E X T O X N E T

Extension Toxicology Network

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Pesticide
Information
Profile

Tributyltin

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INTRODUCTION

Tributyltin (TBT) is the active ingredient of many products that act as biocides against a broad range of organisms. It is primarily used as an antifoulant paint additive on ship and boat hulls, docks, fishnets, and buoys to discourage the growth of marine organisms such as barnacles, bacteria, tubeworms, mussels and algae

TBT by itself is unstable and will break down in the environment unless it is combined with an element such as oxygen. One of the most common TBT compounds is bis(tributyltin) oxide, or TBTO. This form has been the subject of most TBT testing.

TBTO and eight additional TBT compounds are registered for use as marine antifoulants. Other TBT compounds are used as disinfectants, fungicidal wood preservatives, textile disinfectants, and stabilizers in PVC resin. Paper and pulp mills, cooling towers, breweries, textile mills and leather-processing facilities may also use some forms of TBT. Collectively these compounds are refered to as organotins.

All of the organotins are now regulated by the "Organotin Antifouling Paint Control Act of 1988." This act regulates the use of these materials in paints and sets standards for the amount of biocides that can leach from the paint into water.

TOXICOLOGICAL EFFECTS

ACUTE TOXICITY

TBT is moderately to slightly toxic to mammals. Human skin is sensitive to TBTO, although the extent of sensitivity is not known. TBT can cause eye irritation in humans exposed over a few hours (5). Inhalation of TBT may interfere with breathing and cause headache, weakness, tremors and incoordination. The lowest concentration inhaled from the air that causes toxicity in humans is 10 ppm for three minutes and 20 ppm for five minutes (5). The oral LD50 of TBT is 1,500 mg/kg for rats, 2,000 mg/kg for rabbits, and 900 mg/kg for mice (5). The dermal LD50 of TBTO is 11,700 mg/kg for rats and 900 mg/kg for rabbits (7). Two products containing TBT, Triphenyltin hydroxide and triphenyl chloride both carry the signal word WARNING.

CHRONIC TOXICITY

Studies of the effects of TBT products on living organisms have been primarily performed on aquatic life, because TBT is mostly used in bodies of water. Thus, data gaps exist concerning effects of TBT on mammals in regard to reproduction, development and mutagenicity. Although effects of TBT on humans is not clear, several incidents of human exposure to the biocide have been reported. Underwear treated with TBT has caused severe skin irritation to its wearers. Shipyard workers exposed to TBT dust and vapors, while repairing a submarine, developed breathing problems, irritated skin, headaches, colds, flu, fatigue, dizziness and stomach aches (1). TBT exposure can also irritate the eye, skin, and mucous membranes and prolonged exposure may cause liver and kidney damage (5).

Carcinogenic Effects

While one study indicates that rats have developed pituitary gland tumors after exposure to high doses of TBT, the evidence is not conclusive (1) and the carcinogenic status of TBT is still uncertain (5).

Organ Toxicity

In mammals, high levels of TBTO can affect the endocrine glands, upsetting the hormone levels in the pituitary, gonad and thyroid glands. Large doses of TBT have been shown to damage the reproductive and central nervous systems, bone structure, and the gastrointestinal tract of mammals.

TBT compounds damage the immune system. One study of male rats fed TBTO daily for six weeks resulted in decreased resistance to infection (10).

Fate in Humans and Animals

In mice, TBTO is excreted mainly unchanged via the feces, indicating low absorption by the body. An undetermined amount of this compound is known to remain in fat, liver, kidney, and lung tissues. The makers of TBT, M & T Chemicals, claim that workers exposed to this substance metabolize it within three days (2).

ECOLOGICAL EFFECTS

Much of the concern over the use of tributyltin stems from its use as a marine antifoulent in paints. This compound is slowly released from the paint on the hull of the boat into the adjoining water hindering the growth and attachment of a variety of organisms to the boat. Consequently, tributyltin concentrations in harbors and bays in Britain, France and the United States were high enough to significantly affect oyster and mussel production.

TBT is extremely toxic to crustaceans. Lobster larvae show a nearly complete decrease in growth at just 1.0 ppb TBT (1). Molluscs, used as indicators of TBT pollution because of their high sensitivity to these chemicals, react adversely to very low levels of TBT (0.06-2.3 ppb). They release TBT very slowly from their bodies after it has been absorbed.

TBT toxicity in the field may be substantially underestimated in laboratory studies (1). TBT binds to the sides of containers and plankton which contributes to this underestimation of it's potential toxicity.

Generally, the larvae of any tested species are more sensitive to tributyltin exposure than are the adults.

The present use of TBT in antifouling paints may cause TBT exposure to nontarget aquatic organisms such as mussels, clams, and oysters. At low levels, TBT can cause structural changes and growth retardation (3).

