SPECIAL:
Color & Design

Flame Retardant Polyamides for Electronics

Grey? Exactly!

Electrical equipment manufacturers place great importance on representing their brand through a specific color design. This applies to all visible components. However, these do not only have to be visually convincing, but above all, be convincing in terms of mechanical properties and resistance to fire.

Test with an 850 °C hot glow wire on a switching device: If a fault in the connection of an electrical device causes a cable to become overheated, for example, then a potential flame must extinguish by itself. © Ascend

The so-called "corporate branding" poses new challenges for the manufacturers of molding compounds for applications in electrical engineering. In addition to signal properties (such as for the switching states ON and OFF), colors should also signal warnings, hazardous areas, or display shutdown options. For example, every emergency stop command element must be reliably recognizable through its red-yellow color scheme – worldwide, in challenging environments and after decades of use.

In addition, there is often the requirement to individually label molded parts with different laser systems. This may require special additives, which in turn may have a retroactive effect on other properties of the final compound. Filling and reinforcing materials of the plastic additionally affect the ability to mark it. The variations possible are limited by the international approvals of the molding compounds – the permissible additive load and an „infrared spectroscopic fingerprint" of a material stored at licensing organizations set tight limits here.

In order to color fire-protected materials, it requires a thorough understanding of the intrinsic colors of base polymers and fire retardants and also of the colorants. Ascend Performance Materials has a wide portfolio of polyamide materials and color formulas available: From non-fire-protected, standard colored materials to high glass fiber-reinforced compounds in customized coloring, even for low wall thickness. The possible flame retardants range provides cost-effective products with limited performance to additives with capabilities justifying a higher expense.

Color Deviations Undesired

Electrical appliances have not just been light grey or black for a long time now. Most customers generally closely specify "light grey". Permissible color deviations are often limited to $\Delta E \leq 1.0$. This tolerance must be carefully observed across the individual deliveries. Ascend produces well over 100 different color-type combinations (**Fig. 1**) in the area of grey colors alone. Due to the potentially changing intrinsic color of the base polymer and the different intrinsic colors of different flame-retardant batches, it is essential to be able to readjust the so-called color location over the entire manufacturing process – depending on the production quantity for several hours or even days. **Figure 2** shows the color deviations over several production campaigns of a specific color setting over a period of nine months. For such sophisticated compounds, Ascend relies on powder colorants, which allow a rapid color adjustment within the ongoing production process.

The RAL "Classic" color palette includes over 200 different colors between "white" and "black". Consequently, Ascend produces about 100 white colorations on an ongoing basis, and new ones are constantly added, either to adjust to customer-specific initial colors or, for example, to adjust the color stability for defined thermal profiles throughout different timeframes. These adaptations must neither impair the ignition behavior nor the resistance to fire of the respective molding compound. With applications for the electric power supply of vehicles, orange has established itself as a signal color. Since the signal effect must be ensured until the end of "vehicle life", the manufacturers demand proof of color stability even after a long-lasting temperature stress. **Figure 3** shows the results of a temperature storage test of an unreinforced flame-retardant type with different additive formulations.

