Formic Acid
Livestock

Identification of Petitioned Substance

Chemical Names:
Formic acid

Other Name:
Aminic acid
Formylic acid
Hydrogen carboxylic acid
Metacarbonic acid
Methanoic acid
Oxomethanol

Trade Names:
UN1779

CAS Numbers:
64-18-6

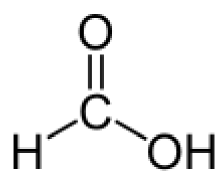
Other Codes:
U.S. EPA PC Code: 214900

Characterization of Petitioned Substance

<u>Composition of the Substance</u>:

Formic acid is the simplest carboxylic acid, which are an organic acids with a carbonyl (i.e., C = O) and hydroxyl (i.e., -O-H) functional groups. The chemical formula of formic acid is HCOOH or HCO_2H and its molecular structure is shown in Figure 1.

Figure 1. Molecular Structure of Formic Acid



Source: Laffitte, 2005

Formic acid is found naturally in small amounts in some fruits and nectars and is a natural component of honey. Formic acid also is present in a natural state in stinging nettles is also present as a defense mechanism in the stings and bites of many insects, including bees and ants (Laffitte, 2005).

<u>Properties of the Substance</u>:

Formic acid is a colorless liquid with a pungent odor. It is considered corrosive to metals and biological tissue and is known to irritate the mucous membranes and blister the skin (NOAA, 2011). It is somewhat soluble in hydrocarbons and most organic solvents, and forms a homogenous mixture (miscible) with water. Functionally, formic acid is not only an acid but also an aldehyde and reacts with alcohols to form esters as an acid. Formic acid is easily oxidized, which is a characteristic property of aldehydes (CDC NIOSH, 2010). The physical and chemical properties of formic acid are summarized in Table 1.

Table 1. Physical and chemical Properties of Formic Acid

Physical or Chemical Property	Value
Physical State	Liquid
Appearance	Colorless, fuming
Odor	Pungent and penetrating
Molecular Weight	46.0
Boiling Point	224 °F (90 percent solution)
Melting Point	47 °F
Freezing Point	20 °F (90 percent solution)
Solubility in Water	Miscible
Vapor Pressure	35 mm Hg
Density	1.22 g/mL, liquid

Source: CDC NIOSH, 2010

Specific Uses of the Substance:

Formic acid has a wide variety of agricultural and industrial uses. In agriculture, formic acid is used as a fumigant to kill the varroa mite (*Varroa jacobsoni*) and tracheal (*Acarapis woodi*) mite, two species that commonly attack beehives. Tracheal mites came to the United States from Mexico in 1984 and varroa mites arrived in 1986 and have spread through all 48 contiguous states (Gegner, 2003). An infestation can quickly destroy an entire hive. Varroa mites live in the hive, attach themselves to the bees' abdomens, and suck the bees' vital fluids. The bees become sick, and the hive slowly dies (Gegner, 2003). Tracheal mites can lay up to 14 eggs in one bee during their 28 day lifespan. New adult tracheal mites then crawl out of the tracheal tubes and transfer onto other bees in the hive. The mites can be spread from hive to hive by the beekeeper transferring bees from hive to hive. Detection of the mites is difficult because no visual symptoms are characteristic of a mite infestation. Detection of small mite populations is difficult and beekeepers are generally advised to assume that some degree of infestation is present (Parise, 2006).

Formic acid can serve as an effective treatment for mite infestations because it harms mites but generally not bees. During treatment, formic acid vapors diffuse through the hive and then dissipate to background levels at the end of the treatment cycle (Health Canada, 2009). One study reported 95 percent tracheal mite mortality in infested hives that received three weekly treatments (30 mL/treatment) of a 65 percent formic acid solution. Only an eight percent mortality rate was reported for mites in an untreated bee colony. In addition, an approximately 95 percent reduction in the percentage of bees infested with tracheal mites (relative to pre-treatment counts) was observed among treated colonies two months after treatment, compared to a 41 percent reduction in the percentage of mite-infested bees found in the untreated hives (Health Canada, 2009).

Formic acid also is used as an antibacterial agent and preservative for livestock feed. Formic acid is sprayed on fresh hay in order to delay or halt decay, thereby allowing the feed a longer survival period. This process is of particular importance in the preservation of winter cattle feed. In poultry farming, formic acid is applied to feed to kill *Salmonella* bacteria. These practices are widespread in Europe, but are not as common in the United States due to the generally low commercial availability of formic acid (Laffitte, 2005; Van Soest, 1994). In addition, the use of formic acid on hay feed may reduce the total milk fat when given to milk cows (Van Soest, 1994).

The many industrial uses of formic acid include the following:

- A reducing and decalcifying agent in dyeing and finishing of textiles;
- An agent for plumping and dehairing hides in leather tanning;
- A solution for electroplating;
- A rubber coagulating agent in the creation of latex rubber and in regenerating old rubber; and

- A component in the manufacture of commercial paint strippers and metal salts, including nickel, cadmium, and potassium (Laffitte, 2005).

