No Chance for Dust

Better Protection against ESD for Plastic Parts

Antistatic additives prevent electrostatic charging, and thereby the attraction of dust to plastic products. This not only ensures an attractive appearance, but can also be safety relevant. However, many antistatic systems develop only an insufficient effect. The masterbatch producer Grafe has therefore developed an antistatic treatment that achieves a significantly lower surface resistivity and can be used together with color masterbatches and various fillers.

Antistatic systems for dust-free plastic parts are developed in the pilot plant at Grafe © Grafe

Electrostatic charging and the resulting dust deposits on plastics represent a considerable problem for many industries. "This impairment of the surface results in customers within the packaging industry making negative purchasing decisions. In the case of clothing or toys, on the other hand, it is particularly important for manufacturers to reduce dust attraction by the surfaces as much as possible, in order to prevent health risks from allergenic dusts. It is therefore increasingly important to have an effective antistatic finish on plastic articles," explains Lars Tonnecker, Sales Manager at Grafe (**Fig. 1**). Automotive manufacturers, too, consider dusty plastic parts in the interior of high-end vehicles undesirable.

This topic is also relevant to personnel safety. Tonnecker refers to ATEX operational directive 1999/92/EC. This defines the minimum regulations for health protection and employee safety, which can be endangered by an explosive atmosphere. "This topic is very relevant to personnel safety. Static electricity is an effective source of ignition. There is therefore the risk of ignition at explosive atmospheres comprising mixtures of flammable gases, vapors or dusts with air," explains the sales manager.

Damage to Electronic Devices

Additionally, electronic devices can be damaged by electrostatic discharge (ESD) effects. "Even discharges below the threshold of perception can lead to the failure of sensitive components," says Tonnecker. Electrostatic charges also have negative effects on instrumentation and equipment control technology, since the function of instruments could be damaged thereby.

To solve this problem, the industry makes use of various antistatic solutions. ""In principle, we distinguish between internal and external antistatic agents as well as between surface- and volume-active substances," explains Petra Henkel, additive specialist at Grafe. However, they all have different disadvantages. Grafe has therefore developed a high-performance antistatic system for plastics applications. The so-called HPAS is mainly interesting for hoses and nonwovens in the industrial field, interior parts in cars and packaging for electronic components, since they particularly bring out its advantages.

Lower Surface Resistivity than in Conventional Antistatic Systems

HPAS is a purely internal antistatic agent, which is generated by means of extrusion and dilution in a carrier polymer, usually polypropylene (PP), but ethylene-vinyl acetate (EVA) is also used. "Depending on the masterbatch dosage, we easily achieve surface resistivities of 10 x 10^6 to 10 x $10^9\Omega$, electrostatically dissipative, after just a short time, often immediately after production of the part and independently of the ambient conditions prevailing in the factory," says Henkel.

As he says, the effect is based entirely on the migration of surface-active substances that form a moisture film on the surface. However, this layer is in many

cases thicker and provided with more charge carriers than the materials used as standard. "As a result we achieve a long-lasting effect over years. In addition, color masterbatches can be combined with fillers such as chalk or talc. Due to the very good effect with low dosage, a significantly better performance and cost efficiency can be achieved," Henkel continues.

Many Antistatic Agents Perform Poorly

Conventional internal antistatic agents are usually used in the form of a masterbatch in the manufacturing of many types of polyolefin films, such as stretch-, oriented PP (OPP), biaxially oriented PP (BOPP) blown and cast films. They are also often applied in injection molding and in extrusion, for example during the production of staple fibers and nonwovens. As antistatically active substances, glycerol monostearate (GMS) and an ethoxylated alkylamine, as a synergistic mixture

Fig. 1. Lars Tonnecker, Sales Manager at Grafe: "Even discharges below the threshold of perception can lead to the failure of sensitive components. Antistatic agents help to protect these components." © Grafe

in a ratio of 2:1, are usually extruded in PE and subsequently used in the final product with a dosage of 2 to 3 % by weight. Here, GMS serves as a fast-acting antistatic agent and the ethoxylated alkylamine as a longer-acting one. The advantage of this combination consists in its price-performance ratio.

However, the low price, which many users have been used to for years and decades, cannot blind us to the fact that there is a discrepancy between dosage and performance. A higher dosage than that proposed or expected is often necessary. In many cases, the antistatic effect lasts for a shorter time than desired; the surface resistivity is higher than assumed and the conductivity is worse than expected, often not better than 10 x $10^{10}\,\Omega$. Depending on the production process, there are other negative issues. Such adverse effects may occur in injection molding with the addition of fillers i.e. glass fibers, or during the transition to extruded parts or after thermoforming, as well as under ambient conditions with high atmospheric humidity.

