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The use of fire retardants in Plastics

By Paul Uphaus

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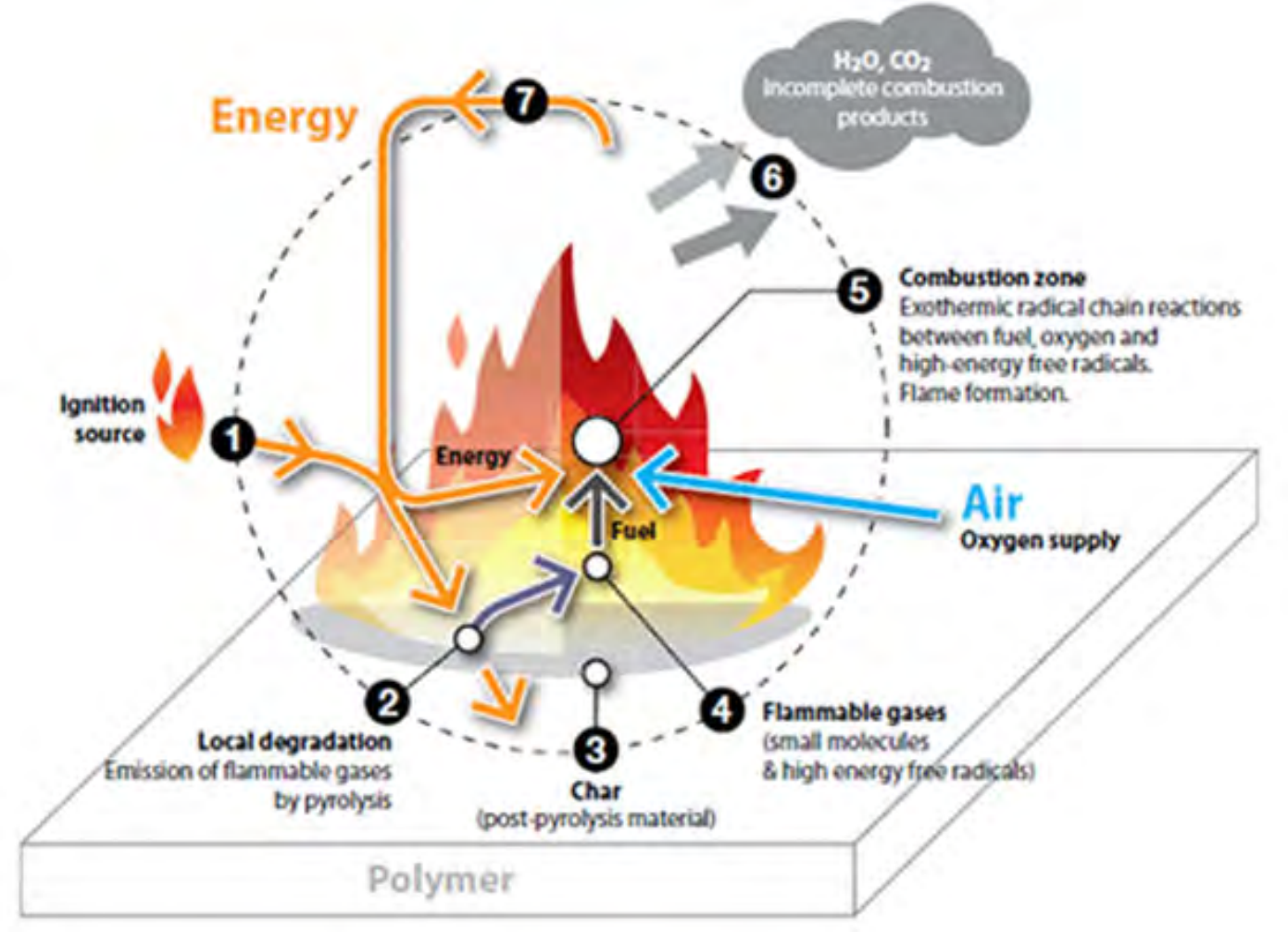
Retarding Destruction from Ignition and Flame

Thermoplastics

Most thermoplastics are flammable hydrocarbons

Decomposition from flame results in the generation of more hydrocarbons, hydrogen, and hydroxyl based free radicals

These elements when formed react during decomposition with oxygen and cause the fire to spread


H_2O, CO_2
Incomplete combustion products
Energy
7
6
5
Combustion zone
Exothermic radical chain reactions between fuel, oxygen and high-energy free radicals. Flame formation.
Ignition source
1
Energy
Fuel
Air
Oxygen supply
2
Local degradation
Emission of flammable gases by pyrolysis
3
Char
(post-pyrolysis material)
4
Flammable gases
(small molecules & high energy free radicals)
Polymer

The Basics

With a fire you have:

