Flame Retardants

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An Introduction to Flame Retardants

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Harwick Standard Distribution Corporation has prepared this flame retardant handbook to help development chemists and rubber compounders who are looking for basic information on flame/fire retarding systems.

It highlights differences between halogenated and halogen-free compounds, methods for retarding combustion, functions of various flame retardants, and lists of associated literature.

The Flame Retardant Handbook also gives recommendations and typical usage levels for various flame-retardant materials.

Harwick Standard Can Help You!

As a full-line supplier of flame retardant materials and services, Harwick Standard Distribution is a valuable resource. We can …

- *assist you with compound development and help solve compounding problems*
- *provide starting formulations to optimize your flame retardant requirements*
- *help you move from theory to practice.*

Our principals can also assist in testing your compounded systems.

Fire Presents Three Major Concerns

1. Flame
2. Smoke
3. Toxic Fumes

Always select raw materials ….

- that interfere with combustion reactions, or
- have low heat of combustion, or
- eliminate the oxygen source.

Combustion Requires 3 Conditions!

1. Oxygen
2. Heat
3. Fuel Source

Fuel sources can be:

- polymers
- plasticizers
- process oils
- resins (hydrocarbon)

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Flame Retardant Functions

1. Vapor phase reactions disrupt the free-radical oxidation process.

2. Endothermic reactions act as heat sinks, which reduce temperatures.

3. Char promoters act as insulators and protect underlying polymers.

Two Types of Systems

- Halogen Containing
- Halogen-Free

HALOGEN CONTAINING			
(Flame Resistance Requirements)			
Additive (phr)	***Low***	***Medium***	***High***
Antimony Oxide	2.50	5.00	10.00
CPW-100 -70% Cl (1) (2)	7.50	15.00	25.00
Alumina Trihydrate	15.00	20.00	30.00
Total	**25.00**	**40.00**	**65.00**
(Low Smoke, Flame Resistance)			
Additive (phr)	***Low***	***Medium***	***High***
Antimony Oxide	2.00	3.00	5.00
Zinc Borate	2.50	5.00	10.00
CPW-100 (70% Cl)	7.50	15.00	15.00
Alumina Trihydrate	20.00	20.00	30.00
Total	**32.00**	**43.00**	**60.00**

(1) Can delete CPW-100 or halogen source with halogenated polymer. Also may have to adjust usage level of halogen material if using less than 100% active halogen source.

(2) Decabromodiphenyl Oxide (Albemarle and Chemtura are domestic suppliers).

Special Note: In halogen containing systems, the antimony oxide to halogen ratio should be maintained at 1-1.5:3. This has been found to develop the optimum in flame retardant properties in polymer compounds. The antimony oxide is used with zinc borate at a 1:1 or 1:2 level to reduce smoke and provide a cost savings.

HALOGEN FREE			
(Reduced smoke & toxicity requirement)			
Additive (phr)	***Low***	***Medium***	***High***
Alumina Trihydrate	35.00	100.00	150.00
Zinc Borate	5.00	15.00	30.00
Total	**40.00**	**115.00**	**180.00**

Flame Retardant Facts

Alumina Trihydroxide (ATH)

- Titan 4E, Titan 7E-Fine precipitated

Magnesium Hydroxide

- Magnesium Hydroxide

Alumina Trihydrate is a white powder that acts as a flame retardant and smoke suppressant. When surface treated with a coupling agent or dispersion aid, ATH can also act as a functional additive.

Untreated, fine precipitated ATH has a major advantage (narrow particle size distribution) over ground ATH when used in processes that include screen packs for removing large particles from the compound. The combination of small particle size and low surface area allows the Titan product to be used at high loading levels (50-150 phr) in halogen-free FR systems. Compounds with halogen-containing FR systems require less ATH (20-35 phr is typical).

Titan precipitated ATH is an effective flame retardant in many polymer systems (elastomers and thermoplastics) including EPDM, PVC, NBR-PVC, PE, XLPE, and ABS. If high processing temperatures are reached (>200°C), ATH should not be used and Magnesium Hydroxide would be required. ATH and Magnesium Hydroxide both act as a heat sink by giving off “water of hydration” when the dehydration reaction temperature is reached. This reaction temperature needs to be above the maximum temperature seen during processing, as premature water vapor evolution can cause porosity problems. The release of water from ATH reduces the temperature of the substrate and retards the combustion reaction.

