Use of DecaBDE Flame Retardants in Plastic Shipping Pallets: Assessing Safer Alternatives

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Solutions for a Sustainable Future
Safer Alternative

Maine law:

“A substitute process, product, material, chemical, strategy or any combination of these”
Issue: Use of DecaBDE in Plastic Pallets

- Pallets used to ship/store wide range of commodities
- Plastic pallets pose higher fire risk than wood
- DecaBDE fire retardant added to plastic to reduce flammability
Questions for the Assessment

• Substitute chemical or material:
  - Safer alternative flame retardants (non-brominated or -chlorinated)?

• Substitute process/strategy:
  - Alternative measures for reducing fire risks

• Substitute product:
  - Non-plastic pallets
Areas to Explore

• Market
  - Service providers
  - End users

• Regulatory drivers & other safety concerns (fire, sanitation, ergonomics, etc.)

• Management landscape: warehouses & palletized storage

• Reasons for use of deca in plastic pallets & availability of potential alternatives

• Hazards posed by potential alternative flame retardants
Finding Information Sources

- Market analyses
- Pallet service firms
- Pallet manufacturers
- Compounders
- Flame retardant experts
- Chemical screens/toxicological assessments
- Regulatory bodies (national, state, local)
  - NFPA
  - EPA (DfE)
  - Fire marshals
- Insurers
- Consumer goods manufacturers & shippers
- Warehouses
Market for Pallets: Type & Use

• Over 3 billion shipping pallets in use nationally
  - Wood dominant material
  - About 900 million plastic
  - “Grocery pallet” (40x48 inches) largest - 30% of market

• “Open pool” leased pallets (c. 85 million, 10 million plastic) - iGPS, CHEP, PECO

• Closed loop/internal use

• Single use
Pallet Market: Open Pool Pallet Leasing
Market: IGPS Open Pool Pallets with RFID
Fire Safety Regulations

• National Fire Protection Association - NFPA 13
  - Sets fire safety (sprinkler & management) standards adopted by states, localities for fire protection for warehouses
  - Standards based on levels of protection required for wood fires
    • Stricter storage standards for plastic pallets
      - Greater heat released by polyolefin plastic fires
      - Unless tests demonstrate plastics burn with equal or less heat than wood.
Can Better Warehouse Protection/Management Systems Provide Safer Alternative?
Effects of Flame Retardants on Plastic & Pallet

• Key properties of plastic compounds
  - Specific gravity
  - Modulus
  - Impact resistance
  - Melt flow index
Alternative Safer Flame Retardants

• Addition of flame retardants to pallets affects performance characteristics of plastic

• Finding the balance
  - Strength
  - Stiffness
  - Durability
  - Design
  - Weight
  - Cost

• Major alternative classes of flame retardants
  - Phosphates
  - Metallics
## Non-Halogenated Flame Retardants
Selected for ‘Safer Alternatives’ Review

<table>
<thead>
<tr>
<th>Flame Retardant</th>
<th>CAS#</th>
<th>Reason for Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melamine polyphosphate</td>
<td>218768-84-4</td>
<td>Recommended by PINFA[^1].</td>
</tr>
<tr>
<td>Ethylenediamine phosphate</td>
<td>14852-17-6</td>
<td>Demonstrated FR properties for polypropylene.</td>
</tr>
<tr>
<td>Ammonium polyphosphate</td>
<td>68333-79-9</td>
<td>Excellent general purpose FR but recommended for use with synergists.</td>
</tr>
<tr>
<td>Red phosphorus</td>
<td>7723-14-0</td>
<td>Demonstrated application in thermoplastics.</td>
</tr>
<tr>
<td>Magnesium hydroxide</td>
<td>1309-42-8</td>
<td>Demonstrated FR properties in thermoplastics and is currently being used in a polypropylene pallet.</td>
</tr>
<tr>
<td>Aluminum trihydroxide</td>
<td>21645-51-2</td>
<td>Demonstrated FR properties in PE but not in PP.</td>
</tr>
<tr>
<td>Zinc Borate</td>
<td>138265-88-0</td>
<td>Useful as a supplemental FR with ATH and Magnesium Hydroxide.</td>
</tr>
<tr>
<td>Magnesium stearate</td>
<td>557-04-0</td>
<td>Magnesium hydroxide particles treated with stearate acid to facilitate a better dispersion of magnesium hydroxide in a polymer matrix.</td>
</tr>
</tbody>
</table>
Green Screen

