Butylated Hydroxytoluene (BHT)
Crops

Executive Summary

A petition was filed with the NOSB to use butylated hydroxytoluene (BHT) as an antioxidant in a number of pheromone formulations. Pheromones and BHT would be enclosed in a plastic matrix, allowing slow release of the materials into the air. Due to low volatility of BHT, most of it would remain in the dispenser and direct contact with the crop would be negligible. BHT is an alkylated cresol that can be synthesized several ways. The *p*-cresol starting material is isolated from coal tar or petroleum. It is also obtained synthetically from toluene. The *p*-cresol is alkylated with isobutylene gas in the presence of an acidic catalyst to produce BHT. It is used as an antioxidant in food, and is also used as a stabilizer in pesticides, gasoline, lubricants, soaps and cosmetics, and as an antiskinning agent in paints and inks.

The material has not been reviewed by NOSB before, and because it is synthetic and on List 3, is currently prohibited for use in organic production under the National Organic Program Standards. However, pheromone formulations that use BHT have been widely used by organic farmers. Impacts on the environment and human health from this application should be negligible. The TAP reviewers unanimously concluded that BHT should be added to the National List as an allowed synthetic with the annotation: for use in organic crop production systems as an antioxidant for pheromones enclosed in plastic dispensers. The reviewers were all concerned with the precedent that this set, and made it clear that addition to the National List should be made only if application and use is limited. Natural antioxidant, and other synthetic antioxidants with fewer identified environmental and human health impacts may be more compatible with organic standards than BHT, and may merit consideration in the future, particularly for formulations that involve direct application of the pheromones to crops.

Summary of TAP Reviewer's Analyses[1]

Reviewer recommendation for annotations are listed separately under each reviewer's report.

Synthetic/ Nonsynthetic	*Allow without restrictions?*	*Allow only with restrictions?*	*Prohibit for all uses*
Synthetic (3) Nonsynthetic (0)	Yes (0) No (3)	Yes (3) No (0)	Yes (0) No (3)

Identification

Chemical Names:
2,6-Bis(1,1-dimethylethyl)-4-methylphenol
2,6-di-*tert*-butyl-*p*-cresol
2,6-di-*tert*-butyl-4-methylphenol

Other Name:
Butylated hydroxytoluene (BHT); Dibutylparacresol (DBPC)

Trade Names:
Antrancine 8, Tenox BHT, Ionol CP, Sustane, Dalpac, Impruvol, Vianol, Sumilizer BHT®

CAS Numbers:
128-37-0

Other Codes: INS 321
NIOSH Registry No. GO7875000

[1] *This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. This review addresses the requirements of the Organic Foods Production Act to the best of the investigator's ability, and has been reviewed by experts on the TAP. The substance is evaluated against the criteria found in section 2119(m) of the OFPA [7 USC 6517(m)]. The information and advice presented to the NOSB is based on the technical evaluation against that criteria, and does not incorporate commercial availability, socio-economic impact, or other factors that the NOSB and the USDA may want to consider in making decisions.*

Characterization

Composition:

BHT has a molecular formula of $C_{15}H_{24}O$, and a molecular weight of 220.34. Chemically it is an alkylated phenol.

Properties:

At room temperature BHT is a white, odorless, low melting solid, with melting point 70°C. Specific gravity of the material is 1.048 (80°C). It has a low vapor pressure (6.5 mm Hg at 120°C) and a high boiling point (265°C at 760 mm). It is insoluble in water and freely soluble in various organic solvents such as methanol, ethanol, toluene, acetone, petroleum ether, benzene and others. It is soluble in food oils and fats, and has good solubility in linseed oil (Merck Index, 1989, PBC, 2002).

How Made:

BHT is synthesized from *p*-cresol. The *p*-cresol is obtained from coal tar (25%), as a by-product of catalytic cracking of petroleum (11%), and by a number of synthetic processes (64%). A major synthetic route is by sulfonation of toluene followed by heating with sodium hydroxide. Toluene is obtained by distillation of petroleum (Fiege, 1987).

The *p*-cresol is alkylated with isobutylene gas in an acid catalyzed reaction. Products and results are sensitive to the catalyst and conditions. In one process, *p*-cresol with 5% phosphoric acid is heated to 70°C. Isobutylene gas obtained by catalytic cracking and distillation of petroleum is bubbled through. The catalyst separates and is removed. The product is washed with sodium hydroxide. Crystals settle out in 46% yield (Stillson, 1947).

