Peracetic Acid
Processing

Identification

Chemical Name(s):
peroxyacetic acid, ethaneperoxic acid

CAS Number:
79-21-0

Other Names:
per acid, periacetic acid, PAA

Other Codes:
NIOSH Registry Number: SD8750000
TRI Chemical ID: 000079210
UN/ID Number: UN3105

Summary Recommendation

Synthetic / Non-Synthetic:	Allowed or Prohibited:	Suggested Annotation:
Synthetic (consensus)	*Allowed (consensus)*	Allowed only for direct food contact for use in wash water. Allowed as a sanitizer on surfaces in contact with organic food. *(consensus)* From hydrogen peroxide and fermented acetic acid sources only. *(Not discussed by processing reviewers--see discussion of source under Crops PAA TAP review.)*

Characterization

Composition:
$C_2H_4O_3$. Peracetic acid is a mixture of acetic acid (CH_3COOH) and hydrogen peroxide (H_2O_2) in an aqueous solution. Acetic acid is the principle component of vinegar. Hydrogen peroxide has been previously recommended by the NOSB for the National List in processing (synthetic, allowed at Austin, 1995).

Properties:
It is a very strong oxidizing agent and has stronger oxidation potential than chlorine or chlorine dioxide. Liquid, clear, and colorless with no foaming capability. It has a strong pungent acetic acid odor, and the pH is acid (2.8). Specific gravity is 1.114 and weighs 9.28 pounds per gallon. Stable upon transport.

How Made:
Peracetic acid (PAA) is produced by reacting acetic acid and hydrogen peroxide. The reaction is allowed to continue for up to ten days in order to achieve high yields of product according to the following equation.

$$\underset{\text{acetic acid}}{CH_3\text{-}\overset{\overset{O}{||}}{C}\text{-}OH} + \underset{\text{hydrogen peroxide}}{H_2O_2} \longrightarrow \underset{\text{peroxyacetic acid}}{CH_3\overset{\overset{O}{||}}{C}\text{-}O\text{-}OH} + H_2O$$

Due to reaction limitations, PAA generation can be up to 15% with residual levels of hydrogen peroxide (up to 25%) and acetic acid (up to 35%) with water up to 25%. Additional methods of preparation involve the oxidation of acetaldehyde or alternatively as an end product of the reaction of acetic anhydride, hydrogen peroxide, and sulfuric acid.

Additional methods of preparation involve the oxidation of acetaldehyde (Budavari, 1996). Another method involves the reaction of tetraacetylethylenediamine (TAED) in the presence of an alkaline hydrogen peroxide solution (Davies and Deary, 1991). These sources appear to be used more frequently in pulp, paper, and textile manufacture (Pan, Spencer, and Leary, 1999).

Specific Uses:
Peracetic acid's primary use in food processing and handling is as a sanitizer for food contact surfaces and as a disinfectant for fruits, vegetables, meat, and eggs (Evans, 2000). PAA can also be used to disinfect recirculated flume water (Lokkesmoe and Olson, 1993). Other uses of PAA include removing deposits, suppressing odor, and stripping biofilms from food contact surfaces (Block, 1991; Mosteller and Bishop. 1993; Marriot, 1999; Fatemi and Frank 1999). It is also

used to modify food starch by mild oxidation and is used as a bleach (Food Chemicals Codex, 1996).

Action:
The primary mode of action is oxidation. PAA disinfects by oxidizing of the outer cell membrane of vegetative bacterial cells, endospores, yeast, and mold spores. The mechanism of oxidation is the transfer of electrons, therefore the stronger the oxidizer, the faster electrons are transferred to the microorganism and the faster the microorganism is inactivated or killed.

Table 1
Oxidation Capacity of Selected Sanitizers

Sanitizer	**eV***
Ozone	2.07
Peracetic Acid	1.81
Chlorine dioxide	1.57
Sodium hypochlorite (chlorine bleach)	1.36
*electron-Volts	

Therefore PAA has a higher oxidation potential than chlorine sanitizers but less than ozone.

PAA also inactivates enzymes that are responsible for discoloration and degradation, such as peroxidase in the browning of potatoes (Greenspan and Margulies, 1950).

