ATH use in flame retardants: An overview of the industry and growth in Asia

Jack Anderson
Research Analyst
Roskill Information Services, UK
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Based in London, UK

Roskill produces **market reports** and does **consultancy research** on steel alloys, minor & light metals and industrial minerals

Flame retardant minerals report released **April 2015**

Metallurgical & non-metallurgical bauxite and alumina reports released **late-2015**
Overview

• Flame retardants overview

• ATH & mineral flame retardants

• Applications for ATH flame retardants

• Future trends – Asia & globally
Market is regulation driven, not consumer driven

- Polymers and natural materials (e.g. wood) relatively easy to ignite
- Flame retardants lower the risk of fire and reduce heat output
- Manufacturers not always keen to add them to products as they nearly always increase costs
Flame retardant market divided into two groups

1. Halogenated (bromine, chlorine in organic compound form)

2. Non-halogenated (also low smoke and fume [LSF]):
   - Aluminium hydroxides (ATH)
   - Magnesium hydroxides
   - Antimony oxides
   - Organo-phosphorus compounds
   - Others: Nitrogen compounds (such as melamine), boric acid & borates, ammonium polyphosphate and expandable graphite
ATH is a significant portion of the flame retardant market

Global market size by tonnage: 2.24Mt

Source: Roskill
Organo-bromine is the highest value sector

Global market size by value: US$6Bn

Source: Roskill
Asia the largest flame retardant-consuming region

Global market consumption by region, 2014

- Asia: 51%
- Europe: 22%
- North America: 21%
- Other: 6%

Source: Roskill
Technical specifications
Properties of flame retardants

• Cost
• Decomposition temperature
• Hardness
• Purity
• Toxicity and environmental impact
• Solubility

• Colour and refractive index
• Weathering and ageing
• Specific gravity
• Electrical
• Effect on mechanical properties of the final article
• Surface chemistry
Fire and flammability testing

- Fire tests play a key role in determining the flammability and fire performance of materials
  - Ease of material to ignite from external heat source
  - Whether or not combustion in self-supporting upon removal of heat source
  - How fast combustion spreads over article (propagation)
  - Amount of heat combustion generates
  - Smoke generation
  - Toxicity of off-gases
  - Tendency of smouldering and re-ignition
  - Spread of fire from burning drips

Source: Go Yen Chemical Industrial
Mineral flame retardant fillers

- Function by endothermic decomposition and release of inert gas
- Principally metal hydroxides
- Do not need to be used in conjunction with another material
- Decomposition temperatures are the key feature
- Boehmite (AlO[OH]) increasingly popular

<table>
<thead>
<tr>
<th>Flame retardant</th>
<th>Decomposition (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium sulphate dihydrate</td>
<td>60-130</td>
</tr>
<tr>
<td>Magnesium phosphate octahydrate</td>
<td>140</td>
</tr>
<tr>
<td>Aluminium hydroxide (ATH)</td>
<td>180</td>
</tr>
<tr>
<td>Basic magnesium carbonate</td>
<td>220</td>
</tr>
<tr>
<td>e.g. hydromagnesite</td>
<td></td>
</tr>
<tr>
<td>Magnesium hydroxide</td>
<td>300</td>
</tr>
<tr>
<td>Boehmite</td>
<td>340</td>
</tr>
<tr>
<td>Magnesium carbonate</td>
<td>400</td>
</tr>
<tr>
<td>Calcium hydroxide</td>
<td>440</td>
</tr>
</tbody>
</table>

Source: Rothon Consultants
ATH flame retardants
ATH as a flame retardant filler

Source: Redrawn from Nabaltec
Aluminium trihydrate/ATH flame retardants

- Aluminium trihydrate is the major mineral flame retardant
- First commercial use in mid-1960s
- Relatively low cost compared to rivals
- ‘Piggy-backs’ on large-scale aluminium production
- ATH functions by endothermic decomposition
- Chemical reaction of ATH under certain conditions:
  \[ 2\text{Al(OH)}_3 \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O} \quad \text{–energy} \quad (-1,300\text{kJ/kg}) \]
Grade and specifications for ATH