In another process, *p*-cresol is heated to 40°C with 5% methanedisulfonic acid. Isobutylene is bubbled through for 6 hours. Upon cooling, the catalyst separates. The product is washed with sodium hydroxide solution. Crystals separate in 88% yield and are recrystallized from methanol (McConnell and Davis, 1963).

Specific Uses:

BHT is used as an antioxidant in food, animal feed, petroleum products, synthetic rubbers, plastics, animal and vegetable oils, and soaps (Merck Index, 1989). It is on the FDA Generally Recognized as Safe (GRAS) list. It is added to food such as dry breakfast cereals, potato flakes, enriched rice, and margarine. BHT is also added to food packaging materials (CFR 1992; Wessling, 2001).

Action:

BHT is an antioxidant due to its ability to scavenge free radicals. Free radicals are very reactive species characterized by unpaired electrons. Free radicals initiate a chain reaction, reacting many times until the chain is terminated by electron pairing. Free radicals can be formed by thermal cleavage of a hydrocarbon chain or hydrocarbon reaction with oxygen or light.

Oxygen reacts with the double bonds present in insect pheromones forming peroxides. The peroxide bond is weak and is photochemically or thermally cleaved into two free radicals. At higher temperatures molecular oxygen can react directly with a hydrocarbon, removing a hydrogen atom and producing a free radical (Dexter, 1992; Shahidi, 2000).

BHT protects pheromones by reacting much faster with free radicals than the pheromones do. Once formed, the phenolic free radical of BHT forms an inactive dimer or reacts once more with a free radical, terminating the chain. Since BHT terminates a free radical chain reaction, it is called a free radical scavenger or quencher (Dexter, 1992).

Addition of BHT to a pheromone formulation can increase the lifespan of the double bond system from 2 weeks to 8 weeks (Ideses and Shani, 1988).

Combinations:

For food use, BHT is combined with butylated hydroxyanisole (BHA) as a margarine preservative (PBC, 2002). In crop protection it is combined with pheromones for mating disruption to provide an alternative for toxic pesticides for control of codling moth and other serious agricultural pests (PBC, 2002).

Status

Historic Use:

BHT was patented in 1947 and was approved as a food additive by the FDA in 1954. Since 1959 it has been on the Generally Recognized as Safe (GRAS) list maintained by the FDA. It is one of the most commonly used antioxidants in processed fats (PBC, 2002).

OFPA, USDA Final Rule:
BHT is not listed in the Final Rule. Inert ingredients classed as List 4 by EPA -Inerts of Minimal Concern are permitted when used with permitted active pesticide ingredients (7 CFR 205.601(m)(1)). EPA List 3 inert ingredients are permitted when specifically recommended by the NOSB (65 *Fed. Reg.* 80612).

Regulatory: EPA/NIEHS/Other Sources
OSHA 10 mg/m3 permitted in air (NTP, 2002)
NPFA Hazard Rating: None
EPA places BHT on List 3: Inert ingredients of unknown toxicity.

Status Among U.S. Certifiers
California Certified Organic Farmers (CCOF) –CCOF Certification Handbook (rev. January, 2000). Not listed.
Maine Organic Farmers and Gardeners Association (MOFGA) –MOFGA Organic Certification Standards, 2001. Not specifically listed.
Midwest Organic Services Association (MOSA) –MOSA Standards January, 2001. Not listed.
Northeast Organic Farming Association of Vermont (NOFA-VT) – 2001 VOF Standards. Not specifically listed.
Oregon Tilth Certified Organic (OTCO) – OTCO Generic Materials List (April 30, 1999). Not specifically listed.
Organic Crop Improvement Association International (OCIA) –OCIA International Certification Standards, July 2001. Not specifically listed.
Quality Assurance International (QAI) – QAI Program, Section 5.2 Acceptable and Prohibited Materials. Not specifically listed.
Texas Department of Agriculture (TDA) Organic Certification Program – TDA Organic Certification Program Materials List. Not specifically listed.
Washington State Dept. of Agriculture Organic Certification Program. Not specifically listed, though formerly allowed for use in pheromone mating disruption formulations (PBC, 2002).

International
CODEX – Not specifically listed.
EU 2092/91 – Not specifically listed.
IFOAM – Not specifically listed.
Canada – Not specifically listed.
Japan – Not specifically listed.

Section 2119 OFPA U.S.C. 6518(m)(1-7) Criteria

1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*
   Chemical interaction with other materials used in organic farming should be minimal. The BHT is encapsulated in a plastic dispenser. Despite its low vapor pressure (Merck Index, 1989), a small amount might vaporize under high temperature field conditions. Since BHT is a solid at room temperature, vaporized material probably deposits as a solid on foliage and fruit near where it is applied.