Combinations:
Peracetic acid usually occurs with hydrogen peroxide and acetic acid in an aqueous solution. Stock commercial preparations usually contain a synthetic stabilizer such as 1-hydroxyethylidene-1,1-diphosphonic acid (HEDP) or 2,6-pyridinedicarboxylic (dipicolinic) acid to slow the rate of oxidation or decomposition (Kurschner and Diken, 1997). According to FDA regulations, HEDP may be used with PAA at a level not to exceed 4.8 ppm in water used to wash fresh fruits and vegetables (21 CFR 173.315(a)(5)).

Sanitizing combinations approved by 21CFR 178.1010 to be used with PAA under (b)(38) include: hydrogen peroxide; acetic acid; sulfuric acid; and 2,6-pyridinedicarboxylic (dipicolinic) acid. Under (b)(45) they include: hydrogen peroxide; acetic acid; octanoic acid; peroxyoctanoic acid; sodium 1-octanesulfonate; and 1-hydroxyethylidene-1,1-diphosphonic acid.

These stabilizers, surfactants, and synergists are not evaluated in this TAP review. Some are specifically mentioned in the context of the OFPA criteria.

Status

OFPA 7 USC 6517(b)(1)(C)(i) is listed as an equipment cleaner.

Regulatory
FDA approved it for direct food contact for use in wash water or to assist in the peeling of fruits and vegetables (21CFR 173.315). Also approved as sanitizer on food contact surfaces (21 CFR 178.1010). Registered as an EPA Section 3 pesticide (40 CFR 152.25(a)--regular registration).

Status among U.S. Certifiers
Variable. Most allow it with a fresh water rinse. Some may require continuous testing of rinse water by on-line meter. Some may allow direct food contact use at present, but many will not allow for direct food contact unless the NOSB recommends that it be included on the National List.

Historic Use
Peracetic acid was patented in 1950 to treat fruits and vegetables to reduce spoilage from bacteria and fungi destined for processing (Greenspan and Margulies, 1950). It has since been used in systems to disinfect recirculated wash water used to handle fresh produce (Lokkesmoe and Olson, 1995). Research as an alternative to chlorine and irradiation as a disinfectant for meat and poultry is relatively recent.

International
Does not appear on the IFOAM Basic Standards Appendix IV or EU 2092/91 Annex VI. It is not clear if those standards require that disinfectants need to apper; these lists are “positive” lists.

Criteria from the February 10, 1999 NOSB Meeting

A PROCESSING AID OR ADJUVANT may be used if;

1. *It cannot be produced from a natural source and has no organic ingredients as substitutes.*
   Alternatives include: fresh, clean water; rapid cooling; and reducing the time between harvest and consumption. Physical methods such as heat and steam can also be used in some situations. Other alternatives previously reviewed by the NOSB include hydrogen peroxide (synthetic, allowed at Austin 1995), chlorine bleach (synthetic, allowed at Austin 1995 and includes calcium hypochlorite, sodium hypochlorite, and chlorine dioxide), phosphoric acid (synthetic and allowed with annotation "for cleaning food contact surfaces and equipment" at D.C. 1999), and sodium hydroxide (synthetic and allowed with annotation "Prohibited for use in lye peeling of fruits and vegetables and where natural sodium bicarbonate is an acceptable substitute" at Orlando 1995). Peracetic acid is superior to hydrogen peroxide in antimicrobial activity (Evans, 2000).

2. *Its manufacture, use, and disposal do not have adverse effects on the environment and are done in a manner compatible with organic handling as described in section 6513 of the OFPA.*
   Impacts of manufacture depends on processes used. Various methods of manufacturing involve the use of acetaldehyde. Breakdown products are acetic acid (same acid found in vinegar at 5% level) and hydrogen peroxide that breads down to O_2 and H_2O. Disposal in municipal sewer system may have a positive effect due to oxidation capabilities (Arturo-Schaan et al., 1996). It is more persistant than chlorine-based disinfectants, but less so than quaternary ammonium compounds (Evans, 2000). It can have a longer residual activity than chlorine (Gruetzmacher and Bradley, 1999).

3. *If the nutritional quality of the food is maintained and the material itself or its breakdown products do not have adverse effects on human health as defined by applicable Federal regulations.*
   Limited studies have shown no significant loss of water soluble vitamins as a function of direct food contact (asserted, but not backed up by any reference journal studies). It may inhibit various dairy cultures, but this effect is short-lived (Langeveld and van Montfort-Quasig, 1996). Peracetic acid is an irritant of the skin, eyes, mucous membranes, and respiratory tract (NTP, 2000; Budavari, 1996; Lenga, 1985). When heated to decomposition it emits acrid smoke and toxic fumes of carbon monoxide and carbon dioxide. The vapor is heavier than air and can travel a considerable distance to a source of ignition and flash back (NTP, 2000).

