# Diverse Shapes and Applications

## *Styrenic Polymers*

Styrenics can be polymerized using different technologies and it can be modified with a range of copolymers. The resulting plastics offer a wide range of properties allowing to customize them for different applications. Because of this range of properties they are suitable for many industries. Strong demand is for example driven by the automotive industry, healthcare and the packaging industry.


Styrene copolymers are frequently used in the exterior of vehicles. The Chinese manufacturer Lixiang, for example, uses an ASA for the radiator grill of its electric vehicles © Lixiang

Styrenic polymers are amongst the economically most important plastics. They combine benign processing with a large variety of product properties – from stiff and transparent to tough and durable. The fact that styrene can be polymerized by different reaction mechanisms (radical, ionic and metal catalyzed) makes this line of products unique in terms of their properties and applications.

The term styrenics (or styrenic polymers) is used to describe a family of major plastic products that use styrene as the key building block. Due to their amorphous structure, styrene polymers can be easily processed over a wide temperature range well above their softening point, the so-called "glass transition temperature" (Tg). Other than partly crystalline polymers such as polyethylene (PE) or polypropylene (PP), polyamides (PA), polyesters, styrenic polymers (except syndio- and isotactic polystyrene – PS) do not show a distinct melting point and, hence, no thermal energy for melting of polymeric crystals (melt enthalpy) is required during processing. That means faster processing under the same conditions, but also high dimensional stability and largely constant mechanical properties up to the Tg. Styrenics

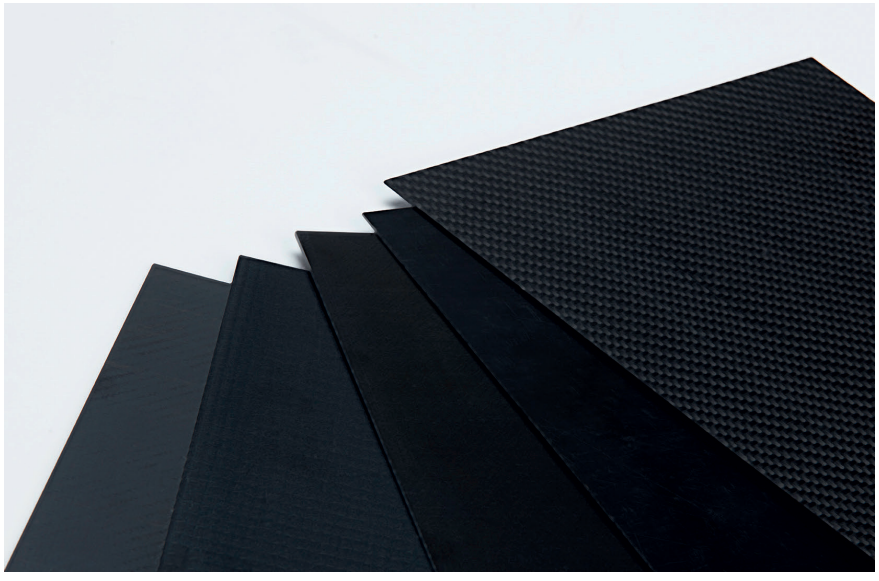

**Fig. 1.** The composite material StyLight has a low weight and high rigidity and is easy to process. Since it can be used to create attractive surfaces, automotive manufacturers use it in vehicle interiors © Ineos Styrolution

show a comparably slow change of melt viscosity with temperature. This benign rheological behavior is beneficial for processing as well.

Examples of styrene polymers are:

- Polystyrene (PS) is being used as crystal clear, stiff, but brittle homopolymer general purpose polystyrene (GPPS) or as impact modified, stiff but opaque (high) impact polystyrene (HIPS).
- Styrene-acrylonitrile copolymer (SAN) is a transparent, stiff and thermoplastic polymer material with enhanced stress cracking resistance. SAN is based on the monomers styrene and acrylonitrile.
- Styrene-methyl methacrylate copolymer (SMMA) is a transparent and brittle polymer with enhanced scratch resistance compared to that of polystyrene (GPPS). It is often used in blends with styrene-butadiene copolymers (SBC) for clear and tough goods, which need enhanced scratch resistance.
- Acrylonitrile-butadiene-styrene copolymer (ABS) is an opaque, ductile and stiff thermoplastic polymer with a broad processing window, which is strong and durable even at low temperatures, with good resistance to heat and chemicals.
- Methylmethacrylate-acrylonitrile-butadiene-styrene copolymers (MABS) are transparent, ABS-like materials with improved resistance against fats and oils compared to acrylonitrile-free styrenic polymers.
- Acrylonitrile-styrene-acrylate copolymer (ASA) is a product similar to ABS, but with excellent weatherability because of the use of butyl acrylate rubber containing no double bonds compared to butadiene rubber. It is widely used for automotive exterior parts (mirror housings, grilles, and so on) and for other outdoor applications in the area of sports/leisure and durable electrical and electronics (E&E) housings.
- Blends: polystyrene blends homogeneously with polyphenylene ether (PPE) to yield high temperature resistant, stiff and tough materials (polyphenylene ether (PPE/HIPS). ABS and ASA blend well with polycarbonate (PC) and PA to yield PC/ABS, PC/ASA, PA/ABS and PA/ASA blends combining the excellent thermal properties of the engineering thermoplastics PC and PA with those of ABS and ASA.
- Styrene-butadiene copolymers (SBC) are transparent, stiff and tough polystyrenes manufactured by a specific anionic process. SBC are widely used in food packaging (beakers, multilayer co-extruded and thermoformed "modified atmosphere packaging" or shrink sleeves). They are different from styrene-butadiene rubber (SB) made by similar technologies, which have rubber-like properties. They also need to be differentiated from »

