

PVC and Brominated Flame Retardants: reasons for concern

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Polyvinyl chloride products in a hospital

- Disposable healthcare products
- Durable medical equipment
- Office supplies
- Construction projects
- Furniture

PVC

- Vinyl chloride polymer
- Produced with fillers, stabilizers, pigments, plasticizers, lubricants, flame retardants
- Stabilizers – lead, cadmium
- Plasticizers – phthalates; di-ethylhexyl phthalate (DEHP) used in medical devices; butyl benzyl phthalate (BBP) in flooring

PVC - advantages

- Cost, variable flexibility, resistance to breakage

PVC - disadvantages

- Potential impacts on patient health and safety – leaching of DEHP; solvents (cyclohexanone)
- Public health and environmental impacts of PVC production, use, and disposal
 - Dioxin produced during PVC production and incineration
 - Leaching of plasticizers, metals from landfills
 - Difficult to recycle

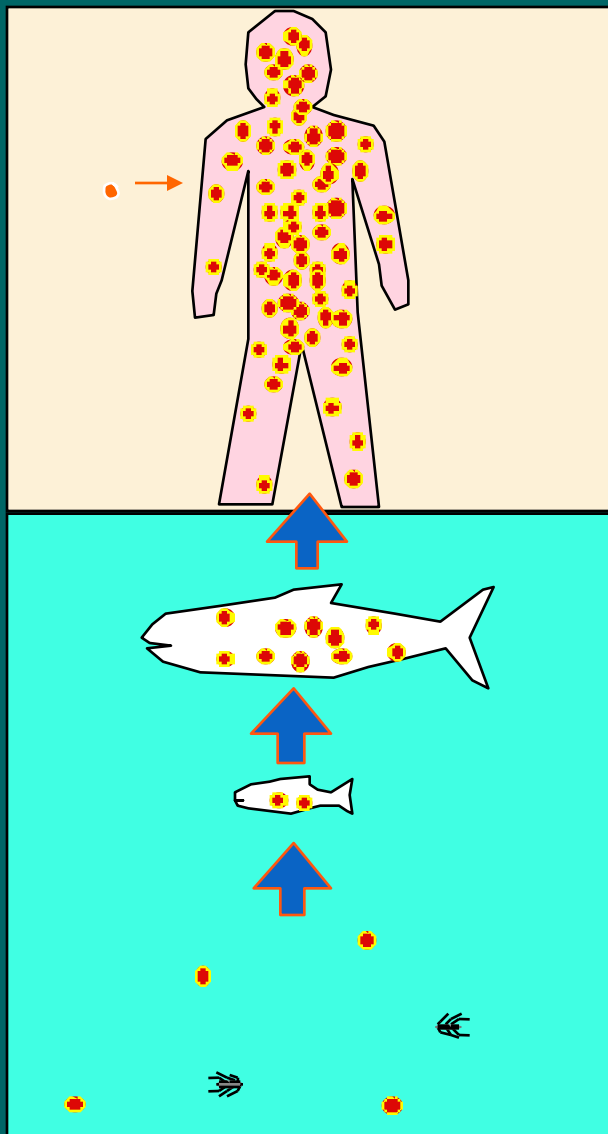
Patient health and safety – DEHP toxicity

- Critical (lowest dose) health effect is testicular toxicity in immature organisms
- Other impacts on male reproductive tract depending on dosing
- The metabolite, MEHP, is the apparent testicular toxicant

National Toxicology Program's Center for the Evaluation of Risks to Human Reproduction

- "serious concern" for the possibility of adverse effects on the developing reproductive tract of male infants exposed to very high levels of DEHP that might be associated with intensive medical procedures such as those used in critically ill infants.
- "concern" that, if infants and toddlers are exposed to levels of DEHP substantially higher than adults, adverse effects might occur in the developing male reproductive tract.

PBTs



- **Persistence**
- **Bioaccumulation (or bioconcentration from water)**
- **Toxic exposures**

PVC and dioxin

- Dioxins and furans generated as by-products of manufacture of PVC feedstock
- Dioxins, furans, HCl formed and released when PVC is burned
- Dioxins and furans are “PBTs”

PVC and dioxin

- Dioxins and furans formed in incinerator depend on:
 - Design, including air pollution controls (consider ash as well)
 - Operating conditions
 - Composition of waste feed; chlorine source, metal catalysts
- PVC is a major source of chlorine necessary for dioxin synthesis

PVC and dioxin

- Open burning, landfill fires – dioxin air emissions strongly related to PVC content

(Costner et al. Estimating Releases and Prioritizing Sources in the Context of the Stockholm Convention.

