Evaluation of HEXABROMOCYCLODODECANE (HBCD)

as a Possible Chemical of High Concern for MOU Listing in Connecticut

Summary:

HBCD Toxicity: Very High Concern, Hazard Rank Score = 13 points
HBCD Children's Exposure: High Concern, Exposure Rank Score = 40 points
Overall Assessment (tox and exposure combined): High Concern
Candidate for MOU Listing: Yes
Total Rank Score = 520 points

1) **Persistence in body and/or environment: Very High concern (4 points)**
   - The May 2013 meeting of the United Nations (UNEP) Stockholm Convention on Persistent Organic Pollutants (POPs) agreed to label HBCD as a POP. The announcement can be found here. That convention also agreed to list HBCD as a POP for elimination from products and manufacturing.
   - HBCD elimination half-life in humans is estimated at 64 days and in the rat at 8 days (Arnot et al. 2009). This suggests persistence and bioaccumulation, especially in humans.

2) **Acute Toxicity: No concern (0 points)**
   - USEPA HBCD Alternative Assessment (2014) lists HBCD oral rat LD50 as >5000 mg/kg

3) **Repeat Dose Testing: Very High concern (4 points)**
   - USEPA HBCD AA lists HBCD as having a moderate level of concern for ***neurotoxicity*** effects based upon negative findings in adult rats but then an effect on movement latency (slower reaction time) and poorer hearing in offspring dosed in utero and tested as adults. The effect on hearing had a BMDL of 0.2 mg/kg/d.
   - Anti-thyroid effects as shown in Ema et al. 2008 and other studies; metabolic effect (on pancreas?) as described (Yanagisawa et al. 2014); these ***endocrine disruptive effects*** occur at low dose (Ema et al. 2008 LOAEL – 10 mg/kg/d; Yanagisawa et al. 2014 LOAEL = 0.005 mg/kg/d.

4) **Mutagenicity/Genotoxicity: No concern (0 points)**
   - Health Canada (2011) review describes genotoxicity testing as "overall negative"
   - USEPA HBCD Alternative Assessment (2014) lists HBCD as negative in Ames, chromosomal aberration and mouse micronucleus testing; one positive test was found in an unorthodox (non-guideline) test system

5) **Reproductive/Developmental Toxicity: Very High concern (4 points)**
   - Two generation reproduction study in rats (Ema et al. 2008) decreased ovarian follicles in F0 females down to 100 mg/kg/d (reproductive NOAEL = 10 mg/kg/d) and produced anti-thyroid effects in F0 and F1 females at lowest dose (10 mg/kg/d).
   - Developmental neurotoxicity in rats, dosing during gestation, neurological testing postnatal and into old age: LOAEL = 3 mg/kg/d (Miller-Rhodes et al. 2014).
   - Metabolic/obesogenic effect in young mice dosed at 0.005 or 0.1 mg/kg/d from 6 to 20 wks of age. Effects also seen on glucose and insulin regulation (Yanagisawa et al. 2014)
   - USEPA HBCD AA lists HBCD as having a high level of concern for developmental effects
   - Based upon the ovarian follicle effect at 100 mg/kg/d (Ema et al. 2008), this endpoint could receive a moderate concern. However, evidence for low dose developmental neurotoxicity (Miller-Rhodes et al. 2014 LOAEL in rats of 3 mg/kg/d) yields a Very High Concern for this area. Other findings, particularly Yanagisawa et al. 2014 support a low dose effect of HBCD on a developmental life stage.

6) **Carcinogenicity: Low concern (1 point)**
   - USEPA HBCD AA lists HBCD as having a moderate level of concern for cancer. In a single (18 month) bioassay, male and female mice both showed evidence of liver tumors but the incidence was not elevated relative to historical controls.
   - HBCD is not listed by NTP, IARC, USEPA, or OSHA as a carcinogen

Total Toxicology Rank = 13 points

HBCD Exposure Ranking

1) Is the chemical currently in children's products? Yes, however not widespread.

Washington State provides limited test data for HBCD concentrations in children's products. This report found HBCD in one child's bean bag chair at 563 ppm and in one pair of sports glove at >14,000 ppm. Other results were mostly negative at a detection limit of approx. 100 ppm. HBCD was one of 9 flame retardants detected in children's car seats, specifically in the polystyrene foam padding (Ecology Center, 2015). The HBCD detections occurred in 3 of 15 different brands of car seat.

HBCD was detected at 100 to 1000 ppm in polystyrene packaging material (e.g., rigid Styrofoam boards) some of which could be in households (e.g., insulation) but not a child's product. Coffee cups and most food related polystyrene was low in HBCD (Rani et al. 2014).

