Public
T Reilly, A Beard
Div. PA - BU Specialties
BS Flame Retardants
30-Sep-2009

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

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Outline

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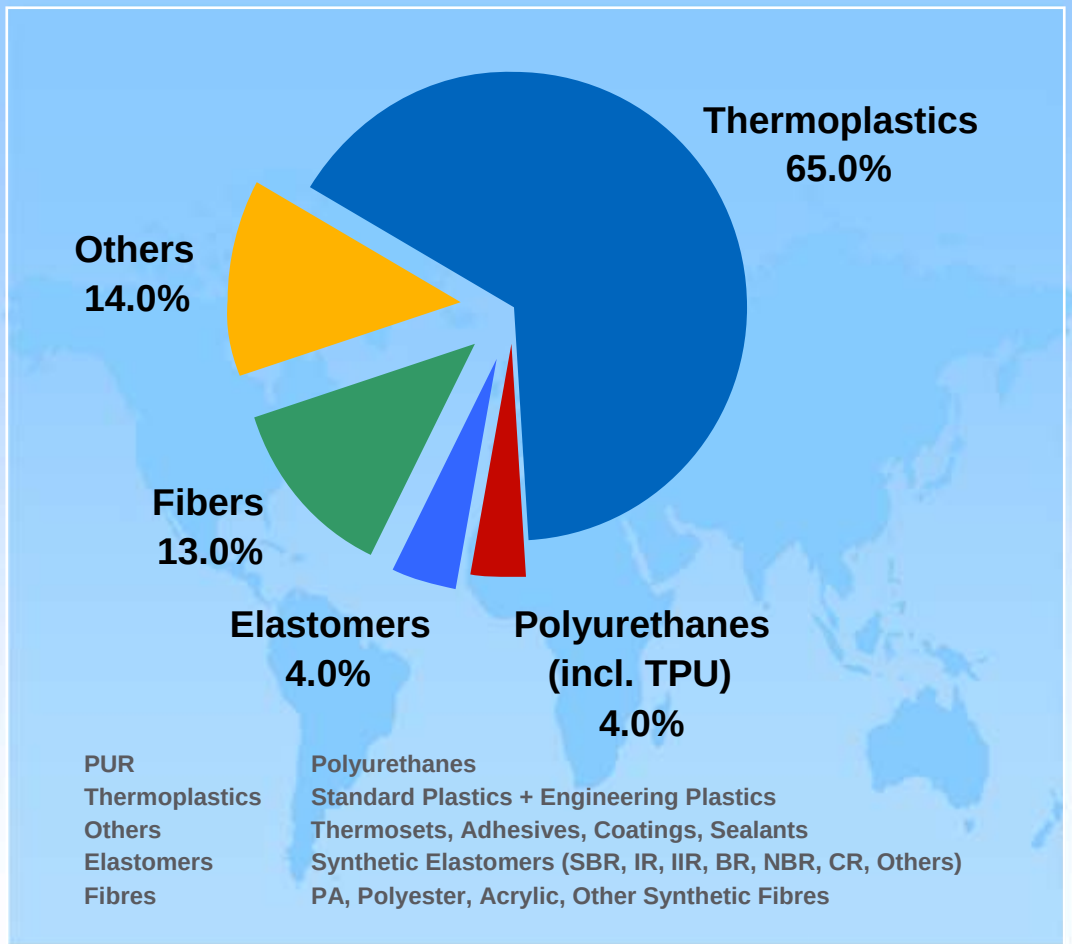
- Global consumption of polymers and key application areas
- Formulation of additives into Polymers
- Compounding of polymers
- Flammability and fire risk of polymers
- Global FR market consumption and trends

World
Synthetic Polymers Production: 2007



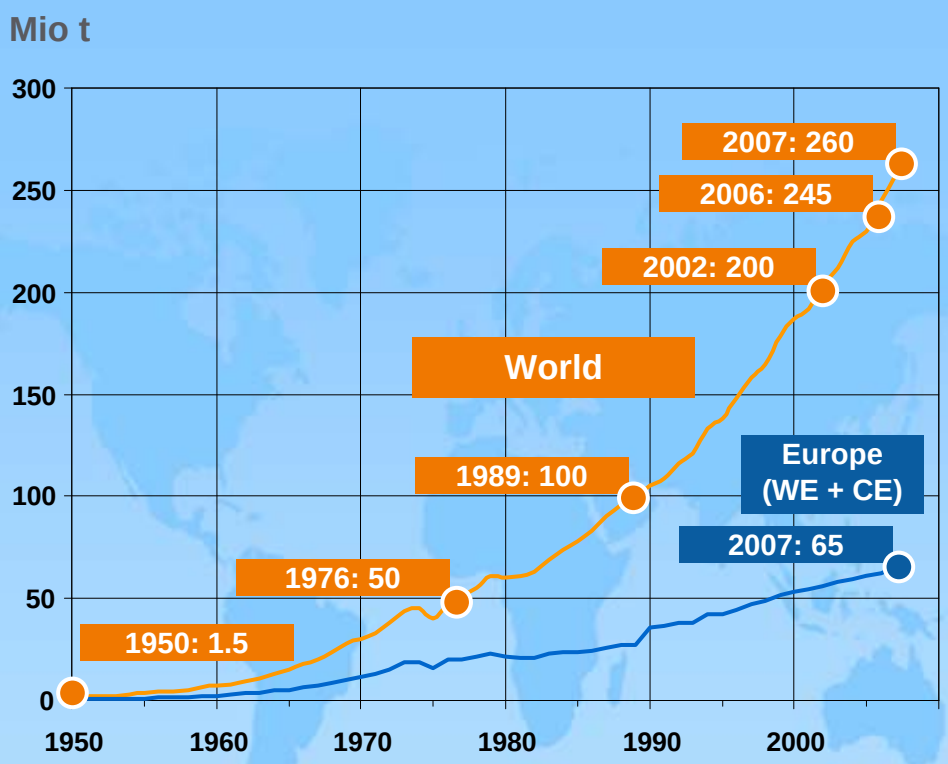
PUR	Polyurethanes
Thermoplastics	Standard Plastics + Engineering Plastics
Others	Thermosets, Adhesives, Coatings, Sealants
Elastomers	Synthetic Elastomers (SBR, IR, IIR, BR, NBR, CR, Others)
Fibres	PA, Polyester, Acrylic, Other Synthetic Fibres