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.*
   The toxicity of BHT is discussed in (4). BHT is an antioxidant whose mode of action is free radical scavenger. It reacts quickly with free radicals terminating chain reactions and slowing further oxidation of a protected substrate (Dexter, 1992).

   Because of its low vapor pressure (Merck Index, 1989), most of the BHT should remain encapsulated in the plastic dispenser. Any that escapes to soil should be quickly degraded. In sterilized soil, the half-life is about 24 hours. Where microbials have access, degradation is even faster. At least 10 non-volatile polar degradation products are formed by progressive oxidation. Major metabolites are formed by oxidation of the methyl group, forming a BHT alcohol, a BHT acid, and a BHT aldehyde. These are further metabolized at a slower rate completely to CO2 and water. BHT and its degradation products are biodegradable and do not persistent in the soil environment (Mikami et al., 1979a).

   BHT in water is destroyed by sunlight. About 94% is destroyed within 30 days. Degradation products are similar to those seen in soil. Destruction is faster if soil and microbes are present with the water (Mikami et al., 1979b).

   Half-life of BHT degradation to polar metabolites in sewage sludge is 3-7 days. About 50% is converted completely to carbon dioxide and water in about 3 months (Inui et al., 1979a).

In model aquatic ecosystems containing soil, water, BHT, fish, water fleas, algae and fish, BHT did not bioaccumulate in the aquatic organisms. BHT and metabolites reached a maximum in fish within 7 days, then slowly declined (Inui et al., 1979b).

3. *The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.*
Isolation of the BHT precursor *p*-cresol from coal tar and petroleum waste is part of the environmental cleanup from coke and gasoline production. Synthetic production of *p*-cresol from toluene involves sulfuric acid and sodium hydroxide that are recycled (Fiege, 1987). In the actual synthesis of BHT, the catalyst and unused isobutylene gas are recycled (Stillson, 1947). In all of these processes though, there are a number of by-products. Some of the by-products are recovered and sold, but some waste will undoubtedly end up in an incinerator or restricted landfill.

Presumably, the amounts of BHT appearing in the environment are lower than amounts of the active pheromone. As an estimate, maximum residues of tomato pinworm pheromone found on unwashed tomatoes are 72 ppb on the day of application. After one month, residues drop to about 1 ppb (EPA, 1995).

Though misuse of plastic encapsulated pheromones is possible, it is unlikely. The pheromone labels supplied by the petitioner suggest that depleted dispensers be either burned or buried in landfill. Burning these plastic dispensers could lead to air contamination unless conducted in an EPA approved incinerator. If disposed of in landfill, biodegradation of the polyethylene dispensers would be slow. However, the 400 dispensers necessary to treat an acre for a year weigh less than 1/4 pound (PBC, 2001). Pheromones and BHT encapsulated in the plastic have low toxicity and biodegrade quickly. The total mass of plastic appearing in landfill should be negligible compared to the total waste stream.

4. *The effects of the substance on human health.*
As of November, 1999, the EPA had registered 20 moth mating pheromones as pesticide active ingredients and more than 60 individual products containing these active ingredients. During more than 10 years of use of lepidopteran pheromones as pesticides, no adverse effects have been reported (Steinwand, 2001). Since BHT is enclosed in a plastic dispenser, negligible amounts should appear in the environment. Because of this fact, the EPA has exempted from the requirements of a tolerance all of the inerts appearing in pheromone formulations that are encased in a plastic dispenser (Welch, 1993; Thomson et al., 1999). However, BHT toxicity data are given below to help estimate risk.

Metabolism
BHT is oxidized and excreted mostly in urine. In rats, rabbits, dogs and monkeys oxidation of the *p*-methyl group predominates, while in humans oxidation occurs mostly at the *tert*-butyl groups. This difference complicates interpretation of animal toxicology data because humans are exposed to a different spectrum of metabolites.

When a single oral dose of 40mg/kg/bw was given to humans, about 50% was excreted in the urine in 24 hrs. Excretion of the rest took place slowly over 10 days, suggesting tissue retention in humans.

During administration of chronic doses, BHT builds in body fat. Rats given 1% BHT for 5 weeks had 30-45 ppm BHT in body fat. Half-life after the final dose was 7-10 days (Madhavi and Salunkhe, 1995).

Acute Toxicity
The oral LD50 of BHT in rats ranges from 1700-1970 mg/kg. The LD50 in mice is 2,000, rabbits 2,100-3,200, cats 940-2,100, and guinea pigs 10,700 (Madhavi and Salunkhe, 1995; 1996).

