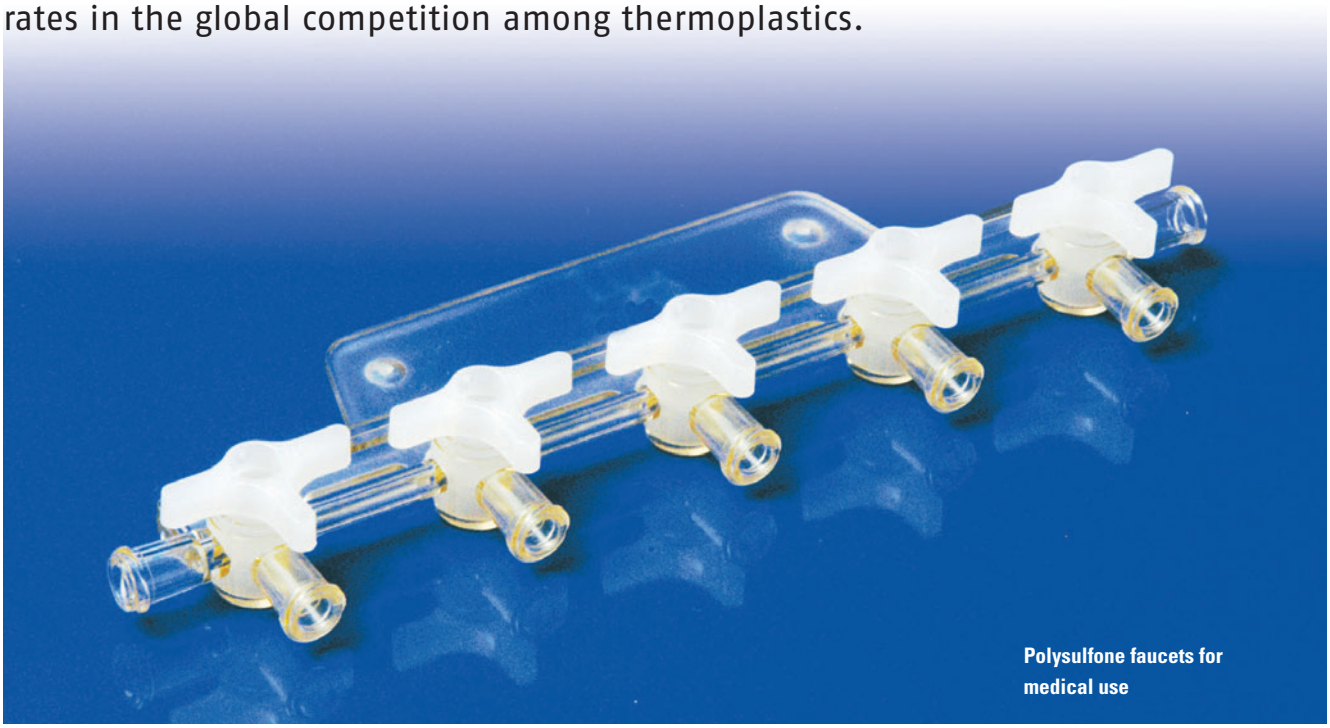
Impressive Variety. With exceptional material properties and the benefit of transparency, sulfone polymers span the range from function to aesthetics. This allows them to continually find new fields of application and assures attractive growth rates in the global competition among thermoplastics.



Polysulfone faucets for medical use

Polysulfones (PSU, PESU, PPSU)

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High-temperature (HT) plastics are enjoying continually growing popularity worldwide. In this regard, the amorphous sulfone polymers appear with their best foot forward. They continue to find new application in modern industries such as automotive, electrical/electronic equipment, medical devices and aerospace. In addition, they are used successfully in household appliances, food processing and plumbing/sanitary applications. A positive development that is not just an accident: the sulfone polymers exhibit an unique property profile that includes not only the benefits of high strength and temperature resistance, but also an inherent transparency in addition to other attributes. As a result, they are especially well-qualified for all applications where traditional materials such as glass and metal are to be substituted.

Essentially three different sulfone polymers are available on the market: polysulfone (PSU), polyethersulfone (PESU) and polyphenylsulfone (PPSU). In addition, polysulfone blends have also appeared in a number of marketable products.

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Service temperature range

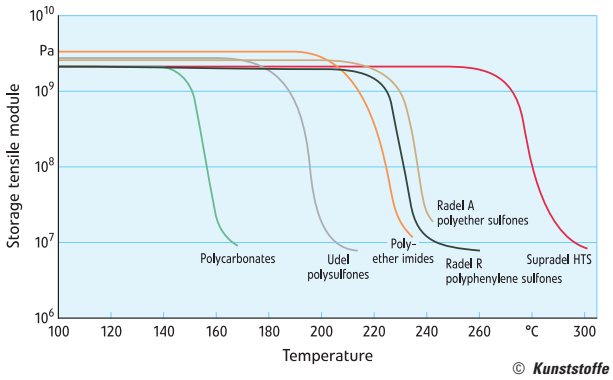

Fig. 1. Performance profile of various high-temperature plastics

Sulfone Polymers Performance

With Udel (PSU), Radel A (PESU) and Radel R (PPSU), Solvay Advanced Polymers covers all three product areas. Polysulfone blends are available under the trade name

Fig. 2. Plumbing faucet from Grohe Water Technology with a polysulfone cartridge

Mindel. Compared to using pure PSU, these blends of PSU and engineering thermoplastics with moderately heat deflection temperature from Solvay Advanced Polymers offer developers the design freedom for custom-tailored properties at a lower cost.