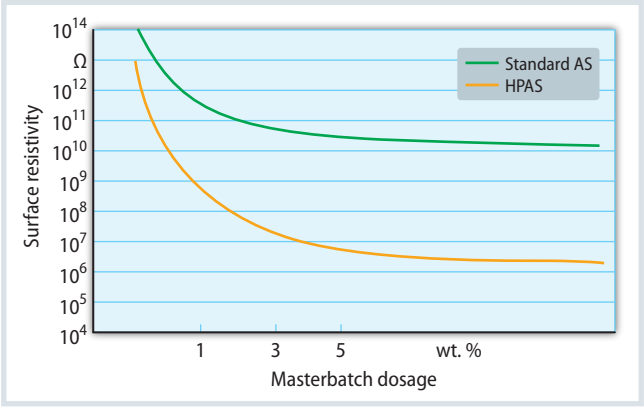

Fig. 2. Surface resistivities of PP cast films depending on the masterbatch dosage: HPAS achieves noticeably better values than comparable systems

Source: Grafe, graphic: © Hanser

The Reason for the Poor Effect

This negative effect is principally the result of the interaction, compatibility and affinity between the primary plastics and the respective antistatic mixture. This is very often the result of the conditions at the converters – i.e. special production processes – which are deliberately targeting a rapid optimization of the final product. Or it is caused by homemade errors, e.g. if the test and measuring equipment in the lab or in quality assurance does not correspond to the requirements made on it. For example, the surface resistivities are very often measured immediately after manufacturing the final part instead of waiting a certain resting time in which the plastic cools slowly so that crystallization of the polymer from the melt can take place at rest.

Other reasons for the poor effect of conventional antistatic masterbatch systems lie in the complex structure of the end product, for example in multilayer films with partly contradictory or self-amplifying surface effects. These are the result of, for example, fillers, pigments, glass fibers and other surface-active substances such as antifogging, dispersing aids and lubricants.

Comparison of HPAS and a Standard Antistatic Masterbatch

To obtain a comparison between a standard antistatic masterbatch and HPAS, Grafe conducted, e.g., trials on thin PP cast films modified with these additives (**Fig. 2**). Depending on the masterbatch dosage, HPAS achieved values below 10 x $10^{10}\,\Omega$. This represents a significant improvement with respect to other existing systems. The optimum ratio between costs (masterbatch dosage) and performance (surface resistivity) is achieved for dosages of 1 to 5 % by wt.

The development took as basis the combination of synergists such as GMS and ethoxylated alkylamines. However, it is necessary to keep an eye on the purity (procurement source) and particle size of all the chemicals used. In addition, the ratio between masterbatch and performance in the end product must be accurately monitored and optimized in order to obtain the best results. Since the substances used here have a strong tendency to absorb moisture, handling under production conditions plays a key role. It is therefore important to deliberately avoid moisture absorption before processing. To obtain the best result in the end product, gentle extrusion conditions are also helpful.

Minimal Dosage, Big Effect

In the studies, the development of the surface resistivity was tracked on PP cast films of 30 µm thickness at various HPAS dosages for several days (**Fig. 3**). The »

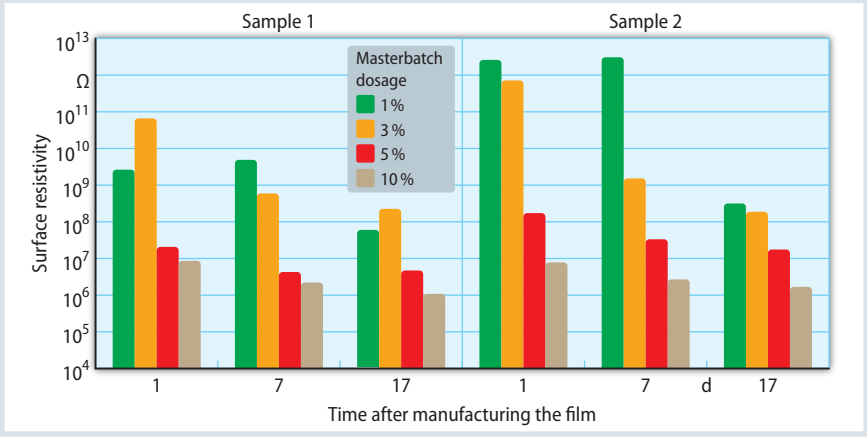

Fig. 3. Electrostatic dissipation on two PP films of the same age (30 µm): at only 1 % HPAS, a significant effect can already be ascertained on the first day of film production Source: Grafe, graphic: © Hanser

