The styrene copolymer Luran S 778T SPF30 can be used to produce high-quality surfaces with long-term durability. The polymer is used, for example, in the MG Linghang vehicle from Saic. © MG Linghang

Styrene Copolymers: High-Quality, Durable, Protective Surfaces

Variability Enables Use in Many Areas

Styrene can be modified with different comonomer building blocks. This allows the resulting materials to be tailored to different requirement profiles. Styrene copolymers have in common that they are easy to process as non-crystalline materials, have a very low tendency to warp, and exhibit low mold shrinkage. Because their properties can be varied to suit specific applications, they are used in many different areas.

Styrene polymers combine appealing aesthetics and good processability with a wide range of product properties – from transparent to tough and stiff to highly stress-crack and UV-resistant. Unlike semi-crystalline polymers such as polyethylene (PE), polypropylene (PP), polyamide (PA), and polyester, styrene polymers, apart from syndiotactic and isotactic polystyrene, have no melting point. Therefore, no thermal energy is required for melting polymer crystals, so-called melting enthalpy, during processing. Conversely, no enthalpy of recrystallization needs to be dissipated during solidification of the molding compounds. The lack of crystallinity leads to very low energy absorption in processing and to higher cycle rates in production. Styrene polymers therefore offer both ecological and economic advantages.

The most important styrene polymers are (**Fig. 1**):

- **Polystyrene (PS):** used as a crystal-clear, stiff but brittle, homopolymeric standard PS (GPPS for General Purpose PS) or as an impact-modified, stiff but opaque PS (HIPS for High Impact PS).
- **Styrene-acrylonitrile copolymers (SAN):** transparent thermoplastics with high stiffness and increased stress crack resistance based on the monomers styrene and acrylonitrile. A special modifica-

tion of SAN is the thermoformable copolymer with alpha-methylstyrene (AMSAN).

- **Styrene methyl methacrylate copolymers (SMMA):** transparent, brittle polymers with higher scratch resistance than GPPS. They are often used in blends with styrene-butadiene copolymers to obtain transparent, tough products with increased scratch resistance.
- **Styrene-maleic anhydride copolymers (SMA):** highly thermoformable, stiff, brittle polymers. They are often used to make acrylonitrile-butadiene-styrene molding compounds heat-resistant.
- **Styrene-butadiene copolymers (SBC):** transparent, stiff, tough styrene copolymers produced by a special anionic polymerization process. SBCs are frequently used in food packaging and medical technology. They should be distinguished from styrene-butadiene rubbers (SB) produced in a similar way, and from partially crosslinked styrene-butadiene latices that are used, for example, in paper coating.
- **Acrylonitrile-butadiene-styrene copolymers (ABS):** opaque, ductile, rigid thermoplastics with a wide processing window. They are tough and rigid, even at low temperatures, and have high resistance to heat and chemicals (see also p. 42 in this issue).
- **Methyl methacrylate-acrylonitrile-butadiene-styrene copolymers (MABS):** transparent, ABS-like plastics that have better resistance to greases and oils than acrylonitrile-free styrene polymers.
- **Acrylonitrile-styrene-acrylate copolymers (ASA):** these polymers are similar to ABS but have particularly high UV resistance because, unlike butadiene rubber, the butyl acrylate rubber used has no double bonds. They are frequently used in exterior applications in the automotive sector, for example as mirror housings »

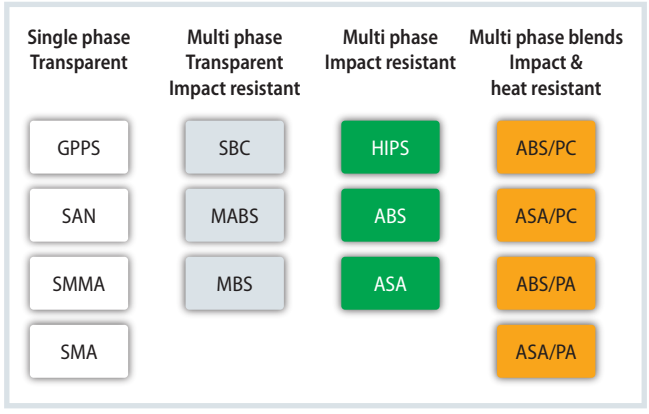

Fig. 1. Styrene polymers are available in a large number of variants, some of which differ significantly in their properties.
Source: Ineos Styrolution; graphic: © Hanser

Fig. 2. The lamp housings of refrigerator LEDs must offer high transparency, good resistance to oils and greases, and high impact strength at low temperatures. © Samsung Electronics

and radiator grills, as well as in the sports and leisure sector and for durable electrical and electronic housings.