http://www.pops.int/documents/meetings/cop_2/followup/toolkit/submissions/IPEN%20Comments/Estimating%20Dioxin%20Releases%20English.pdf)

Dioxin

- A “family” of chemicals, with similar structures, some more toxic than others
- Persistent
 - Environment – up to decades
 - Humans – half-life 7 years
- Bioaccumulative – concentrations increase as it moves up the food chain

Dioxin – low-dose health effects

- Some seen at pg-ng/kg/day levels of exposure;
ng = 1/1,000,000,000 gm
- Cancer (known human carcinogen: IARC)
- Reproductive/Developmental: birth defects, endometriosis
- Endocrine: thyroid
- Immune system: sensitive during development

Dioxin – human exposure

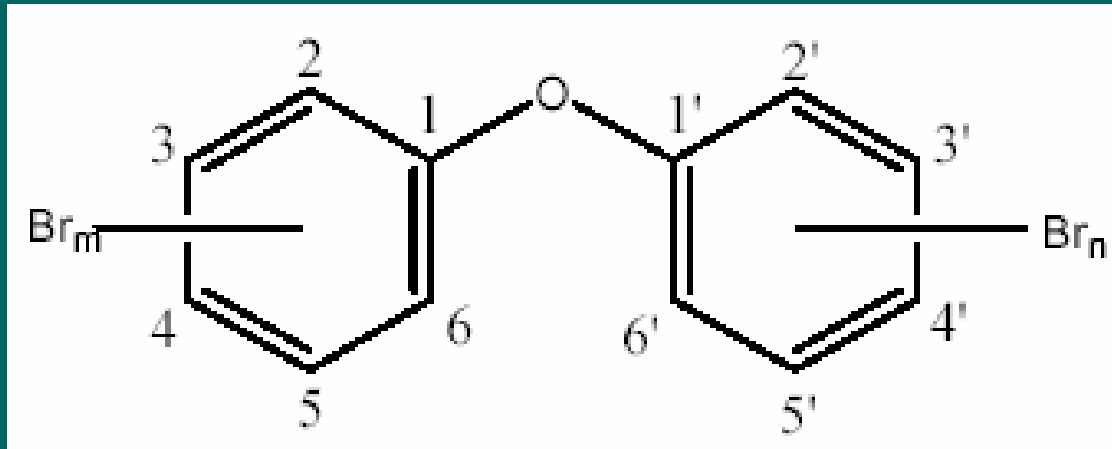
- Human adipose tissue levels of dioxin are at or near those which cause biological changes in animals (enzyme induction, immune system effects)
- Exposures largely dietary; half-life - 7 years
 - breast fed infant 50-100 pg/kg/day
 - infant, first year 34-50
 - 5-9 1-27
 - >20 2

EPA "safe" lifetime level 1; WHO 1-3 pg/kg/day

Brominated flame retardants

- Organic chemicals containing the element bromine.
- Added to products to inhibit ignition or spread of flames.
- Over 75 different brominated flame retardants.

Generalized Structure of PBDEs (where $m+n = 2$ to 10 bromines)