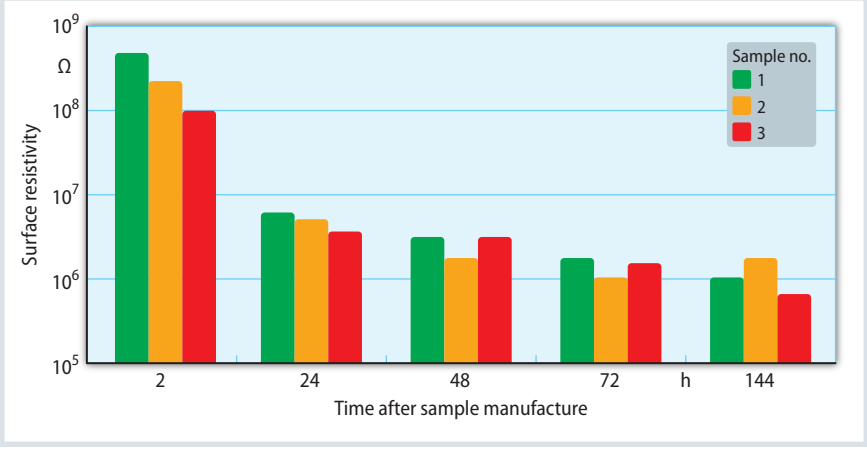

Fig. 4. Combination of HPAS with color masterbatches on PP injection molded samples: the antistatic effect is not reduced after addition of pigment Source: Grafe, graphic: © Hanser

films were stored at 23 °C and 50 % atmospheric humidity in order to base the conditions on DIN-EN test conditions as far as possible. At only 1 % – i. e. the smallest recommended dosage – a signficant effect is achieved on the first day of film production.

The HPAS masterbatch is usually used at 2 to 3 %. In general, values from 10 x 10^7 to 10 x 10^8 Ω surface resistivity are achieved. A further addition of the masterbatch generates values up to 10 x 10^6 Ω. However, the surface of the film is then highly saturated with additive, which leads to turbidity, reduced translucency and poorer tactile properties – the film feels greasy.

Combination of Color Masterbatches Does Not Reduce the Antistatic Effect

The HPAS can also be used in combination with color masterbatches. The resistivities of three PP injection-molded parts of the same age that were previously manufactured with 3 % HPAS and 5 % of a color masterbatch were investigated (**Fig. 4**). Unlike in comparable products, the antistatic effect is not reduced after pigment addition.

In color masterbatches, various fillers such as chalk, talc, barium sulfate, titanium dioxide and carbon black are usually used. It was not possible to ascertain any disadvantages in combinations using these substances. However, there were color deviations in brightness (L-axis). This is due to the increased gloss level resulting from the conducting moisture film on the surface. The other color axes (a and b) remain almost unchanged, on the other hand.

Where Its Use Is Worthwhile

The high-performance antistatic system is primarily intended for industrial applications. It is not suitable for food packaging, medtech products as well as engineering plastics. The relatively high processing temperatures here, coupled with the sensitivity of such polymers to moisture, prove problematic. Since manufacturing such products often involves a second process, such as stretching, thermoforming or coextrusion, migrating masterbatches are not suitable for these. Instead, sprays, painting, coating and a multilayer structure come into consideration.

The use of the HPAS requires more effort for raw materials preparation, process and production. Processors must therefore observe some special features to obtain good results. For example, moisture absorption by the masterbatch must be avoided. It cannot therefore be pre-dried and must be packaged and stored under airtight conditions. The effect of the HPAS is also not permanent for ever. In addition, the modified surface influences printing and painting. The antistatic effect is also reduced by direct or constant contact with washing liquids.

However, in return, the antistatic system offers numerous advantages. Only a small masterbatch dosage of 1 to 3 % shows already a significant effect. This is also effective immediately after production of the part. Moreover, the desired effect is also present on addition of color masterbatches and fillers, and they do not lead to a reduction of the antistatic effect. The HPAS can additionally be used both for thin and thick-walled articles and is characterized by a long-time effect of at least one year. ■

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