Approved Legal Uses of the Substance:

Formic acid is considered by the U.S. Environmental Protection Agency (EPA) as exempted from the requirement of a tolerance in or on honey and honeycomb when used to control tracheal mites and suppress varroa mites in bee colonies, and applied in accordance with label use directions (40 CFR 180.1178).

Formic acid was originally registered (licensed for sale) as a pesticide active ingredient in 1999 for the product, FOR-MITE™ (EPA Reg No 61671-3). A second registration was approved in 2005 for Mite-Away II (EPA Reg No 75710-1). A new product, Mite Away Quick Strips™, was registered by EPA in February of 2011 (NOD Apiary Products, 2011).

The U.S. Food and Drug Administration (FDA) concluded that formic acid should be considered 'generally recognized as safe' (GRAS) (21 CFR 186.1316). FDA found no evidence that demonstrates or suggests reasonable grounds to suspect a hazard to the public when the formic acid is used as an ingredient of paper and paperboard food packaging materials, or when the substance might reasonably be expected to be used for such purposes in the future. In accordance with 21 CFR 186.1(b)(1), formic acid is to be used at levels not to exceed good manufacturing practice. In addition, prior sanctions for formic acid different from the uses established in section 21 of the CFR do not exist or have been waived (21 CFR 186.1316; FDA, 2006).

Formic acid is permitted by FDA for use as a food additive in the feed and drinking water of animals (21 CFR 573.480). Formic acid may be safely used as a preservative in hay crop silage in an amount not to exceed 2.25 percent of the silage on a dry weight basis or 0.45 percent when direct-cut. The top foot of silage stored should not contain formic acid and silage should not be fed to livestock within four weeks of treatment (21 CFR 573.480).

In accordance with 21 CFR 172.515, formic acid is permitted for use as a flavoring agent. Examples of concentrations of formic acid in processed foods are:

Non-alcoholic beverages	1.0 ppm
Ice-cream, ices, etc.	5.0 ppm
Candy	5.0-18.0 ppm
Baked goods	5.0-6.1 ppm
Processed cheese	9.1-28.1 ppm

(Source: EPA, 2011)

Action of the Substance:

When used as a fumigant in beehives, formic acid is used to kill the varroa mites and tracheal mites, two species that are known to infect beehives. Exposure of the mites to formic acid causes death by asphyxiation. The thin exoskeleton of the mite may also contribute to their death following exposure. Formic acid creates fumes strong enough to kill varroa mites and to penetrate cells when the mites feed on pupal and larval bees. Following exposure, the mites are forced to let go of the bees, which typically are not harmed. The heaviest concentration of the formic acid fumes are on the floor of the hive where most mites are killed (EPA, 2010).

Formic acid appears to be highly selective when applied in the correct dose, and bees generally are not harmed (Villalobos, 2009). Fumigant mite control products for beehives generally consist of a gel pad impregnated with formic acid contained in a vented plastic pouch. When used as directed, the product releases vapors of the active ingredient into the beehive, and the mites are killed without substantially disrupting bee behavior or life span (EPA, 2010).

Combinations of the Substance:

No indication as been found that formic acid is used in beekeeping in combination with other substances, including substances on the National List of Allowed and Prohibited Substances (hereafter referred to as the National List). Because formic acid is added to the interior space of the hive, it is unlikely that it will react with any other substances used outside the hive in organic crop and livestock production or handling (Health Canada, 2009).

Status

Historic Use:

Historically, formic acid has been used as an antibacterial agent and preservative for livestock feed. Formic acid is applied to hay in order to delay or halt decay, thereby allowing the feed a longer usable period. This use is of particular importance in the preservation of winter cattle feed. For poultry feed, formic acid is applied to kill *Salmonella* bacteria. These practices are still widespread in Europe, but are not common in the United States (Laffitte, 2005).

As a fumigant, formic acid vapors are released inside of beehives to kill invasive mite species. Varroa mites and tracheal mites threaten honeybee populations across the United States. Microscopic tracheal mites lay eggs in the abdominal breathing tubes of the bee and their larvae feed on the bee after the eggs hatch.

OFPA, USDA Final Rule:

The petitioned substance does not appear on the National List. It has been petitioned for listing in 7 CFR 205.603 (for use in organic livestock production).

International

The Canada Food Inspection Agency, Food and Drug Regulations (last modified in 2009), permit the use of formic acid in organic agriculture for silage preservation when weather conditions are unfavorable to fermentation. Formic acid is also permitted for apicultural use to control parasitic mites, and can specifically be used after the last honey harvest of the season. Use of formic acid products must be discontinued 30 days before the addition of honey supers (i.e., trays within a beehive that may be removed to collect honey) (Canadian General Standards Board, 2009).

