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Flame retardance

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Flame retardance in textile adhesion

The demands for flame retardance have increased appreciably in recent years.
Fire protection regulations stipulating the use of flame-retardant products are particularly common in the construction, transport and furniture sectors. Textiles are used in all these sectors. Typical applications include covers for engine compartments in cars, upholstery fabrics or technical textiles used for construction purposes.
Synthetic materials or textiles can be made flame resistant by treating them with flame retardants.
Within this context, flame retardants both prevent fires from developing and also stop them from spreading. Where effective flame retardance measures are in place, people have more time to escape, and there is less damage to material assets and the environment. In addition to the actual flame-retardant properties brought to a product, the use of flame retardants should involve as few changes as possible to the product's other properties. Furthermore, they should neither be toxic to people or the environment, nor release noxious substances in the event of a fire.
A product, however, is only as good as its weakest component. Textiles can only demonstrate adequate levels of flame retardance if the hot-melt adhesive powders or hot melts used during the adhesion process are also flame-retardant.

Flame retardants and how they work

A wide range of substances are used as flame retardants. These differ widely in terms of their chemical-physical mechanisms and their environmental compatibility. You can only understand how flame retardants work if you first understand how materials actually burn. Solid materials do notburn. Rather, a small amount of the material must be made to decompose and convert to a gaseous state by a source of ignition and the associated heat. The resulting combustible gases ignite in the presence of oxygen and sustain the ongoing process of combustion (see Figure 2).

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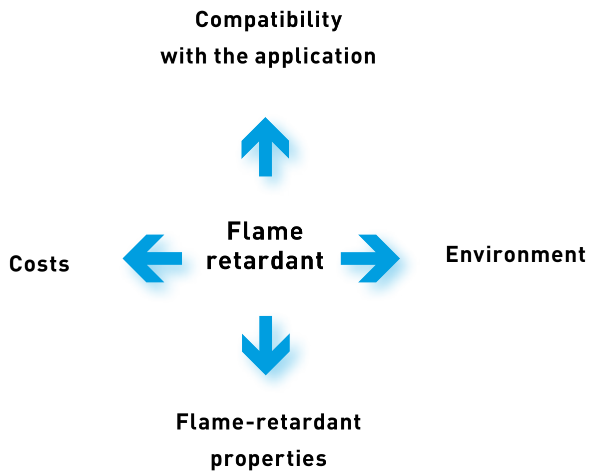

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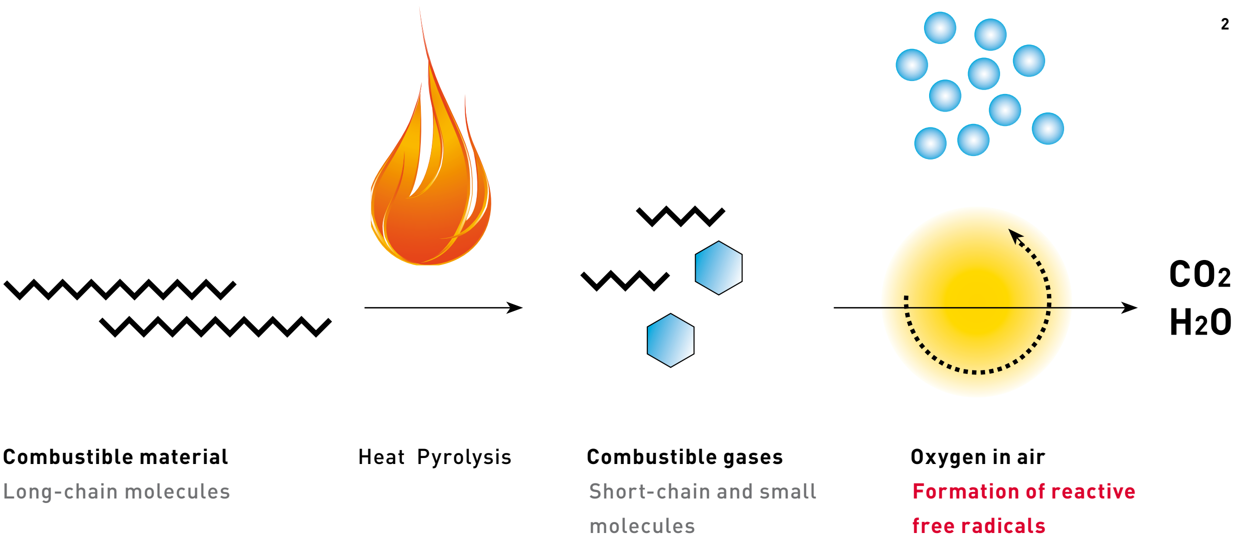

1 **Flame retardance – conflicting considerations**
2 **Schematic representation of the combustion process for polymers**

Within this combustion process, there are various "points of attack" that allow you to step in to delay or even prevent combustion. Often, combinations of substances and their respective modes of action are used for these purposes.