- **Blends:** PS can be homogeneously blended with polyphenylene ether (PPE), resulting in products with high heat resistance, stiffness and toughness. ABS and ASA blend well with polycarbonate (PC) and PA to form PC/ABS, PC/ASA, PA/ABS, and PA/ASA blends. They combine the very good thermal properties of PC and PA with the intrinsic properties of ABS and ASA.

Styrene polymers have the following properties:

- easy to process, good colorability,
- excellent surface aesthetics,
- light weight, high water resistance, and good electrical insulation,
- good toughness-stiffness ratio,
- impact strength and transparency, if required,
- high UV resistance, adjustable, and
- easy to recycle.

The steadily growing global demand for styrene specialties is leading to the construction of new production facilities. As the "little brothers" of ABS, styrene copolymers such as ASA or MABS are often produced in the same production facilities. For this reason, production and consumption figures are usually reported together. Dedicated plants for styrene copolymer specialties are planned, for example, by Ineos Styrolution in Bayport in the US state of Texas. A plant for ASA with an annual capacity of 100,000 t is scheduled to come on stream in the fall of 2022. This is linked to an increase in ABS capacity at the Altamira site in Mexico and the relocation of ASA production there to the new site in Bayport.

SBC – Durable with Good Protection for LEDs

As customizable materials, styrene copolymers are often used for specialty applications. A good example from the household sector is the LED lamp housing of a Samsung refrigerator (**Fig. 2**). It was made from Ineos' SBC, which is called K-Resin. The material offers high transparency with good resistance to oils and greases, as well as good impact strength at low temperatures.

Custom Profile, a manufacturer of extruded thermoplastic profiles and subassemblies, chose Ineos' SBC Styroflex 4G80 for its tubing. This is used for medical devices and must therefore meet stringent safety requirements. The material can be made into a variety of tubing sizes, offering engineers an alternative to existing medical tubing options. It is both a styrene-based thermoplastic elastomer (TPE-S) and a styrene-rich SBC with correspondingly excellent thermal processability. The material offers cost and performance advantages while meeting ISO 10993, USP Class VI and food contact regulations. The extruded medical tubing is phthalate-free, clean, safe and cost-effective, so meeting the needs of a wide range of applications.

Styroflex PG77, an Ineos SBC, was also selected by Hualo Film, a Chinese full-line supplier of flexible plastic and laminate packaging and technical films, as the material of choice for its stretch hood films (**Fig. 3**). In film applications, Styroflex offers very good stretch hysteresis as well as high transparency and

Fig. 3. Stretch hoods protect goods on pallets during transport. They must therefore be made of polymers with high elasticity and impact resistance. © Ineos Styrolution

Fig. 4. Leading edge erosion is a challenge for large commercial wind turbine blades. Protection against this is provided by a so-called Armour-Edge shield made from the styrene copolymer Luran SC.

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puncture resistance. Styroflex PG77 has been specifically tailored for packaging applications such as stretch hood solutions. The material is stretchable up to 200 % with very high recovery. As a result, it snaps back to its original shape, hugs the load tightly and holds it securely.

ABS – Suitable for Drinking Water and Chrome-Plating

In the sanitary sector, materials are required to meet the strict requirements of drinking water applications. A number of materials no longer meet the new regulations, such as important European drinking water certifications like the KTW (Recommendations for the Use of Plastics in Contact with Drinking Water) in Germany, WRAS (Water Regulations Advisory Scheme) in the UK and ACS (Attestation de Conformité Sanitaire) in France. Novodur SBM-90 from Ineos, on the other hand, continues to be approved for drinking water.

The material is a drop-in replacement for other ABS products. It is suitable for a wide range of applications, including those requiring drinking water and food approval. The material offers a comparable property profile and appearance to previously used ABS materials, allowing for very similar processing. Typical applications include showerheads, drinking vessels, molded parts and other applications in direct contact »

Fig. 5. The front grill and fog lamp covers of the Voyah Free SUV are made of Luran S 778T SPF30 from Ineos Styrolution. © Voyah

Fig. 6. A Korean manufacturer uses Ineos Styrolution's blend Terblend N NE-15XF to reduce the carbon footprint of its agricultural vehicles. © Ineos Styrolution

with drinking water. The material can also be chrome-plated.

