Brominated and Chlorinated Organic Chemical Compounds Used as Flame Retardants (BFRs and CFRs)

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Structures of BFRs and CFRs

- Aliphatic

- Cycloaliphatic
Structures of BFRs and CFRs (cont.)

- Aromatic
- Organophosphate
Additive flame retardants
• Incorporated, but not chemically bound
• Over time, released into the environment

Reactive flame retardants
• Chemically bound to material in the product
• Unreacted flame retardant in the product can be released
Uses and production/import volume

- Uses: plastic housings for electrical and electronic equipment, printed circuit boards, foam insulation in construction materials, upholstered furniture, textiles, paints

- Current production/import volume is not available

- In 2002, U.S. production/import volume (millions pounds/yr) was:
  - TBBPA: > 100–500
  - decaBDE: > 50–100
  - HBCD: > 10–50
  - pentaBDE: > 10–50
  - TDCPP: > 10–50
Occurrence in the environment

- Persistent
  - Air, sediment and soil, sewage sludge, streams, Great Lakes, SF Bay.
  - Fish, marine mammals, predatory bird eggs

- Found in house dust, office dust, indoor air
Evidence of human exposure

Certain BFRs and CFRs have been found in:

- Blood (e.g., HBCD, TBBPA)
- Breast milk (e.g., Chlorinated paraffins, HBCD, TBBPA)
- Adipose tissue (e.g., HBCD, TBBPA, TDCPP)
- Umbilical cord and/or umbilical cord blood (e.g., HBCD, 2,4,6-tribromophenol)
Specific California exposure concerns

- Technical Bulletin No. 117 (TB 117) requires all upholstered furniture to meet specified flammability standards.
- TB 117 has resulted in extensive use of chemical flame retardants in California.
- Prior to 2006, the pentaBDE commercial mixture was the primary flame retardant in furniture foam.
- Effective 2006, California banned penta- and octa-BDE mixtures, substitute flame retardants are emerging as a result.
PBDE substitutes in furniture foam

- **Firemaster 550**

- **TDCPP**
Known or suspected health effects of BFRs and CFRs

- Cancer
- Developmental toxicity
- Endocrine disruption
  - Thyroid, estrogen, androgen disruption
- Neurotoxicity
  - Inhibition of neurotransmitter uptake
- Immunotoxicity
## Known or suspected health effects

<table>
<thead>
<tr>
<th>Compound</th>
<th>Cancer</th>
<th>Developmental Toxicity</th>
<th>Endocrine Disruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,2-Bis(bromomethyl)-1,3-propanediol</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorendic acid</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dechlorane</td>
<td>✓</td>
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</tr>
<tr>
<td>2,3-Dibromo-1-propanol</td>
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</tr>
<tr>
<td>Hexabromocyclododecane</td>
<td>NT</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>pentaBDE mixture</td>
<td>IP</td>
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<td></td>
</tr>
<tr>
<td>octaBDE mixture</td>
<td>NT</td>
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<td>✓</td>
</tr>
<tr>
<td>decaBDE</td>
<td>(✓)¹</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Polybrominated biphenyls</td>
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</tr>
<tr>
<td>Short-chain chlorinated paraffins</td>
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</tr>
<tr>
<td>Tetrabromobisphenol A</td>
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</tr>
<tr>
<td>Tetrabromobisphenol A bis(2,3-dibromopropyl ether)</td>
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<tr>
<td>Tetabromoethylcyclohexane</td>
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<tr>
<td>2,4,6-Tribromophenol</td>
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<tr>
<td>Tris(2,3-dibromopropyl)phosphate</td>
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</tr>
<tr>
<td>Tris(1,3-dichloropropyl)phosphate</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tris(2-chloroethyl)phosphate</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vinyl bromide²</td>
<td>✓</td>
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</tr>
</tbody>
</table>

¹ some evidence of carcinogenicity
² copolymer in inherently flame resistant material
IP = NTP study planned or in progress
NT = not tested
Suspected health effects based on structural similarity

DEHP/brominated DEHP

Ethylbenzene/brominated ethylbenzene
Suspected health effects based on common structural feature

Chlorinated norbornene moiety

Other carcinogens/developmental toxicants with chlorinated norbornene moiety:
- Chlorendic acid
- Heptachlor
- Dieldrin
- Endrin
- Chlordane
Need to assess efficacy of public health actions

- Significant concerns about persistence, bioaccumulation and known or suspected human health effects of BFRs and CFRs

- Biomonitoring BFRs and CFRs would
  - Assess the impact of the PBDE ban and determine whether PBDE substitutes are also accumulating
  - Determine whether other BFRs and CFRs are accumulating
  - Uncover environmental and human health concerns
Laboratory considerations

- Availability of analytical methods:
  - Methods for many BFRs or CFRs are either available or are being developed

- Adequate biospecimens:
  - BFRs and CFRs can be detected in blood or urine
  - In some cases, large sample volumes would be required

- Incremental analytical cost:
  - Analyses can be bundled with other BFRs/CFRs
Summary

- BFRs and CFRs are extensively used in California
- BFRs and CFRs have been found in people and the environment
- BFRs and CFRs have known or suspected health effects
- Laboratory methods are available and being developed for most compounds