Bioaccumulation and debromination of polybrominated diphenyl ethers (PBDEs) under environmental conditions

M. J. La Guardia*, R. C. Hale and E. Harvey
Commercial PBDEs Products

**Penta-BDE (DE-71)**
Great Lakes Chemical Corp, USA

**Octa-BDE (DE-79)**
Great Lakes Chemical Corp, USA

**Deca-BDE (Saytex 102E)**
Albermarle Corp., USA
Questions... chemical properties, bioavailability and debromination...

- chemical properties
  - additive BFR
  - 209 congeners
    - mass, 250 – 960 amu
    - logK_{ow} 4 - 10
- debrominate
  - photolysis
    - BDE-209: nona- to di-BDEs
  - metabolic
    - deca- to tetra-, ... BDEs
    - MEO- and HO-BDEs

But, will this happen in the environment?
U.S. Industry BDE-209 Releases

- U.S. EPA Toxic Release Inventory, TRI (http://www.epa.gov/tri/)
  - established 1987
  - includes ~650 chemicals
    - BDE-209 is the only PBDE listed
  - report includes releases from:
    - manufacturers producing >25,000 lbs
    - industry using >10,000 lbs

  - totals, 17.8 million lbs (>8000 MTs)
  - released to WWTPs, 2.6 million lbs (>1100 MTs)

-209 WWTP Transfers, Roxboro NC.

![Graph showing BDE-209 releases from 1992 to 2002](image)
Receiving Stream Sediments

PBDE Congeners

Sed. (0.0km) Sed. (1km)
Tetra-Hexa PBDEs in Sediments and Biota

PBDE Congeners

- tetra-a
- -47
- -66
- -100
- -99
- -85
- hexa-a
- penta-a
- -154
- hexa-b
- hexa-c
- -153
- hexa-d
- -138

ng/g (%TOC)

ng/g (% lipids)

minnow
sunfish

sediments

Tetra-Hexa PBDEs in Sediments and Biota

(Gambusia holbrooki)

(Lepomis gibbosus)
Hepta-Deca PBDEs in Sediments and Biota

PBDE Congeners

ng/g (% lipids)

ng/g (% TOC)

minnow
sunfish

sediments

204,000
Bioaccumulation Factors (BAFs) (Biota/Sediment)

- PBDEs Congeners
- BAF
- log Kow

Bioaccumulation Factors (BAFs) (Biota/Sediment)

- minnow
- sunfish
- log Kow

PBDEs Congeners

- tetra-
- penta-
- hexa-
- hepta-
- octa-
- nona-
- deca-

* World Health Organization, 1994
Octa-BDE % Congener Distribution

PBDE Congeners

- octa-b
- octa-c
- -204
- -197
- -203
- -196
- -205

% Congener

- SAYTEX 102E
- octa-B
- octa-C
- BDE-197
- BDE-203
- BDE-196

Legend:
- minnow
- sunfish
- sediments
PBDE % Congener Contribution

Saytex 102E
- tetra-
- penta-
- hexa-
- hepta-
- octa-
- nona-
- deca-

Stream
- tetra-
- penta-
- hexa-
- hepta-
- octa-
- nona-
- deca-

Sediment
- tetra-
- penta-
- hexa-
- hepta-
- octa-
- nona-
- deca-

Biota
- tetra-
- penta-
- hexa-
- hepta-
- octa-
- nona-
- deca-
Conclusions

• Twenty-eight (28) tetra- through deca- PBDEs identified
  – Eleven (11) were unnamed (*commercial standards not available*)
    • not detected: BDE138, -185, -192, -191, -204, -205

• WWTP effluent and receiving stream (water & seds) dominated by BDE209, 85 to 97%
  – hepta-BDEs NOT detected, tetra- through nona-BDEs detected
  – high levels of –209 may indicate slower environmental degradation routes vs. controlled photolysis experiments

• Biota contained tetra- through deca-BDEs
  – major congeners BDE47, -99 and –100, ranged 427 – 7380 ng/g, % lipid
  – hepta- to deca-BDEs ranged < 5 to 492 ng/g, % lipid
Conclusions

• BAFs ranged from ~5 to <0.002 for tetra- through deca-BDEs
  – Hepta-BDEs only detected in biota, BAF not determined

• Potential BDE209 biotransformation products detected in Biota
  – These products may increase BDE body burdens
  – Twelve (12) BDE products detected
    • Include tetra- through octa-BDEs
      – BDE184, -183 and ten (10) unnamed
    • Although not detected in stream (water or seds), preferential uptake cannot be ruled out

Mark La Guardia, e-mail: markl@vims.edu