Peracetic Acid

Crops

Identification

Chemical Name(s):
Peroxyacetic Acid
Ethaneperoxic Acid

Other Names:
PAA, Per Acid, Periacetic acid

CAS Number:
79-21-0

Other Codes:
NIOSH Registry Number: SD8750000
UN/ID Number: UN3105

Summary Recommendation

Synthetic / Non-Synthetic:	Allowed or Prohibited:	Suggested Annotation:
Synthetic (consensus)	*Allowed (consensus)*	1. Allowed to disinfect equipment. Prohibited for soil (field) application. Allowed to disinfect seed and asexually propagated planting material (i.e., bulb, corm, tuber) used for planting crops. From hydrogen peroxide and fermented acetic acid sources only. *(consensus)* 2. Allowed for fireblight control with Experimental Use Permit with documentation that alternatives including biocontrols have been tried. *(1 in favor, 2 against)*

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.

Properties:
Peracetic acid is a very strong oxidizing agent and has a stronger oxidation potential than chlorine or chlorine dioxide. It is a clear, colorless liquid with no foaming capability. It has a strong pungent acetic acid odor, 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.

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

The NOSB recommended that hydrogen peroxide be added to the National List of synthetic substances allowed for crop production (Austin, 1995).

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:
Its major use in the food industry is as a sanitizer. Peroxyacetic acid is used to control deposits, odor, biofilms from food contact surfaces, and as a microbial control agent for both food contact surfaces and direct contact with fruits and vegetables.

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 inactiviated or killed. It has also been reported to be virucidal (Arturo-Schaan, 1996).

Combinations:
Peracetic acid usually occurs with hydrogen peroxide, acetic acid, and a stabilizer in an aqueous solution. Most stabilizers used are EPA List 3 (unknown toxicity) and are not considered in this TAP review.

Status

OFPA
Falls under Production Aid (7 USC 6517(b)(1)(C)(i)).

Regulatory
EPA regular Section 3 registration (40 CFR 152.25(a)). First registered in 1985 (US EPA, 1993). Registered for indoor use only (US EPA, 1993). Some Special Local Need registrations (40 CFR 160) may have been granted for specific crops and applications (Cal-EPA, 2000).

EPA/NIEHS/Other Appropriate Sources
OFPA 6518 (l)(1) states, "In establishing the National List or proposed amendments to the National List, the Board shall review available information from the Environmental Protection Agency, the National Institute of Environmental Health Studies, and such other sources as appropriate, concerning the potential for adverse human and environmental effects of substances considered for inclusion in the proposed National List."

EPA: It is on EPA's Extremely Hazardous Substances list (US EPA, 2000). See the Re-registration Eligibility Document for Peroxy Compunds (US EPA, 1993).

NIEHS: See attachment from the National Toxicology Program.

Other sources: See New Jersey Department of Health and Senior Services attachment.

Status Among U.S. Certifiers
None appear to explicitly allow it for crop use.

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). It is used to treat bulbs (Hanks and Linfield, 1999), to disinfect potting soil, clean irrigation equipment, (Larose, 1998), and in seed treatment to inactivate fungal or other types of plant disease. While there is a long history of experimental field use as a fungicide / bactericide, efficacy has only recently been established (Hei, 2000). Peracetic acid is effective at reducing *Escherichia coli* O157:H7 on apples when used in a wash and as a chemical sanitizer (Wright et al., 2000).

International
Peracetic acid does not appear on IFOAM Appendix 2 for Plant Pest and Disease Control (IFOAM, 2000). It does not appear on EU 2092/91 Annex II. Field use of this material is not allowed under any known International Organic Standards. Post-harvest application is discussed in the processing TAP review.

OFPA 2119(m) Criteria

1. *The potential of such substances for detrimental chemical interactions with other materials used in organic farming systems.*
This material is a strong oxidizing agent. It can react violently with acetic acid anhydride, olefins (e.g., mineral oil), and organic matter (NTP, 2000).

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.*
Toxicity high via oral for guinea pigs; moderate via oral and dermal routes for rats and rabbits (Sax, 1979). Skin and Eye Irritation Data: skin-rabbit 500 mg open SEV; eye-rabbit 1 mg SEV (NTP, 2000). An experimental neoplastinogen (tumor-causing agent) via dermal route (NTP, 2000). It is on EPA's Extremely Hazardous Substances list (US EPA, 2000).