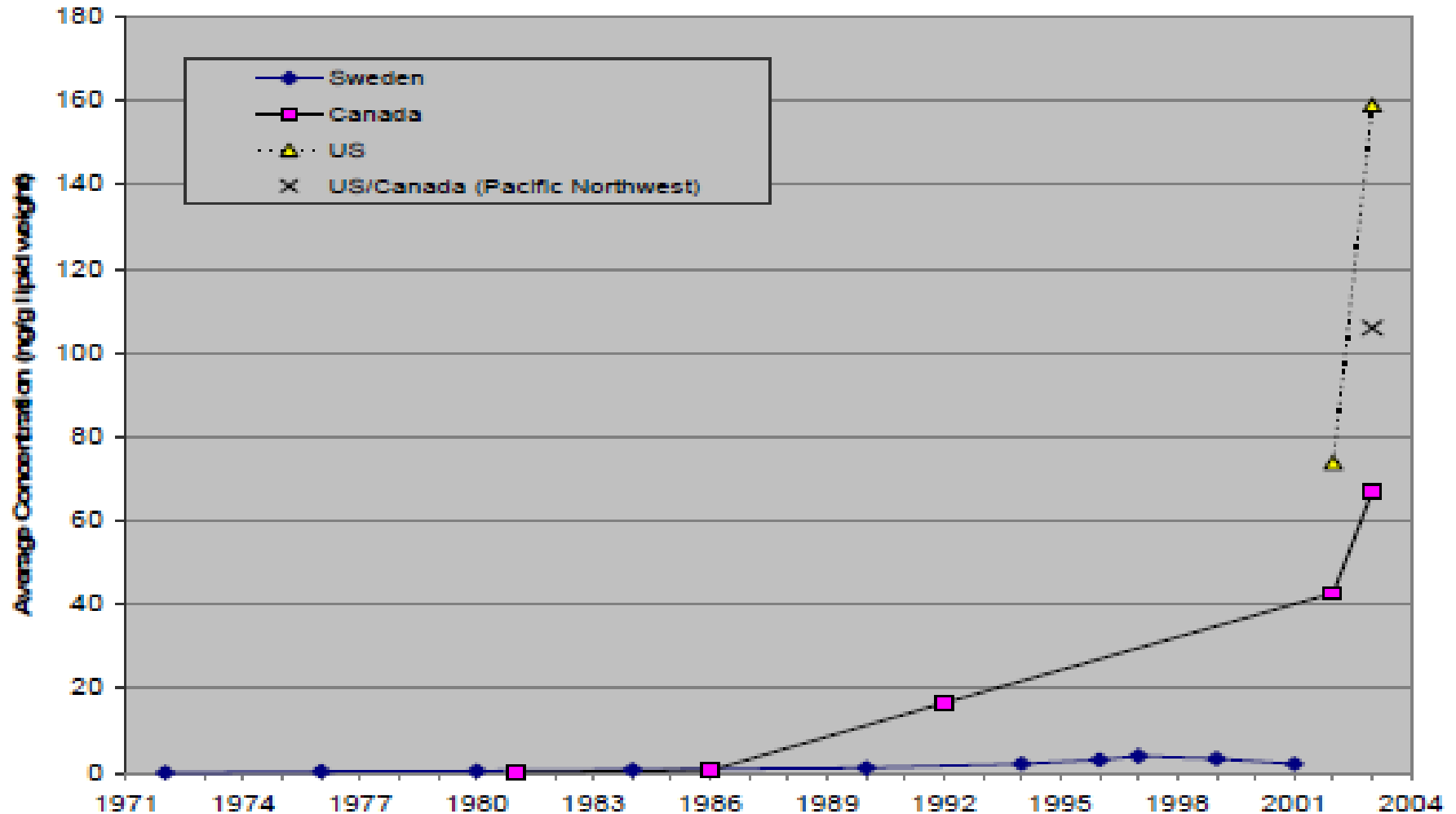
decaBDE 10 bromines
octaBDE 8 bromines
pentaBDE 5 bromines
etc.

Concerns regarding use of brominated flame retardants

- BFRs are released into the environment; manufacturing, use and disposal
- Human, wildlife, and environmental levels of the highest production BFRs are increasing.
- Toxicity concerns
- Some BFRs are PBTs
- Deca debrominates into octa- and penta-

Trends of PBDEs in Human Milk for Sweden, Canada, and the United States

(Data from Meironyte et al., 1999; Ryan et al., 2002; Guvenius et al., 2003; Schechter et al., 2003; EWG, 2003; Northwest Environmental Watch, 2004)



Sources of human exposure to BFRs

- Inhalation or ingestion of dust particles containing BFRs, especially indoors.
- Ingestion of food contaminated with BFRs, in particular, fish.
- Fetuses and infants: absorption across the placenta or ingestion of contaminated breast milk.

Potential Health Effects of BFRs

- Neurodevelopment
- Endocrine disruption
- Carcinogenicity
- Immune suppression
- Reproductive system effects

Neurodevelopmental studies

- Exposure to PBDEs (Penta, Octa, Deca) during critical windows of brain development results in decreased memory and learning that worsens with age. (Eriksson, 2001; Viberg, 2003)
Deca: persistent hyperactivity (Johansson, 2008)
- Hexabromocyclododecane (HBCD) exposure causes changes in memory and learning in rodent studies (Birnbaum, 2004)
- TetrabromoBPA and HBCD alter levels of neurotransmitters in the brain. (Mariussen, 2003)

Other Potential Toxic Effects

- Deca-BDE: increase in liver and thyroid tumors in rodent studies.
- HBCD also has been associated with liver tumors. (Darnerud, 2003)
- PBDEs and TBBPA have immune system suppressing effects. (Darnerud, 2003; Birnbaum, 2004)
- Some BFRs interfere with estrogen hormone action; delayed puberty, abnormal gonads and egg development in animal tests (Birnbaum, 2004; Legler, 2003)

BFR concerns: summary

- Found in a wide variety of consumer and commercial products.
- Released to environment, both indoors and outdoors, globally distributed.
- Bioavailable, with increasing levels found in the environment, wildlife, and humans; some are PBTs.
- Exposures are occurring to fetuses and children during critical times of development.
- Animal studies have shown interference with thyroid hormone, neurodevelopment, immune system and possible cancer.