High transparency and good heat deflection temperature make a high-performance polyamide suitable for exciting architectural applications

High-performance Polyamides. Transparent polyamides are now finding applications in many hitherto inaccessible areas: examples can be found in household, safety technology and medical applications. Among the reasons for the success are the basic properties of amorphous polyamides, which, thanks to the special monomer structure, achieve the heat resistance of high-performance polymers

Transparency for all Occasions

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Within the polyamide family, amorphous polyamides, due to their transparency, hold a special position. The transparency results from the structure of the monomers used. Special, e. g. asymmetric building blocks in the polymer chain hinder or weaken crystallisation. This make the polymers crystal clear in comparison to semi-crystalline polyamides, such as PA 6 or PA 66. Amorphous polyamides include both homopolymers and copolymers. The resultant properties of the polyamide materials can be controlled and adjusted for a particular purpose by varying the nature and ratio of the diamines and dicarboxylic acids or lactams used.

Transparent high-performance polyamides include the products Grilamid TR 55 and Grilamid TR 90 and the glass fibre-filled TRV-4X9 from Ems-Chemie, Domat/Ems, Switzerland. These materials combine the properties of semi-crystalline polyamide 12 grades with those of amorphous thermoplastics. The material characteristics include excellent flexural fatigue strength and low specific weight. The newly developed products TR 60 and TR 70 offer plastics processors opportunities for a range of potential new applications.

Besides having the basic properties of existing amorphous polyamides – the newly developed polymers exhibit some further special features: The use of aromatic or cycloaliphatic monomers significantly increases the glass transition temperature compared to other high-temperatureresistant polyamides, up to 190 °C (Grilamid TR 60) or 200 °C (Grilamid TR 70). The mechanical properties remain virtually unchanged from room temperature almost up to the glass transition temperature. The monomer variants used contribute to an outstanding heat deflection temperature that is comparable to that of polysulphones and HT polycarbonate.

This class of polyamides is characterised by minimal water absorption, achieved by a significant reduction in the proportion of amide groups compared to short-chain standard polyamides (Table 1). At the same time, the weathering and UV stability are significantly increased.

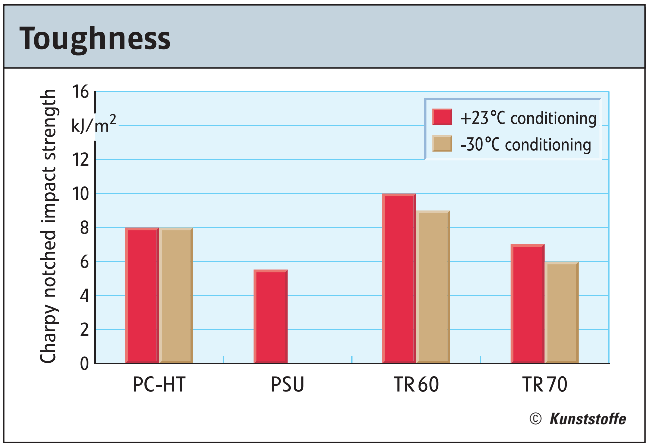

Fig. 1. Comparison of the Charpy notched impact strengths of PC-HT and PSU with newly developed high-temperature polyamides (Grilamid TR 60 and TR 70) at temperatures of 23 and –30 °C

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Meeting Medical Requirements

These newly developed high-temperature polyamides open up applications in the fields of food and medical technology, which are subject to strict hygiene requirements. Polyamides absorb more water than HT polycarbonate and polysulphone (Table 1). However, because of the special polymer structure, Grilamid TR 60 shows extremely high hydrolytic stability and is therefore especially suitable for medical technology. Repeated sterilisation over the long term, such as that required in hospitals, does not pose a problem for the material. Even after 300 cycles in steam at 134 °C and 2 bar, this polyamide does not show any embrittlement, which would otherwise render it unsuitable. Grilamid TR 60 also withstands sterilisation with ethylene oxide or dry heat without material deterioration. With gamma radiation sterilisation, it easily withstands the full dose of 2.5 megarad (the upper limit for aliphatic polyamides).

Fig. 3. Wireless monitoring and alarm unit for compressed air respirator with crystal clear display and all-round sealing element of Grilamid TR high-temperature polyamide

Modification with „compatible“ crystalline structures results in a finely dispersed micro-crystallinity, which does not affect the optical transparency but increases the chemical resistance. Here, too, the material scores particularly in medical applications, since the parts exhibit the necessary long-term stability to various reagents.(Table 2). The varied applications include analytical instruments, containers vessels or various trays.

These amorphous polyamides also showclear advantages over HT-PC and PSU as regards notched impact strength, which remains unchanged even at temperatures down to – 60 °C (Fig. 1). Medical specimens can be frozen in containers made of these polyamides which remain extremely robust even after long periods at extremely low temperatures.

Unlike previous amorphous polyamides, the product has exceptionally good microwave resistance. As a result, baby bottles (Fig. 2), carbonated beverage bottles or other containers for household use with direct food contact can be easily manufactured by injection stretch blow moulding (ISBM) or injection blow moulding (IBM).