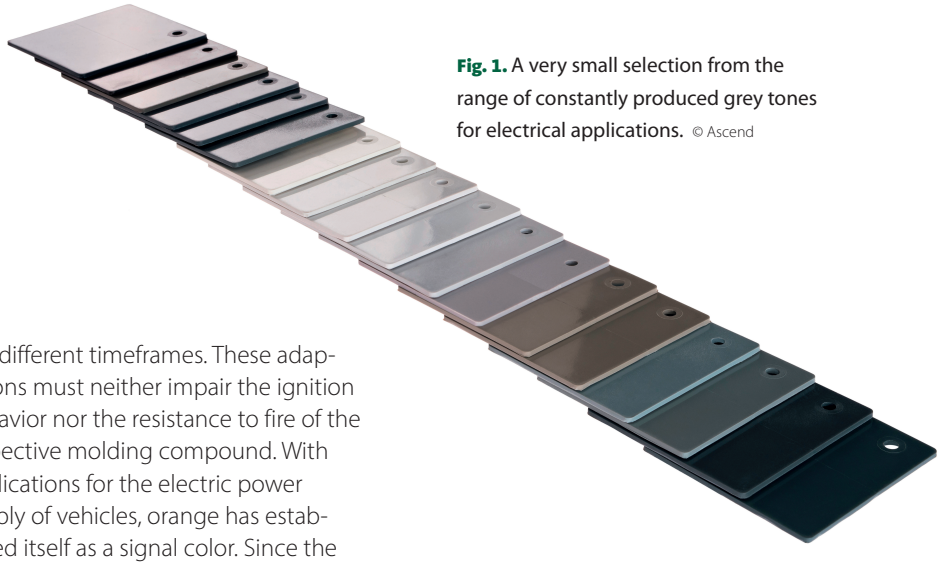

Fig. 1. A very small selection from the range of constantly produced grey tones for electrical applications. © Ascend

Selecting the Correct Flame Retardant

The range of flame retardants (FR) used in polyamides ranges from nitrogen-based products to organic phosphorus compounds to red phosphorus (RP). Often times, it is also not possible to avoid relying on halogen-containing FRs. The fire behavior of solid, non-foamed plastics in so-called "small applications" is often grouped into different performance classes in accordance with the requirements of UL 94. Here, "HB" describes a non-fire-protected material, whereas a material that meets the requirements of class "V-0/5VA" has passed a test with a 500 watt gas burner, among other things.

While FRs based on nitrogen and organic phosphorus compounds are color neutral, products with red phosphorus can only be produced in dark red, which is characteristic of red phosphorus, or in dark grey/black colors. The different flame retardants are incorporated into the compound at concentrations between about 5 and 25 percent by weight, which affects the material properties more or less significantly, depending on the FR type. An »

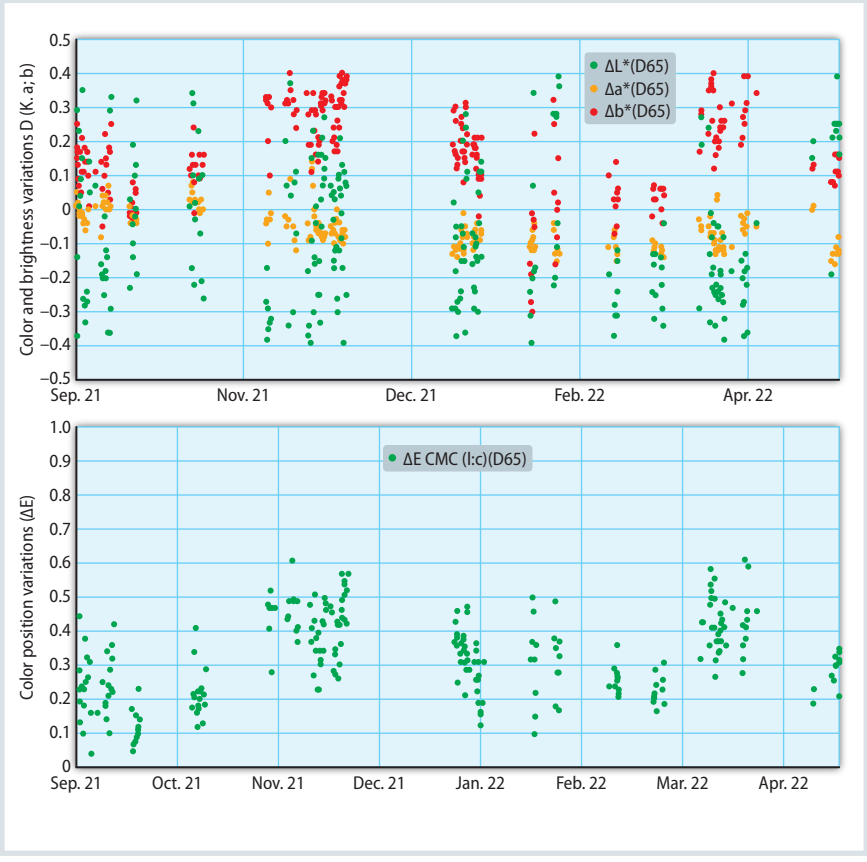

Fig. 2. Color variations for various production campaigns of a flame retarded PA66 compound.
© Ascend

example: The stiffness of a Polyamide reinforced with 25 % glass fibers is reduced by more than 30 % as a result of moisture absorption. Whereas in a brightly colored, fire-protected version only by less than 20 %. Color formulations that are not ideally selected may have additional–in some cases significantly negative– effect on the compound properties here.