- ✓ Fuel
- ✓ Oxygen
- ✓ Ignition Source
- ✓ Exhaust Gases

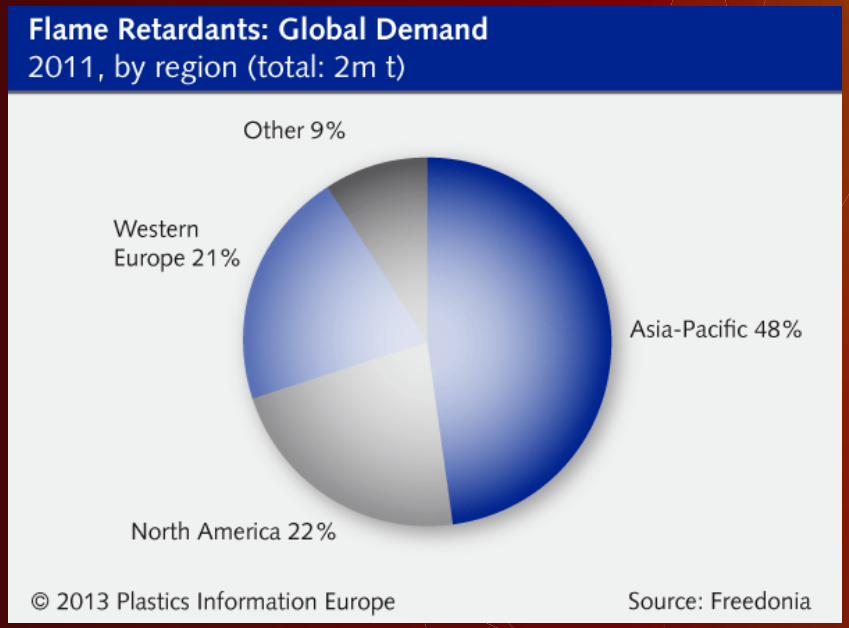
Flame Retardants interfere with one of more of these by:

- ✓ Sealing off the Fuel Source
- ✓ Extinguishing the Flame
- ✓ Cooling the Substrate
- ✓ Reducing the Exhaust Gases

Commercial Flame Retardants

Halogen and Non Halogenated

- Brominated
- Chlorinated
- Phosphorous
- Metallic Oxides



Halogen, by definition means "salt former" and components containing halogens are called "salts." There are five chemicals that contain halogens: Fluorine, Chlorine, Bromine, Iodine and Astataine.

Halogenated Types

Bromine Types

- Most common
- Most cost effective
- They halt the Exothermic processes which cools the
- System limiting the supply of flammable gases
- Lower loadings are required
- Physical properties like tensile and elongation are maintained
- Required a synergist like Antimoy or Zink Compounds

Chlorinated Types

Normally Chlorinated Paraffin's and Cycloaliphatic's

Paraffin's have lower heat stability and are corrosive to equipment

Cycloaliphatic's are more heat stable up to 320C

Requires a synergist like Antimony or Zinc Compounds

Non-Halogenated Types

Phosphorous Types (Char Formers)

- Organic and Inorganic forms
- Create char to keep the flame from the fuel
- Alter how the polymer degrades
- These materials decompose at 400F creating acids limiting their use
- The Acids created in extrusion can damage equipment

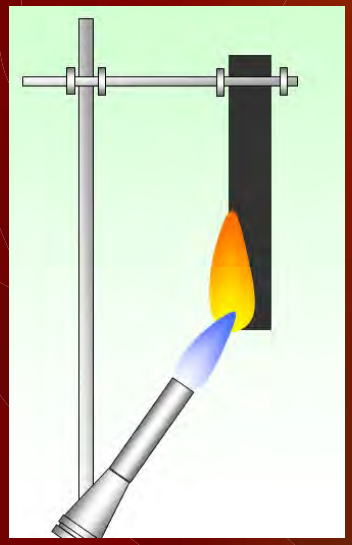
Metal Oxides (Endothermic)

- Metal Hydroxides are the most common halogen free
- Aluminum Trihydrate ATH is low in cost and found in nature
- ATH is of use under 200C since the reaction occurs @ 180 to 200 C
- Magnesium Hydroxide is stable to 300C
- Mag Hydrox is found in nature also loadings are high in this class
- Physical properties compromised

UL 94 Test

Vertical Burn Test

- Test Flammability and Dripping
- Polymers for use in Electrical, electronic, appliances, etc.
- Categories are Ease of Ignition, Burn Rate, Flame Spread, Fuel Contribution, Intensity of Burn, and Products of Combustion
- Uses a plastic bar 5”X .5” and either 1/8” or 1/16” thick
- A burner lights the bar for 10 seconds and the results documented
- The test is repeated 5 times
- Dripping is also noted



UL 94 HB Test

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UL 94 Test V-0, V-1, and V-2

94 V-0

- No flames for more than 10 seconds
- Specimens do not burn up to the clamp
- Specimens do not drip and ignite the cotton below
- Specimen does not have glowing combustion for 30 seconds after the 2nd removal of the test flame

94 V-1

- No specimen shall flame for more than 30 seconds after each ignition
- Specimens do not burn up to the clamp or drip and ignite the cotton
- Specimens do not have afterglow for more than 60 seconds
- 94 V-2
- Same as V-1 except specimens can drip and ignite the cotton

Other Tests

LOI

- Limiting Oxygen Index is oxygen concentration that supports flaming of a material expressed as percent O2 in oxygen and nitrogen mixture

UL181 Nat' Fire Protection Assn.

- For air duct, HVAC, and air connector systems

UL 214

- addresses flame propagation in fabrics and films

E-84

- Surface burning behavior of construction materials
- Flame spread and smoke density are measured

Motor Vehicle Safety Standard 302

- US Federal standard for passenger compartments
- Measures flame spread that cannot exceed 4"/min

Choosing The Right Flame Retardant

What is the application?

- Is it for outdoor use? What colors?
- Does the volume support development work?

What standard are we meeting?

- UL 94, E-84, MVSS, ASTM?
- If it is UL 94 is V-0, V-1, or V-2? UL listed?

What polymer are we starting with?

- Low MFI? High MW?
- Are physical or mechanical properties critical?
- Halogenated or Non-Halogenated system allowed?
- Is SPG an issue? Is there a printing or sealing process where blooming is an issue?

Resin and Formulation Considerations

Resin

- High Molecular Weight
- Low Melt Flow
- Resin designed for low dripping is desired

Formulation

- Polyolefin LDR's 5% to 15% for UL V-2
- And 15% to 25% for UL V0
- Clay and Fillers can reduce dripping but they can also interfere with the FR

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Any Questions?