Chronic Toxicity
In rats, daily doses of 0.3-0.5% cause an increase in serum cholesterol within 5 weeks. Doses of 0.5% led to reduced growth rates and liver enlargement.

High dose levels in animals cause depressed growth and body weight, lung damage and inflammation, bleeding, liver enlargement, and induction of liver enzymes (Gosselin et al., 1984). Liver effects are seen within 2 weeks at 500 mg/kg/day. Bleeding occurs at chronic doses of 7.5 mg/kg/day. In mice, doses of 0.5-2% for 21 days caused lung damage and bleeding. In mice acute damage to lungs is seen with 400-500 mg/kg (Madhavi and Salunkhe, 1995;1996).

Carcinogenesis
In one study, doses up to 1% in rats for 2 years caused decreased weight but no statistically significant cancers. In another study that included intrauterine exposure and analysis of a second generation, increased liver cancers were seen. A 2-year study in mice at levels up to 0.5% did not cause cancer. Doses of 1-2% caused increases in liver cancer. Mice fed 0.75% for 16 months showed an increase in liver and lung tumors (Madhavi and Salunkhe, 1995;1996).

BHT has also been tested with chemical carcinogens. When given before or with the carcinogen, lung, liver and stomach cancers in rats are inhibited. However, bladder, thyroid, and lung cancers are increased (Madhavi and Salunkhe, 1995;1996).

According to IARC, "there is limited evidence for the carcinogenicity of butylated hydroxytoluene in animals" and BHT is "not classifiable as to its carcinogenicity to humans" (IARC, 1986; PBC, 2002)

Reproductive Effects
At 50 mg/kg BHT had no adverse effects on reproduction and was not teratogenic in rats, mice, hamsters, rabbits and monkeys. At 500 mg/kg in mice reduction in birth weights and birth numbers were seen. Similar effects were observed in rats. At high doses, rabbits had a larger number of intrauterine deaths (Madhavi and Salunkhe, 1995; 1996).

Mutagenicity
The majority of the data show that BHT is not a genetic toxicant (Sherwin, 1990). Mutagenic effects seen in some tests occurred only at the highest doses (Madhavi and Salunkhe, 1995; 1996).

Behavioral
Weanling mice, whose parents had been fed 0.5% BHT until preweaning, showed decreasing sleeping times, increased aggression, and learning abilities when fed 0.5% BHT for 3 weeks after birth (Madhavi and Salunkhe, 1995; 1996).

Allergies
Allergies are rarely seen with BHT consumption. Sometimes contact dermatitis occurs in a delayed sensitivity reaction (Hannuksela and Haahtela, 2002).

Experience from the Chemical Industry
According to IPCS (1999), BHT irritates the eyes and skin of chemical workers. "Repeated or prolonged contact with skin may cause dermatitis." According to the Aldrich Chemical MSDS, "Material is irritating to mucous membranes and upper respiratory tract. Prolonged contact can cause damage to the eyes, nausea, dizziness and headache" (MSDS, 1994).

Exposure
Maximum concentration permitted in air by OSHA is 10 mg/m3. Gloves, protective clothing and eye protection are needed in BHT manufacturing facilities. In animal experiments, the NOEL is 25 mg/kg, and the allowed daily ingestion (ADI) in humans is 0-0.3 mg/kg. The ADI is probably exceeded in the U.S. Average estimated daily intake based a model diet is 0.4 mg/kg/day (Vavasour, 1994; WHO, 1999). For field use with pheromone dispensers, exposure to BHT should be negligible (MSDS, 1998; PBC, 2002).

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.*
Soil microbes, sunlight and air quickly metabolize BHT. About 85-90% is degraded within 24 hours (Mikami et al., 1979a). Amounts reaching the phylloplane or soil should be low due to its low vapor pressure and encapsulation within a polyethylene matrix. Adverse effects on soil organisms, crops and livestock should be negligible, since very little should escape the dispenser (PBC, 2002).

6. *The alternatives to using the substance in terms of practices or other available materials.*
(a) Modification of the formulation. Natural antioxidants such as Vitamin E could be used. However, according to the petitioner (PBC, 2002), vitamin E is not an effective free radical scavenger in conjugated diene structures such as found in the codling moth pheromone. Other non-synthetic antioxidants, such as carnosol from rosemary extracts, are good scavengers of free radicals. In fact, many non-synthetic phenolic materials are antioxidants (Shahidi, 2000). However, commercial development and field trials of such alternatives in pheromone formulations could lead to delay in availability and cost increases that would make the pheromones too expensive.

