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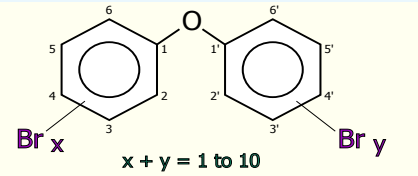
Columbia Environmental Research Center

Brominated Flame Retardants in the Environment

Introduction

Brominated flame retardants (BFRs) are being found as contaminants of indoor and outdoor environments. BFRs are added to plastics to reduce fire damage and harm. Thermoplastic products such as polyurethane furniture foam, carpet, high impact cases, circuit boards, appliances, and electrical equipment are made of 5 to 30% BFR.

BFRs such as polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecane (HBCD) are not strongly bound to the host polymer and can release ("bleed" or "bloom") from the plastic and become environmental contaminants. HBCD is used in polystyrene foams and as a backcoating in fabrics. Limited studies indicate the HBCD has a high potential to bioaccumulate and is likely very persistent.



Of the BFRs, PBDEs (above) are persistent environmental contaminants, accumulating in sediments and animal tissues to relatively high levels. PBDEs can disrupt thyroid hormone action and may impair neurodevelopment. There are 209 possible bromine combinations, known as congeners, numbered 1 through 209.

Recent evidence shows that levels of PBDEs in breast milk in North America are as much as 50 times higher than in Europe, increasing from <1 ppb to 200 ppb in the last 25 years.

Research at CERC shows that across the U.S., PBDEs bioaccumulate in fish and birds of prey.

Concentrations in eggs of bald eagles and double-crested cormorants (wet/wt total PBDEs):

- Lower Columbia River (1995)
  400-2,000 ppb
- 1995 Newark Bay/New York Harbor (1995)
  500-2,000 ppb
- 1992 Hood Canal, WA (1992)
  100-300 ppb

PBDE Pollution Research at CERC

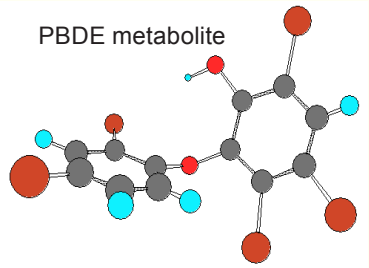
- Environmental distribution and fate.
- Identifying types of PBDEs in fish and wildlife across the U.S.
- Tracking biologically relevant ultraviolet radiation breakdown of PBDEs.
- Creating congener-specific PBDE analysis methods with fractionation techniques and GC/high resolution mass spectrometric definitive analysis of mono- to deca- BDEs.
- Measuring indoor air levels of PBDEs in home and office.
- Determining potential for weathered recycled computer equipment to contaminate nearby soil and sediments.

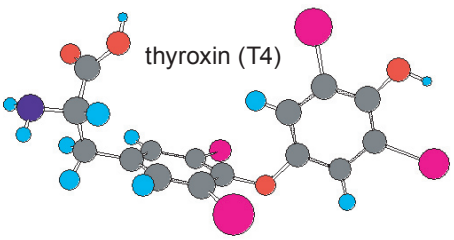
Environmental Fate

• Biological lipids (fats) containing PBDEs exposed to sunlight, formed lower brominated, more bioavailable and potentially more toxic PBDEs. PBDE congeners 47, 99, and 100 were stable while 153, 154, and 183 were moderately UV stable; all are frequently found in the environment, indoor air, and biota. It is known that in sunlight, deca-BDE (PBDE congener 209) rapidly breaks down to lower brominated BDEs.

• PBDEs with four to six bromines (e.g., PBDE congener 47) tend to be bioavailable and have the potential to form PBDE metabolites similar to the thyroid hormone (thyroxin).

• "Penta" commercial mix that contains PBDEs that have four to six bromines was recently removed from the market in Europe; California and other states are taking similar action.



