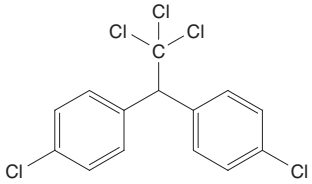
Dichlorodiphenyltrichloroethane

CAS No. 50-29-3

Reasonably anticipated to be a human carcinogen

First listed in the *Fourth Annual Report on Carcinogens* (1985)

Also known as DDT or 1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)-ethane



Carcinogenicity

Dichlorodiphenyltrichloroethane (DDT) is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals.

Cancer Studies in Experimental Animals

DDT caused liver tumors in two rodent species and by two different routes of exposure. It caused primarily malignant primary liver-cell tumors (hepatocellular carcinoma) in mice of both sexes and in rats (of unspecified sex) following dietary exposure; in mice of both sexes following administration by stomach tube; and in female mice following subcutaneous injection (reviewed by IARC 1991). Increased incidences of lung tumors and malignant lymphoma following oral exposure to DDT were observed in some, but not all, of the studies in mice.

Cancer Studies in Humans

No epidemiological studies of the carcinogenicity of DDT in humans were identified at the time DDT was listed in the *Fourth Annual Report on Carcinogens.* Since then, a number of epidemiological studies of human cancer and DDT exposure have been identified. Studies reviewed in 1991 by the International Agency for Research on Cancer were inconclusive because of co-exposure to numerous pesticides and the small sizes of the study groups (IARC 1991).

Epidemiological studies conducted since 1991 have mainly been case-control or nested case-control studies, plus a few prospective or occupational cohort studies, and include over 20 studies of breast cancer. Comparison of the results of breast-cancer studies has been complicated by differences in exposure assessment, dietary factors, breast-tumor type and estrogen-receptor status, age, menopausal status, lactation history, body mass status, race or ethnicity, or exposure to other potential carcinogens (Snedeker 2001, Calle *et al.* 2002, Clapp *et al.* 2008, Eskenazi *et al.* 2009). The majority of breast-cancer studies (mostly of older women in the United States) did not find statistically significant associations with estimated exposure or with serum or adipose-tissue levels of DDT or 1,1-dichloro-2,2-bis(*p*-chlorophenyl) ethylene (DDE, a metabolite of DDT) (see reviews above and ATSDR 2002, 2008, Lopez-Cervantes *et al.* 2004). However, positive associations between DDT exposure and breast cancer were reported in a few studies among women with higher levels of exposure and among certain subgroups of women (Wolff *et al.* 1993, Hoyer *et al.* 2000, Romieu *et al.* 2000, Rubin *et al.* 2006, Cohn *et al.* 2007).

Several studies have investigated the association between DDT or DDE exposure and cancer at other tissue sites. One study reported an association between DDT exposure and leukemia among agricultural workers (Morris-Brown *et al.* 1990). Increased risk or incidence of multiple myeloma with DDT exposure was found in a case-control study of farmers (Eriksson and Karlsson 1992) and a cohort proportionate-mortality study of pesticide applicators who had used 94% DDT (Cocco *et al.* 1997). Increased risk of liver cancer also has been associated with serum DDT level (McGlynn *et al.* 2006), DDT pesticide application (Cocco *et al.* 1997), and levels of DDE in adipose tissue (Cocco *et al.* 2000). Increased risks of cancer at other tissue sites, such as the gallbladder (Shukla *et al.* 2001), prostate (Settimi *et al.* 2003), and testes (McGlynn *et al.* 2008), have been reported in one study for each site.

Properties

DDT is a chlorinated aromatic hydrocarbon insecticide (NCI 1978) that in its pure form exists at room temperature as colorless to off-white needles or powder with a slight aromatic odor (Akron 2009, HSDB 2009). It is practically insoluble in water, but it is soluble in many organic solvents, including acetone, benzene, benzyl benzoate, carbon tetrachloride, chlorobenzene, cyclohexanone, ethanol, ethyl ether, gasoline, isopropanol, kerosene, morpholine, peanut oil, pine oil, tetralin, and tributyl phosphate (IARC 1974, HSDB 2009). DDT is highly soluble in lipids (HSDB 2009). It is very stable and exceptionally persistent in the environment (IPCS 1989). Technical-grade DDT is a mixture of three forms, *p,p′*-DDT (85%), *o,p′*-DDT (15%), and *o,o′*-DDT (trace amounts) (ATSDR 2002). Technical-grade DDT may also contain DDE and 1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethane (DDD) as contaminants; both are breakdown products of DDT. Physical and chemical properties of DDT are listed in the following table.

Property	Information
Molecular weight	354.5
Specific gravity	0.98 to 0.99
Melting point	108.5°C
Boiling point	260°C
Log K_{ow}	6.91
Water solubility	5.50×10^{-6} g/L at 25°C
Vapor pressure	1.6×10^{-7} mm Hg at 20°C

Source: HSDB 2009.

Use

DDT was first used in the United States as an insecticide in 1939 (ATSDR 2002). From 1946 to 1972, DDT was one of the most widely used insecticides in the world (HSDB 2009). It was used for the control of insect pests such as the pink bollworm on cotton, codling moth on deciduous fruits, Colorado potato beetle, and European corn borer (ATSDR 2002). In the public health field, DDT was used to control malaria, typhus, and other insect-transmitted diseases and to treat body lice (HSDB 2009). It was also used for mothproofing clothing (ATSDR 2002). Its usage peaked in the 1960s, but in 1972, it was banned for the vast majority of uses in the United States (ATSDR 2002, HSDB 2009). DDT is currently used in the United States only under Public Health Service supervision for public health emergencies and by the U.S. Department of Agriculture or U.S. military for health quarantine. It is also still used in many countries where malaria is endemic, as an insecticide to control mosquitoes (HSDB 2009).

