HEALTH AND ENVIRONMENTAL HAZARDS OF POLYBROMINATED DIPHENYL ETHERS (PBDEs) AND OTHER BROMINATED FLAME RETARDANTS (BFRs)

IPEN Factsheet

What Are PBDEs and BFRs?

The polybrominated diphenyl ethers (PBDEs) are a group of brominated flame retardants (BFRs) that are commonly used in consumer electronics, including computers, as well as in the polyurethane foam of upholstered furniture. Brominated flame retardants are, in turn, a subclass of the over 175 different types of flame retardant chemicals in common use on the world market. The main classes of flame retardant chemicals are the halogenated organics (brominated and chlorinated), phosphorus-containing, nitrogen-containing, and inorganic flame retardants (25%, 20%, <5% and 50% of the market, respectively[I].)

Flame retardant usage has increased over the last two decades with increased use of plastics and polymers in electronics and construction. Brominated flame retardants work well in small quantities and in a variety of applications, and the market demand for these chemicals is continuing to increase, with a growth of 100% in the period from 1990 to 2000[II]. Common brominated flame retardants include the PBDEs, tetrabromobisphenol A (TBBPA) and hexabromocyclododecane (HBCD.) The PBDEs are commercially available in three primary forms, penta-BDE, octa-BDE and deca-BDE.

The total market demand for these major brominated flame retardants is shown in Table 1. The highest usages are of penta-BDE, deca-BDE and TBBPA, with the highest usage of penta-BDE, used in polyurethane foam, in the United States. The usage of TBBPA is high and increasing in Asia as electronics manufacturers phase out of penta- and octa-BDE in response to national and regional government bans.

Where Are They Used?

PBDEs and the other brominated flame retardants are commonly used in a wide variety of applications, including the plastic housings of televisions, computers, mobile phones and other small consumer appliances such as toasters and hair dryers. They are also used in wires and cables and

Table 1: Total 2001 Market Demand for Brominated Flame Retardants in Metric Tons (MT)

MT	Americas	Europe	Asia	Rest of the world	Total
TBBPA	18.000	11.600	89.400	600	119.700
HBCD	2.800	9.500	3.900	500	16.700
Deca-BDE(DBDPO)	24.500	7.600	23.000	1.050	56.100
Octa-BDE(OBDPO)	1.500	610	1.500	180	3.790
Penta-BDE(PBDPO)	7.100	150	150	100	7.500
TOTAL	53.900	29.460	117.950	2.430	203.790

Source: www.bsef.com

printed circuit boards. Penta-BDE is used in mattresses, upholstered furniture, and carpet underlay. Deca- and octa-BDE and TPPBA are used in the housings of computers and other consumer electronics. HBCD and deca-BDE are used in thermal insulation for building and construction. The PBDEs and HBCD are used in the textiles and cushioning found in automobiles, buses, and airplanes.

What Are the Concerns?

