Additives used in Flame Retardant Polymer Formulations: Current Practice & Trends

“Fire Retardants and their Potential Impact on Fire Fighter Health” Workshop at NIST, Gaithersburg, MD USA, 30-Sep-2009
Outline

- Global consumption of polymers and key application areas
- Formulation of additives into Polymers
- Compounding of polymers
- Flammability and fire risk of polymers
- Global FR market consumption and trends
World Synthetic Polymers Production: 2007

- Synthetic Polymers production in 2007: 315 mm mt globally
- Thermoplastics and Polyurethanes account for close to 70% of this market

Source: PlasticsEurope Market Research Group (PEMRG)
Flame Retardant Polymer Formulations

World
Plastics Production 1950 - 2007

- Plastics are a global success story
- Continuous growth for more than 50 years
- Compound Annual Growth Rate (CAGR) is about 9.0%

Includes Thermoplastics, Polyurethanes, Thermosets, Elastomers, Adhesives, Coatings and Sealants and PP-Fibers. Not included PET-, PA- and Polyacryl-Fibers

Source: PlasticsEurope Market Research Group (PEMRG)
Western Europe
Plastic Materials Demand by Segments 2007

Source: PlasticsEurope Market Research Group (PEMRG)
The Plastics Pyramid – commodity polymers are the most flammable

Resistance against chemicals, heat and fire

High Performance Polymers
5 ... 20 (100) EUR / kg

Engineering Plastics
2.50 ... 3.50 EUR / kg

Commodity Plastics
1.00 ... 2.00 EUR / kg

Global Consumption (2007)
- 500 kt < 1%
- 20,000 kt 10%
- 185,000 kt 90%

data PlasticsEurope 2008
Why are Additives added to Polymers?

Three Functional Classes for Additives:

1) Additives which are essential to fabrication of parts

2) Those which improve properties

3) Those which correct problems caused by the other additives!

Source: Polymer Modifiers & Additives, Lutz, Grossman 1988
Additives for Property Enhancement
Example of Additives used in Plastics

- Mineral Reinforcement/Fillers: improve stiffness, surface hardness, cost reduction
- Dyes and Pigments: color & appearance
- Antioxidants & stabilizers: delay/prevent oxidation during processing/application
- UV Stabilizers: interfere with light-induced degradation, weathering
- Blowing Agents: production of foams, weight reduction
- Lubricants: improvement in processing, release properties
- Coupling Agents: impart compatibility between polymer & additives
- Antistats/Conductives: prevent electrostatic discharge, improve conductivity
- Antimicrobials: prevent microbiological attack and property degradation
- Impact Modifiers: enhance toughness of material to impact
- Optical Brighteners: enhance appearance, off-set yellow color
- Flame Retardants: prevent ignition & flame spread, prolong escape time
**Limiting Oxygen Index (LOI)**

*ASTM 2863*

<table>
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<tr>
<th>Resin</th>
<th>LOI (approx.)</th>
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<tbody>
<tr>
<td>POM</td>
<td>15.5</td>
</tr>
<tr>
<td>PE</td>
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<td>PC</td>
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<tr>
<td>PA 6</td>
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<tr>
<td>F-PVC</td>
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<tr>
<td>PA 66</td>
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<tr>
<td>R-PVC</td>
<td>42.5</td>
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<tr>
<td>PTFE</td>
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A High LOI value indicates a Lower Flammability!
Compounding of Additives into Polymers

Processor Method Examples:

- Extrusion
- Film Blowing
- Sheet Thermoforming
- Rotational Molding
- Injection Molding
- Blow Molding

Source: Industrial Polymers, E. Campo
Flame Retardant Selection Criteria

some considerations:

- Efficiency/Cost
- Ease of Compounding
- Adequate Thermal Stability
- Corrosivity Issues
- Physical Properties
- Appearance
- Compatibility (Migration?)
- Environment/Toxicity
- UV Stability/Weathering
- Electrical Properties
- Combustion Products (corrosives, toxics, smoke)
Many different chemistries can achieve Flame Retarding effects

- different physical / chemical properties, environmental fate, toxicology, and regulatory status
Global Consumption of Flame Retardants (2007)