Fig. 2. High temperature polyamide can be readily blow formed to containers such as babies' bottles

Product name	Density [g/cm³]	Water absorption 50 % r. h. [%]	Water absorption saturated
Grilamid TR 60	1.06	1.8	3.7
Grilamid TR 70	1.07	2.0	4.0
PA 6	1.13	3.0	9.5
PA 66	1.14	2.8	8.5
PC-HT	1.15	0.2	0.4
PSU	1.24	0.3	0.8

Table 1. Comparison of the water absorption of polycarbonate (PC-HT), polysulphone and semicrystalline polyamide with two high-performance polyamides (Grilamid TR) at 23 °C

Media	Grilamid TR	HT-PC	PSU
Solvents, non polar	+++	–	– (aromatics)
Solvents, polar	++	–	++
Alcohols	+	+	++
Petroleum spirits	++	++	++
Mineral oils	+++	+++	+++
Strong alkalis	+++	–	+++
Acids	–	–	++

+++ resistant; – non-resistant

Table 2. Chemical resistance of polyamides compared to polycarbonate and polysulphone

Product name	Light transmission [%] 2 mm/ 560 nm (Ems)	Refractive index ISO 489-A
PC-HT	89	1.57
PSU	85	1.63
Grilamid TR 60	92	1.54
Grilamid TR 70	91	1.54

Table 3. Optical characteristics of high-performance polyamides (Grilamid TR) compared to polysulphone and polycarbonate

An Alternative Thanks to Improved Transparency

Conversion from conventional high-temperature materials such as HT polycarbonate or polysulphone to the two new heat-resistant polyamides is relatively easy. Both polyamide grades are characterised by high stiffness, comparable with PC and PSU. Consequently, the material can be substituted without modifying the part design. As regards processing shrinkage, amorphous polyamide shows a significantly lower difference between transverse and longitudinal shrinkage than, for example, polysulphone.

An example of material substitution is for baby bottles, which were previously made of polysulphone. The lower process temperature of the polyamide results in shorter cycle times, and therefore an appreciable increase in productivity. At the same time, the final product has a lower weight and much better transparency than PSU. Where manufacturers intend to replace an existing material, Ems-Grivory can help with technical support, such as rheological part design, FE analysis or mould optimisation, to achieve a rapid and technically successful transition.

The optical characteristics of the new polyamides are better than those of HT polycarbonate and polysulphone (Table 3). Parts demanding high trans-

Fig. 4. Two-component safety mask of high-performance polyamide with all-round rubber sealing

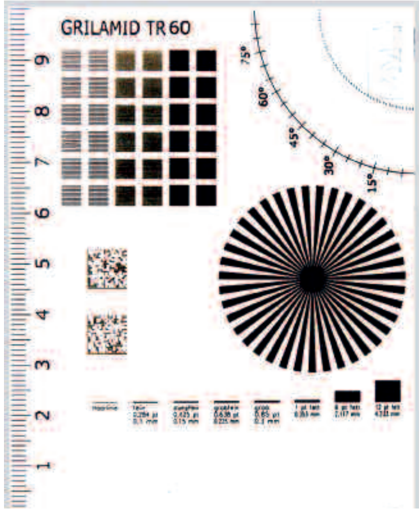

Fig. 5. Specimen plate of high-performance polyamide, exhibiting high-quality laser marking for different demands

parency can be produced with the required product characteristics from amorphous polyamides. These include lenses and clear or intrinsically coloured displays (Fig. 3).

High temperature-resistant Grilamid TR can be readily injection moulded together with different elastomers in a two-component process. This allows parts to be produced economically with different forms of sealing elements in a single operation. For example, producers of safety masks find this advantageous (Fig. 4), where both mask components are subject to extreme demands for reasons of safety. A benefit here is the high material hardness of the transparent polyamide, which provides the lenses with good long-termdurability. The ball indentation hardness, at 130 MPa, is about 15 MPa higher than for the HT polycarbonates commonly used. Another important feature is the outstanding resistance to environmental stress cracking.

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High-contrast Laser Marking

For laser marking of the polyamide parts, special laser-sensitive additives are used, which are tuned to the Nd:YAG laser (1064 nm wave length) most widely used. This allows transparent parts to be marked with high contrast (dark lettering on a transparent background) without reducing general transparency (Fig. 5). Black parts can also be easily marked, since Grilamid grades are also available with additives that provide a colourful contrast against black after exposure to the laser beam. The edge definition possible particularly for Grilamid TR 60 is comparable to that of pad printing and laser printing. At the same time, laser marking results in a high marking depth while maintaining a smooth part surface, providing products which are tamper proof. Applications for this include, e. g., data matrix codes, which can even be applied to extremely small parts.

Summary

Grilamid TR 60 and Grilamid TR 70, which have been developed for enhanced temperature resistance, offer an alternative to conventional high-temperature materials such as HT polycarbonate and polysulphone for many applications. Because of the excellent properties, these polyamide materials have particular advantages in the challenging fields of food and medical technology. Their outstanding transparency and high hardness open up additional applications, such as displays and sight glasses. Grilamid TR grades also permit cost reductions compared with the commonly known conventional established high-temperature polymers whilst providing comparable part properties. Overall, thanks to their balanced characteristics, Grilamid amorphous polyamides open up a variety of potential uses where high-temperatures are encountered. ■

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