Generally speaking, flame retardance relies on the following mechanisms:

- **Prevention of the free radical chain reaction during the combustion process by free radical quenchers using halogens.**
- **Cooling by splitting and evaporating bound water**
- **Thinning combustible gases by splitting inert substances (e.g. water and nitrogen oxides)**
- **Formation of protective coatings (intumescent coating) through chemical and physical processes**

What all these mechanisms have in common is that they reduce the flammability of materials. This is represented schematically in Figure 3.

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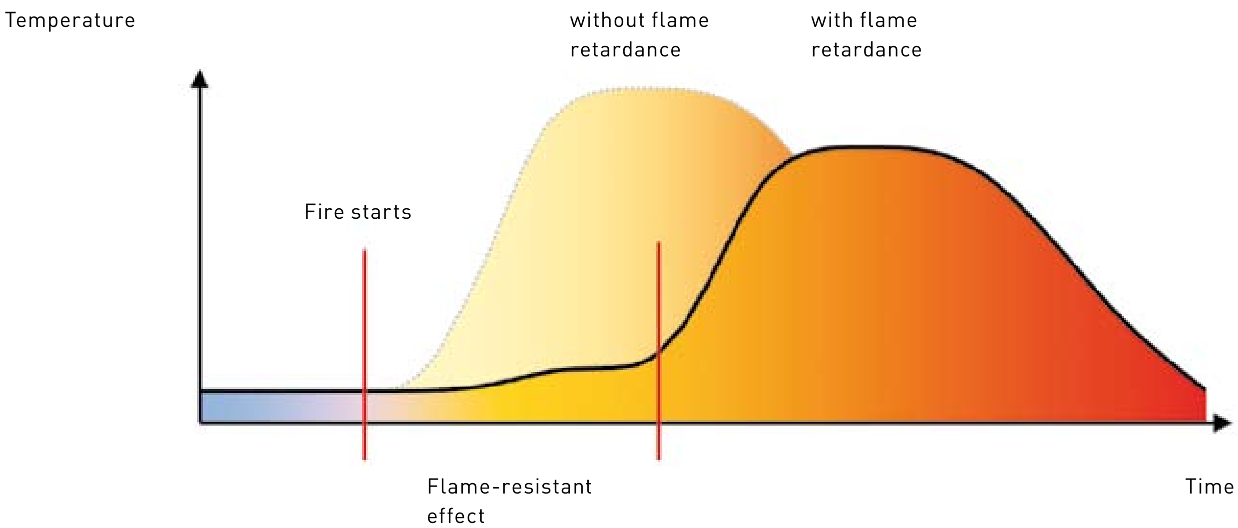

3 Progress of a fire with/without the use of flame retardants

Flame retardant additives

The amount of flame retardant used can range from less than 1% for highly effective substances to over 50% for inorganic filling materials.

Some flame retardants raise questions in terms of their impact on health and environment. With halogen flame retardants in particular, there are substances which demonstrate longevity and/or accumulate within organisms and the environment. Even when fires actually start, many halogen flame retardants represent a hazard, as high concentrations of dioxins can develop. In addition, corrosive fire gases can also develop and cause damage. A number of flame retardants containing bromine have already been banned in the EU.

As far as flame retardants containing phosphorus are concerned, a broad distinction is made between elemental red phosphorus, organic esters of phosphoric acid/phosphonic acid/phosphinic acid, and ammonium polyphosphates. The last of these are frequently combined with nitrogenous compounds for use within synergistic systems in intumescent building materials known as “intumescent paints”.