- 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)

World
Plastics Production 1950 - 2007

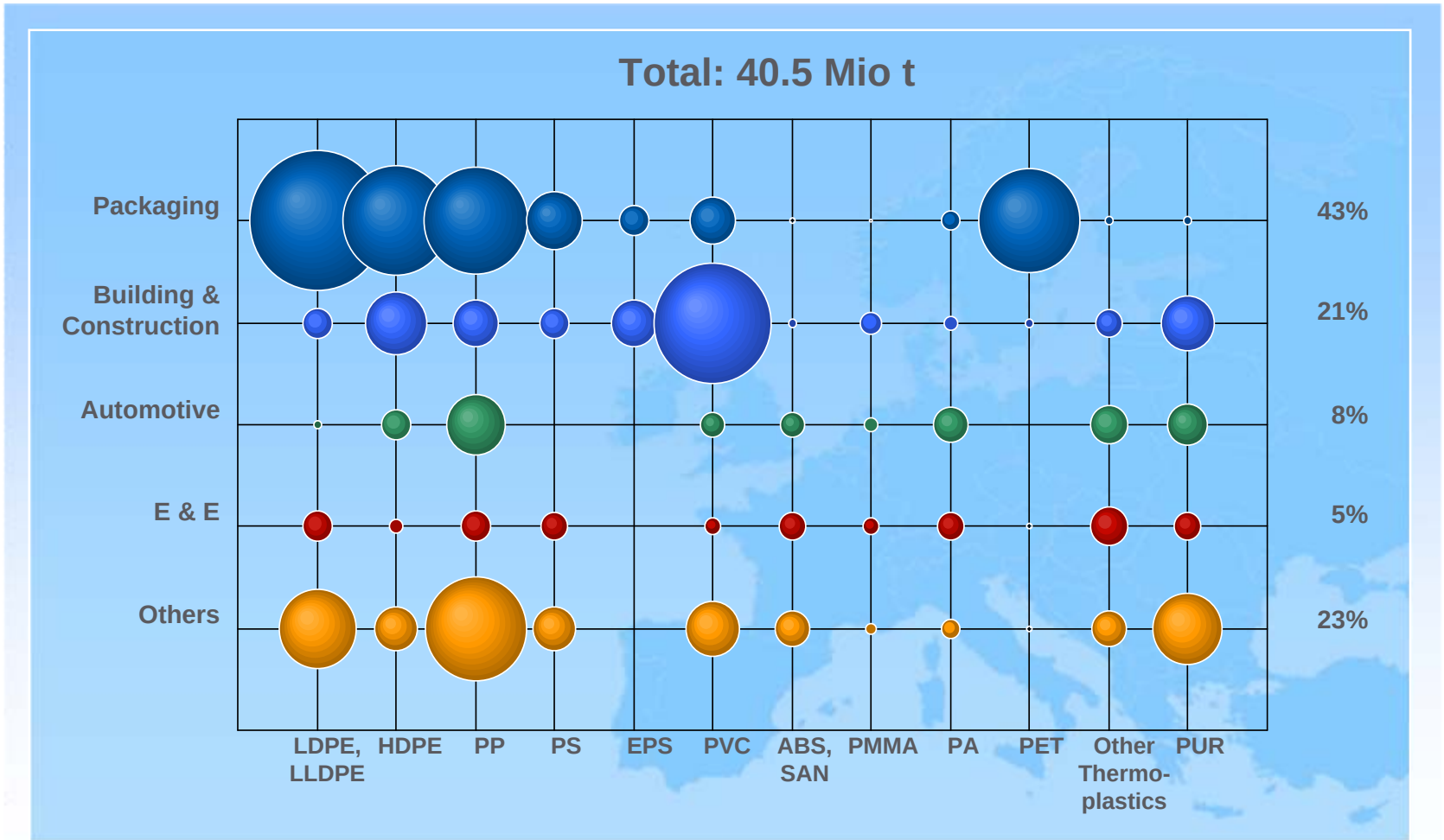


Includes Thermoplastics, Polyurethanes, Thermosets, Elastomers, Adhesives, Coatings and Sealants and PP-Fibers. Not included PET-, PA- and Polyacryl-Fibers

- Plastics are a global success story
- Continuous growth for more than 50 years
- Compound Annual Growth Rate (CAGR) is about 9,0%

