

# Sucrose Octanoate Esters

Crop

## Identification of Petitioned Substance

### Chemical Names:

sucrose octanoate esters

### CAS Numbers:

15 CAS NO. 42922-74-7 (mono-octanoate), 58064-47-4  
16 (dioctanoate)

### Other Name:

( $\alpha$ -D-glucopyranosyl- $\beta$ -D-fructofuranosyl-  
octanoate), mono-, di-, and triesters of sucrose  
17 octanoate

### Other Codes:

OPP Chemical Code: 035300

### Trade Names:

Avachem Sucrose Octanoate Manufacturing Use  
Product  
Avachem Sucrose Octanoate [40%]

## Characterization of Petitioned Substance

### Composition of the Substance:

Sucrose octanoate esters (SOEs) belong to the organic chemical family sucrose fatty acid esters (SFAEs).<sup>1</sup> SFAEs are surfactants (or surface active agents) that lower the surface tension of a liquid, allowing easier spreading and evaporation. Surfactants are usually organic compounds that contain both hydrophobic (fat-soluble) and hydrophilic (water-soluble) groups (Wikipedia, n. d.). SFAEs have sucrose residues as the hydrophilic group and fatty acid residues as the lipophilic group. SOEs are manufactured from sucrose (table sugar) and an octanoic acid ester commonly found in plants and animals. Sucrose esters, as a class of related compounds, vary depending on the number and locations of esters attached to the sucrose molecules. Sucrose has eight potential places where individual esters may attach (Montello Inc., n. d.). The substance under review is a mixture of mono-, di-, and triesters.

Sucrose esters were first isolated when researchers investigated the insecticidal properties of the tobacco leaf hairs. This insecticidal property of sucrose esters acts by dissolving the waxy protective coating (cuticle) of target pests, causing them to dry out and die (U.S. EPA, 2002b). SOEs marketed as biopesticides are intended to mimic the pest control properties of *Nicotiana glauca* (wild tobacco) and other *Nicotiana* species. In addition to the tobacco plant, insecticidal sugar esters have been found in wild tomato and wild potato species and in the petunia plant (Chortyk et al., 1996). According to the petitioner, naturally occurring sugar ester biopesticides are present at low concentrations in their host plants; the highest-yielding plant, *Nicotiana glauca*, has less than three grams of sucrose esters per kilogram of plant material (Barrington, 2004a).

### Properties of the Substance:

Product Chemistry (U.S. EPA, 2002a)	
Color	Amber
Physical State	Liquid
Odor	Faint sweet smell
Melting Point	Exists in liquid state

<sup>1</sup> An ester is a product of the reaction of an acid and an alcohol, notable as sweet smelling organic compounds produced by plants and fruits, such as pineapples and oranges. The most common esters found in nature are fats and vegetable oils. [Source: <http://en.wikipedia.org/wiki/Ester>]

<b>Boiling Point</b>	Decomposes above 221°F/105°C
<b>Solubility</b>	Forms an emulsion with water
<b>Stability</b>	Stable below 104°F/40°C
<b>Oxidizing or Reduction Action</b>	Does not contain an oxidizing or reducing agent
<b>Flammability/Flame Extension</b>	None; decomposes above 221°F/105°C
<b>Explosibility</b>	Not potentially explosive
<b>Miscibility</b>	Not to be diluted using petroleum solvents

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 46 **Specific Uses of the Substance:**  
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 48 SOE is an EPA-registered biopesticide. As a biopesticide, SOEs are currently used as an insecticide to  
 49 control certain soft-bodied insects (e.g., mites, aphids, thrips, whiteflies and psyllids (Puterka, n. d.)). SOEs  
 50 are permitted by EPA for use as a biopesticide for foliar spray in field, greenhouse, and nursery use on any  
 51 type of agricultural commodity (including certain non-food ornamentals), as well as on mushroom-  
 52 growing media and on adult honey bees (U.S. EPA, 2002a).

