Polycarbonate (PC)

The Hotspot of Asia is Driving Global Consumption in Molding Compound, Sheet and Film

Almost two thirds of global polycarbonate sales are made to the Asian economic area. The growth drivers are the automotive industry, the electrical and electronics industries and health care. Applications for lightweight design using continuous fiber-reinforced composites, and additive manufacturing processes such as 3D printing are showing great potential. In the integration of displays, films play a key role in new concepts for the automotive interior.

The nocks at the end of the bow transfer the kinetic energy of the bow directly to the arrow. They are manufactured from the PC Makrolon 2805 by the company Werner Beiter
(© Günter Kuhr)

Global PC consumption has been showing satisfactory growth for about three years. The growth rates are clearly showing a positive trend. The global PC market was estimated at over 4 million t in 2016. By 2021, it will grow by roughly 4 % annually on average to about 5 million t, according to the estimates of various market institutes. These figures not only reflect the good prospects for the plastics business, but also demonstrate that new applications have compensated for the decline in sales of optical data storage media. In the boom years 2006 to 2008, they still represented about 25 to 30 % of total PC demand. Currently, their share has fallen back to about 8 %.

PC is a high-performance polymer that, besides being employed in some large fields of application, is also used in a wide variety of niches. In 2016, the biggest consumer was the electrical and electronics industry, with a share of 34 %. The consumer goods, household appliances, packaging and medical manufacturers together held a share of 26 %, followed by the automotive and construction industry with 19 and 13 % respectively. The biggest PC consumer worldwide in 2016 was China again with a share of 38 %, followed by the Europe, Middle East and Africa region (EMEA), as well as the NAFTA area (incl. Latin America) with 25 and 15 % respectively. Japan had a share of 7 %. The other Asian-Pacific countries were responsible for 15 % of consumption.

The global PC market has coped well with the consolidation and restructuring measures of recent years. For example, since 2013 plant closures in the USA (Dow/Trinseo), Japan (Idemitsu), Singapore (Teijin) and Brazil (Unigel) have removed about 400,000 t capacity from the market. However, these losses were quickly offset through investment in China – currently

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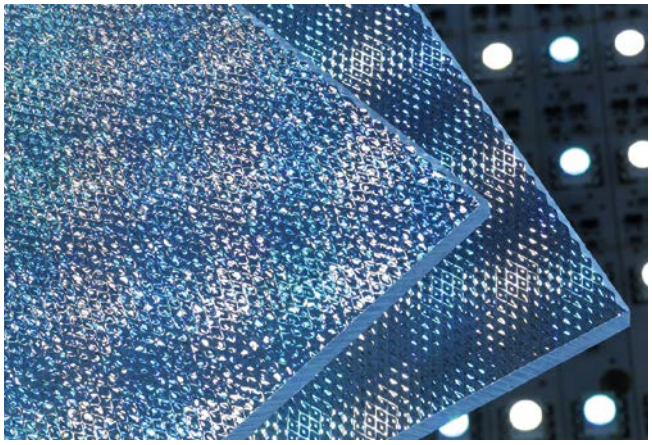

Fig. 1. The distinctive feature of Makrolon SX Shark is the domed microprism optics on one side of the sheet and the glossy surface on the other (© Covestro)

this is also held by new market players. For example, Ningbo Zhetie Dafeng Chemical and Luxi Chemical operate new production sites and are planning expansions. The plants of other Chinese competitors, such as Heng Yuan Chemical, Lihuayi Weiyuan Chemical and Wanhua Chemical are under construction and will successively commence production in coming years. Other Chinese companies have also announced their entry into the PC business. Besides China, there is also increased investment in higher capacities in Korea – for example in Yeosu by the »

the fastest growing regional market at over 5 %. The biggest share of this was held by Covestro. In October 2016, the company doubled its capacity at its Shanghai site to 400,000 t/a, thereby becoming the world's biggest PC manufacturer with a total capacity of 1,480,000 t/a. Covestro plans to further increase PC production in Shanghai significantly to 600,000 t/a. This quantity is scheduled to come onto the market in 2019.

