POLYCHLORINATED BIPHENYLS (PCBs)
CAS No. 1336-36-3

First Listed in the *Second Annual Report on Carcinogens*

CARCINOGENICITY

There is sufficient evidence for the carcinogenicity of several mixtures of polychlorinated biphenyls, including Aroclor® 1260 (11096-82-5), Aroclor® 1254 (11097-69-1), and Kanechlor® 500 (37317-41-2), in experimental animals (IARC V.18, 1978; IARC S.4, 1982; Norback & Weltman, 1985; IARC S.7, 1987). When administered in the diet, Aroclor 1260 induced liver tumors including trabecular cell carcinomas, neoplastic nodules, simple cholangiomas, and cystic cholangiomas in rats of both sexes, and hepatocellular carcinomas and liver adenocarcinomas in female rats. When rats that had undergone a partial hepatectomy were administered Aroclor 1260 in the diet, liver tumors were induced, including neoplastic nodules in both sexes and simple and cystic cholangiomas, trabecular cell carcinomas, and adenocarcinomas in females. When administered in the diet, Aroclor® 1254 induced hepatomas in male mice and Kanechlor® 500 induced hepatocellular carcinomas in male mice (Norback & Weltman, 1985; IARC V.18, 1978).

There is inadequate evidence for the carcinogenicity of polychlorinated biphenyls in humans (IARC S.4, 1982). A slight increase in the incidence of cancer, particularly melanoma of the skin, has been reported in a small group of men exposed occupationally to Aroclor 1254. A study of 1,310 workers with at least 6 months of exposure to polychlorinated biphenyls in a capacitor manufacturing plant showed an excess of all cancers among male workers. The excess was mainly due to cancers of the digestive system and of the lymphatic and hematopoietic tissues (IARC S.4, 1982).

PROPERTIES

Theoretically, there are 209 possible polychlorinated biphenyl isomers, although not all are found in manufactured products. Polychlorinated biphenyls vary in appearance from mobile, oily liquids to white, crystalline solids to hard, noncrystalline resins. They are thermally stable, resistant to oxidation, acids, bases, and other chemical agents, and have excellent dielectric properties. Chlorobiphenyls are colorless crystals in the pure form. Commercial products are liquids because the melting point is depressed when polychlorinated biphenyls are mixed. Polychlorinated biphenyls are practically insoluble in water and soluble in oils and organic solvents. When heated to decomposition, they emit toxic fumes of hydrochloric acid and other chlorinated compounds. Technical-grade polychlorinated biphenyls have varying proportions of the different chlorobenzene isomers with small amount of polychlorinated dibenzofurans and polychlorinated naphthalenes as contaminants.

USE

Since 1974, all uses of polychlorinated biphenyls in the United States have been confined to closed

systems such as electrical capacitors and transformers, vacuum pumps, and gas-transmission turbines. Before 1972, polychlorinated biphenyls were used in transformer cooling liquids, heat-transfer and hydraulic fluids, vacuum pump fluids, lubricants, plasticizers, fillers in investment casting waxes, surface coatings and sealants, pesticide extenders, and copy paper (IARC V.18, 1978; Merck, 1983).

PRODUCTION

Polychlorinated biphenyls are no longer produced in the United States, except for limited research and development applications; import and export of the compounds has not been permitted since 1979. The 1979 TSCA Inventory identified one company producing 35,555,500 lb of polychlorinated biphenyls in 1977 (TSCA, 1979). Domestic production reached a peak volume of 86 million lb in 1970 and decreased to about 41 million lb by 1974. Polychlorinated biphenyls were first produced commercially in the United States in 1929 (IARC V.18, 1978).