The European Economic Community (EEC) Council Regulation permits the use of formic acid when protecting frames, hives, and combs that may be infested with the mite species *Varroa destructor* (Regulation EC No. 889/2008). Formic acid also is permitted as a feed additive for silage preservation only when weather conditions do not allow for adequate fermentation[1] (Regulation EC No. 889/2008).

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

Evaluation Question #1: What category in OFPA does this substance fall under: (A) Does the substance contain an active ingredient in any of the following categories: copper and sulfur compounds, toxins derived from bacteria; pheromones, soaps, horticultural oils, fish emulsions, treated seed, vitamins and minerals; livestock parasiticides and medicines and production aids including netting, tree wraps and seals, insect traps, sticky barriers, row covers, and equipment cleansers? (B) Is the substance a synthetic

[1] Formic acid is an additive for silage preservation. Chemicals used as silage preservatives inhibit undesirable bacterial and mold growth. Formic and propionic acids enhance the preservation of forage. The major benefit of adding weak acids to silage appears to be in reducing spoilage in open storage structures (Schroeder, 2004).

inert ingredient that is not classified by the EPA as inerts of toxicological concern (i.e., EPA List 4 inerts) (7 U.S.C. § 6517(c)(1)(B)(ii))? Is the synthetic substance an inert ingredient which is not on EPA List 4, but is exempt from a requirement of a tolerance, per 40 CFR part 180?

(A). Formic acid is considered a livestock parasiticide.

(B). Formic acid is exempt from a requirement of tolerance in or on honey and honeycomb when used to control tracheal mites and suppress varroa mites in bee colonies, and applied in accordance with label use directions (40 CFR 180.1178). The formic acid that is used in fumigant products is the synthetic form (EPA, 2010).

<u>Evaluation Question #2:</u> Describe the most prevalent processes used to manufacture or formulate the petitioned substance. Further, describe any chemical change that may occur during manufacture or formulation of the petitioned substance when this substance is extracted from naturally occurring plant, animal, or mineral sources (7 U.S.C. § 6502 (21)).

A significant amount of formic acid is produced as a byproduct in the manufacture of other chemicals, such as acetic acid. However, these sources do not meet the present demand, and additional formic acid is manufactured using the process described below (HSDB, 2010).

Formic acid is synthesized in a process that begins with the hydrolysis of methyl formate. Methanol is also a byproduct of this reaction. First, methanol and carbon monoxide are combined along with a strong base, such as sodium methoxide. Methyl formate (HCO_2CH_3) is produced. This reaction is performed in the liquid phase at an elevated pressure. Typical reaction conditions are 80° C and 40 atm.

$$CH_3OH + CO \rightarrow HCO_2CH_3$$

Next, methyl formate is hydrolyzed and produces formic acid.

$$HCO_2CH_3 + H_2O \rightarrow HCO_2H + CH_3OH$$

Source: HSDB, 2010

<u>Evaluation</u> <u>Question #3:</u> Is the substance synthetic? Discuss whether the petitioned substance is formulated or manufactured by a chemical process, or created by naturally occurring biological processes (7 U.S.C. § 6502 (21).

Synthetic formic acid is being proposed for inclusion on the National List. The primary manufacturing process is discussed in Evaluation Question #2.

Natural forms of formic acid are not available in a sufficient quantity for commercial use. Formic acid is found naturally in some fruits and nectars and is a natural component of honey (Laffitte, 2005). Formic acid also is present in a natural state in stinging nettles and causes a burning sensation on contact with them. The substance is also found in the stings and bites of many insects, including bees and ants, which use formic acid as a chemical defense mechanism. When an ant contracts its poison gland, the formic acid stored in the gland passes in the sting and is propelled out towards the attackers of the ant. Since formic acid has a pH between two and three, it is corrosive or irritating and attackers usually flee or are killed (Laffitte, 2005). Clouds also naturally produce formic acid by the oxidation of formaldehyde by hydroxyl radicals, oxygen, or hydrogen peroxide (HSDB, 2010)

<u>Evaluation Question #4:</u> Describe the persistence or concentration of the petitioned substance and/or its by-products in the environment (7 U.S.C. § 6518 (m) (2)).

In currently marketed fumigant products for use in beehives, formic acid is stored in slow-releasing gel pads that are contained within sealed plastic bags. When the formic acid is to be released to the hive, the plastic bag is sliced open (Gegner, 2003). Formic acid products are only approved by EPA for use as a pesticide within honeybee hives. Because of the limited use of formic acid in beekeeping, a persistence of environmental residues is not expected to occur outside of the hive (EPA, 2010).

EPA has examined the potential for formic acid residues to appear in beeswax and honey. Residues above those found naturally are not expected when a formic acid product is used as directed (EPA, 2010). The tolerance exemption for formic acid in honey and beeswax was established in 1999 (40 CFR 180.1178).