Global Presence, Local Service

The success of a PC manufacturer stands and falls by its global production network. This enables it to supply the most important regional markets reliably and quickly with products of a uniform, high and constant quality. It is just as important to have globally networked R&D centers, providing customer-specific technical services locally to internationally active project partners at their development centers around the world. Because PC has many applications that are subject to strict optical specifications, coloring and design centers are indispensable for picking up the latest trends and helping processors design their components. Covestro has oriented its PC business according to these key strategic parameters.

Asian Compounders and Distributors Look to Europe

Currently and for the near future, global PC capacity will grow in a balanced way and track the expected market growth. In China, a share of

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Fig. 2. Due to the PC HT+ABS blends, LEDs can be integrated into the exhaust trim to make the part more attractive (© Covestro)

Korean company Lotte Chemical. It goes without saying that the Asian companies are not only eyeing the demand in their own countries.

The trend is continuing for Asian PC compounders and distributors to involve themselves in Europe in order to become more independent of their own local markets. PC manufacturers from Japan and Korea (e.g. Lotte Advanced Materials, Samyang Kasei, LG Chem) have been active in Europe for some years with their own compounding capacity, or in cooperation with local contract manufacturers. Besides electrical and electronics applications, they are also focused on specialties and automotive. In 2016, Kingfa was the first Chinese plastics finisher to open a production site at the Kalle-Albert industrial park near Wiesbaden, Germany.

LED Lighting Systems – a Growth Market

LEDs are advancing rapidly around the world as very economical light sources, and replacing conventional light sources – in vehicles, buildings, street lighting and displays. This especially benefits PC. The reasons for this are its thermal stability, transparency, design flexibility and low weight – with not only pellet stock, but also sheet and film as starting material. It replaces materials such as glass, metals and thermosets. Typical injection molding applications include LED lamp covers, optics, focusing elements and waveguides. PC films permit a very flat, compact part design – for example LED-backlit displays. PC sheets are used to make large-area parts that deflect, scatter or reflect light, or perform a combination of these functions. A new development with applications, for example, in LED office lighting, is Makrolon SX Shark from Covestro (**Fig. 1**). The sheet has curved microprism-optics on one side and a glossy surface on the other. Consequently, it is both highly light transmitting and light scattering, and can thus be used to provide non-glare, bright light. With Markofol LM, a wide portfolio of light management films are available, which scatter light (diffusor films) or selectively guide or deflect it, or, as reflection films, improve the efficiency of lighting units.

The design freedom of PC is also used to manufacture geometrically complex but lightweight LED heat sinks. Appropriate heat-conducting, flame-retardant grades are now available. An example of such a material is Makrolon TC8030. It has a thermal conductivity of 20 W/m·K, and offers an alternative to aluminum if its high thermal conductivity is not required.

3D Printing – a Future Market

Additive manufacturing processes are well on track to be used for the efficient mass production of complex or individualized plastic parts in the future. Covestro is therefore currently building up a wide assortment of filaments, resins and powders for various processes. In addition, the company has set up a 3D printing lab in Leverkusen, Germany, for developing and testing material solutions together with partners. Filaments based on PC from Covestro are characterized by very good thermal stability and hardness. 3D printed products from these filaments are used in lighting and industrial housing components, as well as in other applications where high strength even under hot operating conditions is required.

Plastic Exhaust Trims

Copolycarbonates of bisphenol A and bisphenol-trimethylcyclohexane (BP-TMC) have gained an established place, for example in automotive engineering and medical and safety technology. For example, Apec (PC-HT) from Covestro is used to manufacture thermally stressed components of car headlamps, superheated-steam-sterilizable housing components of disinfection systems or flame-retardant visors of safety helmets. Tailored material developments are also capturing new applications that would not normally be considered suitable for plastics due to the extreme service conditions. One example of this is the new electroplatable PC-HT+ABS blend Apec 150 PG, which is intended for manufacturing chrome-plated, extremely thermally stressed components. The material was created for a project by Gerhardi Kunststofftechnik GmbH, Lüdenscheid, Germany, with the aim of replacing stainless steel with plastic in the production of car exhaust trims. The trim material, with a Vicat B softening point of 146 °C, is not only a match for the heat specifications but also offers great design flexibility as regards part geometry, functional integration and color. The exhaust trims made from the blend are also only half the weight of their sheet-steel counterparts (**Fig. 2**). Other possible applications include logos, emblems, lettering and covers.