Ascend offers the entire range of flame retardants suitable for Polyamides in technical applications in the various types of the "Starflam" product range (**Fig. 4**). The ideal balance between the various requirements must be established through close communication between the customer and the molding compound manufacturer. Here, too, the use of powder-shaped input materials expands the possible variations. The advantages and limitations of various flame retardants are shown in **Figure 5**.

Frequently, molded parts made from fire-protected molding compounds are used to manufacture applications which are later used in the scope of the regulations of Underwriters Laboratories (UL). In this case, the characteristic properties of the respective formulation are stored at UL and the variation possibilities of the molding compound manufacturer are extremely limited.

As is so common, the benefits of powder input materials must be "bought" in the color adjustment through compromises elsewhere: Dosing the relatively small amounts of required formulation components is more complex and cleaning the systems is more labor-intensive than, for example, using color concentrates ("Colorant Masterbatches"). It can be more attractive for customers to secure lower-cost solutions with compromising color consistency by using batches.

Effect of Functional Additives

Functional additives and colorants may significantly affect the electrical properties of a molding compound. For example, the Comparative Tracking Index (determined according to IEC 60 112) is a integral characteristic for dimensioning geometric distances in electrical devices. The use of unsuitable additives may reduce the Tracking Resistance and consequently the Comparative figure of creep path formation (CTI) of a molding compound to such an extent that a given design no longer meets the relevant standards. In such a case, the manufacturer of a device may face significant liability. Additives with a negative influence on the Comparative Tracking Index can be, for example, flame retardants or their synergists, or also compounds used to increase the contrast in the laser markability of plastics.

The production of flame-retardant molding compounds is concentrated in the Fosses plant (France). Among others, an in-house laser laboratory enables the targeted optimization of the laser markability of custom colors, while the simultaneous monitoring of the other properties that are critical for the respective application ensures the required overall performance. This includes, for example, incorporated lubricants used to minimize friction and the resulting wear. Ascend uses the entire range of additives provided by the upstream industry to offer molding compounds with the desired property profiles. With the acquisition of Polibblend (Mozzate, Italy), competence and capacity were acquired to be able to supply such formulations, some of which are customer-specific, in small and large quantities.

Fig. 3. Sample body in orange color after temperature storage test. © Ascend

Use of Radiation Crosslinkable Materials

Molding compounds produced with a special chemical can be crosslinked molecularly by means of radiation through electrons ("beta radiation") or electromagnetic waves ("gamma radiation"). This significantly affects the properties of polymers.

Molded parts made of radiation crosslinkable materials will no longer melt after radiation crosslinking. While the strength and toughness typical for polyamide is retained, the original melting point is eliminated. While Polyamide 66 melts at 260 °C, cross-linked polyamides retain their shape for several minutes even at temperatures well above 300 °C. Such temperature peaks occur, for example, in electrical switching devices. When currents are switched off, light arcs are created, with temperatures reaching several thousand degrees. Such light arcs are appearing in for example industrial switching devices or in DC-power circuits of electrically-driven motor vehicles.

Traditionally, such temperatures could only be handled with thermoset materials, which in turn require numerous compromises. The list is by no means complete, and can include high wall thicknesses, long curing and thus long cycle times, deburring, limited ductility and high wear on moving parts.

Radiation-crosslinked Polyamides can also substitute thermosets for applications in metal welding systems in where plastic parts are required to withstand metal particles having >100 °C. Particularly for molded parts with small dimensions required to resist repeated temperature peaks, radiation crosslinkable Polyamides (according to the standard ISO 1043, marked by an "-X" after the molding compound designation) can offertheir advantages.