<u>Evaluation Question #5:</u> Describe the toxicity and mode of action of the substance and of its breakdown products and any contaminants. Describe the persistence and areas of concentration in the environment of the substance and its breakdown products (7 U.S.C. § 6518 (m) (2)).

Formic acid vapors cause asphyxiation of mites. The heaviest concentration of formic acid fumes are on the floor of the hive and this is where most mites are killed. Following exposure to formic acid vapors, the varroa and tracheal mites are forced to let go of the bees. Honeybees are particularly tolerant of formic acid vapors. These vapors are strong enough to penetrate capped cells as the mites feed on pupal and larval bees in their cells, and are effective for knock-down of mites on exposed bees as well as for mites in the reproductive stages inside sealed brood cells. The substance can also penetrate the exoskeleton of the mites and cause additional irritation (EPA, 2010).

The gel-pack formulation of formic acid is expected to minimize the potential for dermal, eye, and inhalation exposure for pesticide applicators. In humans, eye, skin, and mucosal irritation is possible due to the corrosive nature of formic acid, so packaging formic acid in gel-packs prevents the majority of human exposure during application of the product to the hive. Product labels direct beekeepers to use personal protective equipment when handling fumigant products (EPA, 2010).

<u>Evaluation Question #6:</u> Describe any environmental contamination that could result from the petitioned substance's manufacture, use, misuse, or disposal (7 U.S.C. § 6518 (m) (3)).

It is possible that formic acid could be released to the environment in various waste streams during manufacture. In the atmosphere, formic acid will remain in the vapor phase as is indicated by its vapor pressure (35 mm Hg). Formic acid in the vapor phase will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals. The half-life for this reaction is estimated to be 36 days. The substance is not expected to undergo direct photolysis by sunlight because it does not absorb at wavelengths greater than 290 nanometers (HSDB, 2010).

Formic acid is expected to have a very high mobility in soil based upon an estimated K_{oc} of 12. Volatilization from moist soil surfaces is expected and volatilization from dry soils may occur if the vapor pressure is favorable. The pKa of formic acid is 3.8, which indicates that the compound will primarily exist in anion form in the environment. Anions generally do not adsorb more strongly to organic carbon and clay than their neutral counterparts (HSDB, 2010).

If formic acid is released into water, the substance is likely to volatilize from the surface. The estimated half-lives for volatilization from a model river and lake are 150 and 1,100 days, respectively. Formic acid is not expected to absorb sediment and suspended solids. Estimated biochemical oxygen demand (BOD) values using sewage, activated sludge, fresh water, and synthetic sea water inocula, range between 4.3 percent and 77.6 percent after five days. These values indicated that biodegradation is likely to be an important fate process. The potential for bioconcentration in aquatic life is low, as indicated by its estimated bioconcentration factor (BCF) of 3.2. Hydrolysis is not expected to be an important environmental fate process because formic acid lacks functional groups that hydrolyze under environmental conditions (HSDB, 2010).

Misuse or over-use of the product could kill grass and weeds beneath the beehive, so formic acid fumigation products should be used according to the label instructions (Amrine, 2006). Currently manufactured products consist of gel pads that hold formic acid. In the hive, warm air rises from the brood and causes evaporation of activate ingredients from the pads. When these pads are removed from the hive several days later, the formic acid typically has been released making contamination upon disposal unlikely (Amrine, 2006).

It is unlikely that the use of formic acid as a fumigant in beehives will result in environmental contamination (EPA, 2011; Health Canada, 2009). Use of available formic acid products is strictly confined to the interior space of the beehive. The use of formic acid in beehives is currently permitted by the Canadian General Standards Board and the Commercial Chemicals Branch of Canada states that the proposed use of a 65 percent solution of formic acid for the control of mites in bee colonies is unlikely to result in significant contamination of the general environment (Health Canada, 2009).

<u>Evaluation Question #7:</u> Describe any known chemical interactions between the petitioned substance and other substances used in organic crop or livestock production or handling. Describe any environmental or human health effects from these chemical interactions (7 U.S.C. § 6518 (m) (1)).

Formic acid is a strong acid, and as such the potential for chemical interaction does exist, but on the Material Safety Data Sheet (MSDS) the substance is classified as stable for reactivity under normal storage and use conditions (NOD Apiary Products Ltd., 2005).

The Commercial Chemicals Branch of Environment Canada has conducted an environmental assessment for formic acid and states that the use of a 65 percent solution of formic acid for the control of mites in bee colonies is unlikely to result in significant contamination of the general environment. Because formic acid is added to the interior space of the hive, it is unlikely that it will react with any other substances used in organic crop and livestock production or handling (Health Canada, 2009). EPA concluded that because formic acid is approved for use as a pesticide solely within the confines of a honeybee hive, environmental residues outside of the hive are not expected (EPA, 2010).

<u>Evaluation Question #8:</u> Describe any effects of the petitioned substance on biological or chemical interactions in the agro-ecosystem, including physiological effects on soil organisms (including the salt index and solubility of the soil) crops, and livestock (7 U.S.C. § 6518 (m) (5)).