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 54 The control of *Varroa* mites on honeybees was the initial petitioned use for SOEs. An amendment to the  
 55 petition extends the request to include the other EPA-approved pesticide uses (foliar spray on greenhouse,  
 56 nursery, and field crops, and *Sciarid* fly control in mushroom-growing media). This review addresses the  
 57 petitioned use for crops (i.e., greenhouse, nursery, and field crops; *Sciarid* control on mushrooms). The  
 58 petitioned use for livestock is addressed in a separate report.

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 60 **Approved Legal Uses of the Substance:**

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 62 The primary commercial uses of SOEs are as biopesticide and as an emulsifier, texturizer, or protective  
 63 coating for certain foods.

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 65 **In foods, sucrose fatty acid esters may be used as emulsifiers, stabilizers, texturizers, and components of**  
 66 **protective coatings applied to fresh fruits to retard ripening and spoiling (21CFR172.859, 2004). (See FDA**  
 67 **Status Section, below.)**

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 69 SOEs are also approved for use as a contact-type biochemical insecticide/miticide (EPA Registration  
 70 Number 70950-2, OPP No. 035300) to control soft-bodied insects (Puterka, n. d.). In particular, EPA has  
 71 registered SOEs as a biopesticide for foliar spray on greenhouse, nursery, and field crops; for *Sciarid* fly  
 72 control in mushroom-growing media; and for *Varroa* mite control on honeybees (Barrington, 2004a). (See  
 73 EPA Status Section, below.)

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 75 **Action of the Substance:**

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 77 Sucrose octanoate esters act as biopesticides by dissolving the waxy protective coating (cuticle) of target  
 78 pests (e.g., mites), causing them to dry out and die (Puterka and Severson, 1995).

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 80 **Status**

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 82 **EPA**

83 In 2002, EPA approved SOEs for use as the active ingredient in the end-use product, Avachem Sucrose  
 84 Octanoate [40.0%] (U.S. EPA, 2002b) (Avachem Sucrose Octanoate Manufacturing Use Product for  
 85 formulating into biochemical insecticide/miticide end-use products, EPA Registration Number 70950-1;  
 86 Avachem Sucrose Octanoate [40.0%] for use as a biochemical insecticide/miticide end-use product, EPA  
 87 Registration Number 70950-2). The approve target pest and use sites include:

- 88  
 89 (1) Mites and soft-bodied insects on food and non-food crops, including certain ornamentals;  
 90 (2) Immature forms of certain species of gnats found in media used for growing mushrooms; and  
 91 (3) *Varroa* mites on adult honey bees.

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93 The approved application method is spray with ground equipment (U.S. EPA, 2002b).

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95 EPA's registration review concluded that no FFDCAs tolerance level is required for SOE residues in or on  
96 any food commodity. EPA arrived at this conclusion as a result of data that demonstrated no toxicity,  
97 except from ocular exposure (discussed in Evaluation Question #11, below) (U.S. EPA, 2002a).

98  
99 **FDA**

100 Since 1983, the US Food and Drug Administration (FDA) has allowed sucrose fatty acid esters, including  
101 SOEs, to be added to certain processed foods (21CFR172.859, 2004). Sucrose fatty acid esters may be used  
102 as emulsifiers or as stabilizers in baked goods and baking mixes, in chewing gum, in coffee and tea  
103 beverages with added dairy ingredients and/or dairy product analogues, in confections and frostings, in  
104 dairy product analogues, in frozen dairy desserts and mixes, and in whipped milk products. They also are  
105 allowed to be used as texturizers in biscuit mixes, in chewing gum, in confections and frostings, and in  
106 surimi-based fabricated seafood products. They may also be used components of protective coatings  
107 applied to fresh apples, avocados, bananas, banana plantains, limes, melons (honeydew and cantaloupe),  
108 papaya, peaches, pears, pineapples, and plums to retard ripening and spoiling. Sucrose fatty acid esters  
109 must be used in accordance with current good manufacturing practice and in an amount not to exceed that  
110 reasonably required to accomplish the intended effect (21CFR172.5, 2003).