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). Breakdown products are acetic acid (same acid found in vinegar at 5% level) and hydrogen peroxide that breaks down to O_2 and H_2O.

The primary mode of action is oxidation. with 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.

3. *The probability of environmental contamination during manufacture, use, misuse or disposal of such substance.*
Production from hydrogen peroxide and acetic acid would depend on the process used. Hydrogen peroxide is commonly produced by the electrolysis of water (Kirchner, 1981). Acetic acid may be produced by fermentation (vinegar) or distillation from plant sources. However, acetic acid may also be synthesized by hydrolysis of acetylene or oxidation of acetylaldehyde (Budavari, 1996). Acetylene and acetaldehyde are generally produced from petrochemical sources. The environmental consequences of petroleum production and refining are beyond the scope of this TAP review.

Misuse in handling would cause a bleaching out effect on the color of fresh fruits and vegetables resulting in loss of quality that could be visually detected. Under normal use and disposal conditions, PAA decomposes into acetic acid, oxygen, and water.

4. *The effect of the substance on human health.*
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).

While it is not rated as a carcinogen by itself (NTP, 2000), studies indicate that it is a possible co-carcinogen, promoting tumor production by known carcinogens (Bock, Myers, and Fox, 1976, from abstract).

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.*
The substance is used *because* of its biological and chemical interactions and its physiological effects on microorganisms, including many that are naturally found in a soil environment. Among the model organisms that show significant reductions in populations after exposure to PAA are *Bacillus cereus* (Blackiston et al., 1999); *B. subtilis* (Leaper, 1984; Blackiston et al., 1999; Lindsay and von Holy, 1999); *B.. stearothermophilus* (Blackiston et al., 1999); *Clostridium botulinum* (Blackiston et al., 1999); *C. butyricum* (Blackiston et al., 1999); *C. sporogenes* (Blackiston et al., 1999); *Ditylenchus dipsaci* (Hanks and Linfield, 1999); *Enterococcus faecium* (Andrade et al., 1998); *Escherichia coli* (Arturo-Schaan et al., 1996), including *E. coli* O157:H7 (Farrell et al., 1998), *Fusarium oxysporum* (Hanks and Linfield, 1999); *Gluconobacter oxydans* (Winniczuk and Parish, 1997), *Lactobacillus plantarum* (Winniczuk and Parish, 1997), *L. thermophilus* (Langeveld and Montfort-Quasig, 1996); *Leuconostoc mesenteroides* (Winniczuk and Parish, 1997); *Listeria monocytogenes* (Mosteller and Bishop, 1993; Restaino et al., 1994); *Pseudomonas aeruginosa* (Restaino et al., 1994; Lambert et al., 1999); *P. fluorescens* (Mosteller and Bishop, 1993; Lindsay and von Holy, 1999); *Saccharomyces cerevisiae*(Winniczuk and Parish, 1997); *Salmonella typhimurium* (Restaino et al., 1994); *Staphylococcus aureus* (Restaino et al., 1994; Lambert et al., 1999); *Streptococcus delbreuckii* subsp *bulgaricus* (Langeveld and Montfort-Quasig, 1996); and
Yersinia enterocolitica (Mosteller and Bishop, 1993).

The immediate effect against soil organisms would be broad-spectrum and, if mishandled, potentially violent. The toxic effects would be short-lived, and somewhat selective, favoring acid-tolerant and aerobic bacteria. For example, experimental evidence indicates that *Bacillus* spp. would likely be less affected and would recover more quickly than *Clostridium* spp. (Blackiston et al., 1999). However, at least one study indicates no difference between the susceptibility of plasmid-containing *E. coli* strains and those strains that do not contain plasmids (Arturo-Schaan, 1996). The breakdown products--oxygen, water, and acetic acid--are all part of the agroecosystem. Acetic acid is produced in nature as a function of acetobacter species of microorganism found in soil, and is part of the natural carbon cycle (Alexander, 1991).

Salt Index: The salt index has not been calculated for this substance.

Solubility: Water: 100mg/ml at 19°C. (freely soluble). Also soluble in alcohol.

6. *The alternatives to using the substance in terms of practices or other available materials.*
Organic alternatives for post-harvest handling include hot water and steam. It is an alternative to such conventional treatments as formaldehyde and thiabendazole (Hanks and Linfield, 1999).