(crosslinked) styrene-butadiene latexes, which are used, for example, as paper sizing dispersions.

Styrenic polymers offer many industries a wide variety of benefits, including:

- Lightweight, water resistant and excellent thermal insulation.
- Rigidity, with a high strength-to-weight ratio that offers energy-savings benefits in transportation and an excellent cost performance.
- Can be impact resistant and transparent if required.
- Good electrical insulation.
- Easy to process and produce in a range of attractive colors.
- Easy to recycle.

**Fig. 2.** Styrenics are very well suited for medical equipment due to their mechanical strength and stiffness, their chemical resistance and the possibility of transparency



Demand for styrenics specialties continues to grow globally, leading to the construction of new production sites. One example is the construction of a new 100 kt ASA (acrylonitrile styrene acrylate) plant in Bayport, TX/USA. Ineos Styrolution GmbH, Frankfurt am Main, Germany, hosted a groundbreaking ceremony for its new 100kt ASA plant in Bayport. The development of the new site is part of a bigger expansion plan for the Americas, which includes increased ABS (acrylonitrile butadiene styrene) capacity at the Altamira site in Mexico, while transition the ASA production to the new site in Bayport.

## *New Process for Transparent Blends*

The dynamics around styrenics is not only related to increased production capacities, but also related to new developments. In a cooperation between Fraunhofer LBF Institute, Darmstadt, Germany, and Ineos Styrolution, a novel styrenic polymer structure for transparent, ductile materials was developed. This fundamentally new structure paves the way for new transparent materials offering properties such as weatherability, toughness and stress crack resistancy. New developments can be expected in the near future.

Styrenic polymers are widely used for the transportation industry. They are used for interior and exterior car applications, for two-wheelers, trucks and agricultural vehicles. Four materials stand out in particular: Novodur Ultra 4255 and H701 have been developed to become the materials of choice for interior automotive applications. Exterior automotive applications take advantage of Luran S materials which provide a perfect surface even for high gloss aesthetic applications. It can be combined with the hot stamping technology and helps to reduce production cost.

Luran S also makes inroads into the development of new electric and hybrid vehicles. An example is Lixiang that builds unpainted exterior applications with the help of the AS) material. For Lixiang, Beijing, China, the enhanced UV resistance and lasting premium high gloss appearance with mold-in pitch black color of the ASA grade were the key criteria to selecting this material for its front grill application. The SAN based composite StyLight is also making inroads into the automotive industry (**Fig. 1**). This composite has been validated by ARRK Shapers, La Séguinière, France, for interior applications, becoming a serious option for future applications. StyLight combines exceptional light weight with stiffness, aesthetics, processability and stability.

Styrencs specialty polymers can also be found in the healthcare industry (**Fig. 2**). Styroflex 4G80 paved the way towards a full-styrenics IV. Together with medical technology providers, the company works on the next generation of drip chambers, e.g. based on Styrolux 4G60.

Terlux and Zylar are excellent materials for Luer locks and IV connectors. These materials exhibit excellent transparency, good mechanical strength and stiffness and excellent chemical resistance/good environmental stress cracking resistance (ESCR) and bonding performance. In addition, the good processability of these materials make them excellent materials for both complicated and multicavity tooling.

## *Growing Demand in Medicine*

For superior stiffness of IV Spikes, Ineos Styrolution has developed Novodur HD M203FC G3 with 16 % glass fiber content. It offers easy moldability, excellent property retention after gamma-radiation, E-beam, $NO_2$ or ethylene oxide sterilization, and excellent bondability.

ABS materials such as Novodur HD offer a well-balanced mix of properties that make them the material of choice for a range of casing applications. The ABS (acrylonitrile butadiene styrene) copolymers offer good impact strength, dimensional stability and heat resistance and colorability. The material is a good fit for applications such as inhalers or injector pens. They are also used for the segment of wearable devices. This segment is growing due to an aging population resulting in an increasing number of home devices. Mobile devices also help clinicians in their daily work, e.g. with long-term blood pressure measurement devices.

