Polybrominated Diphenyl Ethers (PBDEs) in U.S. Mothers' Milk

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No previous reports exist on polybrominated diphenyl ether (PBDE) congeners in human milk from individual U.S. mothers. This article on PBDEs is an extension of our previous studies on concentrations of dioxins, dibenzofurans, polychlorinated biphenyls, and other chlorinated organic compounds in human milk in a number of countries. PBDE commercial products are used as flame retardants in flexible polyurethane foam (penta-BDE), in acrylonitrile-butadiene-styrene resins (octa-BDE), and in high-impact polystyrene resins (deca-BDE). Their use is permitted in the United States but is banned in some European countries because of presumed toxicity, demonstrated persistence, and bioaccumulation. Different commercial products can be found in various consumer products such as television sets, computers, computer monitors and printers, carpets, and upholstery. Analyses of human levels of these compounds suggest low but rising levels in European human milk, which may have peaked, at least in Sweden, in the late 1990s. Very few data exist on levels of PBDEs in humans in the United States, and none from milk from individual nursing mothers. To address this issue, we analyzed 47 individual milk samples from nursing mothers, 20–41 years of age, from a milk bank in Austin, Texas, and a community women's health clinic in Dallas, Texas. Up to 13 PBDE congeners were measured. The concentrations of the sum of PBDE congeners varied from 6.2 to 419 ng/g (or parts per billion) lipid, with a median of 34 ng/g and a mean of 73.9 ng/g lipid. The PBDE levels in breast milk from Texas were similar to levels found in U.S. blood and adipose tissue lipid from California and Indiana and are 10–100 times greater than human tissue levels in Europe. Their detection in breast milk raises concern for potential toxicity to nursing infants, given the persistence and bioaccumulative nature of some of the PBDE congeners. These results indicate a need for more detailed investigation of the levels of PBDE in people and food, as well as determining if animal fat in food is the major route of exposure of the general U.S. population. Other routes of intake may also be significant. *Key words:* **brominated diphenyl ethers, brominated flame retardants, human milk, nursing mothers.** *Environ Health Perspect* **111:1723–1729 (2003). doi:10.1289/ehp.6466 available via** *http://dx.doi.org/* **[Online 5 August 2003]**

Synthetic halogenated compounds, including some of the persistent organic pollutants (POPs) such as chlorinated dioxins, dibenzofurans, and polychlorinated biphenyls (PCBs), have been identified as global environmental and human contaminants over the past 30 years. Some brominated flame retardants can also be persistent synthetic environmental contaminants. Within this group, brominated diphenyl ethers (BDEs) are one class of brominated flame retardants used in large amounts in the United States. Three commercial products are available: penta-BDE, octa-BDE, and deca-BDE. They are used as flame retardants in electrical appliances, including television sets, computers, computer printers, and fax machines, as well as in carpets and furniture upholstery [Bromine Science and Environmental Forum (BSEF) 2001]. These commercial mixtures differ in content of specific polybrominated diphenyl ether (PBDE) congeners, which in turn differ in their bioavailability, bioaccumulation, and toxicologic properties (de Wit 2002; Hardy 2002a, 2002b; McDonald 2002).

Regarding available commercial products, deca-BDE consists almost exclusively of deca-substituted BDE-209 (97%), with some 3% nona-BDE. In 2001, about 24,500 metric tons of penta-BDE was marketed in the United States. Smaller amounts of octa-BDE and penta-BDE mixtures are produced, 1,500 and 7,100 tons a year, respectively (BSEF 2001). Octa-BDE commercial mixtures include some hexa-BDE but mainly hepta-BDE and octa-BDE congeners, some nona-BDE and a very small amount of deca-BDE congeners. Almost all (98%) of the global penta-BDE is produced and used in the United States (BSEF 2001). The major use for penta-BDE has been in flame-retarding polyurethane foam, which is widely used in furniture upholstery. It consists of tetra-, penta-, and hexa-brominated congeners, especially BDE-47 (tetra), BDE-99 (penta), and BDE-153 (hexa), but also BDE-100 (penta) and BDE-154 (hexa) (Hale et al. 2002; de Wit 2002).

Lower brominated congeners, the tetra-BDEs and penta-BDEs, bioaccumulate to a greater degree than do the higher brominated BDEs such as deca-BDE. This may be caused by degradation of higher brominated congeners [International Program on Chemical Safety (IPCS) 1994]. Although the debromination of deca-BDE occurs under experimental conditions, it is not clear whether this decomposition occurs in the environment (Eriksson et al. 1998; Olsman et al. 2002). Results of a 2-year chronic rodent bioassay suggest that the deca-BDE mixture may be a possible human carcinogen, although this effect was observed in laboratory animals only at very high levels of exposure [National Toxicology Program (NTP) 1986]. Octa-BDE and penta-BDE are more bioactive, with possible endocrine, hepatic, reproductive, and neurodevelopmental toxicities (Branchi et al. 2002; Darnerud and Thuvander 1999; Darnerud et al. 2001; Eriksson et al. 1998, 1999, 2001; Fowles et al. 1994; Gillner and Jakobsson 1996; Hallgren and Darnerud 1998, 2002; Hallgren et al. 2001; Hardy 2002a, 2002b; Howie et al. 1990; McDonald 2002; Meerts et al. 1998, 2001, 2002; Morse et al. 1993; Pijnenburg et al. 1995).

Although levels of the dioxins, dibenzofurans, PCBs, and other organochlorines appear to be decreasing in humans living in industrialized countries over the past decades (Fürst 2001; Fürst and Päpke 2002; Fürst et al. 1994; Liem et al. 1995; Päpke 1998; Schecter et al. 2000; Smith 1999), levels of BDEs seem to be rising in some European countries (Noren and Meironyte 1998, 2000). Recently, the lower brominated PBDEs have been found in humans, in a small number of U.S. studies of blood and adipose tissue (Mazdai et al. 2003; Petreas et al. 2003; She et al. 2000, 2002; Sjödin et al. 2001) and Canadian milk studies (Ryan and Patry 2000, 2001; Ryan et al. 2002). Six congeners

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