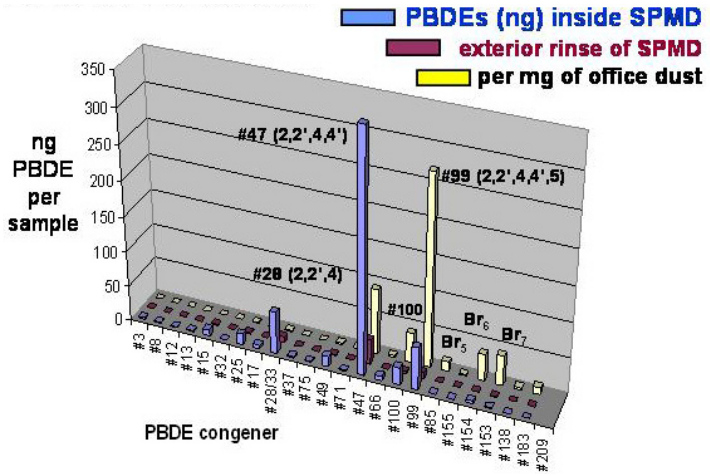


Metabolites, compounds produced from PBDE break-down in cells, are structurally similar to the thyroid hormone, thyroxin (T4). In addition, studies show PBDEs to cause neurodevelopmental and liver toxicity.

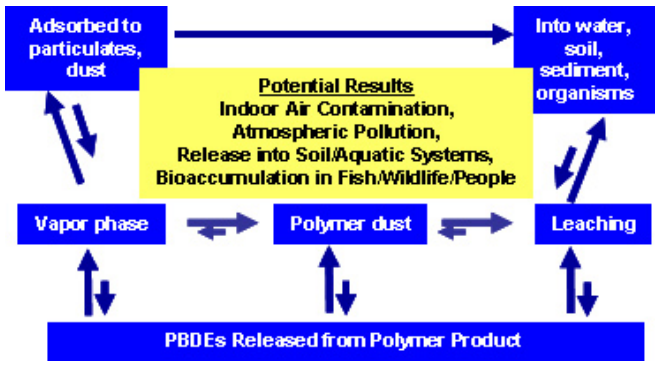
Sources and Fate of PBDEs

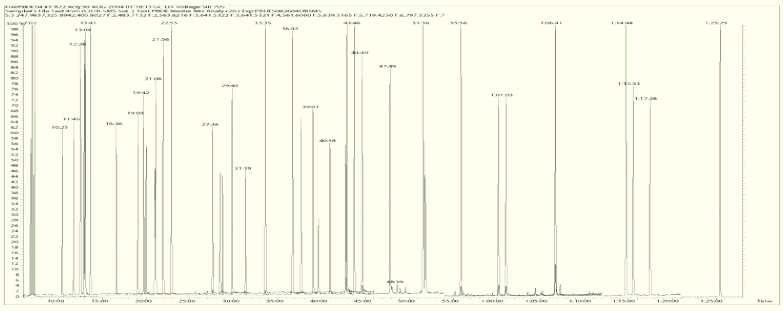
Indoor Air

Using semipermeable membrane device (SPMDs) passive samplers CERC research shows that the indoor air environment contains significant levels of PBDEs, both in the volatile and particle-bound phases. Office dust contained 50 ppm total PBDEs. Volatile PBDEs were 1 ng/cubic meter, of which 80% was PBDE congener 47.



Because PBDEs are not permanently bound to the plastic they can be released as volatiles or dust (particle-bound). Other researchers have shown that elevated concentrations of PBDEs were present in the blood of full-time computer operators and people who dismantle electronic equipment (Sjödin et al.,1999).





GC/HRMS of mono- to deca-PBDE congeners

CERC uses capillary chromatography with high resolution mass spectrometry (GC/HRMS) for the definitive, isotope dilution analysis of mono to deca PBDEs (44 congeners); calibrated with several European Union research centers. CERC also studies HBCD and tetrabromobisphenol-A (TBBA), using LC/MS and GC/MS methods.

Thirty million computers are thrown out every year in the U.S. alone. CERC is investigating potential PBDE soil and water pollution from used computer equipment, subjected to a decade of weathering.

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