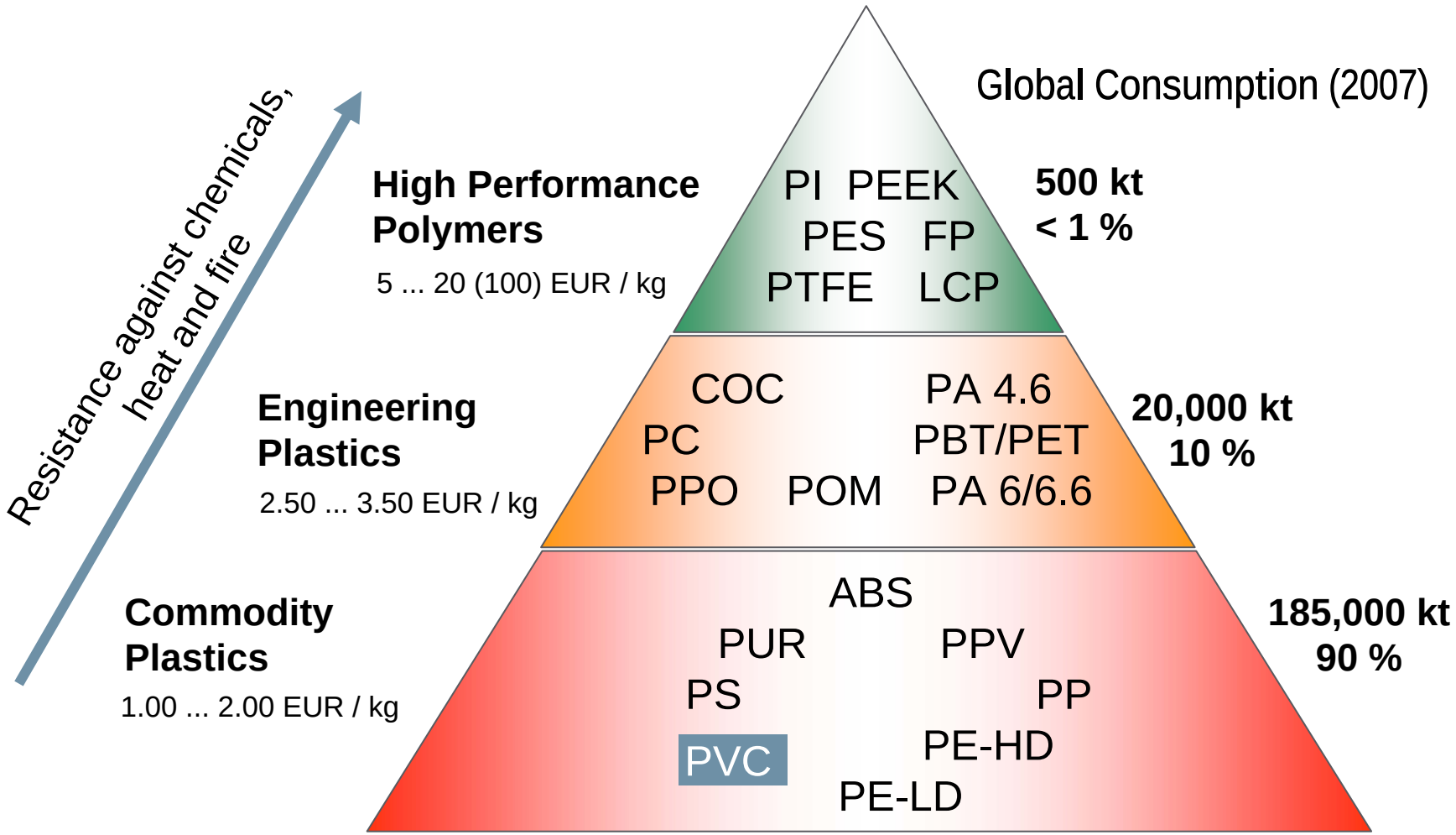
Source: **PlasticsEurope Market Research Group (PEMRG)**

Western Europe
Plastic Materials Demand by Segments 2007



Source: PlasticsEurope Market Research Group (PEMRG)

The Plastics Pyramid – commodity polymers are the most flammable



data PlasticsEurope 2008

Why are Additives added to Polymers?

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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 & Additves, Lutz, Grossman 1988

Additives for Property Enhancement

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Example of Additives used in Plastics