USEPA has finalized a SNUR that prevents any new uses in consumer textiles without prior 90 day notice to USEPA. USEPA claims that the only consumer use is in car textiles, which would not qualify as a child's product.

2) Is there indirect evidence that HBCD might be in children's products?
    - Chemical is widely used in commerce/other household products

      Yes, HBCD is a high production volume chemical with 10 to 50 million pounds produced and/or imported into the US in 2005 (last year data available) (USEPA HBCD alternative assessment, 2014). According to European data, 96% of HBCD is used in rigid polystyrene foams used as insulation materials within the building and construction industry. HBCD-containing foams are used in both residential and commercial buildings. While USEPA states that there are no consumer uses for HBCD-based materials, European sources cited by USEPA state that 2% of HBCD goes into textiles used in draperies, upholstery, wall coverings and automobile interiors.

    - Chemical is not banned from children's products

      Yes, the HBCD is not banned from any type of product, children or otherwise. The USEPA SNUR prevents new uses without prior EPA review but would not affect existing uses and may not prevent increased use in current applications (e.g., higher percentage of car seats with HBCD). The Stockholm convention on POPs determined that HBCD should be included on the POPs list and thus targeted for worldwide phaseout. This determination may have some influence on governments and industries to shift away from this flame retardant.

- Chemical is found in house dust

Yes, numerous studies have detected HBCD in house dust. Data collected by CT DPH indicates a range of HBCD concentrations of 0.26 (median) to 4700 (maximum detect) ppm in the dust of US homes which were sampled recently.

- Chemical is found in indoor air

Yes, several studies suggest HBCD can be detected in indoor air samples, especially in the particulate fraction (Ni and Zeng, 2013). Miyaki et al. (undated but available here) found an increase in HBCD indoor air concentration simply from opening a set of drapes.

- Chemical is found in children's biomonitoring studies at levels higher than adults

HBCD has been detected in numerous biomonitoring studies with detection in both plasma and breast milk (Aylward and Hays 2011). Data for children are not available but with a fat soluble compound such as this one may expect nursing infants to receive the greatest exposure.

3) Is the amount of chemical exposure in children within range of a health benchmark?

Likely Yes. We don't have quantitative information for children. However, HBCD has been detected in a diversity of biomonitoring studies; intake dose from amounts found in body lipid yield an estimate in the general adult population of approximately 4 ug/kg/d (highest human measurement converted to external dose, Aylward and Hays 2011). A HBCD RfD is not available but a range of toxicity endpoints (developmental neurotoxicity, anti-thyroid, metabolic disorder) have been seen in mice and rats at LOAELs of 3-10 mg/kg/d with one study showing a much lower effective dose (Yanagisawa et al. 2014). Using typical uncertainty factors yields a range of possible RfDs that are near or below 1 ug/kg/d. This suggests that adult exposures are in range of possible health benchmarks and this does not factor in the potentially greater exposure of children.

4) Is the chemical currently in products children frequently contact but not designed for children?

Yes, a variety of possibilities exist including car interiors, polystyrene products around the home and textiles in furniture and drapery.

Summary of Exposure Assessment for HBCD

HBCD receives a high concern for exposure because there is direct evidence that it is present in children's products (e.g., child's padded chair, car seats). This merits an exposure rank score of 20 points. Indirect evidence is supportive of this finding. The amount of HBCD exposure in the general population appears to be within range of risk-based health benchmarks for endpoints of relevance to children's development (neurotoxicity, anti-thyroid effect, metabolic disorder). While quantitative exposure estimates for children are not available, HBCD's presence in breast milk adds to the children's exposure concern. The finding that the adult-based exposure dose is within range of potential health effect benchmarks doubles the exposure rank score from 20 to 40 points.

Quantitative Score for Ranking

Toxicology Score: 13

Exposure Score: 40

Total Score: 520

References

Aylward LL and Hays SM. Biomonitoring-based risk assessment for hexabromocyclododecane (HBCD). Int J Hyg Environ Health. 214: 179-87.

Ema M et al. 2008. Two-generation reproductive toxicity study of the flame retardant hexabromocyclododecane in rats. Reprod Toxicol.25: 335-351.

Ni HG and Zeng H. 2013. HBCD and TBBPA in particulate phase of indoor air in Shenzhen, China. Sci Total Environ. 458-460:15-9.

Rani M et al. 2014. Hexabromocyclododecane in polystyrene based consumer products: an evidence of unregulated use. Chemosphere. 110:111-119.

Yanagisawa R et al. 2014. Impaired lipid and glucose homeostasis in hexabromocyclododecane-exposed mice fed a high-fat diet. Environ Health Perspect. 122(3):277-83.

HBCD Ranking for MOU Prioritization