Speciality Chemicals Magazine

JULY 2014

Tin machine

Zinc stannate flame retardants

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Zinc stannate synergists in engineering thermoplastics

Dr John Williams and **Dr Christopher Rainford** of **William Blythe** present new results for Flamtard S synergists

Polyamides (PAs), such as PA 6,6 and high temperature PAs, are used in many engineering applications due to their excellent mechanical and electrical properties at elevated temperatures, good chemical and wear resistance and low levels of friction. In electrical and electronic applications, these critical performance parameters are pushed to the limit, with additive combinations being incorporated to provide flame retardancy to meet the required standards. The ideal flame retardant (FR) additive mix is that which delivers the necessary FR performance while preserving, as much as possible, the required mechanical properties.

The challenge of meeting the ever higher levels of polymer performance demanded is further complicated by the miniaturisation of electronic components and electrical devices, which require the filling of thinner and more complex moulds. This challenge is perhaps greatest in reinforced polymer systems where interactions between additives and reinforcing agents can have a profound impact not only on the compound's strength but on its moulding properties as well. Regulations create an additional level of complexity, because the additives employed to overcome the technical and practical challenges must do so without causing harm to health or to the environment.

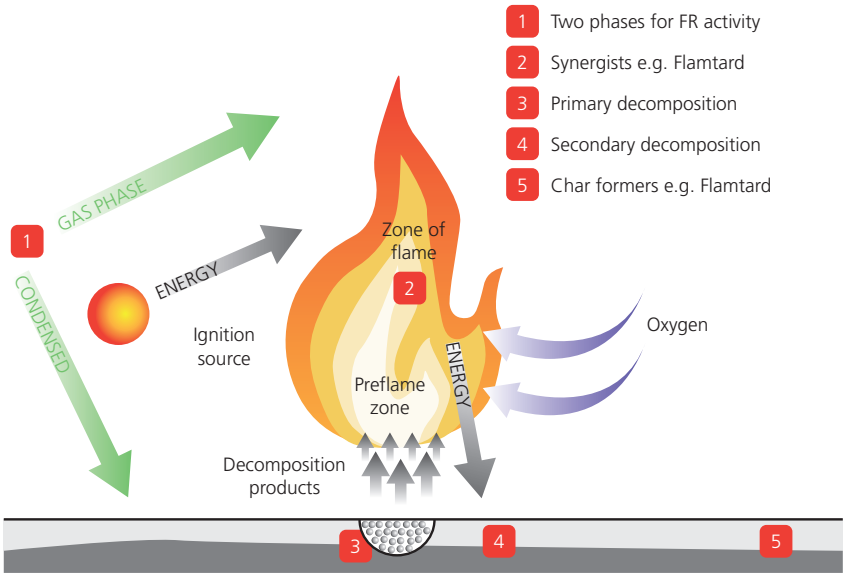

Figure 1 - Modes of Action of FR synergists

Zinc stannate FRs

William Blythe launched its Flamtard S and H ranges of zinc stannate and zinc hydroxystannate FRs over 20 years ago and has progressively increased its R&D efforts as demand for highly active polymer additives with no hazardous characteristics has grown. In compliance with regulatory directives, the company has extensively characterised the hazard properties of its tin-based FR range to demonstrate that no harm is presented to either health or the environment.

Structurally, Flamtard S is an anhydrous bimetallic material composed of the oxides of tin and zinc and is thermally stable at temperatures up to 400°C. In combination with a halogen source, both elements are involved in the suppression of flame and smoke via distinct mechanistic pathways.

As shown in Figure 1, during the early stages of combustion, tin is released into the gas phase where it combines with halogen radicals that are released from the decomposition of a halogenated FR. This inhibits flame formation. The zinc component acts in the condensed phase, where it catalyses the conversion of the decomposing polymer into a carbonaceous char, rather than smoke.

Experimental evaluation

In recognition of the changing regulatory environment and the need to provide detailed application data, a programme of work was commissioned to compare the performance of flame retarded glass-filled PA compounds containing Flamtard S with those containing a classical antimony trioxide (ATO) system.