For fireblight control: Cultural practices such as pruning and sanitation; biological controls such as *Pseudomonas fluorescens* (non-GMO); and copper products. Antibiotics such as oxytetracycline and streptomycin are registered for fireblight. The NOSB recommended that these be added to the National List (Austin, 1995).

7. *Its compatibility with a system of sustainable agriculture.*
Peracetic acid is a synthetic pesticide. As such, it is in a category that is generally considered incompatible with sustainable agriculture, with only a few exceptions. PAA's broad-spectrum nature and its tendency to oxidize organic matter make it antagonistic to organic farming systems. The short period that it has had a field use label means that there is little experience with how the material fits into organic farming systems. There are a number of reasons to think that it is compatible with a system of sustainable agriculture. Given that the compound is made from and decomposes into acetic acid and water, it appears to have a similar compatibility to those parent substances.

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

[Organic farmer and research plant pathologist]

After reviewing the documentation on Peracetic Acid I recommend that the product should be listed as Synthetic, **Allowed** as a sanitizer for disinfecting surfaces of equipment, floors, walls, and indoor processing and packaging facilities, and as a post-harvest treatment of fruits and vegetable surfaces at the lowest effective dilution possible in the literature. All treated surfaces including vegetables and fruits should be rinsed with water following the treatment. I recommend it should be **Allowed with annotation** as a microbiocide for disinfecting seed and asexually propagated planting material (i.e., bulb, corm, tuber). I recommend that it should be **Prohibited** for soil (including soil mixes) or plant application.

Justification: Peracetic Acid appears to be an effective microbiocide for disinfecting equipment, seeds, plant materials, and as a post-harvest treatment of fruits and vegetables. However, Peracetic Acid is a hazardous substance to work with and therefore protective clothing, eye gear, and respiratory equipment is required (U.S. EPA, 2000). Peracetic acid breaks down to acetic acid, water, and oxygen that naturally occur in the agroecosystem (Alexander, 1991). It has the advantage over chlorination, which can seriously damage aquatic life and the formation of chlorinated hydrocarbons with mutagenic or carcinogenic properties (Arturo-Schaan, 1996). Additionally, the microbial activity of hypochlorite is reliant on environmental factors such as the pH, temperature, organic load, and ionic concentration of the solution and may not be an effective disinfectant if conditions are not monitored closely (Wright et al., 2000). The Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables (U.S. Dept Health and Human Services and Food and Drug Adminstration, 1998) was published as a result of President Clinton's 1997 Food Safety Initiative ("Radio Address of the President to the Nation" January 25, 1997). The guide outlines steps to decrease the probability of contaminating food and food products with food pathogens. Organic growers need to have effective microbiocides available for use in their packaging and processing operations.

Peracetic Acid should be **Allowed with annotation** as a microbiocide for disinfecting seed and asexually propagated planting materiel (i.e., bulb, corm, tuber) used for planting crops. The annotation should be that it is allowed only in cases where there are documented plant or human pathogens or pests present that can not be eliminated by hot water or temperature treatments. Such treatments should be limited to an indoor environment with ventilation systems available and proper handling procedures followed.

Peracetic Acid should be **Prohibited** for soil (including soil mixes) or plant application including use for fireblight. Its broad-spectrum, non-specific mode of action makes it incompatible to organic farming systems. Additionally, its extremely hazardous classification with potential handling, reactivity, and human exposure dangers may have greater implications in situations where the product is sprayed in an outdoor, less controlled environment. There are effective organic alternatives to disinfecting materials used in soil mixes that include heat and steam. For fireblight control cultural practices, copper products and biological control (*Pseudomonas fluorescens*) options are available. Additionally, cultivars with better resistance to the pathogen should be employed. Antibiotics such as oxytetracycline and streptomycin are registered for fireblight and were also recommended by the NOSB to be added to the National List (Austin, 1995).

I recommend that production of the product be limited to the process of obtaining hydrogen peroxide by the electrolysis of water (Kirchner, 1981), and acetic acid by fermentation or distillation from plant sources. Obtaining acetic acid synthesized by hydrolysis of acetylene or oxidation of acetyladehyde (Budavari, 1996) should be prohibited.

