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THE RECYCLING OF PLASTICS CONTAINING BROMINATED FLAME RETARDANTS LEADS TO CONTAMINATION OF PLASTIC CHILDREN'S TOYS

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Introduction

Brominated flame retardants have been widely added to foam and plastics used consumer and electronic products. Pentabromodiphenyl ether (PentaBDE) has been used extensively in polyurethane foam, but also appears in electronics. Octabromodiphenyl ether (OctaBDE) has been used in acrylonitrile butadiene styrene (ABS) and other plastics used in electronics such as office equipment. Decabromodiphenyl either (DecaBDE) is widely found in plastics used in electronics and is a common component of electronic waste. In 2009, delegates at Stockholm Convention 4th Conference of the Parties (COP4) agreed to list commercial PentaBDE and OctaBDE in Annex A for global elimination (Stockholm Convention 2009). COP4 also agreed to create an exemption that permitted recycling of plastics, foam, and other materials containing these substances until 2030. Due to concerns about the possible impacts of this recycling exemption, the COP4 requested the treaty's expert committee to examine its implications. Subsequently, the expert committee known as the POPs Review Committee developed recommendations on the recycling exemption for COP5. The Committee warned against the practice and recommended to "…eliminate brominated diphenyl ethers from the recycling streams as swiftly as possible" noting that, "Failure to do so will inevitably result in wider human and environmental contamination and the dispersal of brominated diphenyl ethers into matrices from which recovery is not technically or economically feasible and in the loss of the long-term credibility of recycling." (Stockholm Convention 2011) We conducted a survey of PBDE flame retardants in Rubik's cubes, a children's product often made of recycled plastic, along with a few other plastic toys. We asked whether OctaBDE and DecaBDE commonly found in the plastic parts of electronic waste were present in the toys as predicted by the POPs Review Committee technical report.

Materials and methods

The black parts of Rubik's cubes and several other consumer goods were tested because manufacturers often blacken the color of recycled plastics for aesthetic reasons. Products were screened for bromine using a handheld XRF analyzer to identify samples with significant bromine levels (above 1000 ppm). Positive samples were analyzed for PBDEs at the Institute of Chemical Technology, an accredited laboratory in the Czech Republic. Brominated flame retardants were extracted by n-hexane and the leachate transferred into isooctane. Identification and quantification of flame retardants was accessed via gas chromatography/mass spectrometry in the mode of electron ionization (GC-MS/MS-EI). The limit of detection for was 0.1 ppb and the main components of congeners listed in the Stockholm Convention were analyzed.

Results and discussion

Laboratory analysis of forty-one Rubik's cubes and six additional samples (thermo cup, hair clip and hand band, finger skateboard, toy robot and hockey stick) from sixteen countries including EU Member States, Eastern European and South-East Asian countries found that forty samples (85%) contained OctaBDE at concentrations ranging from 1 to 108 ppm. Ranges of the measured concentrations per country follow (purchased in/number of samples/ PentaBDE (ppm)/OctaBDE (ppm)): Bangladesh/2/27 – 41/33 – 96, Belarus/2/3 – 5/134 – 153, China/1/13/36, Czech Republic/6/0 – 75/2 – 96, Germany/2/1/3 – 4, Hungary/2/0 – 6/0 – 58, India/48/67, Indonesia/5/0 – 52/0 – 63, Nepal/3/17 – 58/19 – 234, Philippines/4/2 – 108/5 – 293, Poland/4/0 – 51/0 – 79, Serbia/3/13 – 57/36 – 47, Slovakia/1/26/98, Sri Lanka/2/46 – 48/44 – 131, Sweden/1/0/0 and Thailand/2/25 – 48/21 – 23.

Seven samples (15%) contained OctaBDE at levels greater than 50 ppm – the low POP content limit in wastes for PCBs (which PBDEs resemble).

Note that at Basel Convention COP12, Parties adopted technical guidelines on the environmentally sound management of wastes consisting of, or contaminated with POPs. The provisional definition of low POP content for the congeners of OctaBDE (HexaBDE and HeptaBDE) was set at 50 ppm or 1000 ppm.

This indicates that Parties choosing the lower value for low POP content could have children's toys with OctaBDE levels that warrant treatment under the Stockholm Convention waste obligations.

Forty-two samples (89%) contained DecaBDE, a toxic chemical commonly found in electronic waste. Sixteen of the samples (34%) contained DecaBDE at levels greater than 50 ppm. Note that the provisional definition for low POP content limit for DecaBDE has not yet been set but PBDEs strongly resemble PCBs which have a low POP content limit of 50 ppm. Concentrations of PBDEs in other products than Rubik's cubes follow (item/name/made in/ OctaBDE (ppm)/ DecaBDE (ppm)): hair headband/-/-/9/33, thermo cup/Banquet, Akcent Bike/China/3/6, hair clip/-/-/19/18, finger skateboard (toy)/Finger Skate Board/China/95/121, hockey stick/-/-/6/9 and robot (toy)/-/-/0/1.

The data indicates that OctaBDE and DecaBDE used in plastics for electronics are recycled into plastic children's toys. This finding is in accordance with the study of Chen et al. (2009) and an analysis of the POP-BDE stream in the Netherlands by Leslie et al. (2013) illustrating that 22% of the POP-BDE in waste electrical and electronic equipment is expected to end up in recycled plastics. This survey also complements a recent study by Samsonek and Puype (2013) which found flame retardants from electronic waste recycled into plastic food contact materials such as thermo cups and kitchen utensils. The problem of recycling materials containing POPs and contaminating "new products" also occurs in recycled foam products such as carpet padding. (DiGangi J, Strakova J, and Watson A, 2011)

The provisional definition for low POP content limit for DecaBDE has not yet been decided, but the POPs Review Committee has outlined concerns with the similarity between PBDEs and PCBs. In the 2006, the Committee published in the risk profile on commercial PentaBDE (UNEP/POPS/POPRC.2/17/Add1) that, "The neurotoxic effects of PBDEs are similar to those observed for PCBs and so children exposed to PBDEs are likely to be prone to subtle but measureable developmental problems." The following year, the POPs Review Committee concluded in the risk profile on commercial OctaBDE (UNEP/POPS/POPRC.3/20/Add6) that, "There is increasing evidence suggesting similar toxicological profiles and therefore, equivalent hazards and concerns, between PBDEs and PCBs…" These similarities indicate that plastic children's toys should not contain PBDEs and suggests that the low POP content limit for DecaBDE should not be set higher than 50 ppm, the limit established for PCBs.

The Stockholm Convention POPs Review Committee correctly predicted the dispersal of flame retardant chemicals into products where they should not be present as a result of recycling materials such as plastics that contain them. The results add to concerns about the existing Stockholm Convention recycling exemption for PentaBDE and OctaBDE and provide a warning against a recycling exemption for DecaBDE.

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