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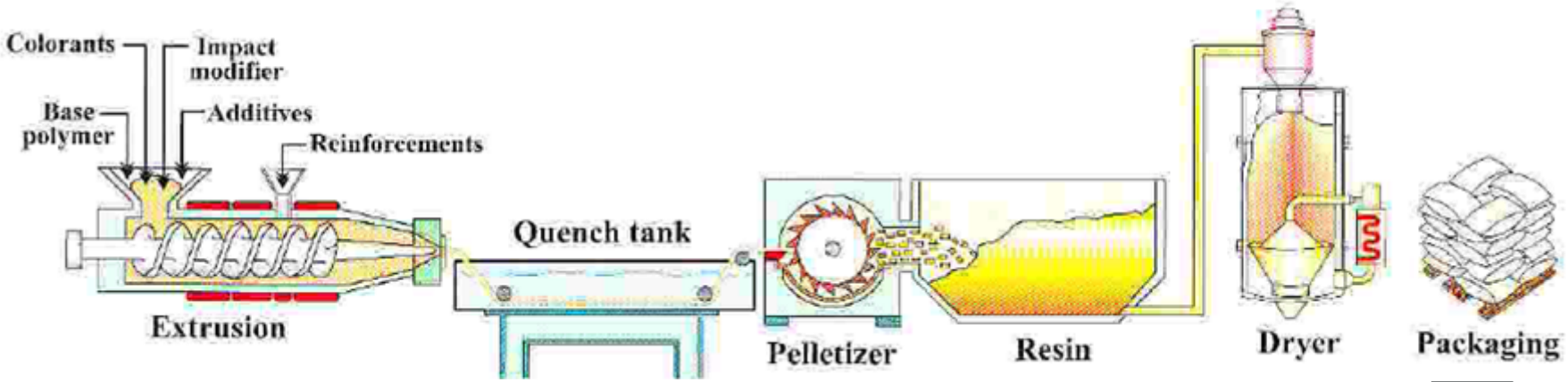
- Mineral Reinforcement/Fillers: improve stiffness, surface hardness, cost reduction
- Dyes and Pigments: color & appearance
- Antioxidants & stabilizers: delay/prevent oxidation during processing/application
- UV Stabilizers: interfere with light-induced degradation, weathering
- Blowing Agents: production 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

Resin	LOI (approx.)
POM	15.5
PE	17.3
PMMA	17.5
PP	17.6
PS	18.0
ABS	18.5
PBT	21.5
PET	22.0
PC	24.0
PA 6	24.5
F-PVC	24.5
PA 66	25.0
R-PVC	42.5
PTFE	95.0

A High LOI value indicates a Lower Flammability !

Compounding of Additives into Polymers



Source: Industrial Polymers, E. Campo

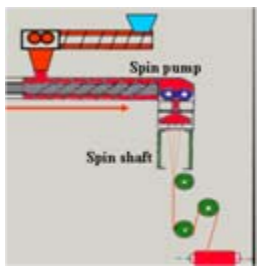
Compound Shipped to Processor

Processor Method Examples:

Extrusion

Film Blowing

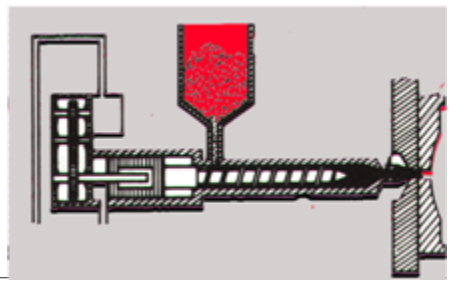
Sheet Thermoforming



Rotational Molding

Injection Molding

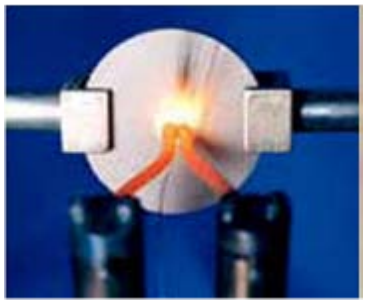
Blow Molding

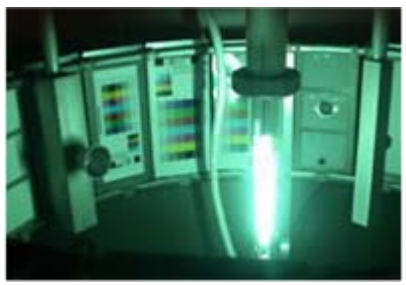


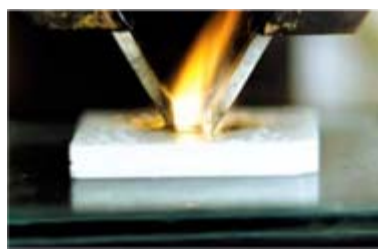
Flame Retardant Selection Criteria

some considerations:

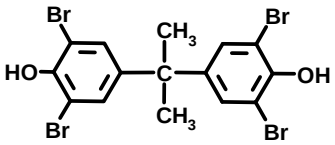
- Efficiency/Cost
- Ease of Compounding
- Adequate Thermal Stability
- Corrosivity Issues
- Physical Properties
- Appearance
- Compatibility (Migration?)
- Environment/Toxicity
- UV Stability/Weathering
- Electrical Properties
- Combustion Products (corrosives, toxics, smoke)

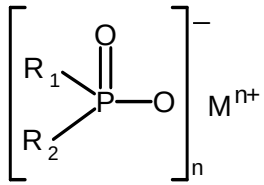






Many different chemistries can achieve Flame Retarding effects

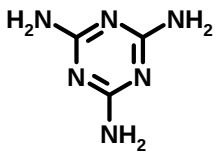




^{35}Cl

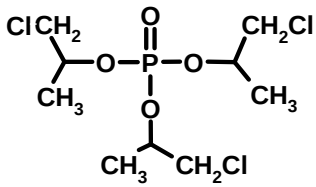
^{31}P

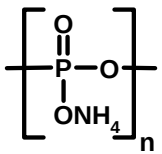
^{27}Al



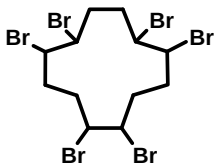
$Al(OH)_3$

^{80}Br





^{14}N



^{11}B

^{24}Mg

- different physical / chemical properties, environmental fate, toxicology, and regulatory status

Global Consumption of Flame Retardants (2007)