Antimony Oxide

BrightSun™

Gas Phase Reaction

Antimony oxide is a white, free-flowing powder used at fairly low loading levels (2-10 phr), that must be used with a halogen synergist (bromine or chlorine). Antimony oxides are available in various particle sizes; including H, L, UF, and treated grades. The following table illustrates the ranges:

GRADES	*TYPES OF ANTIMONY OXIDE PARTICLE SIZE**	*TINT STRENGTH*
H	1.0-1.8	High
L	2.5-3.5	Low
UF	Submicron (0.2-0.4)	High
*Microns		

In critical applications, the submicron grade UF can be used to reduce loss in physical properties. If the application involves the use of pigment, it is necessary to use a low-tint type product such as L Grade, so that the color remains the same.

Antimony oxide reacts chemically with halogen to reduce flame spread by disrupting free-radical oxidation. It is important to remember that halogens must be present for antimony oxide to be effective.

Zinc Borate

- Firebrake® ZB/ZB Fine

Solid Phase Reaction

Firebrake ZB, a unique form of zinc borate, offers a number of advantages and works synergistically with antimony oxide.

Firebrake ZB can be used either as a partial or complete replacement for antimony oxide. It serves mainly as a char promoter and smoke and afterglow suppressant. Char acts as an insulating barrier, which reduces oxygen penetration and reduces temperature of the substrate and smoke evolution. Its refractive index is similar to most organic polymers and does not induce opacity to the base polymer.
Zinc borate is typically used at a 1:1-3:1 ratio with antimony oxide and is an important multifunctional product for flame retardant systems.

Halogen Sources

- Tyrin® CPE – Chlorine Containing Polymers
- Paroil® and Chloroflo® – Chlorinated Paraffins (Liquid)
- CPW-100 (Solid)

Gas Phase Reaction

Chlorinated paraffins contain various levels of chlorine, depending on the form; liquid or solid. These products can be used as a halogen source to react with antimony oxide, or as a processing aid.

The liquids, Paroil and Chloroflo, can vary from 40-70% chlorine and exhibit viscosity within a range of SUS 130 – 210 at 37°C./100°F. Paroil can also be used as a secondary plasticizer in various elastomers, polyolefins, and PVC.

A solid product, CPW-100 contains 70% chlorine and is available in flake or powder form.

Bromine Compounds

- Chemtura
- Albemarle

Gas Phase Reaction

The most common and cost-effective brominated additive used in elastomer and plastic applications is an aromatic compound known as decabromodiphenyl oxide (DBDPO). Bromine compounds tend to produce a higher level of smoke than chlorine containing systems since they are twice as active.

In addition to the aromatic bromines most commonly used in elastomers and commodity thermoplastics, aliphatic types are used in thermoset plastics, polystyrene, and polyurethane foams.

Phosphorus Compounds

- Lindol®
- Phosflex®

Gas/Solid Phase Reaction

Organophosphorus compounds (liquids) are used at fairly low levels to replace aromatic, naphthenic, or paraffinic oils.

These materials react to form polyphosphoric acid char, which inhibits flame propagation, reduces the substrate temperature by char formation, and acts as an oxygen barrier.

Summary

We hope this handbook has helped answer some flame retardant questions you might have when compounding. Use it as a reference tool to guide you through the essential aspects of elastomer flame retardation. The main questions to ask yourself when compounding include:

- What is the polymer system?
- What fire standard is to be met?
- Halogen or non-halogenated?
- How will the materials function?
  and
- At what level do I add them?

Remember: Flame retardant requirements must be addressed during development.

For answers to your Flame Retardant questions, call us at (330) 798-9300

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Additional Flame Retardant Literature Available upon Request

Flame Retarding Materials

David R. Schultz…Harwick Standard Distribution Corporation

PE-200 as the Carbonific Source in Intumescent Fire-Retardant Paints

Pentaerythritols……Hercules PTV

Flame Retardants

Titan 4E

Alumina Trihydroxide ….. Industrial Chemicals Ltd.

Magnesium Hydroxide B

……Harwick Standard Distribution Corporation

BrightSun™

Antimony Oxide……Minxia

Firebrake ZB
Zinc Borate/ATH in flexible PVC
Unique Multifunctional Additive

Zinc Borate……US Borax

CPW-100 Solid
Paroil and Chloroflo-Liquids
Tyrin CPE

Halogenated Additives……
Chlorinated Paraffins …. Harwick Standard and Dover Chemical
Elastomers … Dow Performance Elastomers

Phosphorus Chemicals
Phosflex 41-P
Phosflex® T-BEP

Phosphate Esters……Supresta U.S. LLC.