4. *Its primary purpose is not as 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.*
   Peracetic acid is approved by the FDA for sanitizing and disinfection (21 CFR 178.1005-1010). Proper disinfection of equipment and facilities can reduce the need for synthetic preservatives contained in food products (Bundgaard-Nielsen and Nielsen, 1995).

   Peracetic acid may be used with hydrogen peroxide as a bleach and to produce artificial flavors (Pan, Spencer, and Leary, 1999). For example, when used to disinfect chicken chillwater, some bleaching is observed (Kurschner and Diken, 1997). PAA is also used to modify food starch through mild oxidation (21 CFR 172.892 and Food Chemicals Codex, 1996).

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 FDA tolerances.*
   Peracetic acid is not explicitly listed as GRAS by FDA. However, PAA arguably benefits human health by controlling food-borne pathogens (Cherry, 1999). The maximum residues for washwater used for fruits and vegetables is 80 ppm (21 CFR 173.315). The maximum residues allowed on a food contact surface are 200 ppm (21 CFR 178.1010).

6. *Its use is compatible with the principles of organic handling.*
   In comparison to other most-used sanitizers in the food industry, peracetic acid may be more compatible with organic handling than the use of halogen-based sanitizers and disinfectants such as chlorine bleach, iodine-phosphorous (iodophors), or quaternary ammonia products (quats). For example, chlorination can seriously damage aquatic life and form chlorinated hydrocarbons with carcinogenic and mutagenic properties (Arturo-Schaan et al., 1996). Quats have the longest residual activity (Block, 1991). PAA degrades rapidly, leaves little residue, and decomposes into relatively harmless naturally-occurring substances (Evans, 2000).

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 disinfectants and sanitizers, these are also synthetic. The efficient (minimal) use of peracetic acid as a disinfectant in a HACCP program requires constant monitoring but is technically feasible (Schultz, 1992). Minimum levels for allowed for sanitizing food contacts surfaces are established by FDA (21 CFR 178.1010(c)).

TAP Reviewer Discussion

TAP Reviewer Comments

OMRI's information is enclosed in square brackets in italics. Where a reviewer corrected a technical point (e.g., the word should be "intravenous" rather than "subcutaneous"), these corrections were made in this document and are not listed here in the Reviewer Comments. The rest of the TAP Reviewer's comments are listed here minus any identifying comments and with corrections of typos.

Reviewer #1
[Food Scientist in a research laboratory.]
Synthetic/Non: It is synthetic.

Allow or prohibit: Allowed with annotations.

Annotations:
Allow as an equipment sanitizer where organic food contacts the equipment.

Allow for direct food contact use in wash water (with a concentration limitation of maybe 100 ppm). Must be followed by a fresh water rinse.

Notes: the only concern that I have is with the added stabilizers. Are we approving peracetic acid ONLY if it doesn't contain any stabilizers? Do we need to evaluate the potential stabilizers? I was unable to find any pertinent information about the various stabilizers listed in the packet.

Annotations should be written to NOT allow use for peeling or starch modification if these are not implicitly prohibited. The notes about rinsing (when used as an equipment sanitizer) or not are still up for debate. I tend to NOT want to see sanitizer rinsed off (preferring to allow time for it to volatilize off), but I know that *[other experts want]* to see them rinsed off. I can go either way on this.

Reviewer #2
[Facility pest management expert]
Thank-you for the opportunity to participate in the Technical Advisory Panel (TAP) Review of peracetic acid. This subject is especially important because in my fieldwork in both food safety and organic certification of food products; the area of sanitizers and disinfectants is a difficult issue. Organic consumers, producers, and handlers are not only faced with concerns of appropriate materials selection for the handling and processing of organic commodities, but are responsible for controlling the incidence of potentially harmful pathogens in food products.

