U.S. EPA Design for the Environment (DfE) Program

September 10, 2008

Clive Davies
Design for the Environment (DfE) Program
U.S. Environmental Protection Agency
Washington, DC
Presentation Outline

• DfE Program
  – Tools and methods
  – Alternatives Analysis

• DfE Product Recognition
  – How it works
  – Improvements

• Safer Detergent Stewardship Initiative (SDSI)
DfE Program Overview

• Focus
  – Green Chemistry
  – Informed Substitution
  – OPPT technical tools and expertise

• Considerations
  – Business client
  – Multi-stakeholder participation
  – Business realities
  – Potential benefits for industry and the environment

• Results
  – Industry partners reduced about 160 million pounds of chemicals of concern last year
Furniture Flame Retardants Partnership
Alternatives Assessment

• Predominant flame retardant (pentaBDE) was being found increasingly in human tissue, breast milk and the environment.
  – PentaBDE was phased-out at the end of 2004.
  – Need for fire safety will likely increase based on planned national standards.
  – Decision-making for alternatives to this 19 million pound per year chemical.

• The Report
  – Provides data to inform industry.
  – Summary assessments of chemicals in flame retardant formulations.
  – Detailed hazard reviews.
# Furniture Flame Retardancy Partnership

## Results: Data Presentation

<table>
<thead>
<tr>
<th>Company</th>
<th>Chemical</th>
<th>% in Formulation</th>
<th>Cancer Hazard</th>
<th>Skin Sensitizer</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Neurological</th>
<th>Systemic</th>
<th>Genotoxicity</th>
<th>Acute</th>
<th>Chronic</th>
<th>Persistence</th>
<th>Bioaccumulation</th>
<th>Potential Routes of Exposure</th>
<th>Reactive or Additive?</th>
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<tbody>
<tr>
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</table>
Flame Retardants in Printed Circuit Boards

- Tetrabromobisphenol A / TBBPA is the highest-volume brominated flame retardant in use
- Primary application is in printed circuit boards - at approx. 330 million pounds/year
- Industry need for information on flame retardants
- Concern by some stakeholders over environmental impacts and combustion by-products
- Partnership to identify and characterize commercially available flame retardants and their environmental, health, safety and environmental fate aspects in FR-4 printed circuit boards.
  - Use EPA New Chemicals Program criteria to evaluate hazard and environmental fate concerns
  - Life-cycle thinking provides a more robust context
### Flame Retardants in Printed Circuit Boards

**Results: Data Presentation**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>CASRN</th>
<th>Acute Toxicity</th>
<th>Skin Sensitizer</th>
<th>Cancer Hazard</th>
<th>Immunotoxicity</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Neurological</th>
<th>Systemic</th>
<th>Genotoxicity</th>
<th>Aquatic Toxicity</th>
<th>Environmental</th>
<th>Exposure Considerations</th>
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<td><strong>Human Health Hazard Concern</strong></td>
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<td><strong>Ecotoxicity Hazard Concern</strong></td>
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#### Reactive Flame Retardant Chemicals

<table>
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<tr>
<th>Chemical</th>
<th>CASRN</th>
<th>Acute Toxicity</th>
<th>Skin Sensitizer</th>
<th>Cancer Hazard</th>
<th>Immunotoxicity</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Neurological</th>
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<th>Genotoxicity</th>
<th>Aquatic Toxicity</th>
<th>Environmental</th>
<th>Exposure Considerations</th>
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<tbody>
<tr>
<td>TBBPA (Tetraakis[3,5-bis(trifluoromethyl)phenyl]borate) (Albemarle, Chemtura, and others)</td>
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<td>DOPO (6H-Dibenzo[7,12]oxaphosphorin, 6-oxide) (Samko Co., Ltd. and others)</td>
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<tr>
<td>Fyrolflex PMP (Aryl alkylphosphonate) (Supresta)</td>
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#### Reactive Flame Retardant Resins