A two-stage experimental programme was employed to investigate interactions between Flamtard S and three brominated polymeric FRs: brominated polystyrene (ICL Grade FR 803P), brominated polyacrylate (ICL Grade FR 1025) and brominated epoxy (ICL Grade FR 2400) in order to define the ideal combination. These three were

Table 1 - Design & manufacture of flame retarded, glass-filled PA 6,6 compounds

Run Number	PA 6,6 (%)	Glass fibre (%)	Stabiliser package (%)	Br-polymer (%)	Flamtard S (%)	ATO (%)
1	69.4	30.0	0.6	0	0	0
2	46.9	30.0	0.6	22.5	0	0
3	46.9	30.0	0.6	19.05	3.45	0
4	48.7	30.0	0.6	14.3	0	6.3

Table 2 - Fire science results for flame retarded, glass-filled PA 6,6 compounds

Run No.	1	2	3	4
FR 1025 (Br-polyacrylate) (%)	0	22.5	19.05	14.3
Flamtard S (%)	0	0	3.45	0
Antimony trioxide (%)	0	0	0	6.3
UL-94 (1.6 mm)	N.C	V-0	V-0	V-0
UL-94 (0.8 mm)	N.C.	V-2	4 x V-0 1 x V-2	3 x V-0 2 x V-1
LOI (% O_2)	23	33	34	36
Peak heat release rate (Kw/m^2)	556	210	187	238
Total heat release (units)	86.8	43.6	46.9	45.8
Total smoke release	1070	2785	1848	4239

selected because they possess no hazard classifications due to their high molecular weight, making them an ideal co-FR for Flamtard S, especially in applications where the stated objective is to employ a non-hazardous system.

Five sets of glass-filled PA compounds were created on a Leistritz MIC 27 GL/44 D, twin screw extruder operating at 270°C and a screw speed of 300 rpm. Test specimens were moulded on a Klöcker Ferromatik Desma FX-2F with a cycle- time of 40-45 seconds, 120 bar mould pressure and an injection temperature of 255°C.

The compounds used varying quantities of Durethan A30 S PA from Lanxess, 30% CS 7928 [length = 4.5 mm], also from Lanxess, a stabiliser package based on Irganox 1098 and Irgafos 168 by BASF and Caesit AV/PA Baerlocher, ICL-IP's FR-1025 brominated polyacrylate or Flamtard S, plus ATO in masterbatch form from Campine (Table 1). Flamtard S at 3.45% has been found to operate most effectively with 19.05% brominated polyacrylate. This combination was therefore evaluated against the brominated polyacrylate alone and in combination with an alternative synergist.

Analytical methods

Three analytical methods were used to generate a robust data-set to define the fire science in terms of the key components of the classic combustion triangle: oxygen via the limiting oxygen index (LOI) to ISO 4589-2:1999; energy output using cone calorimetry; and, the ability of the ignited compound to self-extinguish using UL 94. The results are shown in Table 2.

This shows that a synergist such as Flamtard S (Run 3) or ATO (Run 4) is required to boost the performance of the brominated polyacrylate alone (Run 2), so that the highest V-0 standard is achieved for the thinnest sections. The inclusion of Flamtard S at 3.45% has the effect of increasing the LOI, reducing the energy output from the system and improving the self-extinguishing properties, whilst also reducing smoke generation. Flamtard S is superior to the classical system based on ATO, achieving the V-0 standard at a significantly lower concentration, with added smoke suppression activity.

Mechanical properties

As an engineering polymer component must operate at a high level of performance during its lifetime its mechanical properties are therefore critical, so the impact of additives on polymer properties was also investigated. The most valuable FR system is that which has a neutral or beneficial effect on the mechanical properties of engineering PA materials.

Table 3 shows the mechanical properties of the various compounds. The decrease in tensile strength caused by the incorporation of FR 1025 (Run 2) is largely restored with Flamtard S (Run 3) and this is accompanied by similar improvements in Young's modulus and elongation properties. It is proposed that Flamtard S has a neutral or beneficial effect on mechanical properties compared with the classical system (Run 4) and can be considered as a valuable component in engineering PA compositions.

Contact

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Table 3 - Mechanical properties of flame retarded, glass-filled PA 6,6 compounds

Run No.	1	2	3	4
FR 1025 (Br-polyacrylate)	0	22.5	19.05	14.3
Flamtard S	0	0	3.45	0
Antimony trioxide	0	0	0	6.3
Tensile strength (Mpa)	173.1	134.2	169.6	135.8
Young's modulus (Mpa)	9809	11606	12039	11098
Elongation at break (%)	3.28	1.69	1.92	1.79

Flamtard S / Flamtard H

Flame inhibition ✓
Smoke suppression ✓
Environmentally benign ✓

With no hazardous characteristics for health or the environment, why not talk to William Blythe about the development of flame retardant polymers?

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