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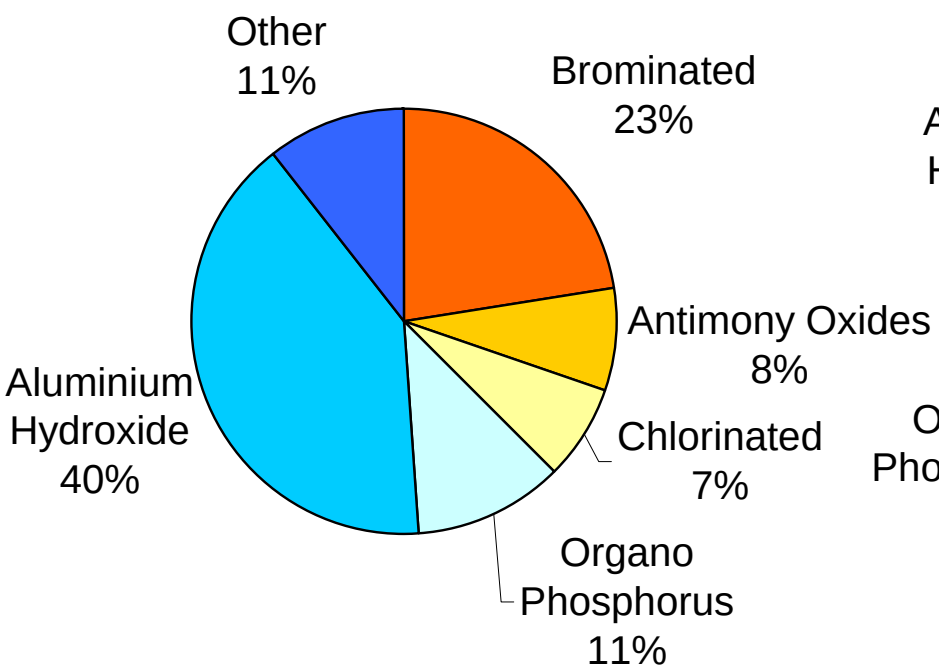
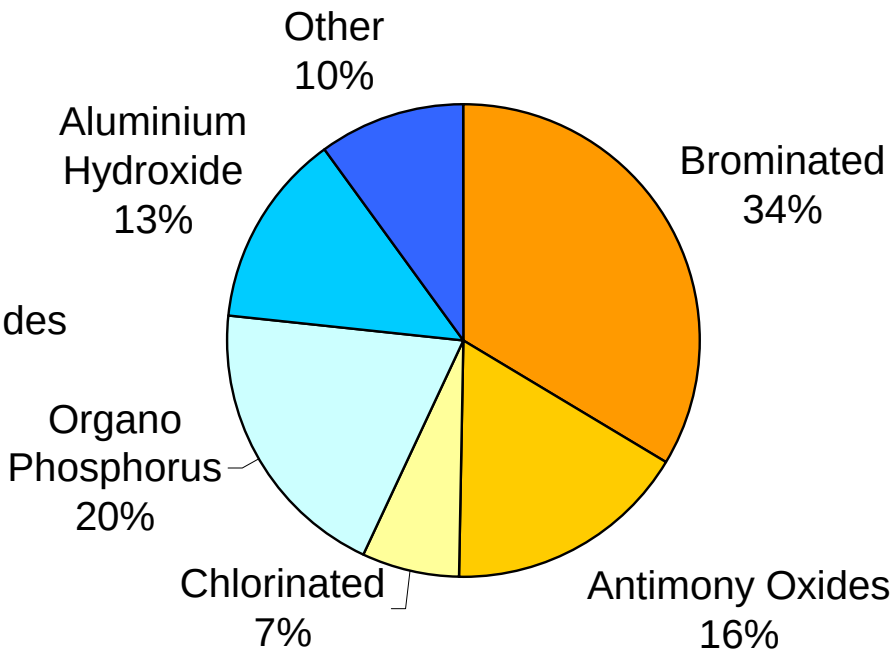
Quantity ca. 1,800,000 tons



Value ca. 4.2 billion US$



Source: SRI Consulting (2008)