The new Zylar 631 is a member of the MBS (methyl methacrylate butadiene styrene) family of materials. It offers a good balance of stiffness and toughness combining a good surface hardness with

clarity. In the Americas, US FDA filing is completed, UL status HB 94B confirmed, Technical and safety data sheets are available. This makes the material ready for healthcare applications such as medical tray racks or syringe valves – just to name a few.

## *Packaging Made of Bio-Based SBC*

The portfolio of styrenics solutions for the packaging industry is rather broad. It ranges from rigid food packaging across shrink sleeves and cosmetic packaging to flexible film packaging and stretch hood solutions. Rigid food packaging solutions are mainly based on polystyrene or selected SBC grades. They are convenient and functional, they are food-contact compliant and they extend the shelf life of packaged food products.

Shrink sleeves are based on SBC materials like Styrolux. They provide tailor-made solutions for high ultimate shrink and medium shrink film with superior surface quality and printability. Flexible film packaging preserving content in the most natural way is based on Ineos Styrolution's SBC (styrene-butadiene copolymers) solutions Styrolux and Styroflex. These materials are also available now as part of the company's ECO family, based on a substitution of fossil source styrene with an RSB-certified bio-attributed styrene.

Stretch hoods are the solution for excellent load stability during transportation and protecting goods against all environmental stress in pallet packaging.

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

Styroflex PG77 is perfectly suited for these applications due to its great elasticity and impact resistance (**Fig. 3**).

In an industry where elegance and beauty must be reflected in product design and surface quality, both transparent and opaque specialty materials offer premium aesthetic solutions. Elegant surfaces and visual effects can be obtained with materials including Luran, NAS, Terlux, Zylar (all transparent) and Novodur (opaque).

Most of the styrenics specialties product families contribute to the construction industry (**Fig. 4**). Solutions range from chrome plated ABS used, for example, for fixtures such as shower heads, across window profiles to thermally optimized plastic spacers for insulating glass. The alpha-methylstyrene-acrylonitrile copolymer (AMSAN) Luran High Heat and ABS Novodur High Heat enhance extruded PVC stability of increased temperatures (e.g. PVC profiles for roller blinds). Being well compatible with a broad range of polymers, SBC materials are transparent modifiers for flexible flooring.

## *Attractive Aesthetics*

Styrenics are used in a wide range of household devices. They all benefit from the attractive aesthetics that styrenics is widely appreciated for. Small appliances such as water filters, coffee machines »

**Fig. 4.** ASA-based window front: styrene copolymers are most frequently used in the construction industry © Shutterstock

or various kitchen processors take advantage of a range of ABS. The same materials are deployed in washing machines or other big domestic appliances. PS and ASA materials are typically the materials of choice for refrigerators. Other applications taking advantage of styrenics are thin-walled applications such as in air-conditioning devices, vacuum cleaners and coffee machines.

NAS is also the material of choice for premium glassware such as the new collection of Golden Dragon, Indonesia (**Fig. 5**). NAS 30, a styrene acrylic copolymer, delivers sparkling clarity and possesses alcohol resistant properties. Due to its low density, NAS 30 also contributes to the lightness of the glassware as compared to classical produced glass. Meeting the wide range of regulatory specifications makes NAS an excellent material of choice for food contact applications. The SMMA (styrene-methyl-methacrylate) material is used across multiple applications such as water filters, glassware, coffee machine water containers and food containers.

## *Good Impact and Chemical Resistance*

Styrenics can be found in several electronics markets. They are the material of choice for communication devices, computers and office equipment, consumer electronics as well as for switches and charging solutions. ABS materials and even the composite StyLight mentioned already above are typical materials for mobile phones due to their superior processing abilities, surface quality, good impact and chemical resistance.

Optimized for electronic antenna housings, SAN and ASA materials as well as the composite StyLight offer key benefits such as superior weatherability, stiffness and low processing temperatures, low specific gravity and low moisture absorption. Other applications suitable for styrenics materials include wi-fi router housings, housings for PCs and monitors from affordable to advanced high-end solutions ensuring required properties and design.

Peripherals benefit from a variety of ABS and ASA materials. Styrenic solutions are typically selected since they offer a good balance of impact strength and processability, and only moderate absorption of high frequency electromagnetic radiation. In consumer electronics, styrenics are present in TV sets, gaming devices, set top boxes and security systems. Benefits of the materials range from easy processing across high surface quality to heat resistance and impact strength. ■

**Fig. 5.** The Indonesian manufacturer Golden Dragon uses NAS for its drinking glasses © Golden Dragon

## The Authors

**Dr. Norbert Niessner** is Director Global R&D und IP at Ineos Styrolution.

**Peter Weinkötz** is Director Product Management Specialties EMEA at Ineos Styrolution.

**Marcela Villegas** is Director Product Management Transparent, EMEA at Ineos Styrolution.

## Service

### Digital Version

- A PDF file of the article can be found at ***www.kunststoffe-international.com/2020-8***

### German Version

- Read the German version of the article in our magazine ***Kunststoffe*** or at ***www.kunststoffe.de***