Novel flame retardant solutions for water based, clear wood coatings

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About ICL Group

Headquartered in Israel, with plants across the globe

Global manufacturer of fertilizer and specialty chemicals

World’s largest producer of elemental bromine

World’s leading producer of a variety of bromine, phosphorus and inorganic Flame Retardants (FRs)

Multiple awards for sustainability efforts, inclusion in FTSE4Good and A- Carbon Score
Product Stewardship & Lifecycle by ICL

- **Development** - *Sustainability Index* for Product Development
- **Production** - **VECAP** – Voluntary Emissions Control Action Program
- **Application** - **SAFR®** – A Systematic Assessment for Flame Retardants
- **End of Life** - Circular Economy Initiatives – PSLoop, Plast2becleaned, etc.

Why Flame Retardants?

• Building codes, Product specs require Fire Safety
• Recent major fires shine a spotlight on fire safety
• FRs are a major way in which flame retardancy is achieved
• Coating's market is well served by APP and ATH:
  • Not possible to achieve transparency
• Other options like chlorinated phosphates and phosphate esters have issues in WB systems
• Market need = Water borne clear, FR wood coatings!
FR Perception: Halogen = BAD  Non-Hal = GOOD

Recent EPA restrictions: 1 Br FR  1 Non-Hal FR
- Already off the market
- Currently in use = Business risk

Next EPA priority review: 1 Br FR  1 Non-Hal FR
- Reacted in use, likely no effect
- Component of major NH FRs

Path forward: Polymeric, reactive or inorganic FRs regardless of chemistry!*

* U.S EPA: "There is an exceedingly low probability that potential exposure to high molecular weight water-insoluble polymers, as a class, will result in unreasonable risk or injury to human health or the environment"  
Current FR products on the market

Historically used chlorinated phosphate esters:
• Excellent compatibility and efficiency
• Problematic HSE profiles, under regulatory scrutiny

Possible replacement with traditional phosphate esters:
• Excellent compatibility but not as efficient
• Very good rheological properties for 100% solids systems

Low particle size brominated flame retardants:
• High efficiency products, polymeric preferred
FR coating development
Goal = Clear, water borne, FR solution

- Developing New FR Molecules
- Application and Small-Scale FR testing
- FR Paint Formulation
- Large scale testing

And here we are today
Development Results

Solid Brominated Polymer

- Low particle size solid
- Easily Formulated
- Translucent Film
- Suitable for water based, solvent based and 100% solids systems
- Oeko-Tex approved

Brominated Acrylic Copolymer

- A submicron water-based dispersion
- Creates a clear film
- High compatibility with water-based resins and paint components
- Acts as co-binder in the paint

ICL patented products
# Product Appearance

<table>
<thead>
<tr>
<th></th>
<th>NO FR, WB</th>
<th>Solid Br Polymer</th>
<th>Br Acrylate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pH as is</strong></td>
<td>7.2</td>
<td>7.3</td>
<td>7.1</td>
</tr>
<tr>
<td><strong>Viscosity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(63S, 100 rpm, RT), cp</td>
<td>921</td>
<td>158</td>
<td>78*</td>
</tr>
<tr>
<td><strong>Gloss</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(20°, 60°, 85°)</td>
<td>11.4, 68.8, 80.5</td>
<td>1.2, 9.1, 20.8</td>
<td>15.5, 55.3, 64.1</td>
</tr>
<tr>
<td><strong>Transparency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(40 m thickness)</td>
<td>99.1</td>
<td>76.5</td>
<td>98.3</td>
</tr>
</tbody>
</table>

* (61S, 60 rpm, RT)
Small Scale NFPA 701 testing

- **No FR, WB Acrylic**
  - Fail = Full burn

- **WB Acrylic + Br Polymer**
  - Pass = Self Extinguish

- **WB Acrylic + Br Acrylate**
  - Pass = Self Extinguish
Small Scale Cone Calorimeter testing

Heat Release Curves

- WB Acrylic - No FR
- 46% Br Acrylate Copolymer + 12% APO
- 15% Solid Br Polymer

Peak Heat Release rate

Time to Ignition

Effect of coating combustion

Effect of Substrate combustion

Heat Release Rate (kW/m²)

Time (s)
Cone Calorimeter results – Solid Br Polymer

### Cone Calorimeter Results

**Heat Release Rate (kW/m²)**

- **WB Acrylic - No FR:** 
  - Avg. Heat Release Rate: 184 kW/m²
  - Peak Heat Release Rate: 385 kW/m²
  - Time to Ignition: 0 sec

- **Solid Br Polymer 10%**
  - Avg. Heat Release Rate: 156 kW/m²
  - Peak Heat Release Rate: 297 kW/m²
  - Time to Ignition: 5 sec

- **Solid Br Polymer 10% APO 7.5%**
  - Avg. Heat Release Rate: 163 kW/m²
  - Peak Heat Release Rate: 274 kW/m²
  - Time to Ignition: 10 sec

- **Solid Br Polymer 15%**
  - Avg. Heat Release Rate: 147 kW/m²
  - Peak Heat Release Rate: 271 kW/m²
  - Time to Ignition: 15 sec

- **Solid Br Polymer 15% APO 11.6%**
  - Avg. Heat Release Rate: 146 kW/m²
  - Peak Heat Release Rate: 235 kW/m²
  - Time to Ignition: 20 sec
Cone Calorimeter results – Br Acrylate

Heat Release Rate (kW/m²)

- WB Acrylic - No FR: 184
- Br Acrylate Disp. 38%: 147
- Br Acrylate Disp. 37% APO 10%: 146
- Br Acrylate Disp. 46.3%: 154
- Br Acrylate Disp. 46.2% APO 12.5%: 144

Average Heat Release Rate

Peak Heat Release Rate

Time to ignition (sec)

- WB Acrylic - No FR: 385
- Br Acrylate Disp. 38%: 288
- Br Acrylate Disp. 37% APO 10%: 254
- Br Acrylate Disp. 46.3%: 261
- Br Acrylate Disp. 46.2% APO 12.5%: 225
Large scale FR testing

EN 13501 (SBI)

ASTM E-84

https://blog.starcysystems.com/blog/astm-e-84-fire-rating-your-questions-answered;
http://virtual.vtt.fi/virtual/innofirewood/stateoftheart/database/euroclass/euroclass.html;
https://www.fire-testing.com/single-burning-item-sbi/
Addition of Br Epoxy with Magnesium Hydroxide improved the rating of the coated wood from class D to class C (~50% red. In FIGRA)

* Patent application published
Indicative SBI results*

Addition of Br Epoxy with Magnesium Hydroxide reduced smoke, producing s2 rating with Class C FIGRA

* Patent application published
Addition of Br polymers changed the rating of the coated plywood from class C to class B.
Addition of Br polymers reduced flame spread and maximum burn temperature.
Summary

**Product formulation and appearance:**
- Both Br polymers easily dispersed in water
- Br Acrylate provides superior gloss

**Cone calorimeter testing:**
- More than 20% improvement in peak heat release
- Magnesium hydroxide resulted in improved smoke parameters

**SBI test (EU):**
- Achieved Class C on FR MDF board based on FIGRA (Br FR + Mg(OH)₂ synergist)
- SMOGRA for s2 rating is very close to S1

**ASTM E84 Test (NA):**
- Achieves Class B on Douglas Fir plywood
- Large margin for Flame Spread and Smoke developed
To conclude..

- Development of and effective sustainable polymeric flame retardants for paint and coating.
- The products gained good FR results in international large-scale testing.
- All these, while maintaining paint stability and wood appearance in the application.
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