The economic importance of sulfone polymers results from their unique spectrum of performance characteristics (Fig. 1). The most important characteristics are high strength and stiffness even at elevated temperatures, a high continuous use temperature and a high heat deflection temperature (HDT-A), outstanding resistance to hydrolysis and resistance to acids and bases as well as good dimensional stability even in complex geometric shapes. PPSU offers in addition exceptional mechanical properties such as low susceptibility to environmental stress cracking and an extremely high notched impact strength on the level of polycarbonate.

As a technology leader, Solvay Advanced Polymers has initiated market introduction of a next-generation sulfone polymer in which the upper temperature limit in use has been raised even considerably higher. With a glass transition temperature of 265 °C, this new high-temperature polymer with the trade name Supradel HTS currently represents the peak performer among amorphous thermoplastics.

Focus on Applications

The growing interest in the performance potential of sulfone polymers is leading continually to new applications for this interesting group of materials. Potable water as well as sanitary and plumbing applications represent an innovative and promising field of use. Here, sulfone polymers excel with their unbeatable combination of properties: resistance to hydrolysis, resistance to chlorine and calcium deposits as well as outstanding biocompatibility and lack of toxicological concerns in contact with hot (drinking) water (Fig. 2).

The exceptional compressive strength and resistance to aging under long-term hydrostatic stress make PPSU in particular an interesting material alternative to brass fittings and manifolds (Fig. 3), especially where resistance to hot water is required, for instance, in household plumbing.

Currently, sulfone polymers are profiting from the trend among developers and designers to pay more and more attention to the appearance and esthetics of applications. The medical device field provides one example of the growing importance of the aesthetic aspect from rather unexpected areas. It has been found that high clarity and bright clean colours elicit greater acceptance by both the health care professionals as well as patients in a hospital. Originally, sulfone polymers had a yellow or amber colour, an appearance that over the years lost its attractiveness in clinics and other areas of health care. To keep up with the trends in medical device technology and other fields of application as well as the newly encountered requirement profiles, Solvay Advanced Polymers has in recent years introduced to the market high clarity and clarified grades of the natural sulfone polymers. High clarity polysulfone was first introduced in 2004 under the designations Udel P-1700 HC (Fig. 4) and P-3700 HC.

Comparable grades based on polyethersulfone followed, for instance, the grade Radel A-300 CL 128. In the same vein, brightly coloured transparent Radel R PPSU grades for durable medical component applications have been introduced recently as the Radel R-5800 TR series for use in medical device applications capable of repeated sterilisation (Fig. 5).

The interior of aircraft passenger compartments represents an additional field of application for plastics where a high degree of functionality in sought together with appealing esthetics. Thanks to its outstanding flame retardance in conjunction with minimal smoke generation and a wide range of colours that allows it to satisfy the most varied of design requirements, PPSU has been employed here successfully for over 15 years.

It is precisely this design flexibility and the opportunity to use transparent plastics with high light transmission values that has given wings to sulfone polymers in aircraft

Fig. 3. Polyphenylene sulfone water manifold from Wavin

Fig. 4. High-clarity polysulfone ((left) compared to standard polysulfone (right)

interiors. Accordingly, Solvay Advanced Polymers developed and introduced to the market the transparent product line Radel R-7000 TR in order to satisfy this growing demand from the aircraft industry. Applications include transparent plastic components such as room dividers and display case windows. It was the development of these new grades that opened the door for such applications.

In addition to the standard PESU grades, there are special high-stiffness grades with a glass fibre content of 20 to 30 % and a lower moisture uptake. As a result of these properties – and their exceptional dimensional stability – they are especially well-suited for electrical and electronic applications. Thus, the grades Radel AG-340 and Radel AG-360 have been employed successfully under the hood and in headlight components, i. e. wherever low weight, dimensional stability and heat resistance are sought.

Fig. 5. Transparent polyphenylene sulfone lid for sterilisation container

Custom Polysulfone Blends

The polymeric materials in the Mindel product family form three primary groups: Mindel A, Mindel B and Mindel S. Mindel A was developed for electro-platability metallisation. As glass fibre-reinforced materials, they are thus predestined for fields of application where high chemical resistance, good dielectric properties and flow flammability are required in conjunction with heat resistance over an extended period of time. Accordingly, these polysulfone blends have found a place in electrical distribution and control applications, where, because of their dimensional stability and resistance to heat ageing, they have succeeded in displacing materials such as polyester and polyamide. Applications here include components for power distribution and switchgear, for instance.

Mindel S is a blend whose performance profile fills the gap between PSU and polycarbonate (PC). All materials in the Mindel product groups are immiscible blends of two or more phases and thus opaque throughout.

With its performance characteristics in the middle range, Acudel 22000 falls between PPSU und PSU. This material finds many possible uses above all in hot water applications in case the property profile of PSU encounters its limits and PPSU cannot be used because of cost reasons.

Conventional Processing Technology

Conventional processing technologies for thermoplastics, such as injection moulding, extrusion, film production and blow moulding, can also be readily employed for polysulfones. Where the hot melt poses problems, for instance, for special products such as hollow-fibre membranes, ultra-thin films and coatings, processing in some polar organic solvents is possible.

Standard injection moulding machines are suitable for sulfone polymers, provided that the plasticising unit permits a sufficiently high melt temperature close to 400 °C. Depending on the part geometry and several other factors, the correct melt temperature for injection moulding with PSU lies between 325 and 400 °C. The mould temperature must thus lie between 100 and 170 °C. For PESU and PPSU, the values range between 360 and 400 °C (mould temperature 120 to 190 °C).

Because of the outstanding thermal stability of sulfone polymers, processing residues can be recycled and repelletised without difficulty, and after drying be processed once again together with virgin material. It should be noted, however, that to avoid quality fluctuations during production the amount of reclaimed material should not exceed 25 %. Care must also be taken to not mix different resin types. ■

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