Melamine and its salts, melamine cyanurate, melamine phosphate, melamine pyrophosphate and melamine polyphosphate, are used within many flame-retardant applications such as flexible polyurethane foams and unfilled and fiberglass reinforced polyamides. In the case of melamine phosphates, the synergistic effects of melamine (containing nitrogen) and compounds containing phosphorous can, in turn, be harnessed.

In terms of volume, the largest share of the world market for flame retardants is accounted for the mineral flame retardants aluminium hydroxide (ATH)[1] and magnesium hydroxide (MDH)[2]. Aluminium hydroxide is the less expensive of the two and starts splitting water at 220°C. The endothermic decomposition of magnesium hydroxide at around 330°C requires rather more energy compared to ATH. MDH is preferred in systems requiring low smoke density and high thermal stability of the flame retardant used. Whilst mineral flame retardants are better than the other inorganic and organic alternatives when it comes to toxicity, volatility and chemical inactivity are disadvantaged by the fact they can only pass fire tests at weight percentages between 35% and 65% when added to synthetic materials. When the filling ratio in the flame-retardant end product is high, the chemical and physical properties of the basic polymers are likely to change.

Schaetti AG only uses environmentally compatible flame retardants which require no hazardous markings in its products. All flame-retardant hot-melt adhesives are free of chlorine, bromine and antimony.

The flame retardants are compounded into the hot-melt adhesives. In order to minimize the negative impact on the properties of the hot-melt adhesives used, flame retardants are selected in terms of their suitability for each polymer class involved and adapted to ensure the level of flame retardance is sufficient. During internal flame retardance tests we compare the reduction of flammability offered by fire retardant hot melts with unmodified hot melts in the product as well as checking compatibility of the fire retardant within the polymer matrix.

These measures enable Schaetti AG to offer its customers a wide range of innovative, flame-retardant hot-melt adhesives, whilst satisfying customer-specific requirements.

1 aluminium trihydrate, ATH

2 magnesium dihydrate, MDH

Standards and testing methods

It is essential that flame retardants and flame-retardant items are tested in terms of their suitability to ensure that relevant safety standards are met. "Fire tests" make it possible to evaluate the fire risk associated with materials, individual components or finished products. These are key to assessing how products behave in the event of a fire. Internationally, there many fire protection standards in place for a wide variety of applications. In view of this, we shall restrict ourselves for current purposes to a selection of tests which are relevant to the textiles sector.

For technical textiles such as seat covers, carpets and interior trim used in the automotive sector, the test procedure contained in Directive 95/28/EC, Appendix IV is usually applied. This is comparable with FMVSS 302 (USA), U.T.A.C. 18-502 T1 (France), ISO 3795 (international) and DIN 75200 (Germany). A predefined flame is applied for 15 seconds to the open end of a horizontally arranged test specimen in a combustion box (Fig. 4). A measurement is taken of the time from when the flame passes an initial test mark to when it either extinguishes or covers a predefined test distance. In accordance with Directive 95/28/EC, Appendix IV, the maximum acceptable burning rate for category M3 vehicles is 100 mm/min. A maximum of 102 mm/min applies under FMVSS 302. The in-house standards of various car manufacturers often involve more stringent requirements.

As far as upholstery fabrics, building materials, curtains and composites for the interior decoration of rooms are concerned, DIN 4102 B2 (Germany) is the relevant standard. With this fire test (similar to Fig. 5) a predetermined flame is applied vertically for 15 seconds to the test specimen starting at the lower edge. The B2 requirements stipulate that the tip of the flame should not cover the distance between the reference marks on the specimen within 20 seconds or less.

Upholstery materials are typically tested in accordance with European Standard EN 1021-1/2. Here a model of a fire chair is covered with the textile to be tested and ignited with a cigarette (EN 1021 part 1) or a predefined butane flame in the form of a match (EN 1021 part 2). While the cigarette is burning and smoldering, 60 minutes must pass without the fire chair itself smoldering or burning. Using butane gas, a flame is applied for 15 seconds to the angle between the backrest and the seat of the fire chair. The material must not start to burn within 2 minutes of the source of ignition being removed.

Other test methods frequently used in the textiles sector are those covered by ISO 6941 (Textile fabrics – Burning behavior – Measurement of flame spread properties of vertically oriented specimens) and DIN 54333-1 (Testing of textiles; determination of burning behavior; horizontal method; ignition at the edge of the specimen).