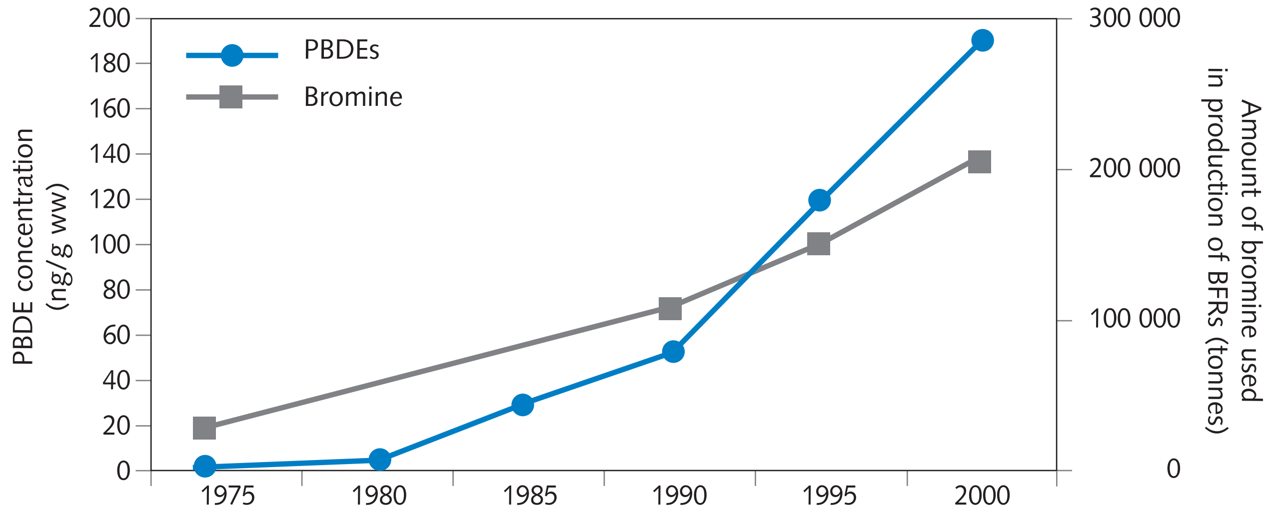
PBDEs are persistent and bioaccumulative, and have been found virtually everywhere in our environment, from soil, water, and sewage sludge to fish, birds, seals, whales, and polar bears, and in human blood and breast milk. The levels of PBDEs in the environment are increasing rapidly. PBDEs biomagnify up the food chain and travel long distances such that they are now appearing in Arctic wildlife, far from manufacturing locations. PBDE levels in humans and wildlife are climbing worldwide, doubling every 3 to 5 years. Levels in humans are significantly higher in North America than Europe or Japan[III]. However, recent levels found in wildlife such as Swedish peregrine falcons that eat high up on the food chain, are high and approaching levels that have caused neurological damage in laboratory experiments on rodents[IV]. An analysis of North American breast milk indicates that PBDEs in humans are approaching similar levels[V].

Herring gull eggs from the Great Lakes have PBDE concentrations at ~7000 ng/g lipid, up from ~100 ng/g lipid in the early 1970s. Similarly, guillemot eggs in Sweden have PBDE concentrations at ~1000 ng/g lipid, up from ~100 ng/g lipid in a similar timeframe. Marine mammals have current PBDE levels of ~1000 ng/g lipid. Current PBDE human concentrations (blood, milk and other tissues) in Europe are ~2ng/g lipid, and ~35ng/g lipid in North America[VI].

What Are the Health Effects?

The primary health effects of the PBDEs occur during the development of the brain and reproductive organs. PBDEs block the function of the thyroid hormone at a critical time in development, with resulting impacts on behavior and learning behavior in adult animals. Penta-, octa- and deca-BDE are absorbed by the body at different levels, with penta-BDE the most likely to bioaccumulate. The ability of a PBDE to be absorbed apparently decreases with an increasing number of bromines. It has been shown, however, that even deca-BDE can be absorbed by humans and wildlife, and can break down in the environment and animals to other chemicals with even greater potential harm[VII].

Studies of developmental effects have so far been done in mice and rats, but the chemical similarity of PBDEs to polychlorinated biphenyls (PCBs) have raised concerns that PBDEs may have simi-



Comparison of total PBDEs in Lake Ontario trout and total use of bromine in BFR production (M. Alaee, 2002) lar effects, and/or worsen existing effects of PCBs and related chemicals. Recent studies have shown that long-term exposure to even low levels of PCBs affect learning ability and intelligence in humans[VIII]. While these developmental and endocrine disrupting effects are of greatest concern, there may also be additional effects, such as cancer, for which PBDEs and other BFRs have not been adequately tested.

Concerns about the potential toxicity of penta-BDE has caused the electronics industry to shift to TBBPA and HBCD for some applications. While these chemicals may not have the effects to the same extent as the PBDEs, TBBPA has been shown to have some effects on the brain, liver and immune system, and is an endocrine disruptor, while HBCD is persistent and bio-accumulative, and has impacts on the developing brain.

