewing industry. It is also used as a sequestrant in hair tonics, nail polishes and skin fresheners. The concentrated form is irritating to skin and mucous membranes.

Direct food / consumer product applications are beyond the scope of this review. Only use as an equipment cleaner and sanitizer of food contact surfaces is under consideration.

Action:
The chemical reaction of phosphoric acid with minerals found in deposits makes them water soluble and thus easy to remove. Phosphoric acid is a sequestering agent that binds cations such as Fe, Cu, Ca, and Mg in fat and oil processing.

Combinations:
For cleaning purposes phosphoric acid is almost always combined with a surfactant. Usually the surfactant will be a synthetic detergent, such as derivatives of naphthalenesulfonic acid and sodium dodecylbenzene sulfonic acid. May also be combined with organic acids such as carboxylic acid, citric acid or lactic acid, or with isopropyl alchohol. See 21 CFR 178.1010 for a list of FDA approved sanitizing solutions in combination with phosphoric acid. It is also sometimes combined with a sequestrant or chelating agent, such as ethylenediaminetetraacetic acid (EDTA).

Status

OFPA
The substance is used in handing and is necessary for the handling of agricultural product because of the unavailability of wholly natural substitute products (7 USC 6517(c)(1)(A)(ii)).

Regulatory
On USDA dairy division list of cleaning aids for dairy processing operations (USDA, 1993). FDA approved for use as a cleanser, sanitizer, and disinfectant (21 CFR 178.1010).

Status among Certifiers
Generally not listed, but has been allowed for use by certified organic processors and handlers.

Historic Use
Most certification agents do not specifically regulate individual cleaning agents, except to specify that they be rinsed off food contact surfaces.

International
Not mentioned in IFOAM standards.

OFPA 2119(m) Criteria

(1) The potential of such substances for detrimental chemical interactions with other materials used in organic farming systems. As this is a processing material, the substance is not used in organic farming systems.
(2) The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment. See processor criteria 3 below.
(3) The probability of environmental contamination during manufacture, use, misuse or disposal of such substance. This is considered below under item (2).
(4) The effect of the substance on human health. This is considered in the context of the effect on nutrition (3) below as well as the consideration of GRAS and residues (5) below.
(5) The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock. As this is not released into the agroecosystem, there is no direct effect.
(6) The alternatives to using the substance in terms of practices or other available materials. See discussion of alternatives in (1) below.
(7) Its compatibility with a system of sustainable agriculture. This is considered more specifically below in the context of organic handling in (6) below.

NOSB Processing Criteria

A SYNTHETIC PROCESSING AID OR ADJUVANT may be used if;

1. An equivalent substance cannot be produced from a natural source and has no substitutes that are organic ingredients.
   The most common use for phosphoric acid in the food processing industry is as an equipment cleaner. Other acids which involve less environmental impact and/or human health hazard are organic acids such as citric, gluconic, tartaric, or acetic acids; these materials must also be used with care though, some more than others, depending on their respective concentrations. Such alternatives may or may not be as effective as phosphoric acid.

   Other strong acid agents used for cleaning operations include hydrochloric (muriatic), hydrofluoric, sulfamic, sulfuric, and nitric acids. Nitric and sulfuric acids are so corrosive that they are not generally used as cleaners. Hydrofluoric acid is very unstable and dangerous to handle and also extremely corrosive. Hydrochloric acid is very effective at descaling metals but produces highly toxic fumes in the form of hydrogen chloride gas. Phosphoric acid is preferred because it is the lowest in corrosiveness at the low concentrations which are effective and is compatible with many surfactants (Marriott, 1994). Organic acids such as citric, tartaric, and gluconic are effective in some situations, especially removing mineral deposits formed as a result of using alkaline cleaning compounds or other cleaners. They are not as corrosive or irritating to the skin and they are good water softeners and rinse easily. They can be irritating to the eyes, cost more, and do not work as well on metals.

   Phosphoric acid is sometimes used in the food processing industry as a disinfectant or microbial control for fresh produce, by addition of it to flume or rinse water such as in the processing of oranges and other citrus fruits). In this case, there may or may not be traces of the material entering into the final food product, depending on the care with which it is used in the processing line. The acidulating action is the mechanism of microbial control here; there are alternatives to this, in the form of organic acids like those mentioned above. Other ways to treat water, such as filtration, ozonolysis, ultraviolet radiation, and chlorination vary as to how much they are in line with organic production principles. It is hard to imagine a case where phosphoric acid is the best possible strategy for such biocidal purposes in an organic processing system.

   As a food additive, phosphoric acid is used as an acidulating agent, to which there are several natural an/or organically-produced alternatives.

   Alkaline cleaning agents have different functions and would not be considered alternatives to acids, but would be used as a separate step in a thorough cleaning program. Synthetic detergents are also effective cleaning agents but do not replace by themselves the specific uses that require an acid cleaning agent.

2. Its manufacture, use and disposal does not contaminate the environment.
   There are many environmental consequences from the manufacture, misuse and disposal of phosphates in general and these cannot be separated out for phosphoric acid in particular. In figures from world phosphorus consumption in 1980, about 90% of phosphate consumption is for fertilizer, while 4.5% is for all detergents including other cleaners such as trisodium phosphate (Becker, 1989). There are extreme environmental impacts from mining of phosphate ore which occurs in many parts of the world. Worker safety is of prime concern in the wet-process acid and elemental phosphorous used in the thermal process because of high acidity, heat released upon neutralization and toxic gases released. Plants will be equipped with proper safety procedures and equipment to deal with these issues.