Reviewer #2

[Research Entomologist]

Peracetic acid is a strong, oxidizing acid that is being reviewed for possible use in organic crop production because of its antimicrobial properties. It is probably more effective as a disinfectant in aqueous solutions (Greenspan and Margulies 1950) than on biofilms (Ntsama et al. 1997) or in organic waste slurries (Bohm et al. 1983). It may be a better biocide for viruses (Quiberoni et al. 1999) and bacteria (Meyer and Meltz 1999) than it is for fungi (Colgan and Johnson 1998). Some bacteria, such as spore formers, are more resistant (Lensing and Oei 1985).

Possible crop production uses include fireblight control (Hei 2000), bulb disinfestation (Hanks and Linfield 1999; Hanks et al. 1997), as a foliar spray to control greenhouse thrips (Gill et al. 1998), as a postharvest treatment to protect fruits against rot (Brown 1987; Mari et al. 1999; Colgan and Johnson 1998), and as a seed protectant (Wilson 1976). Since it is a synthetic, it would have to be added to the National List before it is used. Although current formulations have stabilizers added, concentrated solutions still pose a problem with fire and explosion. Exposure to aerosols can irritate skin and cause respiratory damage, as explained in the analysis.

As a postharvest treatment of apples and pears, it actually caused increased damage from fungal rots (Colgan and Johnson 1998). It might be more effective for control of brown rot (*Monilinia* sp.) on stone fruit (Mari et al. 1999). As explained below, use in soil is prohibited by the EPA label and may be counter to the principles of sustainable agriculture. Concentrated solutions would probably be needed to disinfest potting soil, and questions of human and environmental safety would have to be answered. Organic methods are already available for this purpose and for thrips control. Though it might have use as a seed protectant, bleach is more effective (Wilson 1976). Though it effectively controlled *Fusarium* sp. and nematodes in vitro, field experiments conducted with treated narcissus bulbs showed that 1-1.5% solutions did not give adequate protection unless a fungicide was added (Hanks and Linfield 1999). Presumably, this would not be possible in organic agriculture. According to Hei (2000), sprays of peracetic acid are not effective for fireblight control. However, injections into trees were effective for this purpose.

Although injections for fireblight control are promising, more data on effectiveness is needed. My recommendation is that field application of this material does not appear to be warranted at this time. Evaluation under OFPA 2119 (m) and answers to specific questions are given below.

<u>Evaluation Under OFPA 2119 (m) Criteria</u>
1. It is a strong oxidizing acid. It would reaction with materials such as pyrethrins if sprayed onto foliage. It would react violently with potting soil mixtures containing organic material. It might be phytotoxic in concentrated solution. Other interactions in processing and livestock production are outside the scope of this review.

2. The LD50 orally in rats is about 315 mg/kg (Busch and Werner 1974). It is a severe skin and respiratory irritant. A solution of 1.5%, which is about half that of peroxide purchased at the drugstore, when applied to the skin of pigs produced “signs of distress, rapid breathing, struggling, lacrimation and coughing.” Reddening of the skin occurred, and after 40 days fissures and scaly crusts began to develop.

The material is not persistent in the environment, and breakdown products are benign. None of the breakdown products are xenobiotics.

The mode of action is oxidation. Electrons are removed from living tissue causing chemical changes, and probably disruption of membranes.

3. Industrial production of this material is probably through oxidation of acetaldehyde using a cobalt acetate catalyst. Another way to produce concentrated solutions is reaction of acetic anhydride, hydrogen peroxide, and sulfuric acid. It can also be made by oxidizing acetic acid in a special generator (Hei 2000). The spent cobalt catalyst would have to be discharged into a toxic waste dump. The other materials could possibly be reacted and diluted with water and discharged into waste water with a special permit.

In processing operations, misuse could cause excessive bleaching of fruits. Concentrations greater than 3% when used in treatment of organic wastes leads to massive amounts of foaming (Bohm et al. 1983). If used without proper protection, lungs and eyes of workers could be damaged. Peracetic acid is unstable and degrades quickly in the environment into water, oxygen and acetic acid. The oxygen can increase the chance of fire, and acetic acid is itself a respiratory irritant. Otherwise, the active ingredient seems to pose no threat. Stablizers and chelating agents present in the formulations should be separately evaluated. It is possible they are all approved inerts.

