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Tributyltin

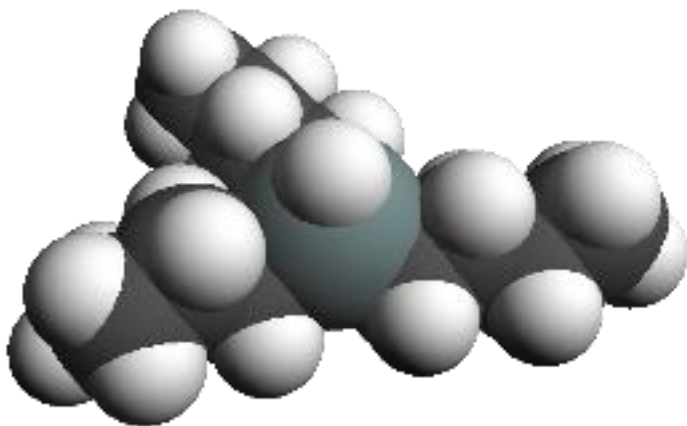
Overview

Tributyltin (TBT) is a highly toxic biocide that has been used extensively to prevent the growth of marine organisms on the hulls of large ships. It is a problem in the aquatic environment because it is extremely toxic to non-target organisms, is linked to immuno-suppression and imposex (development of male characteristics in females) in snails and bivalves, and can be persistent.

Tributyltin (TBT) compounds include: tributyltin oxide, tributyltin benzoate; tributyltin chloride, tributyltin fluoride, tributyltin linoleate, tributyltin methacrylate, tributyltin naphthenate.

Chemical Description

Tributyltin is organotin. Organotins are compounds consisting of one to four organic components attached to a tin atom via carbon-tin covalent bonds. When there are fewer than four carbon-tin bonds, the organotin cation can combine with an anion such as acetate, carbonate, chloride, fluoride, hydroxide, oxide, or sulfide. Thus a species such as tributyltin (TBT) is a cation whose formula is $(C_4H_9)_3Sn^+$. In sea water, TBT exists mainly as a mixture of the chloride, the hydroxide, the aquo complex, and the carbonate complex.



Uses

The principal use of organotins is as a stabilizer in the manufacturing of plastic products, for example, as an anti-yellowing agent in clear plastics and as a catalyst in poly(vinyl chloride) products. Another and less extensive use of organotins is as a biocide ([fungicide](#), bactericide, [insecticide](#)) and as a preservative for wood, textiles, paper, leather and electrical equipment. A large market exists for organotins in antifouling paint for the wet bottoms of ship hulls. The most common organometallics used in these paints are TBT oxide and TBT methacrylate.

Routes of Exposure and Metabolism

Tributyltin can enter the body through inhalation of contaminated air, ingestion of contaminated food or through contact with the skin.

Metabolism in mammals is rapid: metabolites are detectable in blood within 3 hours of TBT administration. TBT is a substrate for mixed-function oxidases in vitro, but these enzymes are inhibited by TBT in vitro at very high concentrations. Metabolism occurs in lower organisms but is slower, particularly in mollusks. The capacity for bioaccumulation is therefore much greater than in mammals. Excretion of tributyltin is via the bile rather than the urine. Tributyltin can be transferred across the blood-brain barrier and from the placenta to the fetus.

Human Health Effects

Acute Health Effects

Acute toxicity of organotin compounds is strongly influenced by the length of the alkyl chains attached to the tin. Tributyltin (TBT) is generally less toxic than trimethyl- and triethyltins. Tributyltin compounds are moderately toxic via both ingestion and dermal absorption. The tributyltin compounds may be strongly irritating to the skin in humans, especially the hair follicles, and skin exposure may result in chemical burns in only a few minutes if the concentration of tributyltin is high enough. Shipyard workers exposed to TBT (occupationally exposed to dusts and vapors) developed irritated skin, dizziness, difficulty breathing, and flu-like symptoms. Other mucous membranes such as the eyes and nasal passages may also become irritated upon exposure.

Chronic Health Effects

Tributyltin compounds are listed as [endocrine disruptors](#) by the [EU](#) and as a "known" endocrine disruptor by the [Illinois EPA](#).

Environmental Health Effects

Much of the concern over the use of tributyltin stems from its use as a marine antifoulant in paints. TBT is slowly released from the paint into the adjoining water, hindering the growth and attachment of a variety of organisms to the boat.

As a result of its low water solubility and lipophilic character, TBT adsorbs readily onto particles. The degree of adsorption depends on the salinity, nature and size of particles in suspension, amount of suspended matter, temperature, and the presence of dissolved organic matter.

TBT bioaccumulates in organisms because of its solubility in fat.

Tributyltin is highly toxic to marine mollusks. It has been shown experimentally to affect shell deposition of growing oysters, gonadal development and gender of adult oysters, settlement, growth, and mortality of larval oysters and other bivalves, and to cause imposex (the development of male characteristics) in female gastropods.

Tributyltin has been shown to be toxic to schistosome (a type of worm) larvae in the aquatic stages. The sensitivity of snails to TBT decreases with age, but eggs are more resistant than both young and adults. The exposure of terrestrial organisms to TBT results primarily from its use as a wood preservative. TBTO is toxic to bees housed in hives made from TBT-treated wood. TBT compounds are toxic to insects exposed topically or via feeding on treated wood.

Precautions

A health risk was identified from the mixing of TBT-based paints due to the release of TBT to the atmosphere during mixing. The use of protective equipment during this operation is likely to reduce the level of exposure to acceptable limits but the use of such equipment is uncertain.

A potential health risk was also identified from the ingestion of contaminated seafood. The use of TBT can result in concentrations in water that pose an unacceptable risk to human health where daily intake of fish comes from shellfish raised in waters near commercial harbours. Using worst case values for bioaccumulation, daily fish consumption, and acceptable daily intake (ADI), a TBT concentration in water necessary to keep the dietary exposure to TBT below acceptable daily intake levels was calculated. It was found that this concentration would be exceeded in areas close to shipping ports, although it was unlikely in more distant locations and the open sea.

Regulation

The International Convention on the Control of Harmful Anti-fouling Systems on Ships prohibits the use of harmful organotins in anti-fouling paints used on ships and establishes a mechanism to prevent the potential future use of other harmful substances in anti-fouling systems.

Many countries have restricted the use of TBT anti-fouling paints as a result of effects on shellfish. The regulations vary in detail from country to country, but most ban the use of TBT paints on boats 25 meters in length or less. Some countries have excluded boats with aluminum hulls from this ban. In addition, some regulations restrict the TBT content of paints or the leaching rate of TBT from paints (to 4 or 5 $\mu\text{g}/\text{cm}^2$ per day, long term).

References

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