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<th>Immunotoxicity</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Neurological</th>
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<th>Genotoxicity</th>
<th>Aquatic Toxicity</th>
<th>Environmental</th>
<th>Exposure Considerations</th>
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<tbody>
<tr>
<td>D.E.R. 538 (Reaction product of TBBPA - D.E.R. 538)</td>
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<td>Reaction Product of DOPO - Dow XZ-92547</td>
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<td>Dow XZ-92547</td>
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<tr>
<td>Reaction product of Fyrolflex PMP with bisphenol A, polymer with epichlorohydrin (Representative Resin)</td>
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<td>L</td>
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<tr>
<td>Representative Fyrolflex PCB Resin</td>
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</tr>
</tbody>
</table>

Availability of flame retardants (FRs) throughout the lifecycle for reactive and additive FRs chemicals and resins.
Lead-Free Solder Partnership

Background

- The U.S. electronics industry is moving away from lead solder (176 millions pounds per year)
- E.U. banned lead in electronics as of June 2006
- Industry approached DfE based on past relationship
- Partnership is helping U.S. industry adopt lead-free alternatives and maintain international competitiveness
Lead-Free Solder Partnership

Goals

Evaluate:

• The relative life-cycle environmental impacts of Sn/Pb solder and selected Pb-free alternative solders
• Both paste (reflow) and bar (wave) solder technologies – wave solders are lower technology solders than paste solders
• Leachability of solders
Lead-Free Solder Partnership
Life-Cycle Assessment

SnPb Paste Solder Life-Cycle Process
Lead-Free Solder Partnership
Life-Cycle Assessment

Composition of tin-lead and alternative solders:

• 95.5% tin, 3.9% silver, and 0.6% copper
• 57.0% bismuth, 42.0% tin, and 1.0% silver
• 96.0% tin, 2.5% silver, 1.0% bismuth, 0.5% copper
• 99.2% tin and 0.8% copper
Lead-Free Solder Partnership
Life-Cycle Assessment

Key Findings

• Cost and impacts of mining silver may drive choices
• Energy-efficient ovens will cut manufacturing costs and impacts
• Lead was found to leach to a much greater extent than the other metals in the solders being analyzed in this study
Formulator Program Review
3 Basic Components

1) Review *every* ingredient by functional use class
   - To promote green chemistry
   - To understand toxicity
     - Data (generated for DfE or unpublished)
     - Literature
     - Analogous chemicals – SAR

2) Review formulation as a whole
   - Negative chemical interactions
   - pH
   - Performance testing
   - Life cycle thinking

3) Partnership Agreement
DfE Product Recognition Program

- Expert Chemical Evaluation
  - Ability to interpret experimental studies
  - Predict hazard and environmental effects in the absence of data – SAR approach
- Discriminating Process Focused on a Given Formulation
  - Review every ingredient by functional use
  - Focus on endpoints of concern and continuous improvement
- Driven by Green Chemistry
  - As Innovation Occurs Continua May Shift

## Continuum of Improvement

**Formula Ingredient by Functional Class**

- **Of Concern**
  - Characteristics of Ingredient of Concern
- **Improved**
  - Characteristics of Improved Ingredient
- **Sustainable**
  - Characteristics of Sustainable Ingredient
Continuing Improvement

• **Transparency**
  – Screens for safer ingredients document DfE decision logic by functional use class
  – We plan to document the DfE review methodology in the form of a standard

• **Access**
  – Third-party profiler now provides enhanced access to partnership with DfE
  – CleanGredients™ was developed to enhance access to chemicals from the green end of the spectrum by functional use class
CleanGredients™

• CleanGredients™ is a marketplace…
  – for suppliers to showcase safer chemical ingredients for cleaning products, and
  – for formulators to find those ingredients.
  – CleanGredients™ houses chemicals that are acceptable in DfE-labeled products

• CleanGredients™ is at the intersection of safer chemistry and high performance ingredients
CleanGredients™ - Marketplace for Green Chemistry Ingredients

• Multi-stakeholder development
  – More than 800 stakeholders
  – Technical Committees define modules for safer functional ingredient classes
    • 15-30 organizations typically represented on each Technical Committee
    • Expertise in formulary chemistry and toxicology
    • Formulators, chemical suppliers, NGOs, and Government

• Steering Committee overseas project development
  • Akzo Nobel
  • BASF
  • Consumer Specialty Products Association
  • Corporate Express
  • Dow Chemical
  • EPA DfE
  • Green Blue Institute
  • International Sanitary Supply Association
  • Investor Environmental Health Network
  • NSF International
  • Reckitt Benckiser
  • SYSCO
DfE Screen for Surfactants

- Safer surfactants degrade quickly to low toxicity degradates.