Formic acid is applied to the interior spaces of the beehive and is unlikely affect biological or chemical interactions in the agro-ecosystem if used as directed by the manufacturer (Health Canada, 2009).

Misuse of the product could result in the release of vapors to grass and weeds growing below the hive. Formic acid acts as a desiccant and removes moisture from foliage. When plants are exposed to formic acid, water is drawn out of the leaves and the top growth of the plant is killed. Formic acid has a very low pH and is capable to quickly killing plant life. It has been determined that fumigant products containing less than 50 percent formic acid are less likely to kill any plants that fumigant vapors may reach (Amrine, 2006). Formic acid products that are currently marketed contain a 65 percent solution of formic acid (NOD Apiary Products Ltd., 2005).

<u>Evaluation Question #9:</u> Discuss and summarize findings on whether the petitioned substance may be harmful to the environment (7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i)).

Formic acid, if used as directed for fumigation in beekeeping, is not likely to cause adverse effects to the environment (EPA, 2011).

If vapors leak from the hive, formic acid may damage or kill above-ground plant growth near or directly beneath the hive. However, formic acid is unlikely to damage to the plant roots (Amrine, 2006).

In the atmosphere, formic acid will remain in the vapor phase and will be degraded following reaction with photochemically-produced hydroxyl radicals. Formic acid is not expected to undergo direct photolysis by sunlight (HSDB, 2010).

If released to water as a result of accident during manufacturing, formic acid is expected, based on chemical properties, to volatilize from the surface of water and is not expected to absorb sediment and suspended solids. Hydrolysis is not expected to be an important environmental fate process because formic acid lacks functional groups that hydrolyze under environmental conditions. The BCF for formic acid (i.e., 3.2) indicates a low potential for bioconcentration (HSDB, 2010).

Formic acid is expected to be very mobile in soil and to volatilize from moist and dry soil surfaces. The substance will primarily exist in anion form in the environment. Anions generally do not adsorb more strongly to organic carbon and clay than their neutral counterparts (HSDB, 2010).

Evaluation Question #10: Describe and summarize any reported effects upon human health from use of the petitioned substance (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)).

Following a human health risk assessment, EPA concluded that formic acid is mildly acutely toxic via the oral and inhalation routes (Tox. Cat. III), severely irritating to the eyes (Tox. Cat. I), corrosive to the skin (Tox. Cat. I), and highly irritating to the respiratory tract. Laboratory studies cited by EPA report negative results for mutagenic potential (EPA, 2011).

Chronic exposure to formic acid may damage the kidneys and this damage is indicated by elevated levels of the proteins albumin and globulin and an increase in the number of red blood cells in the urine. Chronic skin contact may cause sensitization dermatitis, particularly in workers previously sensitized to formaldehyde (HSDB, 2010).

Acute overexposure to formic acid causes irritation to the eyes, skin, and mucous membrane of the mouth, throat, and esophagus. Acute formic acid exposure also may be associated with complications such as cardiovascular collapse and ischemic damage to the heart, liver and kidneys, swelling of the airway, and respiratory distress (OSHA, 1996). Because of the irritating and corrosive properties of the substance, ingestion of formic acid may cause ulceration of the gastrointestinal tract, which results in perforation and scarring of the gastrointestinal tract (OSHA, 1996).

Adverse human health effects from formic acid have been documented from occupational exposure incidents:

- Workers exposed to formic acid in textile manufacturing plants reported nausea. The exposure concentration was reported to be fifteen parts per million (ppm) (HSDB, 2010).

- Twelve farm workers engaged in silage making and were exposed to formic acid for eight hours. Following exposure (30 hours post exposure), increased renal ammoniagenesis and urinary calcium excretion were observed. These biochemical effects were thought to result from the interaction of formic acid with the oxidative metabolism of renal tubular cells (HSDB, 2010).

- A worker splashed in the face with formic acid developed respiratory distress and difficulty in swallowing, and died within six hours (HSDB, 2010). Additional reports state that splashes of formic acid in the eye have caused permanent clouding of the cornea with loss of visual acuity. In one case, the injury required removal of the affected eye (HSDB, 2010).

Evaluation Question #11: Describe all natural (non-synthetic) substances or products which may be used in place of a petitioned substance (7 U.S.C. § 6517 (c) (1) (A) (ii)). Provide a list of allowed substances that may be used in place of the petitioned substance (7 U.S.C. § 6518 (m) (6)).

Researchers have determined that the fungus *Metarhizium anisopilae* is highly pathogenic to varroa mites. This fungus has been tested and has not been observed to cause any harm to honeybees or affect their queen's production. In testing, plastic strips were coated with dry fungal spores and placed inside of the hive. Instinctually, bees will attack anything foreign that enters the hive. The bees quickly attempted to chew the plastic strips, in turn spreading the spores throughout the hive. Spread of the fungus throughout the hive took between five and ten minutes. The mites that were attached to the bees died within three to five days and the fungus was effective in killing mites for 42 days (Flores, 2004).