Benchmark 4
- ready biodegradability (low P) + low B + low Human Toxicity + low Ecotoxicity
- (+ additional ecotoxicity endpoints when available)

Prefer—Safer Chemical

Benchmark 3
- a. moderate P or moderate B
- b. moderate Ecotoxicity
- c. moderate Human Toxicity
- d. moderate Flammability or moderate Explosiveness

Use but Still Opportunity for Improvement

Benchmark 2
- a. moderate P + moderate B + moderate T (moderate Human Toxicity or moderate Ecotoxicity)
- b. high P + high B
- c. (high P + moderate T) or (high B + moderate T)
- d. moderate Human Toxicity for any priority effect or high Human Toxicity
- e. high Flammability or high Explosiveness

Use but Search for Safer Substitutes

Benchmark 1
- a. PBT: high P + high B + high T (high Human Toxicity or high Ecotoxicity)
- b. vPvB: very high P + very high B
- c. vPT (VP + high T) or vBT(vB + high T)
- d. high Human Toxicity for any priority effect

Avoid—Chemical of High Concern
## Green Screen Results

### Screening Level Toxicology Hazard Summary

<table>
<thead>
<tr>
<th>Chemical</th>
<th>CAS #</th>
<th>Carcinogenicity</th>
<th>Mutagenecity</th>
<th>Reproductive/ Development</th>
<th>Endocrine Disruption</th>
<th>Neurotoxicity</th>
<th>Acute Toxicity</th>
<th>Aquatic Toxicity</th>
<th>Fate</th>
<th>Physical</th>
<th>GS Benchmark Score (Chemical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decabromodiphenyl Ether</td>
<td>1163-19-5</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>vH</td>
<td>1</td>
</tr>
<tr>
<td>Aluminum Trihydroxide</td>
<td>21645-51-2</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>nd</td>
<td>nd</td>
<td>L</td>
<td>vH</td>
<td>L</td>
<td>L</td>
<td>2</td>
</tr>
<tr>
<td>Ammonium Polyphosphate</td>
<td>68333-79-9</td>
<td>L</td>
<td>L</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>4</td>
</tr>
<tr>
<td>Ethylenediamine Phosphate</td>
<td>14852-17-6</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>nd</td>
<td>nd</td>
<td>nd</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>2</td>
</tr>
<tr>
<td>Magnesium Hydroxide</td>
<td>1309-42-8</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>nd</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>vH</td>
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<td>2</td>
</tr>
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<td>557-04-0</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>nd</td>
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<td>M</td>
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<td>nd</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>1</td>
</tr>
<tr>
<td>Zinc Borate</td>
<td>1332-07-6</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>nd</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>nd</td>
<td>L</td>
<td>2</td>
</tr>
</tbody>
</table>

*nd* = not determined/unknown  
*L* = Low Hazard  
*M* = Moderate Hazard  
*H* = High Hazard  
*vH* = very High Hazard  
Endpoints in colored text (*L*, *M*, and *H*) were assigned based on experimental data. Endpoints in black italics (*L*, *M*, and *H*) were assigned using estimated values and professional judgment (Structure Activity Relationships).
Plastic pallets with Non-BFR Flame Retardants

• Currently produced or available plastic pallets with non-BFR flame retardants
  - Passed one or both of two major pallet flame retardant tests (UL 2335/FM 4996)
  - Use flame retardant systems scoring 2 or above on Green Screen