111  
112 **International**

113 SOEs are not specifically listed for the petitioned use or other uses in the following international organic  
114 standards:

- 115
- 116 • Canadian General Standards Board
  - 117 • CODEX Alimentarius Commission
  - 118 • European Economic Community (EEC) Council Regulation 2092/91
  - 119 • International Federation of Organic Agriculture Movements
  - 120 • Japan Agricultural Standard for Organic Production

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122 However, some organic standards do allow the use of some natural *Nicotiana*-derived products that most  
123 likely contain small amounts of sucrose esters, including SOEs, for pest control:

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- 125 • The Canadian General Standards Board allows the introduction of botanical compounds (e.g.,  
126 menthol, vegetable oils, essential oils, herbal teas) in honey production (Canadian General  
127 Standards Board, 1999).
  - 128
  - 129 • Codex Alimentarius allows the use of tobacco tea (except pure nicotine) to combat a pest  
130 infestation (Codex Alimentarius Commission, 2001).
  - 131
  - 132 • The EEC Council Regulation allowed the application of an extract (aqueous solution) from  
133 *Nicotiana tabacum* as an insecticide only against aphids in subtropical fruit trees (e.g., oranges,  
134 lemons) and tropical crops (e.g., bananas); it can be used only at the start of the vegetation  
135 period. This permission expired March 31, 2002 (European Economic Community, 1991).
  - 136
  - 137 • The International Federation of Organic Agriculture Movements allows the use of tobacco tea  
138 as a crop protectant, but pure nicotine is forbidden (IFOAM, 2002).

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## Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

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

SOEs are manufactured in an eight-step process that uses as raw materials a sugar, a fatty acid, and an alcohol, and relies on a number of catalysts and solvents. The process is patented because of its unique solvent recovery and reuse properties (Patent #5,756,716) and is described below:

“First, a fatty acid and methyl or ethyl alcohol is reacted in the presence of sulfuric acid catalyst to produce a fatty acid ester and water. The sulfuric acid catalyst is neutralized with a metal carbonate to make a metal sulfate, with the fatty acid ester being separated from the metal sulfate, the alcohol, and the water. The recovered fatty acid ester is reacted in the presence of a metal carbonate catalyst with sugar dissolved in dimethyl sulfoxide to produce the sugar ester product and alcohol. The dimethyl sulfoxide is separated from the reaction mixture by vacuum distillation, and then water is added to emulsify the sugar ester product and unreacted fatty acid ester. The unreacted sugar and the metal carbonate are dissolved in the water. Next, the emulsified sugar ester product and unreacted fatty acid ester is separated from the water containing dissolved unreacted sugar and metal carbonate by breaking the emulsion of the sugar ester product and unreacted fatty acid ester. The sugar ester product is purified by dissolving the unreacted fatty acid ester in ethyl acetate, and substantially all the dimethyl sulfoxide, alcohol, and ethyl acetate is recovered for reuse in the process. Finally, substantially all the unreacted sugar in a concentrated useful form is recovered.” (U.S. Patent and Trade Office, 1998)

According to the commercial manufacturer of SOEs, it is not possible to extract the naturally occurring sugar esters in sufficient quantity to be commercially viable (AVA Chemical Ventures, 2002).

### **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).)**

As described above, commercially used SOEs are manufactured by a multi-step chemical process that requires a number of catalysts and solvents. The raw materials (sugar, fatty acids, alcohol) for the process can be extracted from naturally occurring sources. However, the petitioner does not specify whether natural sources of raw materials would be used to manufacture SOEs for the petitioned use. The petitioner does not specify whether the various reagents used in the manufacturing process (sulfuric acid, potassium carbonate, dimethyl sulfoxide) would be from natural or synthetic sources, but it is more likely that synthetic reagents would be used. During the process, these raw materials undergo several reactions that substantially change their chemical composition, and produce the material under review, SOEs.