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4 Test chamber for determining horizontal rate of combustion

5 Fire test for determining vertical rate of combustion

SchaettiFIX products with flame retardance

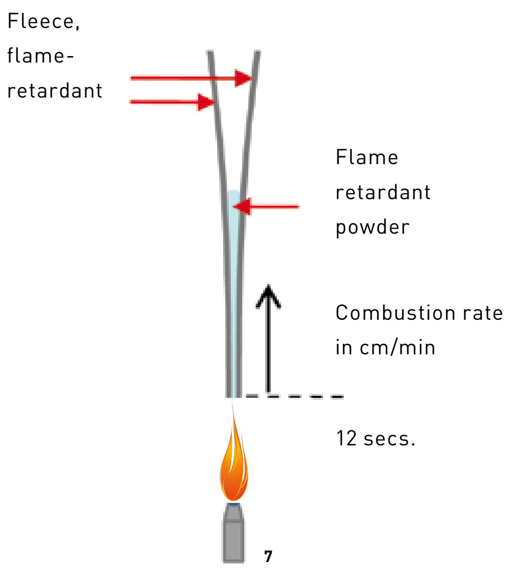
Schaetti offers a wide range of flame-retardant hot-melt adhesive powders. The products available do not require hazard markings and contain neither halogens nor heavy metals. To ensure they can be used in a broad range of applications, flame-retardant SchaettiFIX products are available for many different types of polymer. This enables users to find the right product for their application. Fig. 6 contains an overview of the products available along with their most significant properties.

	SF 1825 F	SF 1825	SF 140 F	SF 140	SF 5005	SF 5000	SF 5000	SF 374 F	SF 374	SF 386 F	SF 386	SF 2190 F	SF 2190	SF 2047 F	SF 2047
Polymer type	**HDPE**		**LDPE**		**Polyamide**			**Polyester**				**EVA/LDPE**		**EVA**	
Fusing T (°C)	150 – 170		130 – 150		140 – 160			130 – 160		160 – 180		130 – 150		90 – 100	
MFR g/10 min (190 °C)	15	20	48	70	–	–	–	–	–	–	–	135	165	104	150
MFR g/10 min (160 °C)	–	–	–	–	29	18	20	39	28	20	20	–	–	–	–
m.p./DSC (°C)	129 – 135		110 – 114		108 – 123			95 – 140		130 – 160		95 – 110		65 – 90	
m.p./TMA (°C)	130	130	104	107	116	118	118	120	123	148	150	89	101	75	70

6 Comparative product overview (F = contains flame retardant)

SchaettiFIX products in the vertical fire test

As well as undergoing a test of bond strength, Schaetti's flame-retardant hot-melt adhesive powders are also subjected to an internal test involving a vertical flame for assessment and comparison purposes. For the purpose of the test a constant coating weight of hot-melt adhesive (20 g/m^2) is spread across a commercially available fleece (which has already been treated with flame retardants), sintered and stuck to another flame-retardant surface. Using a Bunsen burner (Fig. 7), a flame is applied for 12 seconds to the bottom edge of the laminate. The time taken for the flame to go out is recorded. The combustion distance can be used to calculate the rate of combustion in cm/min.



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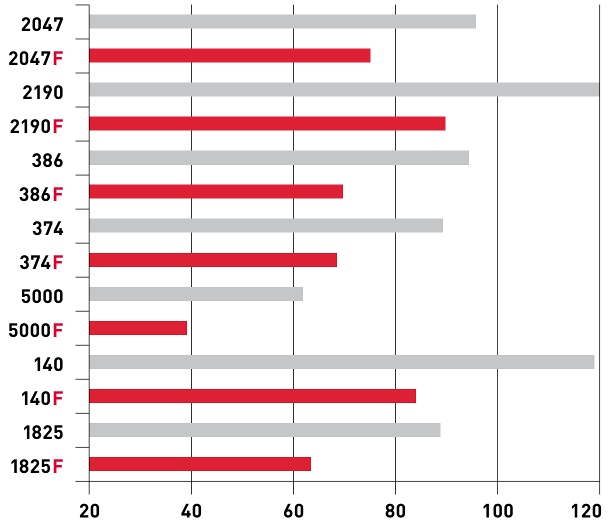
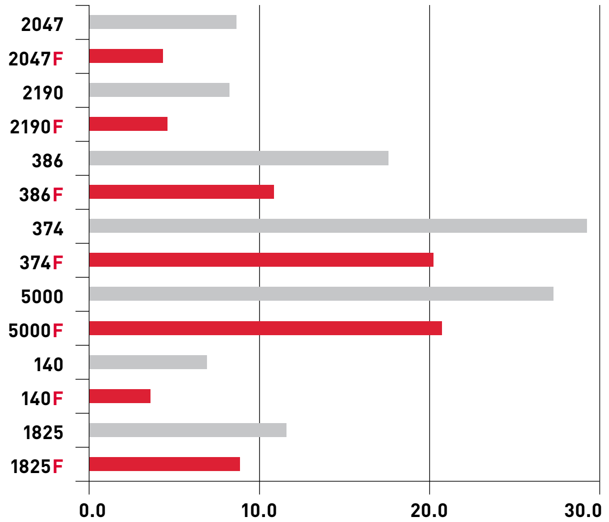
7 Vertical fire test, schematic representation