The EPA currently has one actively registered product containing *Metarhizium anisopilae* as the active ingredient (PC Code 029056) (NPIRS, 2011):

- TAE-001 Technical Bioinsecticide: Novozymes Biologicals, Inc., 5400 Corporate Circle, Salem, VA 24153

This product contains *Metarhizium anisopliae* strain F52 spores, and its specific target pests include various ticks and beetles, root weevils, flies, gnats, and thrips. Mites are not specifically listed as a target pest (EPA, 2003).

Wintergreen-salt grease patties are a natural varroa and tracheal mite treatment used by many beekeepers. The prepared grease patties are not commercially available and are created by beekeepers for personal use. Wintergreen, or salicylic acid, appears on the EPA List 4A Inerts. However it is not listed as an allowed synthetic active ingredient on the National List. The wintergreen used commercially is considered to be synthetic and there are currently, no registered pesticide products containing salicylic acid as an active ingredient (NPIRS, 2011). The grease patties are a mixture of livestock salt, wintergreen, honey, granulated sucrose sugar, and hydrogenated vegetable oil or Crisco® and will last for three to five weeks before being completely used up (Amrine, 2010). Grease patties are placed on top of the brood chamber and at the entrance of the chamber (Parise, 2006). Grease patties have been found to increase mite drop by lubricating the wings of the bees, making it more difficult for mites to grip to the bees. Mites fall to the bottom of the chamber as they lose their grip. Tracheal mites are killed by the grease. Wintergreen has also been observed to irritate varroa mites. Salt is an important component of the grease patties because it prevents the bees from seeking salt sources outside of the hive (Amrine, 2010). Grease patties are a natural method for controlling and killing mites in beehives.

Neem oil, a nonsynthetic pressed oil created from the fruits and seeds of an evergreen tree, has been demonstrated to control both varroa and tracheal mites. Neem oil can be applied to directly to bees or mixed with sugar water and then applied. Dr. T.P. Liu, a Canadian researcher cited by Gegner (2003), showed that a concentration of three milliliters of neem extract per liter of sugar syrup significantly decreased numbers of tracheal mites. Dr. A. P. Melathopoulos, also cited by Gegner (2003) found that a ten percent concentration of neem oil placed directly on bees killed more than 50 percent of varroa mites.

The EPA currently has six actively registered pesticide products containing neem oil as the active ingredient (PC Code 025006) (NPIRS, 2011):

- Safer Brand End All RTU: Safer Inc., 69 Locust St., Ltitz, PA 17543
- Agroneem Plus: Agro Logistic Systems Inc., PO Box 5799, Diamond Bar, CA 91765
- Debug TGAI: Agro Logistic Systems Inc., PO Box 5799, Diamond Bar, CA 91765
- Debug Turbo: Agro Logistic Systems Inc., PO Box 5799, Diamond Bar, CA 91765
- Nimbiosys Neem Oil: The Ahimsa Alternative, Inc, 15 Timberglade Rd., Bloomington, MN 55437
- Plasma Neem Biological Insecticide: Plasma Power Private Limited, # 23 (Old #J-12), 6th Ave., Anna Nagar, Chennai 600, 102

Inert[2] dusts, or non-respirable dusts, may be used to reduce the grip that mites have on their hosts. Adult mites are known to infest the hive by gripping to the backs of bees in the hive. By covering the bees in the colony, mites will be unable to gain a sufficient grip to their host and will fall off. Powdered sugar or

[2] Note that the term 'inert' in inert dusts differs from the definition of 'inert ingredient' as defined under 7 CFR 205.2. "Inert ingredient" is defined as any substance (or group of substances with similar chemical structures if designated by EPA) other than an active ingredient which is intentionally included in any pesticide product (40 CFR 152.3(m)).

pollen substitutes have historically been used. No products marketed specifically for this use have been identified. Application of inert dusts can disrupt a colony and be tedious, but no chemical pesticides are used (Tarpy and Summers, 2003).

Synthetic sucrose octanoate ester is currently allowed on the National List for use as biochemical insecticide/miticide for the control of varroa mites on adult honeybees [§ 205.603(b)]. Avachem Sucrose Octanoate is also approved for use as a contact-type biochemical insecticide/miticide (EPA Registration Number 70950-2, OPP No. 035300) to control soft-bodied insects. In particular, EPA has registered Avachem Sucrose Octanoate as a biopesticide for foliar spray on greenhouse, nursery, and field crops; for *Sciarid* fly control in mushroom-growing media; and for varroa mite control on honeybees (Barrington, 2004).

<u>Evaluation Question #12:</u> Describe any alternative practices that would make the use of the petitioned substance unnecessary (7 U.S.C. § 6518 (m) (6)).

Several mechanical methods are available for controlling mite populations in honeybee hives.