The pheromones could be distributed without antioxidants. However, formulations without antioxidants would be impractical due to extra costs and labor needed to reinstall new dispensers when the active pheromones were destroyed by light and heat in the field.

(b) Approaches other than pheromones. Pheromone technology has led to pesticide reduction in conventional production systems. At the 760 acre Randall Island project in California, pheromone mating disruption allowed growers to reduce from 3-5 organophosphate pesticide applications to one early in the year—an estimated 85% reduction in use (Benbrook et al., 1996; Quarles, 2000).

Approximately 20,000 acres of organic apples and pears are grown in the U.S. (Granatstein, 2001; PBC, 2002). If pheromone technology is not available, organic growers in many instances will be left with less satisfactory alternatives. For the codling moth, the ground can be sprayed or trees banded with nematodes to control the prepupal stage. Postharvest stripping of fruit can reduce numbers in the first flight. *Trichogramma* releases, codling moth granulosis virus, and BT have seen some success. However, timing of treatment is critical. Overhead watering can reduce larval populations and hail nets at orchard boundaries can reduce codling moth immigration. However, none of these alternatives provide the elegance and convenience of pheromone mating disruption (Quarles, 2000).

Similar alternatives are available for other pests and crops (Thomson et al., 1999; Antilla et al., 1996; Jenkins et al., 1990; Trumble and Rodriguez, 1993). Though a combination of these techniques could reduce damage, costs and damage will undoubtedly be higher without the pheromone technology.

7. *Its compatibility with a system of sustainable agriculture.*
Pheromone mating disruption systems use no toxic pesticides and provide an environmentally acceptable way to limit pest populations in agricultural systems. Pheromone systems for the codling moth, pink bollworm, tomato pinworm, armyworm and other pests are available. Crops protected include cotton, tomatoes, apples, walnuts and pears (Thomson et al., 1999; Antilla et al., 1996; Jenkins et al., 1990; Trumble et al., 1993; Benbrook et al., 1996; Granatstein, 2001).

Expected problems are so minimal that the EPA has exempted pheromones and inerts in the formulations from a tolerance requirement in crop production systems (EPA, 1994; 1995; EPA, 1999; Welch, 1993; Steinwand, 2001). Use of pheromones is compatible with sustainable agriculture and antioxidants such as BHT encased in polymers should present no additional problems.

The TAP Reviewers were also asked the following questions:

1. Pheromones applied as twist ties are not usually removed from the orchard after use, but remain on the tree or left on branches removed with pruning, which are subsequently shredded and mulched or possibly burned. Does this represent a problem for contamination of soil or environment?

   Reviewer 1
   Because of BHT's rapid system of degradation, mulching the twist-ties would not be a new risk indicator for the inert. Although a system of organic production would ideally not include mulching any polymer dispenser based products. The label clearly states that the pheromone should be disposed of properly or incinerated.

2. This review does not address use in other pesticide applications. Do you have an opinion or additional information regarding more general use as an inert ingredient in directly sprayed pesticides or foliar fertilizer applications?

   Reviewer 1
   Much of the negligible risk associated with the BHT as an inert in the pheromone containing plastic dispenser is due to its also being encased in the dispenser. In the petition submitted by Pacific Biocontrol, the petitioner states, "since the formulation is impregnated in a polyethylene dispenser and slowly released, there is expected to be little exposure and transport. Minimal to no exposure and risk was expected to non-target and aquatic species." (PBC, 2002). To date, based on the use pattern and lack of exposure, a Tier I assessment has not been completed. Were the inert BHT to be included in sprayed applications or foliar fertilizers, at a minimum BHT would need to undergo a Tier I ecological assessment. Because BHT could prove to be an acute toxin to some species of fish, particularly in the event the waterway has organic debris or a high level of turbidity, a complete assessment of the risk to aquatic invertebrates and vertebrates would be necessary.

TAP Reviewer Discussion

Reviewer 1 *[M.S., Environmental Policy Specialist at a non-profit that does research and education on toxic substances, Western U.S]*

Toxicity

Butylated Hydroxytoluene (BHT) is a synthetic chemical compound that slows and prevents oxygen from reacting with other compounds. In the present situation, BHT is added as an inert ingredient to biochemical pheromones. BHT, when used as an inert in polymeric dispenser products, is exempted (under the Federal Insecticide Fungicide Rodenticide Act) from the requirement of a tolerance. The dispenser products have undergone expedited review by the Environmental Protection Agency and therefore the mammalian toxicity, ecological effects, and environmental fate and groundwater data has for the most part been waived (40 CFR 180.1001(e) (7/1/91)). Therefore, little environmental information is available on the effects of BHT (used as an inert) to terrestrial invertebrates or aquatic invertebrates and vertebrates.