• Currently only two pallets with flame retardants meet both criteria
  - Rehrig Pacific (magnesium hydroxide)
  - CHEP (phosphate-based)
DEP Tests for ‘Functionally Equivalent’

• **Pallet meets the Grocery Industry (GMA) Pallet Performance Specifications (from 1992 recommendations on the Grocery Industry Pallet System) or is capable of being manufactured to meet those standards.**

• **Pallet currently used by grocery industry or other consumer market sectors to ship the same types of goods shipped on pallets containing decaBDE (e.g., pallets made from wood or metal).**
Grocery Manufacturers Association (GMA) Standards

• Fire protection
  - “Meet or exceed current pallet resistance to fire.”

• Size and structure
  - 48x40 inches; no more than 6 inches in height; minimum 85% coverage on the (non-skid) top surface of the pallet; 60% coverage on the bottom surface; ‘4-way entry’ (openings that allow forklifts and other equipment to lift the pallet from any direction); and meet other technical criteria to facilitate consistency with pallet management equipment

• Weight
  - Less than 50 pounds

• Sanitation
  - Material that does not contaminate the product it carries

• Durability
  - Capable of ‘multiple cycles’

• Strength
  - Capable of holding 2800-pound loads both in racks (which provide support only for the edges of the pallets) and, on a flat surface, in stacks five loads high (each fully loaded with 2800 pounds).
### GMA Functional Equivalence Test

<table>
<thead>
<tr>
<th>Pallet</th>
<th>Weight (lb)</th>
<th>Bottom Surface Coverage</th>
<th>Top Surface Coverage</th>
<th>Rack Load</th>
<th>Fire Resistance</th>
<th>Edge Chamfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>iGPS</td>
<td>48.5</td>
<td>57%</td>
<td>97%</td>
<td>≥2,800</td>
<td>UL 2335 &amp; FM 4996</td>
<td>Y</td>
</tr>
<tr>
<td>CHEP all wood</td>
<td>65</td>
<td>unknown</td>
<td>unknown</td>
<td>≥2,800</td>
<td>N/A</td>
<td>N</td>
</tr>
<tr>
<td>CHEP plastic</td>
<td>62</td>
<td>unknown</td>
<td>unknown</td>
<td>≥2,800</td>
<td>UL 2335 &amp; FM 4996</td>
<td>Y</td>
</tr>
<tr>
<td>CHEP composite block</td>
<td>65</td>
<td>55%</td>
<td>unknown</td>
<td>≥2,800</td>
<td>FM 4996</td>
<td>N</td>
</tr>
<tr>
<td>PECO all wood</td>
<td>unknown</td>
<td>unknown</td>
<td>unknown</td>
<td>≥2,800</td>
<td>N/A</td>
<td>N</td>
</tr>
<tr>
<td>Rehrig Pacific plastic</td>
<td>49.5</td>
<td>unknown</td>
<td>unknown</td>
<td>2,000</td>
<td>UL 2335</td>
<td>Y</td>
</tr>
</tbody>
</table>
Functional Equivalence Test for Use in Shipping Same Types of Consumer Goods

• Some alternative pallets fail test
  - Metal pallets rarely used in consumer market
  - Plastic pallets without flame retardants can’t serve similar function in open-pool pallet market

• Wood pallets are used for similar products
  - In determining equivalence, need to consider whether special subcategories rely most heavily on plastic pallets
  - No available data demonstrating such a pattern, but most comprehensive industry survey data from 2007
Approach to Determining ‘Safer Alternatives’

• Broadened perspective on ‘safer alternatives’
  - Safer chemical flame retardant alternatives
  - Systematic review of process and management alternatives that could meet safety &/or functional requirements while eliminating/modify need for flame retardant chemicals

• Provided alternative ways of viewing ‘functionally equivalent’

• Expands horizon of issues considered in search for safer alternatives

• Widens basis for policy decisions
For additional information or questions

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