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

SOEs occur naturally in some plants, as a result of normal plant metabolic functions. The exact process that occurs in nature has not been documented, but it is not the same as the commercial manufacturing process, which entails the use of sulfuric acid and metal carbonate catalysis, filtration, transesterification, refluxing, vacuum and fractional distillation, decanting, and centrifugation.

### **Evaluation Question #4: Is there environmental contamination during the petitioned substance’s manufacture, use, misuse, or disposal? (From 7 U.S.C. § 6518 (m) (3).)**

*Manufacturing:* The petitioner has selected a patented commercial manufacturing process that recovers and reuses much of the solvents used, and has no liquid waste streams and minimal air (U.S. Patent and Trade Office, 1998).

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195 *Approved Usage:* Using SOEs as a field, greenhouse, or nursery pesticide to control soft-bodied insects on  
196 any type of agricultural commodity (including certain non-food ornamentals) and on mushroom-growing  
197 media are two approved agricultural/horticultural applications. When applied according to EPA-  
198 approved label directions, no direct exposure of birds or aquatic organisms to SOE is expected (U.S. EPA,  
199 2002a). EPA concluded that it was not necessary for the petitioner to submit environmental fate and  
200 groundwater data, because the risk is expected to be minimal due to the lack of exposure, low toxicity, use  
201 pattern, and application methods for all approved uses. However, the label includes the following  
202 precautionary statement against applying SOEs directly to:

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204 “water, or to areas where surface water is present or to intertidal areas below the mean high water  
205 mark. Nor should SOEs contaminate water when cleaning equipment or disposing of equipment  
206 wash waters. In addition, spray should not be allowed to drift from the application site and  
207 contact people, structures people occupy at any time and the associated property, parks and  
208 recreational areas, non-target crops, aquatic and wetland areas, woodlands, pastures, rangelands  
209 or animals. SOEs should be applied only when wind speed is not more than 10 mph, and for  
210 sprays, the largest size droplets possible should be applied.” (Barrington, 2004a [Avachem Sucrose  
211 Octanoate label])  
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213 In addition, SOEs biodegrade within approximately five days at approximately 68-80.6°F/20-27°C, in both  
214 aerobic and anaerobic conditions, so minimal potential for exposure exists to insects, fish, and other non-  
215 target wildlife as a result of SOE use (U.S. EPA, 2002a).  
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217 *Misuse:* The precautionary statement listed above implies a potential for adverse effects resulting from  
218 misuse of the product.  
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220 *Disposal:* The EPA-approved label requires disposal of SOEs on site or at an approved waste disposal  
221 facility to mitigate any secondary contamination.  
222

223 **Evaluation Question #5: Is the petitioned substance harmful to the environment? (From 7 U.S.C. § 6517**  
224 **(c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i).)**  
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226 EPA evaluated potential environmental risks associated with sucrose fatty acid esters in the *Biopesticides*  
227 *Registration Action Document* (U.S. EPA, 2002a). EPA concluded that it expected no risks to the environment  
228 from the use of SOE as a biopesticide because:

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230 (1) The esters biodegrade rapidly and therefore do not persist in the environment.  
231

232 (2) The esters are not toxic to mammals or other non-target organisms.  
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234 (3) Organisms are already exposed because these sucrose esters are found in plants.  
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236 (4) The tiny amounts used in pesticide products are not expected to substantially increase the  
237 amount of these esters in the environment (U.S. EPA, 2002b).  
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239 **Evaluation Question #6: Is there potential for the petitioned substance to cause detrimental chemical**  
240 **interaction with other substances used in organic crop or livestock production? (From 7 U.S.C. § 6518**  
241 **(m) (1).)**  
242

243 As stated in Evaluation Question #4, SOEs do not persist in the environment and biodegrade within  
244 approximately five days at approximately 68-80.6°F/20-27°C, in both aerobic and anaerobic conditions  
245 (U.S. EPA, 2002a). This minimizes the opportunity for SOEs to chemically interact with other agricultural  
246 substances within an agricultural environment. Prior to biodegradation, it is possible for SOEs to act as an  
247 unwanted surfactant with detrimental effects, but no information sources reviewed for this report  
248 described or evaluated potential adverse impacts of this nature.