BHT is generally recognized as safe (GRAS) based on its use as a food additive since 1947. Because of BHT's GRAS status and secondarily its addition to pheromones that require reduced data requirements for registration, a complete human and ecotoxicological assessment has not been completed.

According to the National Organic Standards Board Principles of Organic Production and Handling (October 17, 2001) "organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity." The Principles also state pollution of soil, water, and air is to be minimized (Section 1.2.7). At issue is the extent, if any, to which BHT in its proposed formulation potentially degrades the environment.

Traditional methods of determining human and ecological risk to the environment use physicochemical measures of exposure and acute risk criteria, such as a lethal dose or concentration – typically an LD_{50} or LC_{50}.Whereas the exposure data provide information as to how a substance acts in soils and water, the acute hazard endpoints provide limited insight into the effects of toxicants at lower concentrations. A complete understanding of a pesticide's potential impact on non-target organisms requires incorporating chronic and sub-lethal endpoints as well as the environmental fate of the substance's metabolites or breakdown products.

BHT has undergone a limited evaluation of its chronic and subchronic effects to non-target organisms. According to the petitioner, Pacific Biocontrol Corporation, "All Tier I ecological effects data requirements are waived based on proposed use pattern and lack of exposure." Yet, a Tier I assessment is the first evaluative step to qualitatively and quantitatively screen of the properties of the pesticide and its inerts that may engender risk to the environment. Where an excess value is observed, it flags the risk assessor of the need for further evaluation. A Tier I assessment, intended to be protective, would provide a minimal understanding of the product in varying exposure settings.

Knowledge of a substance's persistence is measured by the length of time required for half of the chemical residue to lode its analytical identity through dissipation, decomposition, metabolic alteration, or other factors. The half-life can be applied to soil, water, tissues, etc. It is measured in days [t½ days]. Chemicals with half-lives over 21 days warrant greater review. BHT remains in the environment for a short time. In soil, BHT degrades rapidly, particularly in the presence of microbes. In water, BHT and its degradates have a half-life of 30 days or less.

Half-Life in Days

<5	(non persistent)
5-21	(slightly persistent)
22-60	(moderately persistent)
>60	(very persistent)

Octanol Partition Coefficient

One of the accepted standard measures for a substance's ability to bioaccumulate in individual organisms and bioconcentrate to higher trophic levels is the octanol/water partition coefficient (Log K_{ow}). This is the amount of chemical that concentrates in octanol minus the log of the concentration in water *[note: this is the standard measure for water / oil solubility]*. The resulting log or K_{ow} is the measure of lipophilicity and predicts the degree of concentration of any given chemical in the fat or lipid fraction of cells or organisms. Where the K_{ow} is more than 3, the substance is very likely to concentrate up the food chain (Shaw and Chadwick, 1998). The K_{ow} for BHT corresponds with an unacceptable level of lipid concentration, though studies show that it does not tend to bioaccumulate in aquatic organisms due to its rapid degradation (Inui et al., 1979b; IARC, 1986; Kagan V.E., Serbinova, and Packer. 1990).

The following table summarizes the characteristics of BHT in relation to standard measures and environmental limits.

Acceptable Environmental Hazard & Exposure Endpoints & Evaluation of BHT

Acceptable Endpoints	BHT
LD50 > 500 mg/kg	1,040 mg/kg (oral mouse)
LC 50 > 10 mg/l	**6.2** (48 hr) killifish
Solubility < 500 mg/l	0.6 ppm
Log K_{ow} < 3	**5.1**

* **Bold** indicates endpoints that exceed levels of acceptability and may require attention

<u>*Environmental Contamination*</u>

One additional caveat would be the proper disposal of pheromone plastic dispensers at the end of each growing season as required of plastic mulches under Section 6508 (a)(2) Federal Foods Production Act of 1990. Pheromones containing BHT applied as twist-ties should also be removed from the production area.