ASA Copolymers – High-Quality Surface Protection

Styrene polymers help improve wind turbines, for example. In a joint project, Ineos Styrolution collaborated with the Scottish company Edge Solutions, which specializes in optimizing wind turbines. The two companies developed what is known as ArmourEdge protection for wind turbine rotor blades, based on a customized version of Ineos' UV-resistant styrene copolymer Luran SC.

Leading edge erosion is a serious problem in large commercial wind turbine blades (**Fig. 4**). It is caused by environmental factors such as rain, hail, ice, salt, and UV radiation. Such damage to the blade surface results in increased drag and ultimately reduced power generation. It also increases operating costs due to increased maintenance, regular blade changes, and generator downtime. The problem already exists with onshore turbines, but plays an even greater role with offshore wind farms operating in extreme conditions.

Based on the specifications defined by Edge Solutions, Ineos developed a customized material solution. It became the basis for the ArmourEdge Shield – a protection solution that significantly reduces the impact of environmental factors on the leading edge of wind

Info

Text

Dr. Norbert Niessner is Director Global Innovation and IP at Ineos Styrolution.
Dr. Hannes Kerschbaumer works as Technical Product Manager for Blends and SBC EMEA at Ineos Styrolution.
Dr. Nils Wittenberg is Technical Product Manager for Specialty ABS EMEA at Ineos Styrolution.
Dr. Nils Becker works as Technical Product Manager for Luran S EMEA at Ineos Styrolution.
Dr. Christian Ruthard is Product Manager ECO Specialties EMEA at Ineos Styrolution.

References & Digital Version

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Fig. 7. Using bioattributed styrene polymers can produce more sustainable flooring. © Nora

turbine blades. The protection results in significantly lower operating and maintenance costs. It also increases annual energy production. The ArmourEdge system is currently being installed at an operating offshore wind farm in Northern Europe.

Styrene copolymers such as Luran S offer very good properties for durable use and a high-quality surface appearance. Even when unpainted, the material has good weathering stability for outdoor applications. It is also an ideal material for hot stamping technology, which can be used to create aesthetic effects. Chinese automaker Saic, for example, uses Luran S 778T SPF30 from Ineos for the front grills of its vehicles. Important selection criteria for the company were the high UV and weathering resistance of the material and the durable, high-quality, paint-free, high-gloss surface with deep, dark molded-in color (**Title figure**).

Luran S 778T SPF30 was also selected for the newly launched Free SUV model from Voyah (**Fig. 5**). This is the brand under which Dongfeng Motor, China's second-largest state-owned automaker, sells its premium electric vehicles (EVs) in China. The combination of very good UV resistance and the durable, high-quality, paint-free, high-gloss surface with good dimensional stability was also an important criterion for use of the material. The polymer is used by the car manufacturer for front grills and fog lamp covers.

More Sustainable Products with Styrene Polymers

Sustainability is also playing an increasingly important role with styrene polymers. The PA/ABS blend Terblend N NE-15XF from Ineos Styrolution, for example, was selected by a Korean manufacturer of agricultural machinery as a material for its products, specifically with sustainability in mind (**Fig. 6**). The aim was to improve the carbon footprint of its products by using recyclable, environmentally friendly materials. Terblend N NE-15XF is a recyclable blend of ABS with PA copolymer with very good impact strength, thermoformability, extrusion stability, and paintability. It is therefore particularly suitable for use in vehicle fenders. In addition to agricultural vehicles, the material can also be used for other housing applications using the thermoforming process.

Ineos Styrolution has also introduced sustainable product lines made from styrene plastics – for example, Styrolux Eco and Styroflex Eco. Styroflex Eco is the recently launched [1] extension of the Styroflex product line with materials based on bioattributed styrene polymers. Styroflex Eco 2G66 B60 is a product (certified by ISCC Plus) that can be used as a 100 % replacement for styrene from fossil sources. Compared to fossil-based styrene, it has a 74 % lower greenhouse gas footprint. Interface, a flooring manufacturer, has selected Styroflex Eco 2G66 B60 for its Nora brand, for example, to reduce the carbon footprint of its products (**Fig. 7**). ■