Impact of flame retardant

Fig. 9 shows adhesion levels for laminated samples of cotton/cotton in order to highlight the differences between unmodified adhesive powders and those treated with a flame retardant. In all cases, levels of adhesion were established for both powder types at a constant glue-line temperature. Therefore, these levels do not represent absolute values, but simply provide reference values within the individual product groups. The results clearly demonstrate that the flame retardant is an effective filling material within the polymer matrix and that adhesion values are reduced by 20–40% compared to the unmodified powder. Having said this, adequate adhesion values can still be achieved by carefully matching the flame retardant to be used with adhesion values for a fleece or polyester material rather than those for the cohesion and adhesion of cotton/cotton. The highly combustible SF 140 and SF 1825 polyolefins, as well as SF 2190 have the highest combustion rates in the vertical fire test (Fig. 8). These flame-retardant powders can reduce combustion rates by up to a third. In all the other polymer classes, combustion rates are cut by either a third or a quarter compared to the original rates. The fire test produced clear evidence of significant reductions in smoke development. To a certain extent, there was even evidence of fires extinguishing themselves where laminates had been treated with flame retardants.



8 **Vertical combustion rate [cm/min]**
Adhesion of fleece FR/fleece FR (20 g/m²)



9 **Bond strength, [N/5 cm]**
Adhesion of cotton/cotton (20 g/m²)

Recommendations

Based on our experiences, we recommend the following products for selected textile applications. The list of examples is not intended to be exhaustive.

	Application	5000F	374F	386F	1825F	140F	2190F	2047F
Technical textiles	Engine compartment covers	•		•	•			
	Car trunk interior covers	•		•		•		
	Under-roof covering materials						•	
	Foamed materials		•	•				•
	Protective clothing	•		•				
Home textiles	Upholstery coverings/fabrics		•					
	Carpet backing							•
	Mattress drill							•
	Curtain materials		•					
	Floor mats		•					•

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Summary

Flame retardants are widely used in the textiles industry and are now indispensable in terms of protecting both people and property. A large number of standards are available for the purpose of establishing and checking the requirements made of a material.
Even if the use of flame-retardant hot-melt adhesives alone is not sufficient to reduce the flammability of textiles to zero, flame retardants are still effective in terms of significantly delaying the onset and spread of fires. Reducing the amount of smoke emitted during a fire also lowers the levels of toxicity and irritation created by fire gases.
The best results can only be achieved, however, if all the components within a product are treated with a flame retardant.
With this in mind, Schaetti offers a range of flame-retardant products for a broad spectrum of textile adhesion applications.
None of the flame-retardant SchaettiFix hot-melt adhesive powders require hazard markings. They are free of halogens and heavy metals, making them suitable for product groups where markings are used to show environmental compatibility. In addition, the use of flame-retardant hot-melt adhesives does not affect a product's recyclability.

Sources

- www.flameretardants.eu
- www.specialchem4polymers.com/tc/Flame-Retardants
- Currenta GmbH & Co. OHG, www.brandversuche.de
- www.flammschutz-online.de
- Dr. Adrian Beard, Clariant Produkte GmbH: "**Aktuelle Entwicklungen bei den Anforderungen für Brandsicherheit und Umweltfragen bei Flammschutzmitteln**" (current developments in terms of fire-safety and environmental requirements for flame retardants)

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