4. The material irritates eyes, skin and the respiratory tract. Concentrated solutions are a severe explosion risk. Unstabilized peracetic acid could explode from the friction of being pumped from the container (New Jersey Hazardous Substance Fact Sheet).

Postharvest disinfection vats of produce being treated with dilute solutions could expose workers to low levels that could cause respiratory problems and depress their immune systems (Heinze et al. 1981).

When solutions are heated just to warm water temperatures (40-60°C), heavier than air fumes are released that are flammable in air. There is a danger of fire that releases toxic fumes. If the fire flashes back to the container, an explosion could result (New Jersey Hazardous Substance Fact Sheet). Explosion and fire hazard are more probable with concentrated solutions. Also formulations registered with the EPA have stablizers added that make explosion less likely (Hei 2000).

As pointed out by the review, it is also a possible co-carcinogen.

5. The TAP review does a good job of analysing effects on soil microorganisms. The analysis seems reasonable. There is not enough published information to make a good judgement of its effect on crops. However, according to Hanks and Linfield (1999), it is not effective enough as a disinfectant in horticultural crops, and would have to be used with a chemical fungicide. Presumably, this would not be possible in an organic operation. As a postharvest sterilant for apples and pears, it actually caused increased damage from fungi (Colgan and Johnson 1998). This was possibly because it killed microbials on the surface that were antagonistic to the pathogens. Effects on livestock are not part of this review.

6. Organic alternatives for postharvest handling include steam, hot water, and treatment with biocontrol microbials. As mentioned in the TAP review, cultural controls, biocontrol, and copper is available for fireblight. Possibly, antibiotics will be added to the National List.

7. Broad spectrum soil sterilants generally do not fit in the concept of sustainable agriculture. Composts, manure, and various soil amendments are added to achieve the proper microbial balance. Pathogens can be selectively destroyed by solarization.

There is not enough information to evaluate effects on sustainable agriculture when used as a foliar spray, a seed treatment, or as a solution for injection into trees.

How it fits into processing and organic livestock production is outside the scope of this review.

Answers to Specific Questions

1. The fireblight label is relatively recent. Is it too early to tell if it should be sprayed on trees? Is that regular (Section 3), Experimental Use Permit (Section 5) or Special Local Need (Section 24 c) registration.

According to Hei (2000), topical application of the material is not that effective for fireblight control. He may be somewhat biased, as his patent is for injection into the cambium layer of trees.

If it is sprayed on trees, workers and those in the way of drift would be at risk. Inhalation of aerosols could damage lungs. Eyes could be damaged. Workers would have to use respiratory protection, eye protection, and protective clothing.

If a company wanted to register for fireblight control, it seems like the easiest thing to do would be to register with an experimental use permit, then conduct field trials to get the necessary data for a regular registration. I believe that Hei (2000) Larose and and Abbot (1998) and others conducted their experiments in greenhouses.

To register as a Special Local Need (24 c), I believe the State can apply to extend a registration for an additional use. To register there must be "an existing or imminent pest problem within a state for which the state lead agency, based upon satisfactory supporting information, has determined that an appropriate federally registered pesticide product is not sufficiently available." There are antibiotics already registered for fireblight control. The state must show that these are not effective before getting a 24c for this material. Also, tolerances must have already been established before this registration can be obtained. I don't know if this has been done.

For a company to register for this application, the experimental use permit followed by a regular registration would be the way to go.

It seems like it would be much easier to get a registration for injections into the trees. Then there would be less chance of environmental and health consequences.

2. It is not EPA labeled for soil application at this time. However, the label appears to allow use in potting media. Is this a correct interpretation? What should be the organic status of this use?
The label for Tsunami™ 100 does not mention disinfection of potting soil. It is labeled for dipping or spraying fruits and vegetables to disinfect them. Although I did not look at all the labels of the 21 currently registered products (EPA 2000), it seems most of them are registered for disinfection of equipment, surfaces, etc. I think the potting soil concept is a stretch. Because compost, peat, biosolids and other organic materials are present in potting soils, concentrated solutions would have to be used to be effective. Addition to potting soil would produce a violent exothermic reaction, foaming and fumes. There would be a possibility of fire.