<table>
<thead>
<tr>
<th>Acute Aquatic Toxicity (L/E/IC50 Value)</th>
<th>Rate of Biodegradation</th>
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</thead>
<tbody>
<tr>
<td>≤1 ppm</td>
<td>May be acceptable if biodegradation(^1) occurs within a 10-day window</td>
</tr>
<tr>
<td>&gt;1 ppm and ≤10 ppm</td>
<td>Biodegradation(^1) occurs within a 10-day window</td>
</tr>
<tr>
<td>&gt;10 ppm</td>
<td>Biodegradation(^1) occurs within 28 days without products of concern(^2)</td>
</tr>
</tbody>
</table>

\(^1\) Generally, >60% mineralization (to CO2 and water) in 28 days.

\(^2\) Products of concern are compounds with high acute aquatic toxicity (L/E/IC50 ≤ 10ppm) and a slow rate of biodegradation (greater than 28 days).
**DfE Screen for Solvents (draft)**

- Safer solvents demonstrate low impacts to human health and the environment.

<table>
<thead>
<tr>
<th>PHASE I SOLVENT CLASSES</th>
<th>Alcohols</th>
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<tr>
<td></td>
<td>Esters</td>
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<tr>
<td></td>
<td>Ethylene Glycol Ethers (EGEs)</td>
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<tr>
<td></td>
<td>Propylene Glycol Ethers (PGEs)</td>
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<table>
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<th>Carcinogenicity</th>
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<tr>
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<td>Reproductive and Developmental Toxicity</td>
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<td>Repeated-Dose Toxicity</td>
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<td>Environmental Fate and Toxicity</td>
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# CleanGredients™ Search Results

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<tr>
<th>Supplier</th>
<th>Product Name</th>
<th>Charge Class</th>
<th>Chemical Class</th>
<th>Biodegradability</th>
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<th>DIE Screen</th>
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<tbody>
<tr>
<td>Unicema</td>
<td>Monatrops 1620</td>
<td>Nonionic</td>
<td>Alkyl Polysaccharide</td>
<td>Ready</td>
<td>&gt;10 and ≤100</td>
<td>Meets DIE Screen</td>
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<tr>
<td>Air Products &amp; Chemicals (Toman Products)</td>
<td>Tomadol 400</td>
<td>Nonionic</td>
<td>Liquid 149°C, 70%</td>
<td>Ready</td>
<td>≤1</td>
<td>Meets DIE Screen</td>
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<tr>
<td>Cognis Corporation</td>
<td>Glucopen 625 UP</td>
<td>Nonionic</td>
<td>Allyl glucosides 12, Liquid &gt;100°C, 0.003</td>
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<tr>
<td>Magnesium lauryl sulfate 3097-08-3 (CAS #)</td>
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<td>Linear alkyl sulfate</td>
<td>Ready</td>
<td>&gt;10 and ≤100</td>
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<td>Stepan Company</td>
<td>BIO-SOFT® N1-5</td>
<td>Nonionic</td>
<td>Alcohol Ethoxylates 11.2, Liquid &gt;94°C</td>
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<td>&gt;1 and ≤10</td>
<td>Meets DIE Screen</td>
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Safer Detergents Stewardship Initiative (SDSI)

- Environmental stewardship program to encourage the use of safer surfactants
- Promotes the goals of EPA’s Ambient Water Quality Criteria (AWQC) for Nonylphenol (NP) and harmonizes with international environmental protection efforts
- More than 65 applicants
- Ceremony targeted for late 2008