A wire-mesh screen or similar surface can be used to replace the wooden bottom of a beehive, creating a screened bottom board. Using a screened bottom board has been shown to reduce mite levels when compared to hives containing solid bottoms. A screened bottom may increase the ventilation and also the number of mites that are able to drop from the floor of the hive. While use of a wire-mesh screen board is not disadvantageous, the benefits of bottom screens are minimal, and hives usually require additional methods of treatment (Tarpy and Summers, 2003).

Varroa mites generally infest developing male honeybees, which become drones as adults. The drones develop in an area of drone-sized honeycomb cells called a drone brood. A technique called drone-brood trapping involves placing special combs with drone-sized cells in the hive in order to attract mites to the brood. The combs are then removed before the mites emerge from the cells The effectiveness of this practice is reliant on the season and drone brood trapping has been found to reduce mite levels up to ten fold and during the summer and early fall (Tarpy and Summers, 2003). By removing the drone brood from the colony, a large number of mites are removed without affecting the size of the worker population (Calderone, 2005).

Recently, tracheal and varroa mite resistant strains of honeybees have been developed through conventional breeding and are available for sale. Several tracheal mite resistant bees are available, and the most popular strain is the 'Buckfast' bee (Parise, 2006). Varroa mite resistant strains of honeybees are also available. These strains of honeybee have been tested and crossbred in the hope of finding bees that are tolerant to mites based upon selective breeding for grooming behaviors or for cell-building tendencies. The commercially available strains of mite-resistant bees include "hygienic bees," "Russian bees," and "SMR (Suppressed Mite Reproduction) Smart bees" (Gegner, 2003).

"Hygienic bees" spend more time than most bees grooming themselves and the hive, behaviors that have been shown to promote resistance to varroa mites. Hygienic behaviors have been shown to be heritable, and selective breeding has increased populations with these behaviors. These bees are able to detect and remove diseased bees quickly, before the pest organisms can move to other bees (Gegner, 2003).

"Russian bees" are a strain of honeybee that has co-existed with mites in Russia (Gegner, 2003). Commercial evaluations of Russian bees have shown good mite resistance and winter hardiness. In tests comparing the Russian honeybee with the domestic honeybee, the varroa mite reproduction was two to three times lower with the Russian bees (Suszkiw, 2001). Breeder queens cost around $500 each and from each of these, beekeepers are capable of breeding thousands of production queens, which are subsequently placed in hives for pollination and honey making (Suszkiw, 2001).

"SMR Smart bees" have been developed by researchers who identified a trait of the honeybee that prevents the varroa mite from reproducing, thereby providing genetic resistance to it. The USDA Baton Rouge Bee laboratory has bred a line of honeybees that carry this trait and have released them for commercial sale with several queen bee producers (Gegner, 2003). The U.S. queen rearing industry is geared toward the production of naturally mated queens, which makes the production of commercial inbred resistant queens very unlikely. However, queen producers can readily produce hybrid queens. The USDA determined that mite growth is an intermediate between resistant bees and susceptible bees when resistant queens are free-mated with susceptible drones. Although colonies with hybrid queens (i.e., resistant x control) had intermediate populations of mites, they had half the mites found in the susceptible controls. According to the USDA, a sufficient level of resistance should be provided by the use of hybrid queens (USDA, 2010a).

References:

Amrine, J., 2006. Formic Acid Fumigator for Controlling Varroa Mites in Honeybee Hives, Internat. Acarol., 32(2): 115-126.

Amrine, J., 2010. Mite Control in Honey Bee Hives with Essential Oils and Formic Acid Fumigation, Retrieved February 23, 2010 from http://www.wvu.edu/~agexten/varroa/

Barrington, A., 2004. Petition to Allow Use of Sucrose Octanoate Esters as a Synthetic Substance in Organic Livestock Production, Submitted by Ava Chemical Ventures, L.L.C., Received January 30, 2004.

Calderone, N., 2005. Northeast Beekeeper- May 2005 edition, Retrieved February 23, 2011 from http://www.masterbeekeeper.org/news/newsletter2.htm

Canadian General Standards Board, Retrieved February 15, 2011 from http://www.tpsgc-pwgsc.gc.ca/cgsb/on_the_net/organic/index-e.html

EPA, 2003. Biopesticides Registration Action Document: *Metarhizium anisopliae* strain F52, Retrieved May 6, 2011 from http://www.epa.gov/oppbppd1/biopesticides/ingredients/tech_docs/brad_029056.pdf

EPA, 2010. Formic Acid (214900) Fact Sheet, Retrieved February 15, 2011 from http://www.epa.gov/oppbppd1/biopesticides/ingredients/factsheets/factsheet_214900.htm

EPA, 2011. Formic Acid (214900) Biopesticide Registration Eligibility Document, Retrieved April 7, 2011 from http://www.epa.gov/pesticides/biopesticides/ingredients/tech_docs/red_214900.htm