Imposex, the development of male characteristics in females, has been initiated by TBT exposure in several snail species. In laboratory tests, reproduction was inhibited when female snails exposed to 50 ppt of TBT developed male characteristics (1). Imposex was also noted in the mud snail, or dogwhelk, at less than 3 ppt TBT (1).

Oysters in France and England's marine waters are adversely affected by TBT exposure. TBT-exposed oysters have abnormal shell development, poor weight gain, brittle shells and imposex.

Some fin fish can degrade TBT because of special enzymes these fish contain. Once absorbed in Chinook salmon, TBT breaks down into di-n-butyltin (DBT). Rainbow trout eggs are killed within 10-12 days when exposed to 5 ppb TBT. At lower levels, no deaths occurred, but blood and liver metabolism changes were noticed (6). Growth reduction and liver changes also occurred in young trout exposed to low levels of tributyltin chloride. Also, after seven days at low levels of TBTO, the corneal membranes of the rainbow trouts' eyes were destroyed (1).

TBTO has been shown to inhibit cell survival of marine unicellular algae at very low concentrations; the 72-hour EC50 ranges from 0.33 ppb to 1.03 ppb (1).

TBT is highly attracted to fats and tends to be stored in these tissues. TBT is accumulated in oysters, mussels, crustaceans, molluscs, fish, and algae. Freshwater species will bio-accumulate more TBT than will marine organisms.

Oysters bioaccummulate TBT compounds readily, reach an equilibrium uptake soon after exposure, and are slow to release this chemical. Oysters exposed to very low TBTO concentrations bioaccumulated TBT 1,000 to 6,000 fold. Specific bioaccumulation factors vary depending on the species.

Evidence of organotins entering the human diet has been observed with Chinook salmon, which may be commercially raised in TBT-treated pens. Juvenile chinook salmon accumulate TBT immediately upon exposure to low TBT concentrations. TBT and its metabolite, DBT, were found in the salmon's muscle tissue (8).

ENVIRONMENTAL FATE

Degradation depends on temperature and the presence of microorganisms. The breakdown of TBT leads eventually to the tin ion. All of the breakdown products are less toxic than TBT itself.

Under aerobic conditions, tributyltin takes one to three months to degrade. But in anaerobic (airless) soils, this compound will persist for more than two years.

Because of the low water solubility (inability to dissolve in water) of TBT and other properties, it will bind strongly to suspended material such as minute organic material or inorganic sediments (4). The

extent of binding to bottom sediment will vary with location, organic content, particle size, and type of material.

The half-life of TBT in water is about three months. Also, the chemical nature of TBT compounds generally keeps them within the water areas where they were applied.

Levels up to 800 ppt have been found along the East Coast of the United States. In the Great Lakes, concentrations from 20 to 840 ppt have been recorded. San Diego Bay has reached 1,000 ppt TBT (11).

It has not been found in groundwater.

COMMENTS AND PROBLEMS

U.S. law now restricts the use of TBT on non-aluminum boats shorter than 65 feet.

Two kinds of TBT-containing paints are known. Free-association paint, made by mixing TBT into the paint, dissolves when it contacts water. All of the TBT is leached out from the paint in 12-24 months. In copolymer paint, the TBT is bound to the paint and slowly releases with water movement, and is effective for five to six years.

The EPA has established a cut-off release rate of 4.0 ug/cm2/day as sufficient to keep a ship's hull free of fouling, while causing minimal risk to aquatic mammals.

PHYSICAL PROPERTIES AND GUIDELINES

Tributyltin is a member of the aromatic hydrocarbon chemical family. It is a colorless liquid with an odor similar to gasoline. The molecular weight of TBT is 148.25. One of its metabolites, bis-(tri-n-butyltin) oxide (TBTO) is a slightly yellow, combustible liquid.

Exposure Guidelines:

TOL:	5 ppm (5)
TLV:	10 ppm (TWA); 20 ppm (STEL) (5)
Drinking water health advisory:	2 ppt (British)
Criterion Maximum Concentration (acute):	150 ppt (freshwater), 240 ppt (saltwater)
Criterion Continuous Concentration (chronic):	20 ppt (freshwater), 30 ppt (saltwater)

Physical Properties:

CAS#:	56573-85-4
Solubility in water:	considered insoluble; about 1 ppm (4).
Solubility insolvents:	soluble in hexane and most organic solvents
Melting point:	53 degrees C (5)
Boiling point:	193 degrees C (5)
Vapor pressure:	1 mm Hg at 20 degrees C (5)

Kow:	5500 in 32% seawater (4)
Koc:	1000-8000
BCF:	about 260 (4), varies with species.

BASIC MANUFACTURER

Twenty or more TBT compounds are registered for use in the United States as an active pesticide ingredient.

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