Global Flame Retardant Market

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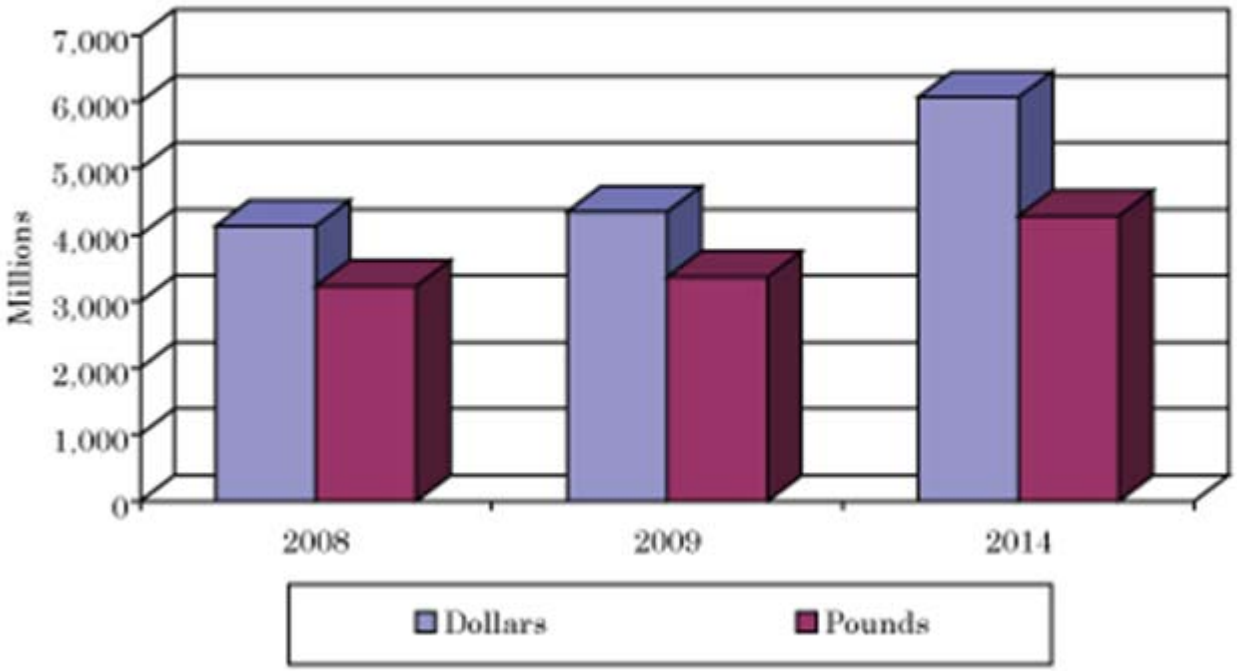
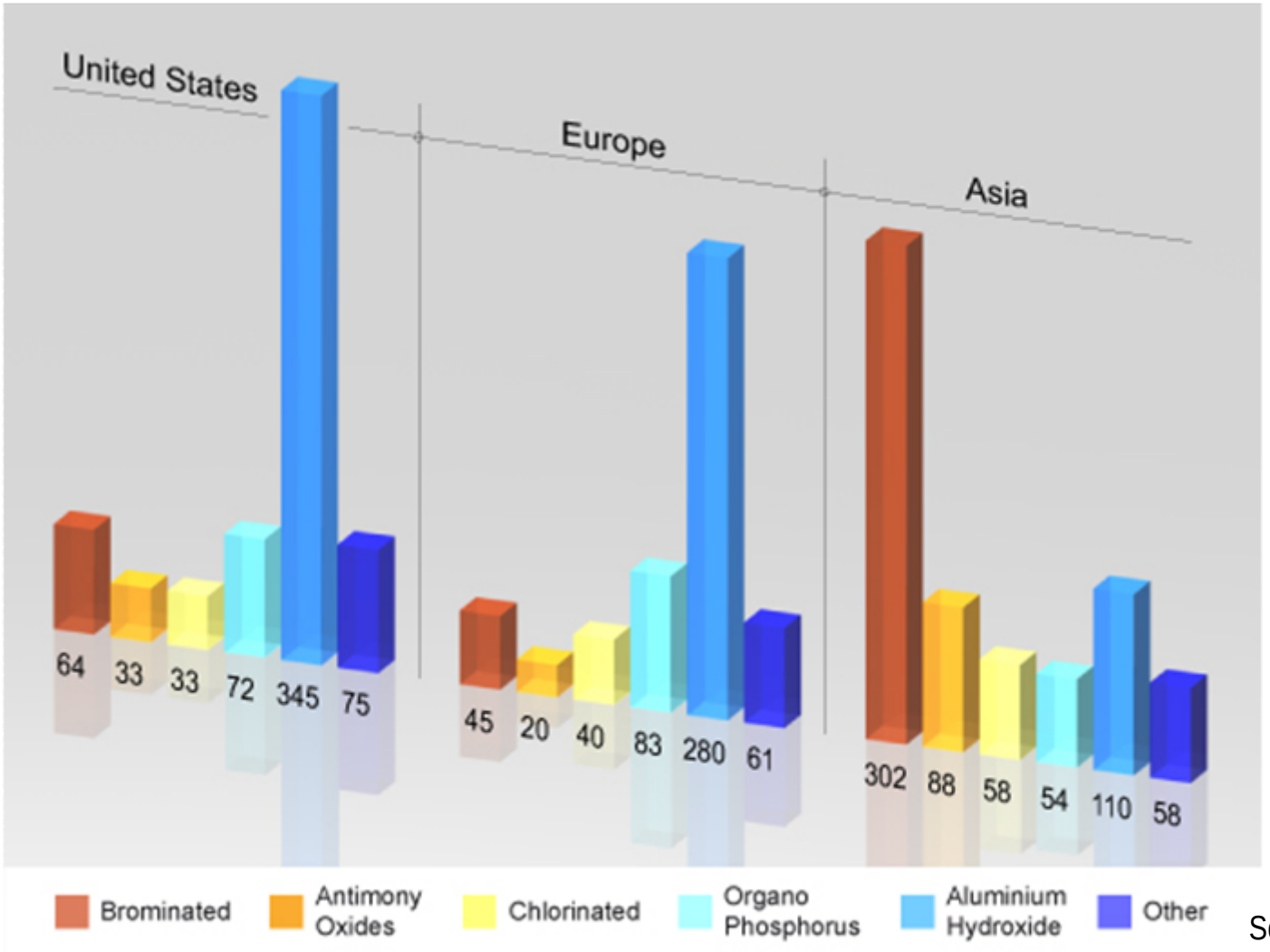
SUMMARY FIGURE
GLOBAL FORECAST OF FLAME RETARDANT CHEMICALS CONSUMPTION, 2008-2014
(MILLIONS)