Production

Technical DDT was first synthesized in 1874, and commercial production in the United States had begun by 1945 (ATSDR 2002, HSDB 2009). In 1962, 82 million kilograms (180.4 million pounds) of DDT was produced in the United States for use on 334 agricultural commodities. In 1971, production in the United States was estimated at 2 million kilograms (4.4 million pounds) (ATSDR 2002). In 2009, no U.S. companies manufactured DDT, but it was produced by six companies worldwide, including one in Europe, two in China, one

in East Asia, and two in India (SRI 2009), and was available from 21 suppliers, including 9 U.S. suppliers (Chem Sources 2009). DDT is no longer imported into the United States (ATSDR 2002); it was last imported in 1972, in the amount of about 200 metric tons (441,000 lb) (HSDB 2009). In 1978 (the last year for which export data specific to DDT were available), U.S. exports of DDT were 13.7 million kilograms (30.2 million pounds).

Exposure

Despite the 1972 U.S. ban of DDT, human exposure continues because of its extensive former use, its current use in some areas of the world, and the persistence of DDT and its breakdown products in the environment (ATSDR 2002). DDT is still released into the atmosphere through spraying in some areas of the world. In addition, it volatilizes from soil in areas where it was formerly used. The volatilization and deposition cycle may be repeated many times, resulting in widespread distribution of DDT worldwide. In addition, DDT readily accumulates in animal fat and thus bioaccumulates through the food chain. DDT and its breakdown products have been found throughout the world, from the Arctic to the Antarctic, having been detected in ambient and indoor air, precipitation (rain and snow), water, soil, and animal and plant tissues. The residual levels of DDT in the environment have declined and continue to decline, but because of DDT's high persistence, it will be present at low levels for decades. In a study of long-term dietary intake of DDT and all of its metabolites, daily intake for a 70-kg 16-year-old U.S. male was estimated at 6.5 µg for 1978–79, 2.4 µg for 1979–80, 1.5 µg for 1984–86, and 0.97 µg for 1986–91. Currently, human exposure to DDT and its breakdown products is primarily through dietary ingestion, particularly of meat, fish, poultry, and root and leafy vegetables. The highest dietary exposure occurs among indigenous Arctic populations that eat traditional foods such as seal, whale, or caribou. The highest average daily intake was observed in the eastern Arctic, where total daily intake of DDT and all of its metabolites was 24.2 to 27.8 µg/day. The foods contributing the most were beluga whale blubber (316 µg/g of wet weight) and narwhal whale blubber (273 µg/g) (ATSDR 2002).

DDT has been measured in numerous human tissues in the U.S. population and in other populations around the world, including indigenous Arctic peoples. DDT accumulates in fatty tissues and is usually found in higher concentrations in human milk than in cow's milk or other infant foods. In the United States, mean concentrations of DDT were 0.99 mg/kg (990 ng/g) in milk fat from Arkansas women in 1986, 28.8 ppb (ng/g) in serum from consumers of Great Lakes fish in 1982, and 252 ng/g in adipose tissue from a national sample of individuals age 45 years or older in 1986 (ATSDR 2002). The median concentration of DDT in plasma samples from 407 highly exposed Inuit individuals living in Greenland was 35 µg/kg of lipid (35 ng/g) (Bjerregaard *et al.* 2001). DDT was detected in 95% of the samples from this population. For the population measured in the United States National Health and Nutrition Examination Survey (NHANES), the geometric mean concentration of DDE in serum was 260 ng/g of lipid in 1999–2000, 285 ng/g in 2001–02 , and 238 ng/g in 2003–04 (ATSDR 2008). The Mexican-American population sampled in NHANES had mean DDE concentrations about twice those for the total population: 674 ng/g in 1999–2000, 652 ng/g in 2001–02, and 444 ng/g in 2003–04.

Regulations

Department of Transportation (DOT)

DDT is considered a hazardous substance and a marine pollutant, and special requirements have been set for marking, labeling, and transporting this material, including transporting it in tank cars.

Environmental Protection Agency (EPA)

Clean Water Act

Designated a hazardous substance.
Effluent Guidelines: Listed as a toxic pollutant.
Water Quality Criteria: Based on fish or shellfish and water consumption = 0.000030 µg/L; based on fish or shellfish consumption only = 0.000030 µg/L.

Comprehensive Environmental Response, Compensation, and Liability Act

Reportable quantity (RQ) = 1 lb.

Federal Insecticide, Fungicide, and Rodenticide Act

Registrations for nearly all uses of DDT have been cancelled.

Resource Conservation and Recovery Act

Listed Hazardous Waste: Waste code for which the listing is based wholly or partly on the presence of DDT = U061.
Listed as a hazardous constituent of waste.

Food and Drug Administration (FDA)

Action levels for DDT in various food items and in processed animal feed range from 0.05 to 5 ppm.

Occupational Safety and Health Administration (OSHA)

While this section accurately identifies OSHA's legally enforceable PELs for this substance in 2010, specific PELs may not reflect the more current studies and may not adequately protect workers.
Permissible exposure limit (PEL) = 1 mg/m^3.
Potential for dermal absorption.

Guidelines

American Conference of Governmental Industrial Hygienists (ACGIH)

Threshold limit value – time-weighted average (TLV-TWA) = 1 mg/m^3.

National Institute for Occupational Safety and Health (NIOSH)

Immediately dangerous to life and health (IDLH) limit = 500 mg/m^3.
Recommended exposure limit (time-weighted-average workday) = 0.5 mg/m^3.
Listed as a potential occupational carcinogen.

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