   The issues of phosphate pollution from disposal are discussed above but in general the dilution of the phosphoric acid will minimize disposal problems in the food processing or livestock facility.

3. If the nutritional quality of the food is maintained and the material itself or its breakdown products do not have any adverse effect on human health.
   Undiluted phosphoric acid is a hazard to living organisms, and as such, must be handled with caution. Phosphoric acid is extremely corrosive and should not come into contact with skin or eyes. The acid can

produce corrosive toxic gases when heated and care should be taken to provide ventilation and protective clothing for workers. Inorganic phosphates are not hazardous to ingest and are in fact essential mineral nutrients.

At low concentrations ingestion is not a health hazard. There could be minor nutritional benefit from low-level ingestion of this material, although the actual commercial formulation in which it is found (i.e. in combination with other materials) may negate such benefit. Assuming that basic GMP's are followed, phosphoric acid would not appear in foodstuffs in a concentration which would be deleterious to human health.

4. Is not a preservative or used only to recreate/improve flavors, colors, textures, or nutritive value lost during processing except in the latter case as required by law.
   The use of phosphoric acid as a food ingredient or pH adjuster to retard spoilage is beyond the scope of the review.

5. Is Generally Recognized as Safe (GRAS) by FDA when used in accordance with Good Manufacturing Practices (GMP), and contains no residues of heavy metals or other contaminants in excess of the tolerances established by FDA.
   The final report to the FDA of the Select Committee on GRAS Substances indicated in 1980 that it should continue its GRAS status with no limitations other than GMP's (Winter, 1989). See 21 CFR 178.1010 for proper use as a sanitizer of food handling equipment. Some technical grades of phosphoric acid can have impurities related to their recovery processes. When properly used with GMPs as a sanitizer, the product will not leave residues.

6. Is compatible with the principles of organic handling.
   Since proper cleaning and sanitation is a key component of any organic management program, and phosphoric acid appears to be among the best and safest of the acid cleaning agents, this material seems to be compatible with an organic production and processing system.

7. There is no other way to produce a similar product without its use and it is used in the minimum quantity required to achieve the process.
   While there are other sanitizers, there may be cases when phosphoric acid is indeed the best possible choice of material as an equipment cleaner.

Discussion

Condensed Reviewer Comments

Reviewer 1
As in the discussion section it is stated that proper cleaning and sanitation is critical to organic programs and phosphoric acid appears to be the product of choice, it seems compatible.

Reviewer 2
Sulfuric, nitric, hydrochloric, and other such stronger acids are less favorable alternatives to phosphoric acid, and would fail OFPA criteria 2119(m)3 and 2119(m)4, and NOSB criteria #2 and #3, perhaps more so than would phosphoric acid.

In many if not all cases there may be an alternative to using phosphoric acid, namely more intensive manual labor in cleaning, at least in cases where surfaces to be cleaned are not enclosed or are reachable by human hands and/or tools. This, combined with materials (such as scouring compounds, enzymatic cleaners, detergents, alkaline cleaners, colloids, and sequestrating/chelating agents) which more ideally satisfy the OFPA and NOSB criteria on environmental effects of manufacture, misuse, and disposal, might likely suffice. Cost should not necessarily play an influential role in deciding which materials are suitable for organic systems, but overall environmental impact should. In summary, compared to the full spectrum of alternatives, phosphoric acid is a reasonable middle ground, but alternatives definitely exist in most cases, which may better fit the principles of organic production.

List phosphoric acid as a synthetic material, REGULATED for use in organic processing systems. Annotation should read: As an equipment cleaner only, and only when it is demonstrated that methods and materials which involve less overall environmental impact are not adequate.

Reviewer 3
Based on how orthophosphoric acid is manufactured, it is clearly synthetic. I have added additional information regarding types and uses of phosphoric acid. I agree with the technical information as presented in the NOSB database. It is also important to recognize that three types of phosphoric acid exist and only the orthophosphoric acid form of phosphoric acid is being reviewed.

After extensive review of all commercially available strong and weak acids, it is clear that there are no competitive alternatives to orthophosphoric acid. In reviewing 2119(m)6 alternatives to substance, I found the information to be technically accurate. There is not a suitable alternative that meets criteria with respect to safety, compatibility to agro systems and environmental impact issues.

I would propose that orthophosphoric acid be added to the National List of Allowed Synthetics. I base this decision on compatibility with sustainable agriculture, OFPA status, and the fact that there are no clear alternatives with less compromise of organic integrity.

I also would like to propose the following annotation: "Only the orthophosphate form of phosphoric acid may be used for livestock use as an equipment cleaner. Additionally, orthophosphoric acid must be of the highest purity and meet the ACS or USP criteria for purity when used in the dilute form, or as an added ingredient in equipment cleaning formulations.

Conclusion

Acid cleaning compounds are necessary for removing encrusted surface materials and dissolving mineral scale deposits on metal equipment, both in livestock production such as milking equipment, and in food processing uses. A thorough review of cleaning agents should also address alkaline cleaning compounds and detergents as well as scouring compounds, colloids, sequestrants, enzymatic cleaners, and auxiliary compounds used in cleaners. Until the review of this very large group of cleaning materials is acheived, the very limited yet very essential uses of phosphoric acid cleaners should be considered for both livestock and processing applications.

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