Source: BCC Research

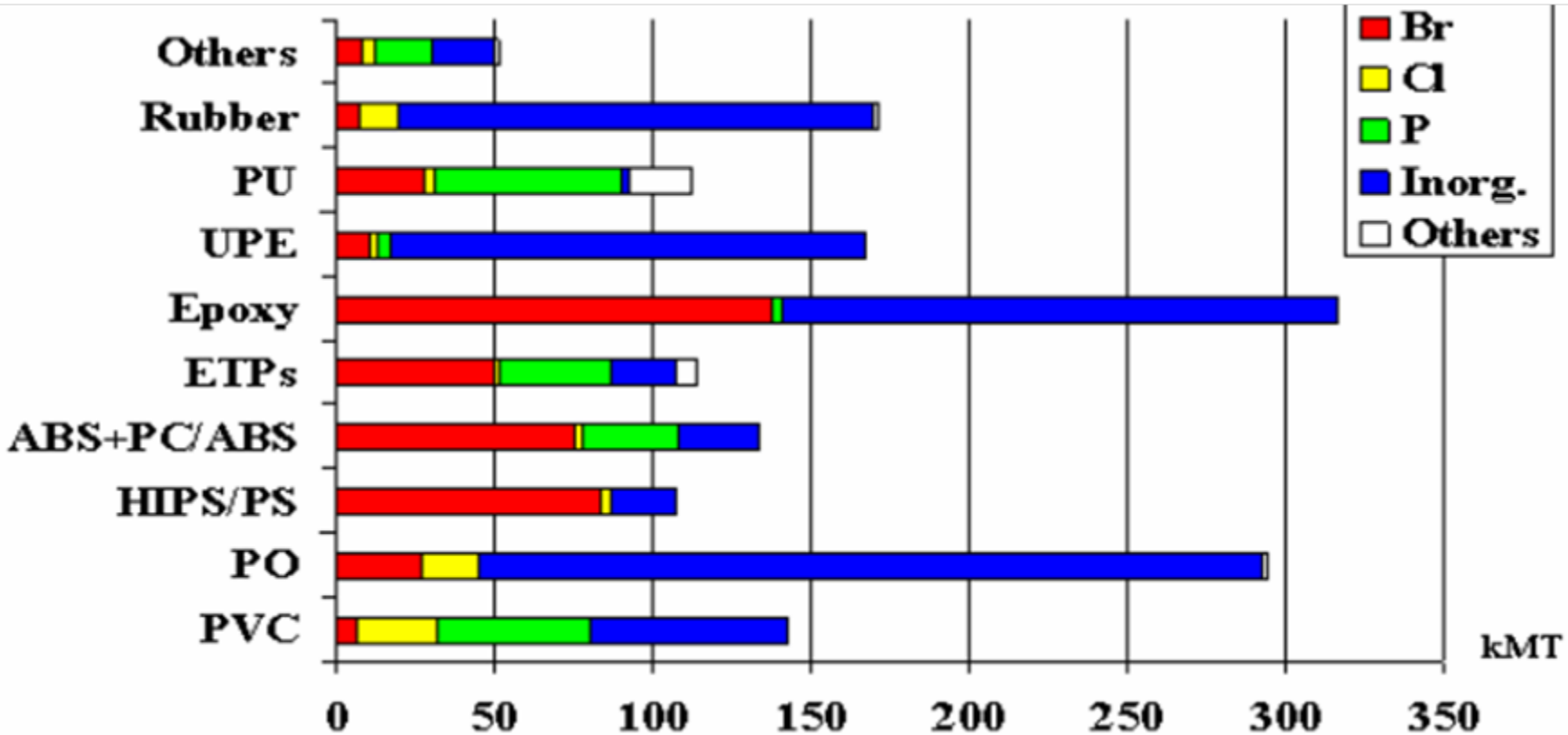
Recent BCC Research Study: the global market for flame retardant chemicals will grow to $6.1 B in 2014 (Compound annual growth rate of 7%).

Flame Retardants Consumption by Region global consumption 1,8 mm mt (2007)