As far as the organic status for potting soil, other alternatives such as steam and solarization are available. To use the material at all, it would have to be added to the National List. Also, it is not true that the material leaves no residue. Peracetic acid leaves no residue, but all the formulations have other material added to reduce the chance of explosion. Most of the registered formulations have surfactants added to make them more effective. Xenobiotics such as 1-hydroxethylidene-1,1-diphosphonic acid are common additives. Approved inerts would have to be used in the formulation.

3. It is not clear what applications are used by organic farmers. While there are several references to cleaning equipment—such as greenhouse and transplant tools, and irrigation installations—data and information on the OFPA criteria for use are not readily accessible in the literature.
I believe that disinfecting equipment, if done indoors, would be consistent with the EPA label and would not violate OFPA. However, I agree the published literature on this is sparse.

4. Should peracetic acid be allowed in organic crop production? Is there a need for an annotation? If so, for what? To clean equipment and for indoor uses? What about irrigation equipment? Should field uses be allowed?
I do not know if organic farmers and farmworkers can handle concentrated solutions of peracetic acid safely. If they are dealing with a more dilute, stabilized material such that fire and explosion risks are minimized, then it could be used as a replacement for bleach as a disinfectant of equipment. I believe the EPA label does not allow it to be discharged into outside irrigation lines.

It possibly has a use as a postharvest disinfectant of fruits and vegetables, but I believe that is covered in another TAP review. Similarly, uses in the organic dairy industry would probably be covered in another review.

I do not think that sprays of this material into tree foliage is a good idea. If it turns out that injection of dilute solutions into trees can stop fireblight, then it might be worth adding it to the National List for that purpose only.

I agree that field application of this material does not appear to be warranted at this time.

5. Peracetic acid does not appear on the EPA master list of inert ingredients, and is therefore List 3 by default. Should the NOSB consider its use as an inert ingredient? What about the stabilizers? Should these be considered in a separate TAP review or are they incidental when PAA is used as an inert? What about when it is used as an active.
I do not see any justification for considering the oxidizing, corrosive, flammable, and explosive PAA as an inert. It injures living material and is a biocide. What did you have in mind? I cannot think of any approved pesticide where this could be considered an inert material. The stabilizers and other additives should be evaluated as part of the approval process for this material.

[E-mail vote on these two sentences in "Suggested Annotation:" Allowed to disinfect seed and asexually propagated planting material (i.e., bulb, corm, tuber) used for planting crops. From hydrogen peroxide and fermented acetic acid sources only.] I support the position that peracetic acid should be obtained from fermented acetic acid sources and peroxide, if this is technically possible and is overall the most environmentally friendly production method. If approved for

organic production, it should be allowed for disinfecting seeds, bulbs, etc. Those who use it in this way, however, should be advised of its efficacy.

Reviewer #3

[Organic farmer and geologist with hazardous materials experience]
Production from petrochemical sources is against one of the core values of organic production, specifically the value of producing crops without dependence or reliance on the petrochemical industry. This is a farmer reaction to both the negative environmental consequences of oil production and the economic constraints of petrochemical based agricultural production. There is a viable alternative manufacturing method. Based on this information, I support Annotation #1 "manufactured from hydrogen peroxide and acetic acid sources only."

The dangerous effects are primarily to workers and NOT to consumers or the environment. Based on this information I support Annotation #2 "All organic personnel handling this material must be informed of its possible co-carcinogenic properties." As a farmer, this is the type of information I would like to have. One of its uses would be to reinforce the importance of handling the material according to specifications. I would also like to know the level of potential danger at concentrations likely to be used when to washing apples for juice or salad mix. I suggest that peracetic acid users be provided a summary of this finding (Bock, Meyers, and Fox, 1976). Any new work is done in this area that information be made available as well. This may be a responsibility put on certification agencies and or the manufacturers of the material as well as farmers.

I suggest that the statement on *[its compatibility with a system of sustainable agriculture]* could be strengthened. Given that the compound is made from and decomposes into acetic acid and water, it appears to have a similar compatibility as the parent substances, therefore PAA should be considered compatible with an organic system of sustainable agriculture.