EXPOSURE

The primary routes of potential human exposure to polychlorinated biphenyls are ingestion, inhalation, and dermal contact. The release of polychlorinated biphenyls from prior industrial uses and the persistence of the compounds in the environment have resulted in widespread contamination of water and soil, with subsequent potential exposure of the general population. Polychlorinated biphenyls have been identified at 10 hazardous waste sites designated in the National Contingency Plan. The Toxic Chemical Release Inventory (EPA) listed 116 industrial facilities that produced, processed or otherwise used polychlorinated biphenyls in 1988 (TRI, 1990). In compliance with the Community Right-to-Know Program, the facilities reported releases of polychlorinated biphenyls to the environment which were estimated to total 3,400 lb. Polychlorinated biphenyls were found in runoff, sediments, soil, creek water, leachate, in an underground oil-water layer, and in pond effluent. Concentrations ranged from 4-440,000 µg/l. The National Organics Monitoring Survey conducted in 1976 to 1977 found polychlorinated biphenyls in 6% of finished ground water supplies at levels of 0.1 µg/l. A major source of exposure is through the diet; fish, cheese, eggs, and contaminated animal feed are the major U.S. commodities in which polychlorinated biphenyls have been found. Residues of polychlorinated biphenyls have been detected in human milk and fat samples collected from the general U.S. population (IARC V.18, 1978). FDA estimated the total adult intake of polychlorinated biphenyls to be 0.93 µg/day. The major sources are dairy products, meat, fish, poultry, fats, and oils. Concentrations in daily human food intake for the years 1977 to 1979 were estimated to be 0.014-0.027 µg/kg body weight. Fires in and/or explosion of electrical capacitors results in contamination of nearby areas. This can result in possible human exposure through inhalation of airborne polychlorinated biphenyls or dermal contact with contaminated surfaces. Proper prevention and management of these fires can greatly reduce possible human exposure (EPA ORD, 1984). EPA estimated that about 12 million persons within 12 miles of three existing and nine projected commercial incinerators may possibly be exposed to releases of polychlorinated biphenyls in the air. In 1977, NIOSH estimated that 12,000 workers had potential occupational exposure as a result of polychlorinated biphenyls in the work environment (NIOSHb, 1977b). Additional exposure information may be found in the ATSDR Toxicological Profile for Polychlorinated Biphenyls (ATSDR, 1995i).

REGULATIONS

The CPSC received a petition to declare sewage sludge products containing polychlorinated biphenyls

hazardous substances. CPSC did not take action based on an anticipated EPA determination on this matter. EPA regulates polychlorinated biphenyls under the Clean Water Act (CWA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Resource Conservation and Recovery Act (RCRA), Superfund Amendments and Reauthorization Act (SARA), and Toxic Substances Control Act (TSCA). EPA has established water quality criteria and a toxic pollutant effluent standard under CWA. These chemicals are subject to reporting requirements under CWA, CERCLA, and SARA. EPA established a statutory reportable quantity (RQ) of 10 lb for polychlorinated biphenyls under CERCLA but lowered the final RQ to 1 lb for these chemicals and specifically for seven commercial mixtures of them. EPA banned the use of these chemicals in pesticides under FIFRA. Certain specific disposal practices of sludges containing polychlorinated biphenyls are prohibited under RCRA. Based upon carcinogenicity, EPA published a Maximum Contaminant Level Goal (MCLG) of zero and a maximum contaminant level (MCL) of 0.0005 mg/l for these chemicals under the Safe Drinking Water Act (SDWA). Under TSCA, EPA banned manufacturing, processing, and distribution of polychlorinated biphenyls and promulgated marketing and disposal rules. EPA has established a polychlorinated biphenyl Spill Cleanup Policy under TSCA. Under the Clean Air Act (CAA), EPA assessed air pollution sources of polychlorinated biphenyls and is considering the need for regulation of emissions from incinerators, the only source for which controls may be essential. FDA regulates polychlorinated biphenyls under the Food, Drug, and Cosmetic Act (FD&CA), establishing tolerances for polychlorinated biphenyls in several foods and in feeds for food-producing animals. The tolerances are 1.5 ppm (fat basis) in milk and manufactured dairy products, 3 ppm (fat basis) in poultry, 0.3 ppm in eggs, 0.2 ppm in finished animal feed, 2 ppm in animal feed components of animal origin, 2 ppm in fish and shellfish (edible portion), and 0.2 ppm in infant and junior foods. FDA established action levels of 3 ppm (fat basis) in red meat and 10 ppm in paper food-packaging material. NIOSH recommends that exposure be controlled to the lowest feasible concentration. OSHA adopted permissible exposure limits (PELs) of 1 mg/m^3 as an 8-hr time-weighted average (TWA) for chlorodiphenyls containing 42% chlorine and 0.5 mg/m^3 as an 8-hr TWA for chlorodiphenyls containing 54% chlorine. These standards were adopted by OSHA for toxic effects other than cancer. OSHA also regulates polychlorinated biphenyls under the Hazard Communication Standard and as chemical hazards in laboratories.

Arochlor® (11097-69-1) was evaluated by the **National Cancer Institute** subsequent to initial listing in the Report on Carcinogens -- see TR 038 (1978).