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**Evaluation Question #7: Are there adverse biological or chemical interactions in the agro-ecosystem by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)**

The petitioner reports that SOEs have been tested on a range of crops, including almond, apple, pear, citrus, cotton, grape, peach, lettuce, tomato, mint, cabbage, melon, and several ornamental crops, including rose and poinsettia, and no phytotoxicity has been reported (Barrington, 2004a). SOEs have been demonstrated to be practically non-toxic to the following beneficial insects, all of which are important predators of homopteran pests: Lady Beetles (*Harmonia* spp., *Curinus coeruleus* Mulsant, *Cycloneda sanguinea* L., *Olla v-nigrum* Mulsant), Green Lacewing (*Chrysopidae rufilabris*), Red Scale Parasoid (*Aphytis melinus* De Bach), Insidious Flower Bug (*Orius insidiosus* Say) (Michaud and McKenzie, 2004), and honey bees (*Apis mellifera* L) (LD50 > 80 ug/bee) (U.S. EPA, 2002a). In addition, SOEs biodegrade quickly (U.S. EPA, 2002a), which reduces the potential for adverse biochemical or chemical interactions.

**Evaluation Question #8: Are there detrimental physiological effects on soil organisms, crops, or livestock by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)**

Michaud and McKenzie (2004) found that SOEs are not poisonous to many beneficial insects (See Evaluation Question #7). However, available information sources do not address the potential for SOEs to cause detrimental physiological effects on soil organisms or other insects not studied by Michaud and McKenzie.

EPA concluded, based on published data, that it is unlikely that any toxic effects will occur in birds, freshwater fish, freshwater aquatic invertebrates, and/or non-target plants, when SOEs are used according to label directions (U.S. EPA, 2002a). In addition, as noted by the petitioner, SOEs occur naturally (at low concentrations) in certain crop and non-agricultural plants (Barrington, 2004a) and are a normal part of animal diets (U.S. EPA, 2002a). This suggests that crop and livestock exposure will have no detrimental physiological effects.

**Evaluation Question #9: Is there a toxic or other adverse action of the petitioned substance or its breakdown products? (From 7 U.S.C. § 6518 (m) (2).)**

Breakdown products of SOEs include sucrose, fatty acids, carbon dioxide, and water, all of which are non-toxic (Wayman, 1971).

**Evaluation Question #10: Is there undesirable persistence or concentration of the petitioned substance or its breakdown products in the environment? (From 7 U.S.C. § 6518 (m) (2).)**

SOEs are rapidly biodegradable, and do not persist or accumulate in the environment (U.S. EPA, 2002a).

**Evaluation Question #11: Is there any harmful effect on human health by using the petitioned substance? (From 7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i) and 7 U.S.C. § 6518 (m) (4).)**

EPA has not identified any subchronic, chronic, immune, endocrine, dietary, or nondietary exposure issues for SOEs in children or the general U.S. population (U.S. EPA, 2002a). In fact, EPA estimated that the SOE acceptable daily intake (ADI) for humans is equivalent to 2.82 lb of SOEs per day for a 176 lb person (U.S. EPA, 2002a).

However, rabbits subject to ocular and dermal exposure to undiluted manufacturing-use SOEs showed irritation that usually resolved in 14 days and 24 hours, respectively. EPA concluded that these reactions are unlikely when SOEs are used according to label directions, which include precautions regarding ocular exposure risks (U.S. EPA, 2002a).