It too early to tell if peracetic acid should be sprayed on trees. I believe it should be annotated as allowed with Experimental Use Permit after alternatives including biocontrols have been tried. (Annotation #3). Peracetic acid is not EPA labeled for soil application at this time. However the label appears to allow use in potting media. It should be allowed for use in certified indoor nurseries if needed for production of organic starts

Commercially formulated peracetic products are relatively new on the market and organic growers are only now becoming aware of them. The NOSB should consider what current applications used in organic production would the use of peracetic acid be an improvement over existing materials and practices. One area of improvement (in the sense of being more closely aligned with OFPA criteria) to look towards is its use as a method of cleaning irrigation systems, greenhouse sanitation, tools etc. Another area of improvement to consider is its use for foreseeable problems of post harvest sanitation, esp. salad mixes, fruits and root crop washes. Sanitation problems in these areas have already damaged organic markets. Part of the problem is the reluctance of organic farmers to use common sanitizers such as chlorine and ammonia, in part due to organic regulations. While there are several references to cleaning equipment such as greenhouse and transplant tools, and irrigation installations data and information on the OFPA criteria for such uses are not readily accessible in the literature.

My general understanding of applying OFPA criteria for these sanitizers is whatever is washed with a sanitizer, needs to be double or triple washed with water. In cases where the water source is not clean (which is common for ag water) this is counterproductive. In situations where food products are involved, the residual effect of the sanitizer is often needed for preservation. This material does not appear to require a wash before the surface comes into contact with organic food.

Other crops should be applied for on a crop by crop basis based on emergency crop needs. This area may need to be under the discretion of the certification agency. Peracetic acid does not appear on the EPA master list of inert ingredients, and is therefore List 3 by default. I am not aware of peracetic acid being used as an inert ingredient in any formulation. The NOSB should not consider its use as an inert ingredient. How can a material this reactive be truly inert in anything?

The stabilizers should be considered incidental. This question should stay open to new knowledge. Specifically, if a List 4 stabilizer becomes known and works well it should be allowed and products using List 3 stabilizers should be disallowed. Disinfecting washwater is very significant for organic products. It is one of the main reasons for allowing its use in organic production. Especially this section "5% acetic acid and peroxyacetic acid solutions were the most effective, causing reduction of 3.1 and 2.6 log units,respectively, without apparent sublethal injury (Wright et al., 2000)."

The conclusion that "PAA is effective, cheap, non-toxic to mammals and not harmful to the environment" places peracetic acid in the category or a synthetic that fits organic criteria. Any material that has these characteristics should be strongly considered for use in organic systems (Lagger, 1998).

Conclusion
While pre-planting, production aid, and post-harvest uses all appear consistent with OFPA and existing organic standards, field application of this material does not appear to be warranted at this time.

I believe the conclusion should include experimental use on fireblight after documented alternatives including biocontrols have been tried. The reasons for this include:

1) That this use is primarily on tree crops and fruit above the soil. It is likely to have some impact on the soil but not the same degree as a pre-planting soil drench or application to a field crop.
2) If it is permitted for post-harvest washing then why shouldn't it be allowed on the crop ten minutes earlier? If it is allowed ten minutes before eating a piece of fruit, then it should be allowed to be used two months earlier when it would be more effective at lower rates.
3) The main reason for not allowing field appliations is environmental damage to the soil. I am against allowing it as a field soil drench. There may be some value in allowing it as a drench for potted plants in certified nurseries. In many cases, especially in Hawaii and California, it may be necessary to pass agricultural regulations on transportation of soil bearing plant materials. Allowing its use in this situation could contribute to production of many more organic starts. Since the OFPA regulations call for growers to use organic starts when possible, this would increase the possibility of using organic starts instead of conventional ones for many large scale organic farms. The reasoning here is if organic starts can't be found then conventional ones are allowed for organic production, which may have much worse environmental consequences that allowing peracetic acid for this specific use.

Therefore I support Annotation #4 "Allowed for use in certified indoor nurseries if needed for production of organic starts."

The substance is SYNTHETIC
Summary Recommendation: ALLOWED
Suggested annotations:
1. Manufactured from hydrogen peroxide and acetic acid sources only
2. All organic personnel handling this material must be informed of its possible co-carcinogenic properties
3. Allowed for fireblight control with Experimental Use Permit with documentation that alternatives including biocontrols have been tried
4. Allowed for use in certified indoor nurseries if needed for production of organic starts.

Conclusion

While pre-planting, production aid, and post-harvest uses all appear consistent with OFPA and existing organic standards, field application of this material does not appear to be warranted at this time.

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