<u>*Effects on Human Health*</u>

The reviewer agreed with the review except as follows:

Carcinogenesis: Conflicting data exists regarding BHT's ability to act as a tumor suppressor and a tumor promoter. The International Agency for Research on Cancer (IARC-WHO) reviewed BHT and could find no consistent evidence that BHT causes cancer in rodents, nor could it find any data showing that BHT causes cancer in humans (IARC, 1986). As noted by the authors of the report, one study on mice and another on rats showed no difference in the incidence of tumors among treated and control groups. In another study with a small number of animals, BHT increased the number of mice with lung tumors, but the effect disappeared when the researcher repeated the experiment with a larger number of animals. BHT did cause liver tumors in one experiment, but the IARC experts could not evaluate this study because the rats that had received BHT lived longer than the controls! To confuse matters even further, other studies in mice and rats showed an increased incidence of tumors in females at the lower dose level but not at the higher. Finally, when BHT was tested to see if it could modify the activity of known carcinogens, the results were again all over the map—BHT either enhanced, inhibited, or had no effect on carcinogenicity.

Allergies: Because contact dermatitis can occur (albeit rarely) with exposure to BHT, applicators should wear protective gloves when applying pheromones as twist ties. BHT in pheromone plastic dispensers would not likely create an exposure of concern for dermatitis.

I . . . also recommend a Tier I ecological assessment particularly when BHT is not used with pheromones encased in polymers. BHT is compatible with a system of sustainable agriculture when used as an inert ingredient in pheromones encased in plastic dispensers and twist ties.

<u>*Conclusions and Summary*</u>

The inert antioxidant BHT is relatively non-toxic. Ecologically, it has a favorable persistence rating, degrading rapidly in the environment. Used as a stabilizer in pheromone products sheathed in plastic dispensers, it lengthens the field life of the product creating a more effective disruption of predator mating. Because this method of application presents only a modest to non-existent risk to the environment, BHT as an inert ingredient of a dispenser product should be added to the National List of allowed synthetics.

The human health toxicity data of BHT generally is inconclusive. Cancer data is conflicting and according to IARC is not classifiable. NTP and OSHA have not classified the material as a carcinogen. Nonetheless, reviewing the material used in cancer bioassays, in some situations it acts as a tumor suppressor and others it behaves as a tumor promoter. Based on potential human and ecological exposure risk, if BHT is added to the national list, it should only be approved for use as a stabilizer in a solid matrix dispenser.

Reviewer 1 Recommendation Advised to the NOSB

The substance is <u>synthetic</u>

For crops, the BHT should be <u>added to the national list *but* be approved only as an allowed inert in pheromone containing plastic dispensers</u>

<u>Reviewer 2</u> *[Ph.D. Agronomy, Technical resource for an organic farmers' association, Northeast]*

<u>*Toxicity*</u>

Evidence presented in the literature supports the conclusion drawn by the TAP review that biodegradation is quick and complete. BHT does not persist in the environment. However, if the input of BHT is over long periods than it and its intermediate break down products would be present in the environment over long periods. This would not be a problem with the use of BHT when encased and the plastic encasement is properly disposed of. It would be a concern with some other methods where the BHT was susceptible to more environmental contamination or with improper disposal of the encasement.

Effects on the Agroecosystem

It is important that timely removal and proper disposal of the encasements is monitored. I also suggest that the NOSB work with the EPA to modify the label instructions that suggest burning the plastic encasement.

Alternatives

At this time I believe that the TAP makes a very good case that pheromone mating disruption is the most effective non chemical control of codling moth, and a good case for BHT being the most appropriate antioxidant available to preserve the pheromone, but natural alternatives may in the future prove workable. I suggest that the NOSB note that when the material comes up for review again in five years that alternative natural antioxidants be reevaluated.

Conclusion

I am a slight bit uncomfortable recommending such a well known food preservative be listed if only because of the appearance of it on the List. However, I believe that the petition makes a good case for its need, lack of good alternatives, limited environmental impact and low toxicity and I believe that the research literature and TAP support those conclusions. Consequently, I support the listing of BHT, but limited to use in pheromone mating disruption and with the stipulation that it must be encased to limit environmental contamination, and that proper disposal of the encasements be enforced.

The literature does note that BHT decomposes quickly and completely and that bioaccumulation did not occur, but it was also noted that BHT was incorporated by some animals and then metabolized before excretion (Inui et al. 1979b). Hence, if continuously added to the soil or water systems it would be continuously available for animal incorporation. It is important, in my opinion that continuous or long term application methods that are susceptible to loss of the material to the environment be prohibited.

Reviewer 2 Recommendation Advised to the NOSB:

a. The substance is Synthetic
b. For Crops and Livestock, the substance should be added to the National List only with an annotation that restricts use. Allowed as Synthetic, restricted.
c. *Suggested Annotation, including justification:* only in pheromone mating disruption, must be encased and encasement disposed of properly.