303 **Evaluation Question #12: Is there a wholly natural product that could be substituted for the petitioned**  
 304 **substance? (From 7 U.S.C. § 6517 (c) (1) (A) (ii).)**  
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306 *Petitioned Use: Biopesticide for Foliar Spray in Field, Greenhouse, and Nursery Use on Any Type of Agricultural*  
 307 *Commodity (Including Certain Non-Food Ornamentals)*  
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309 The breadth of this petitioned use for SOEs use means that there are numerous approved natural products  
 310 that serve as alternatives for some or all of the targeted crops. Whether SOEs would be the preferred  
 311 choice, based on efficacy, safety, or economic standards, needs to be determined on a case-by-case basis.  
 312 However, the petitioner reports some relative effectiveness data that compare SOEs to some natural,  
 313 industry-recognized materials (and products) that have soft-bodied insecticidal uses similar to those of  
 314 SOE (see Table 1) (Barrington, 2004c). The effectiveness data are derived from one non-peer reviewed  
 315 study of the substances’ effectiveness for mealybug control with organic pineapples. The study also  
 316 reports some environmental safety limitations, such as threats to wildlife from the use of the alternatives  
 317 under study. This study found that no other product performs better than SOEs as an insecticide for  
 318 mealybugs (Taniguchi, 2003). However given the extremely limited nature of the reported results from this  
 319 study, it would be difficult to declare conclusively that SOEs are more effective than the materials already  
 320 recognized for this use by the organic industry.

321 *Petitioned Use: Sciarid Control on Mushroom-Growing Media*  
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323 The petition and industry resources identify several natural products currently available to control pests on  
 324 mushroom-growing media. For example, products formulated with neem extract have been used by  
 325 organic mushroom growers to successfully control sciarid flies (fungus gnats), but anecdotally have been  
 326 reported by the petitioner to have a detrimental effect on beneficial insects, as well (Barrington, 2004b).  
 327 Another industry-recognized product is a formulation of *Bacillus thuringiensis* (*Bt*) that controls the larval  
 328 stage of *Sciarid* mushroom flies (Valent BioSciences, n. d.). The safety and efficacy of these products  
 329 relative to SOEs is unknown. The petitioner has identified some natural industry-recognized classes of  
 330 materials (and products) that have insecticidal uses similar to those of SOE, and their use for *Sciarid* control  
 331 is described in Table 1 (Barrington, 2004c). A non-peer reviewed study of the substances’ effectiveness for  
 332 mealybug control with organic pineapples found that no other product performed better than SOEs  
 333 (Taniguchi, 2003); however, these results are uninformative with regard to their to control fungus gnats on  
 334 mushrooms.  
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336 **Evaluation Question #13: Are there other already allowed substances that could be substituted for the**  
 337 **petitioned substance? (From 7 U.S.C. § 6518 (m) (6).)**  
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339 Soap and petroleum-based oils are two synthetic materials that have industry recognition for use as  
 340 insecticides. See Table 1. The safety and efficacy of these products relative to SOEs is unknown.  
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343 **Table 1. Potential Insecticidal Alternatives**

Material Group	Comments
Neem extracts and derivatives	Nonsynthetic; some products not labeled for mite control; potential bee hazard
Nonsynthetic oils	Nonsynthetic; at least one product labeled for mite control
Petroleum-based oils	Synthetic; toxic to fish
Pyrethrum	Nonsynthetic; products not labeled for mite control; toxic to fish
Soap	Synthetic; potential phytotoxicity

344 Sources: Barrington, 2004c; OMRI, 2004  
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348 **Evaluation Question #14: Are there alternative practices that would make the use of the petitioned**  
349 **substance unnecessary? (From 7 U.S.C. § 6518 (m) (6).)**  
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351 No single agricultural practice will apply to the range of crops and growing conditions under  
352 consideration in this petition. However, there are clearly sanitary, pest management, and maintenance  
353 practices, such as replacing mushroom-growing medium, that can have substantial effect on an insect  
354 infestation (Barrington, 2004c). The safety and efficacy of such these practices relative to SOEs are  
355 unknown.

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