In addition to increasing the peak temperature resistance, radiation crosslinking also brings significant improvements in creepage and friction behavior. Ascend's range of crosslinkable compounds extends here from unreinforced material to highly glass fiber-reinforced, halogen-free, fire-protected molding compounds. These products can also be colored according to customer specifications. From the "stable" color, which does not change due to the irradiation, to the formulation with targeted color change, various customer requests can be achieved. The UL recognition, of course, is maintained even after the crosslinking process. ■

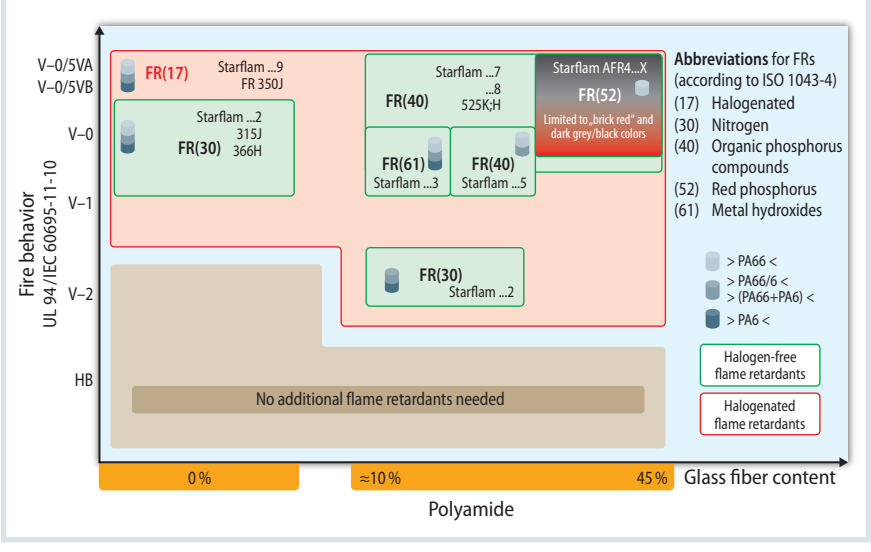

Fig. 4. Overview of flame retardants in polyamide molding compounds. © Ascend

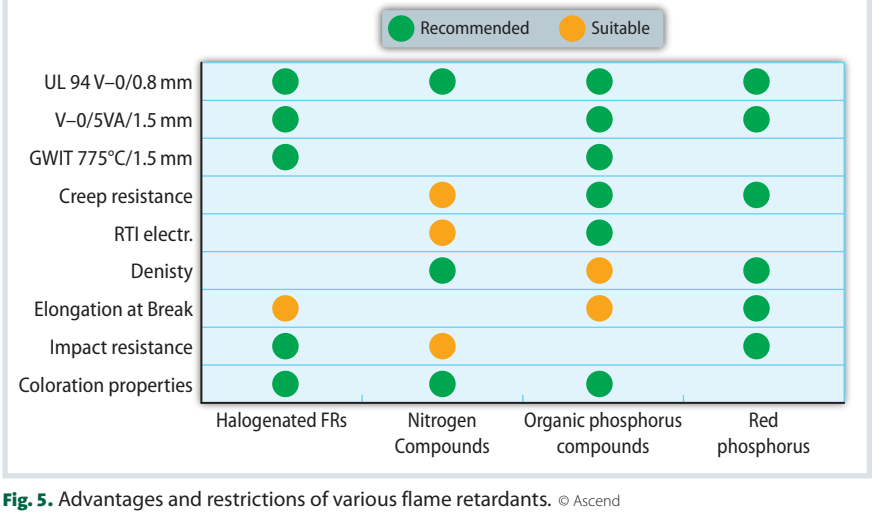

Fig. 5. Advantages and restrictions of various flame retardants. © Ascend

Info

Text

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Company Profil

Ascend Performance Materials is one of the world's largest fully backwards-integrated Polyamide 66 manufacturers. Headquartered in Houston/Texas, with three production sites in Europe (Netherlands, France, and Italy), it allows for serving customers from a wide range of industries with high-volume standard materials as well as with customized compounds based on PA6 and PA66. PA6.10 and PA6.12 compounds are manufactured under the brand name HiDura. With several acquisitions over the past two years, the company is maintaining its strong growth trend despite the crises worldwide. The two recent acquisitions in Mexico and India underline the claim of being a global partner with manufacturing facilities throughout the world.

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