- Difference in purity, colour and particle shape
- Conflicting evidence for performance of ground/milled and precipitated grades

<table>
<thead>
<tr>
<th>Property</th>
<th>Milled Bayer</th>
<th>Fine precipitated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour (as whiteness %)</td>
<td>85-95</td>
<td>&gt;95</td>
</tr>
<tr>
<td>Particle size (microns)</td>
<td>4-100</td>
<td>0.7-3.0</td>
</tr>
<tr>
<td>Specific surface area m²/g</td>
<td>&lt; 2</td>
<td>3-15</td>
</tr>
<tr>
<td>Oil absorption cm³ of oil per 100g of filler</td>
<td>15-30</td>
<td>30-60</td>
</tr>
<tr>
<td>Particle shape</td>
<td>Somewhat platy, especially the smaller particle sizes</td>
<td>Blocky</td>
</tr>
</tbody>
</table>

Source: Rothon Consultants
Main producers of ATH for flame retardants and headquarters

- Albemarle → Baton Rouge, LA, USA
- Alcoa World Alumina Minerals → New York, USA
- Almatis → Frankfurt, Germany
- Alteo → Gardanne, France
- Alumina Chemicals & Castables → Navi Mumbai, India
- Chalco Aluminium Corp of China → Beijing, China
- JM Huber → Edison, NJ, USA
- Magyar Aluminium → Ajka, Hungary
- Nabaltec → Schwandorf, Germany
- Sumitomo Chemicals → Tokyo, Japan
- TOR Minerals Europe → Hattem, Netherlands
Applications
Main applications for ATH as flame retardant filler

1. **Electrical/electronics**
   - Widely used in wire and cable

2. **Building and construction**
   - Used in cables, roofing and various thermoset applications

3. **Transport**
   - Reinforced thermoset composites for vehicle body sections
   - Foam upholstery in seats

4. **Furnishings**
   - ATH widely used in carpet back-coats
ATH in thermoplastics: PVC consumption, 2014 to 2020

- Main markets for ATH flame retardants:
  - Polyethylene
  - Polyvinylchloride (PVC)

Source: Roskill, ICIS Consulting
White goods shipments, 2000 to 2020

- Appliances used for routine housekeeping tasks - includes refrigerators and washing machines

Source: Freedonia Group
World light vehicle sales, 2013 to 2020

- World sales forecast to rise at 3.8% CAGR from 2013-2020
- Chinese sales from at 5.8% CAGR over same period

Source: Roskill
Chinese flame retardants market & ATH use

- In 2013, China produced ~1Mt of flame retardants
- Domestic consumption accounts for ~60% of production
- North America, Europe & Japan main ATH markets
- ATH <10% of Chinese market in 2014 – significant growth in future
- Chinese manufacturers changing to non-halogenated flame retardants because of environmental policies
- Improved fire regulations in China
Looking to the future: regulations
Flame retardant regulations: opportunity for ATH growth

- Enforcement of RoHS & WEEE Directives in EU
- **REACH**: came into force in June 2007. EU producers, importers & users must register certain chemicals before deadlines
- China adopted similar regulations to RoHS and REACH to restrict certain brominated flame retardants in electronic equipment
- **US EPA** stopped manufacturers using decaBDE (bromodiphenyl) for most applications by end-2012
- Independent commitment by OEMs not to use brominated flame retardants
- **All creating trend towards LSF flame retardants (e.g. ATH)**
ATH/Flame retardants summary

• Flame retardants use driven by increasing regulation

• ATH forecast to grow globally at 7.1% CAGR to 2019

• Increase in thermoplastics consumption, especially in China, resulting in greater demand for flame retardants

• Opportunities for ATH when halogenated flame retardants are decreased further (continued substitution)
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Janderson@roskill.co.uk