Quantity ca. 1,800,000 tons

- Aluminium Hydroxide: 40%
- Brominated: 23%
- Antimony Oxides: 8%
- Chlorinated: 7%
- Organo Phosphorus: 11%
- Other: 11%

Value ca. 4.2 billion US$

- Brominated: 34%
- Aluminium Hydroxide: 13%
- Antimony Oxides: 16%
- Chlorinated: 7%
- Organo Phosphorus: 20%
- Other: 10%

Source: SRI Consulting (2008)
Global Flame Retardant Market

**Recent BCC Research Study:** the global market for flame retardant chemicals will grow to $6.1 B in 2014 (Compound annual growth rate of 7%).
Flame Retardants Consumption by Region

global consumption 1,8 mm mt (2007)

Source: SRI consulting
Global FR Uses by Polymers all applications
(Estimates – kt 2007)

source: European FR Association/BSEF
FR Consumption by final application

Source: SRI Consultants, Freedonia and company reports

TAC: textile, adhesives, coatings
Concerns about Flame Retardants

- findings of certain brominated flame retardants in the environment, biota, humans
- some concern about certain phosphate esters in indoor air
- source of endocrine disruption?
- FR Persistence, Bioaccumulation, Toxicity (PBT)?
- risk assessments, scientific studies for materials of concern

Created for ES&T by Andreas Sjödin of the U.S. Centers for Disease Control, shows the levels of the most bioaccumulative PBDE congener, BDE-47, and the most bioaccumulative PCB congener, CB-153, in U.S. human blood samples. ES&T, 37, p. 384, 2003
Legal compliance and ecological trends are key drivers for increased usage of HF FRs

<table>
<thead>
<tr>
<th>Legal Compliance &amp; Industry Standards</th>
<th>Ecological Trends &amp; NGO Initiatives</th>
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<tbody>
<tr>
<td>WEEE-Directive</td>
<td>RoHS-Directive</td>
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<tr>
<td>REACH</td>
<td>TCO Development</td>
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</table>

Original Equipment Manufacturers (OEMs)

- HITACHI
- SONY
- APPLE
- DELL
- intel
- lenovo
- acer
- HP
- LG
- UJITSU
- SIEMENS
Phosphorus, Inorganic & Nitrogen Flame Retardants Association
Small Scale External Ignition Source in contact with Household Appliances (non-FR)

Needle Flame Source (30 w)

1 Minute

2 Minutes

6 minutes

7 Minutes
Small Scale External Ignition Source in contact with Household Appliances (non-FR)

1 minute

2 minute

5 minutes

12 minutes
Station Nightclub Fire
West Warwick, Rhode Island, February 2003

HOW ROCK SHOW TURNED DEADLY

Victims jam the main exit of The Station

Flame Retardant Polymer Formulations
T. Reilly, A. Beard, Div. PA - BU Specialties, BS Flame Retardants (Copyright Clariant. All rights reserved.)
Conclusion

- Plastics are widely used in our society. The global consumption of plastic materials is increasing. New materials and applications are being developed.

- It is necessary to add FRs to some plastics (dependent on application).

- Flame retardant consumption is growing globally due to increased standard of living and fire safety requirements.

- There is a trend towards more environmentally compatible FRs, driven by NGOs, OEMs and legislation like RoHS, REACH, & some U.S. state legislation.

- FR additives are beneficial to prevent ignition, flame spread & prolong escape time.
More Information - Links

Flame Retardants
- www.flameretardants.eu European Flame Retardants Association (EFRA)
- www.flameretardants-online.com
- www.exolit.com
- www.halogenfree-flameretardants.com

REACH:
- http://www.reachcentrum.eu/
- http://ecb.jrc.it/REACH/

WEEE and RoHS Europe:

Ecolabel EU
Thank you for your attendance!

Contact Information:

- Dr. Adrian Beard
  Clariant Produkte (D) GmbH
  adrian.beard@clariant.com
  +49 2233 48 6114

- Timothy Reilly
  Clariant Corporation, USA
  timothy.reilly@clariant.com
  401-823-2444