Opinions:
1. In the assessment of the resource materials provided and based upon personal experience in the food industry, it is the opinion of this reviewer that peracetic acid (PAA) is [by definition of the Organic Foods Production Act of 1990] a *synthetic* substance.
2. Under provision of the Organic Food Production Act of 1990, it is the opinion of this reviewer that the material PAA should be listed as an *allowed synthetic* substance with the following annotations:
    a. From hydrogen peroxide and acetic acid sources only.
    b. Allowed only for direct food contact for use in wash water. (Which should be understood to mean for use in recirculating flume water.)
    c. Allowed as a sanitizer on food contact surfaces (not requiring a rinse step after application).
3. Without additional background materials and discussions on the use of PAA in the assistance in the peeling of fruits and vegetables, this reviewer believes that this use pattern should be prohibited in organic handling practices.
4. This reviewer does not believe that the use of PAA for bleaching of food is consistent with organic handling practices.
5. Without additional background and discussion, this reviewer believes that the modification of starches with PAA should at least be temporarily prohibited.
6. This reviewer found no additional information regarding the use of PAA for the bleaching of organic cotton and has no comments on the topic at this time.

Discussion

With the implementation of the OFPA, the organic certification industry will be in an increasingly difficult position with regard to acceptable materials for food borne pathogen control. The organic industry has traditionally prohibited synthetic materials for the handling and processing of certified organic products, but has made certain allowances depending on circumstances. Under a strict rule, the available options for sanitizing are narrow and can be costly.

As stated in the materials provided by OMRI for this TAP review, there has traditionally been a mixed view amongst organic certifiers in the use of various sanitizers and disinfectants. The range of materials available does not provide a completely "perfect" organic solution. We are faced with the dilemma of allowing potential residues of synthetic sanitizers on organic products, or the use of fresh water rinses after sanitizing—which is problematic because potentially harmful pathogens can be reintroduced to food or food preparation surfaces during this step.

The use of Hazard Analysis and Critical Control Points (HACCP) as a food hazard identification and control tool requires that certain steps routinely occur to control potentially harmful conditions from occurring. Chemical sanitizers and disinfectants are critical to this management program.

It is the opinion of this reviewer that while this material is synthetic under definition of the OFPA, a reasonable and responsible position can be taken by allowing PAA in the handling and processing of certified organic commodities. This allowance is justifiable and should be provided under the auspices of food safety.

Please be advised that the original conflict of interest statement provided by this reviewer to OMRI is still applicable in all respects for this review process. I have no commercial alliances or monetary affiliations that have influenced this position.

Reviewer #3

[Consultant to organic food processors]

I agree with the summary recommendation put together by OMRI. The product is Synthetic, should be Allowed and the suggested annotations are as follows: from hydrogen peroxide and acetic acid sources only. Allowed for direct food contact for use in wash water. Allowed on surfaces in contact with organic food.

Peracetic acid seems to be a much more acceptable sanitizer than chlorine, in that it is a stronger oxidizing agent, but is less detrimental to the environment. It is an irritant in concentrated form, but appears to be relatively easy to handle in its diluted state.

A search of the literature did not turn up any information on the impact of peracetic acid on nutritional quality. I found only one reference to treatment of rice straw (Tamiguchi et al 1982).

My recommendation would be not to approve for peeling of fruits and vegetables or for bleaching of organic cotton. Those uses should be petitioned separately as this review is primarily for its disinfectant properties in food establishments and I believe we need more complete analysis of the literature and feasibility of its use for these purposes.

One concern is a reference to it ability to corrode steel, unless anti-corrosive agents are present (Boulange-Peterman et al, 1997). Would these be included in the inert ingredients in *[brand name products]*? I did not see a reference to anti-corrosion in *[a company's]* literature.

In conclusion, I agree with most of the analysis contained in the current TAP review document.

Conclusion

Organic farmers, handlers, and consumers face a dilemma with the disinfection of wash water used to handle organic food as well as to clean food contact surfaces. On the one hand, organic standards prohibit the use of synthetic biocides. On the other hand, the presence of food-borne pathogens is a concern. While organic farmers and handlers have a number of materials and methods that they can use instead of peracetic acid, these are limited in their ability to disinfect and sanitize certain types of food, equipment, and surfaces. Both acetic acid and hydrogen peroxide are produced in nature as a function of natural processes.

PAA has broad-spectrum impacts on microorganisms, is an irritant, and may cause other health problems if handled improperly. However, if proper safety precautions are taken, then PAA is no worse than the principle alternative chemical sanitizers and disinfectants previously recommended to be included on the National List.

Some bleaching or discoloration may occur as a part of the normal disinfection application. However, the use of PAA to intentionally bleach food would not be compatible with organic principles.

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