Thermoplastic Composites

A relatively new application of PC, which several plastics suppliers are focusing on, is continuous-fiber-reinforced thermoplastic composites (CFRT). It can be used for housing components of mobile elec-

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tronic equipment, such as tablets, notebooks, and smart phones, to make them thinner, lighter and at the same time more robust (**Fig. 3**). Covestro has developed the appropriate tapes and sheets unidirectionally reinforced with carbon fibers and suitable for economical flexible mass production in short cycle times. They have a suitable strength-weight ratio compared to conventional composites, even exceeding metals. They have an attractive grained surface with an organic appearance, and are cool to the touch. They also have good application opportunities in automotive lightweight design – for example for door trim, backrests and body parts for cars, or interior and exterior trim for buses, railcars and trucks.

Fig. 3. A new composite technology allows thin-walled housings and other components of portable electronic equipment to be manufactured efficiently (© Covestro)

Mobility in Transformation

The major trends in automotive engineering, such as electromobility, autonomous driving or individualization of the car interior, will expand and change PC's range of applications in the car. The advanced solutions that will be opened up by thermoplastics in the exterior design, for example of electric cars, is underscored by a vehicle concept that Covestro has developed in collaboration with design students and partners from the auto industry. Lightweight all-round PC glazing seamlessly incorporating the transparent A-pillars ensures an unhampered view with no "blind spots". A new concept for car lighting was developed together with Hella KGaA Hueck & Co., Lippstadt, Germany, for the K trade show last year, in which different light functions are compactly incorporated into body parts in the front and rear sections. The headlamps and tail lamps are seamlessly integrated into illuminated surfaces. The concept builds on an innovative solution based on holographic Bayfol HX films. This allows various light functions to be integrated into body parts, opening up new possibilities for the use of light as a design element. Furthermore, tailored »

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Fig. 4. The display and surface demonstrator shows how displays can be seamlessly integrated into the large-area, three-dimensionally shaped surface of instrument panels (© Covestro)

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Market Information

All the market information is based on Covestro's own assessments and estimates, additional information about investments and technical developments from its own company and from press information from the companies mentioned.

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PC materials permit a good transmission of Lidar signals and the homogeneous integration of sensors.

Large, Elegant 3D-Displays

In new car interior concepts, PC films fulfil important functions indirectly resulting from the future trends of connectivity, individualization and e-mobility. The films may be provided with matt or high-gloss, light-guiding or especially anti-glare properties, or have textured surfaces. The combination of "black-panel" films with smart printing technology allows black panel effects to be achieved in the component décor. PC films additionally permit the various displays in upcoming vehicle generations to be integrated into the large-area 3D surfaces, such as instrument panels, center consoles and seat backs (**Fig. 4**). For such applications, Makrofol HF backprinted and 3D-formable films with a scratchproof, chemically resistant coating have been developed. This coating is finally cured with UV light only after the film insert has been formed and before back-molding. In combination with functional films, electronic switching functions or sensors, for example, can be directly integrated into the component to save both costs and space.

Design Flexibility and Renewable Raw Materials

Another process-engineering "response" to the trend towards new car interior concepts is the DirectCoating/DirectSkinning process (see also ***Kunststoffe international 9/2016***). It has since been developed to maturity by a number of material and machine manufacturers and can produce individualized car interiors with a quality look with creative design and cost-efficient manufacturing. The component is produced in a two-step process in the injection mold with no need for secondary finishing. First, a carrier part is injection molded, which is then decorated with polyurethane (PU) in a second cavity by reaction injection molding (RIM) technology. There is no need for an expensive separate painting step.

The PU coating opens up a kaleidoscope of possibilities for optical and tactile design of the component surface. It may be given a high-gloss piano finish with matt gradations, with a scratchproof and/or textured surface. Metallic effects and adjacent, sharply delineated matt and high-gloss areas are also feasible. For this process, Covestro has developed tailored PC and PC blend grades and PU coating raw materials, which are part of an integrated material concept for designing the car interior.

Finally, it is worth taking a look at bio-based and renewable raw materials. PC grades based on sugar-derived isosorbide have applications in the market. For example, the transparent Durabio from Mitsubishi Chemicals is used for touch displays, instrument panels and in decorative body parts. ■

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