FDA, 2006. Database of Select Committee on GRAS Substances (SCOGS) Reviews – Formic acid (packaging), Retrieved April 5, 2011 from http://www.accessdata.fda.gov/scripts/fcn/fcnDetailNavigation.cfm?rpt=scogsListing&id=139

Flores, A., 2004. Saving Bees: Fungus Found to Attack Varroa Mites, Retrieved February 23, 2011 from http://www.ars.usda.gov/is/ar/archive/oct04/bees1004.pdf

Gegner, L., 2003. Beekeeping/Apiculture, Retrieved February 15, 2011 from http://attra.ncat.org/attra-pub/beekeeping.html#tracheal

Hazardous Substances Data Bank (HSDB). 2010. Formic Acid, CASRN: 64-18-6. Last revised 4-27-2010. Retrieved February 15, 2011, from http://toxnet.nlm.nih.gov/cgi-bin/sis/search/f?./temp/~wLQ2Ex:1

Health Canada, 2009. Note to CAPCO: Proposed Scheduling of 65 percent Formic Acid for the Detection and Control of Honey Bee Mites, Retrieved February 16, 2011 from http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_decisions/c94-05/index-eng.php

Laffitte, M., 2005. Formic acid, Retrieved February 15, 2011 from http://www.chm.bris.ac.uk/motm/formic/formich.htm

NOAA (CAMEO Chemical), 2011. Formic Acid, Retrieved February 15, 2011 from http://cameochemicals.noaa.gov/chemical/3513

NOD Apiary Products, 2005. Material Safety Data Sheet: Mite-Away II Formic Acid Pad, NOD Apiary Products Ltd., Frankford, Ontario Canada, Prepared March, 2005, Retrieved April 7, 2011 from http://www.masterbeekeeper.org/pdf/formicAcid_msds.pdf

NOD Apiary Products, 2011. Mite Away Quick Strips (MAQS) Receives Federal Registration in United States, Retrieved February 15, 2011 from http://www.miteaway.com/

NPIRS (National Pesticide Information Retrieval System), 2011. *Metarhizium anisopliae* strain F52 spores, Retrieved May 6, 2011 from http://ppis.ceris.purdue.edu/htbin/cnamlist.com

NPIRS, 2011. Salicyclic acid, Retrieved May 6, 2011 from http://ppis.ceris.purdue.edu/htbin/cnamkeys.com

OSHA, 1996. Occupational Safety and Health Guideline for Formic Acid, Retrieved February 21, 2011 from http://www.osha.gov/SLTC/healthguidelines/formicacid/recognition.html

Parise, S., 2006. Recommendations for the Control of Honeybee Tracheal Mites, Retrieved February 22, 2011 from http://www.vermontagriculture.com/ARMES/plantindustry/apiary/documents/trachealmite_001.pdf

Schroeder, J.W., 2004. Silage Fermentation and Preservation, North Dakota State University, Retrieved April 7, 2011 from http://www.ag.ndsu.edu/pubs/ansci/dairy/as1254w.htm

Suszkiw, J., 2001. Mite-Resistant Russian Bees Also Have Winter Hardiness, Retrieved February 22, 2011 from http://www.ars.usda.gov/is/pr/2001/010615.htm

Tarpy, D. and J. Summers, 2003. Managing Varroa Mites in Honey Bee Colonies, Retrieved February 21, 2011 from http://www.cals.ncsu.edu/entomology/apiculture/pdfs/2.03%20copy.pdf

The European Economic Community (EEC) Council Regulation, 2008. Retrieved February 15, 2011 from http://ec.europa.eu/agriculture/organic/eu-policy/legislation_en

USDA, 2010a. Agricultural Research Services: Breeding Honey Bees that Suppress Mite Reproduction, Retrieved February 22, 2011 from http://www.ars.usda.gov/Services/docs.htm?docid=2744&page=13

USDA, 2010b. National Organic Standards Board Meeting: Fall 2010, Retrieved April 7, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5086584

USDA, 2005. Technical Report for Sucrose octanoate esters, Retrieved April 7, 2011 from http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5057637

Van Soest, P., 1994. Nutritional Ecology of the Ruminant, Cornell University Press, Retrieved April 7, 2011 from http://books.google.com/books?id=mwUu6PL1UgC&pg=PA226&lpg=PA226&dq=formic+acid,+preservation,+use+in+united+states&source=bl&ots=DNOwu6AiRG&sig=bRL4c0a8xAcVSKw-hvDLlLhDWYU&hl=en&ei=J9udTbapFtSUtwfS7rHDBA&sa=X&oi=book_result&ct=result&resnum=4&ved=0CCkQ6AEwAw#v=onepage&q&f=false

Villalobos, E., 2009. Preliminary Report to the Beekeeping Industry: NOD Apiary Formic Acid Flash Treatment, Retrieved February 15, 2011 from http://www.miteaway.com/V1-wright-varroa.pdf