This is justified because the literature points to potential contamination of the environment if the BHT is applied in susceptible methods or if the encasements are not disposed of properly.

Reviewer #3 *[M.S. agronomy. Provides technical services to growers. Extensive experience in organic and sustainable agriculture. South]*

I believe that BHT should be permitted for use in organic systems, but should be limited to use in mating disrupters at this point in time.

Effect on agroecosystem

The evidence presented has satisfied me that there is no likelihood of adverse reactions to be expected within the organic agroecosystem from the use of BHT in the manner proposed—mating disruption. I am reasonably satisfied that no harmful effects can be expected from the intermediate breakdown products, which appear to have rather short half-lives in biologically active systems. The final breakdown products—CO_2 and water—are harmless.

There appears to be no serious concern about environmental contamination during the manufacturing process. The synthetic process described apparently produces a few non-recyclable by-products. The implication is that these are low-hazard materials…I hope that is true and trust that it is. The derivation of BHT from coal tar actually sounds like a positive recycling. The concern about the fate of the disrupter "package" at the end of the season is valid. However, the fact that less than ¼ lb of waste is created per acre of production suggests this is not going to create a pollution problem, no matter what means of disposal is employed.

Effects on Human Health

I have some questions about the possible impacts on human health. Apparently the EPA does also, hence the List 3 status. However, the literature tells us that BHT abounds in food and other products at this time. Use of BHT in mating disrupters will not measurably increase organic or conventional consumer exposure to this chemical. The amount used is minute and the nature of the application truly negates its potential as a contaminant. On the other hand, the questions about human health impacts make restrictions on BHT in organic production advisable, therefore I recommend annotation that restricts its use to mating disrupters.

<u>*Alternatives*</u>

The question of alternatives to BHT is a two-part issue. The first issue deals with the alternatives to mating disrupters as a tool for organic production. While cultural practices, crop nutrition, and good plant genetics are the preferred first line of defense in managing pests organically, these are not adequate for economic control of most pests currently targeted by mating disruption. The product alternatives to pheromones are more expensive and, in most instances, less effective. Some of them—being pesticides—can pose a risk to non-target organisms. Organic apple production will certainly become more expensive if producers lose access to mating disruption materials.

The second issue is whether there is a suitable alternative to BHT as an antioxidant and preserver in pheromone products. Vitamin E, it is clear, will work only for certain types of pheromone products. Apparently there are a few other candidates, though these have not been adequately evaluated. A decision to prohibit BHT would certainly jeopardize organic production for 1-2 years as alternative antioxidants were evaluated and new recommendations developed. There is also the risk that these alternatives might not perform as well as BHT, increasing costs to organic producers even more.

<u>*Compatibility*</u>

To the extent that BHT makes mating disruption feasible and affordable for organic farming, it is a compatible tool. Mating disruption is not only affordable it has much less environmental impact than many other organically acceptable alternatives. While synthetic, the amount of BHT brought to the field is very low. Furthermore, the manner in which it is used poses little-to-no environmental hazard. Contamination of organic product to any level of concern is highly unlikely. The possible hazard to farm workers is practically nil.

Reviewer 3 Recommendation Advised to the NOSB:

a. The substance is <u>Synthetic</u>

b. For Crops and Livestock, the substance should be <u>Added to the National Lis</u>t only with an annotation that restricts use. Allowed as Synthetic, restricted.

c. Suggested Annotation, including justification:

BHT should be permitted for use <u>only as an inert ingredient in the formulation of mating disrupters for crop (or livestock) protection.</u>

The rationale for this annotation is that BHT remains an EPA List 3 ingredient and uncertainty about its effects warrants caution. I am satisfied that use of BHT as an inert ingredient in pheromone mating disrupters presents little-to-no hazard to the environment, to farmer health, and will not contaminate organic food products to measurable or harmful levels. However, unrestricted freedom to use BHT could lead to future applications that expose people and the environment to much larger quantities of this material. Should we learn that there are problems, we would regret having kicked the door wide open.

Conclusion:

Use of pheromones to control insect pests through mating confusion techniques has become an indispensable part of organic apple production over the past decade. Part of the success can be attributed to stable, convenient packages that can reliably deliver the pheromone over the growing season. Pheromones also promise to help manage pest pressure in other crops as well. While there are environmental and health concerns about the use of BHT, restricted use in pheromones that do not contact the crop will result in negligible risk of residues in organic food. All of the reviewers considered the substance synthetic; all recommended allowing it for use with similar limitations that restrict use to an inert ingredient in pheromones formulated in passive plastic (polymer) dispensers.

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