How Are We Being Exposed?

Information on the location of PBDEs and other flame retardants is still preliminary, but early studies indicate that humans and the environment are potentially exposed throughout the entire life-cycle of these chemicals, from manufacturing through use and disposal of consumer electronics, furniture and other articles. For example, PBDEs and other brominated flame retardants have been found downstream from a Great Lakes Chemical manufacturing facility in the northeastern part of the United Kingdom[IX] as well as in soil and sediment downstream from a polyurethane foam plant in the mid-Atlantic region of the United States[X]. Both of these studies point to releases of PBDEs during manufacturing. Exposures for the general public may come from indoor air and dust, as several studies have shown PBDEs and other endocrine disrupting chemicals in air and dust in homes, workplaces, and public buildings[XI]. We may have some exposure to PBDEs in our food, as these chemicals have been found in water and in sewage sludge used to fertilize food crops[XII]. Increased levels of penta-BDE in the blood of Scandinavian men was found to correlate with the amount of Baltic Sea fish they ate[XIII]. Finally, some exposures may be related to occupation; for example, electronics workers in Sweden showed elevated blood levels of deca-BDE when compared to average office workers[XIV].

Similarly, TBBPA and HBCD have been found in river sediments, and HBCD has also been found in fish, but considerably less environmental data are available on these BFRs[XV]. Thus, while exposure to BFRs is possible through their entire life cycle, it is not clear what the biggest sources of exposure might be for humans and wildlife.

What's Happening?

In response to increasing concerns about BFRs in humans and the environment, some governments have begun to take action to phase out the use of these chemicals. In 1992 the Oslo Paris Convention (OSPAR) for European countries in the North East Atlantic targeted the entire class of brominated flame retardants for phase-out. Norway, Germany and Sweden subsequently started to require companies to replace BFRs with safer alternatives. More recently, the European Union banned the use of all PBDEs and polybrominated biphenyls (PBBs) in electronic products starting in 2006[XVI].

In the absence of national political will on chemicals policy, most bans of BFRs in the United States have occurred at the state level. In 2003, California passed legislation calling for a ban and phase-out of penta- and octa-BDE by 2008. The Governor of the state of Washington signed an Executive Order in January 2004 calling for a phase-out of all PBDEs in his state; the plan is to be developed by December 2004. In April of 2004, the state of Maine became the first to ban all three PBDEs outright, with penta- and octa-BDE to be phased out by January 1, 2006, and deca-BDE by January 1, 2008. Similar legislation is pending in other states, including New York, Massachusetts and Wisconsin.

In response to concerns about rising levels of PBDEs in the environment, many electronics companies have begun to voluntarily phase out PBDEs and other BFRs. Computer and electronics manufacturers have responded by substituting non-bromine flame retardant alternatives and redesigning products to minimize fire risk, as well as incorporating more inherently fire retardant materials[XVII].

Recommendations

PBDEs are chemicals that have concerns similar to chemicals already on the POPS Convention list that are slated for elimination worldwide. We recommend adding PBDEs to the POPS list and encouraging companies to find less toxic alternatives, including product redesign.

IPEN Dioxin, PCBs and Waste Working Group

The IPEN Dioxin, PCBs and Waste Working Group was established in May 2001 in Sweden, after the text of the Stockholm Convention was agreed.

The Working Group, within its capacity and resources, works to assure that measures addressing dioxins, PCBs and wastes are appropriately interpreted and fully incorporated into each country's Stockholm Convention Enabling Activities and Implementation Plans. Furthermore, it works and campaigns to promote policies and practices in every region and country aimed at the elimination of dioxins and PCBs; and aimed at reduction and elimination of wastes, and appropriate waste management for the residues.

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XVI. Computer Take Back Campaign, op cit. This report details some of the alternatives to BFRs available for the plastics of consumer electronics.

XVII. Information on these companies can be found on the Computer Take Back Campaign's Scorecard at http://www.svtc.org/cleancc/pubs/2003report.htm.

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