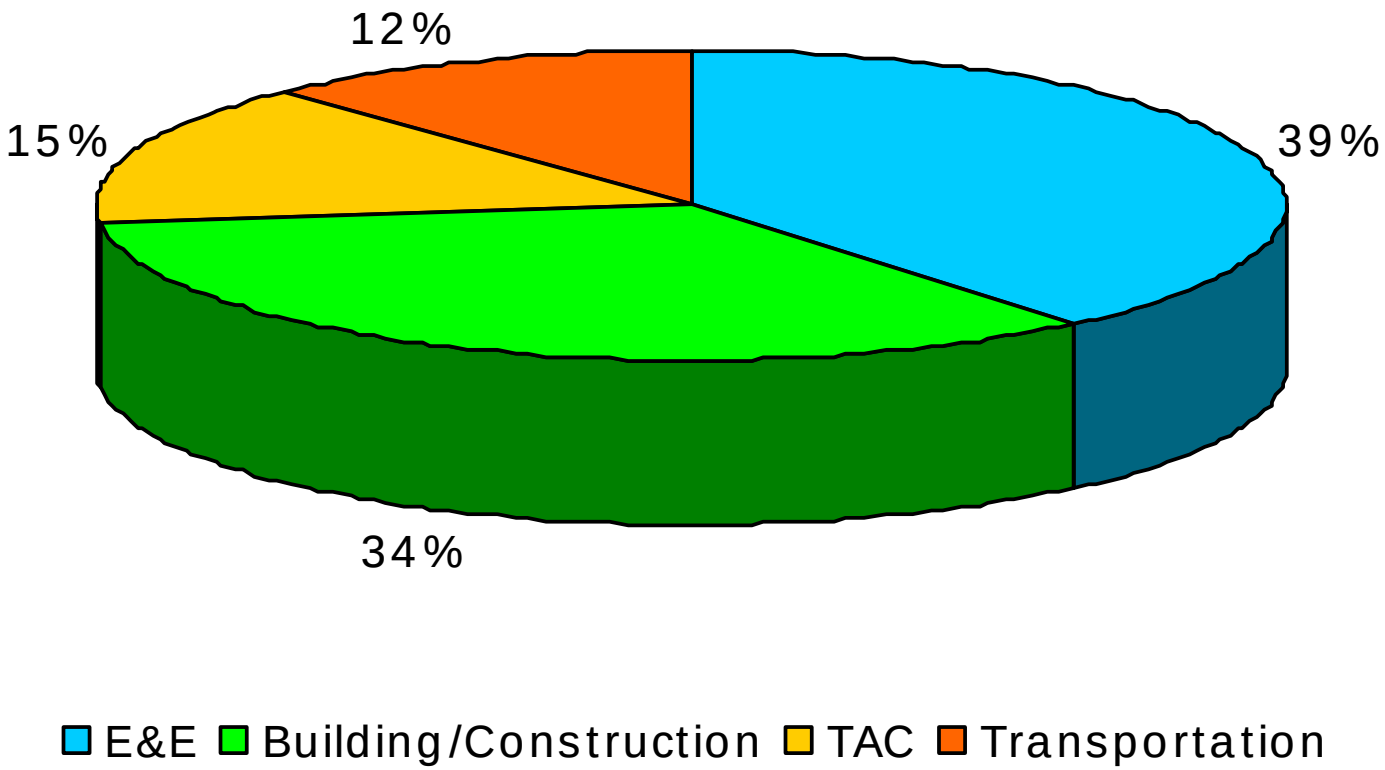
Source: SRI consulting

Global FR Uses by Polymers all applications
(Estimates – kt 2007)



source: European FR Association/BSEF

FR Consumption by final application



TAC : textile, adhesives, coatings

Source: SRI Consultants, Freedonia and company reports

Concerns about Flame Retardants

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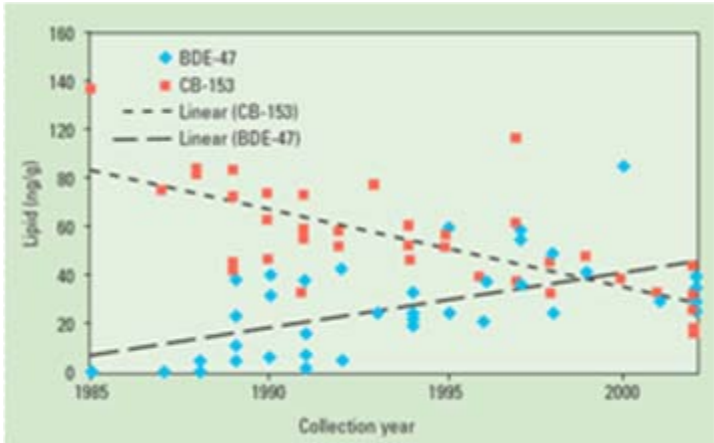
- findings of certain brominated flame retardants in the environment, biota, humans
- some concern about certain phosphate esters in indoor air
- source of endocrine disruption ?
- FR Persistence, Bioaccumulation, Toxicity (PBT) ?
- risk assessments, scientific studies for materials of concern



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

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Legal Compliance & Industry Standards

WEEE-Directive

RoHS-Directive

REACH

Ecological Trends & NGO Initiatives

GREENPEACE

TCO Development

Original Equipment Manufacturers (OEMs)

HITACHI
Inspire the Next

intel

SONY

APPLE

DELL

lenovo

acer

LG
Life's Good

FUJITSU SIEMENS COMPUTERS

hp
invent

pinfa

cefic

Phosphorus, Inorganic & **Nitrogen Flame Retardants Association**

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Energizing Chemistry

Responsible Care®
Good Chemistry at Work

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

Needle Flame Source (30 w)

1 Minute

6 minutes

2 Minutes

7 Minutes

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

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1 minute

5 minutes

2 minute

12 minutes

Station Nightclub Fire
West Warwick, Rhode Island, February 2003

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Victims jam the main exit of The Station

Conclusion

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- 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

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

- REACH:
  - http://ec.europa.eu/environment/chemicals/reach/reach_intro.htm
  - http://www.reachcentrum.eu/
  - http://ecb.jrc.it/REACH/
  - http://ec.europa.eu/echa/home_en.html
- WEEE and RoHS Europe:
  - http://ec.europa.eu/environment/waste/weee/index_en.htm
- Ecolabel EU
  - http://ec.europa.eu/environment/ecolabel/news/index_en.htm

Thank you for your attendance !

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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