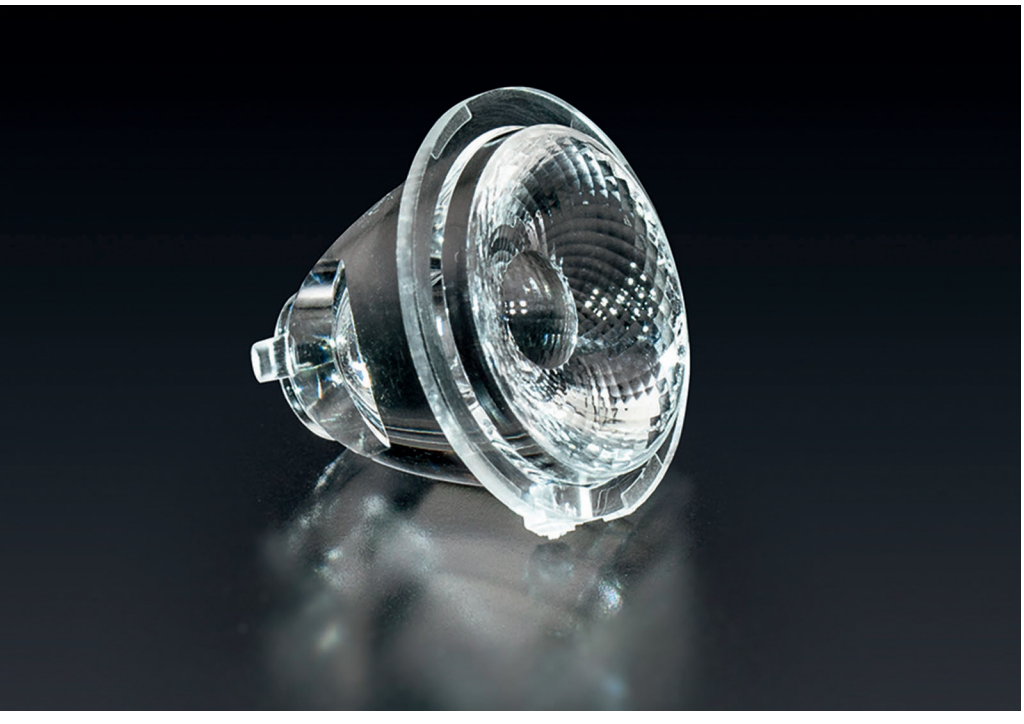
Polymethyl Methacrylate (PMMA): Turbulence in Key Industries

Despite Raw Material Shortages, the Signs for PMMA Point to Growth

Even though growth has fluctuated since the beginning of the corona pandemic, the development of the global PMMA market is predominantly positive. The strong demand for PMMA is based on the continually expanding diversity of applications. These include durable products that score highly in terms of sustainability as well as articles in which light is used as a design element.



Design trend light: in the TIR lens LFO by Bartenbach and kdg Opticomp made of a Plexiglas PMMA of Röhm, the surface of the lenses is structured using free-form surface facets in such a way that the light appears homogeneous. © kdg Opticomp GmbH

The beginning of the corona pandemic was a globally critical event that also affected the PMMA market. Although in 2021, around 2.1 million t of PMMA molding compounds and semi-finished products were sold, the market still has some catching up to do and has not yet returned to pre-pandemic levels of 2.2 million t. The industry is concerned about continuing additive and raw material bottlenecks, increased energy and logistics costs, and long delivery times. Nevertheless, the signs for the PMMA market point to growth, especially through new and diverse applications in the automotive, electrical and construction industries. The focus is also on the circular economy and climate protection.

Fluctuations during the Pandemic

Over the past two years, the PMMA market has sometimes behaved contrary to the prevailing economic trend. At the beginning of the pandemic, in early 2020, global economic output slumped by 3.1 %, but the overall PMMA market saw growth of around 2 %. The semi-finished products sector saw a sharp increase in demand for standard transparent protective screens in the first year of the pandemic, while the PMMA molding compounds market experienced a noticeable decline, especially in specialty applications. In 2021, on the other hand, global gross domestic product rose significantly by 6.1 %, while at the same time demand for PMMA molding compounds picked up again. However, the PMMA semi-finished products market was still struggling with the effects of the pandemic and the overall market recorded a decline.

One reason for these fluctuations is closely linked to the corona virus: transparent protective screens made of PMMA very quickly became ubiquitous in retail outlets, the catering industry, and public buildings. They help to minimize the risk of infections and break chains of infection. Demand for PMMA semi-finished products skyrocketed. This led to a boom in the PMMA market and ensured growth in 2020. In the course of 2021, however, market saturation was reached for protective screens. With the development of vaccines, demand for protective screens collapsed.

Other sales markets were also subject to strong fluctuations during the pandemic. For example, trade fair and shop fitting business came to a complete standstill due to the restrictions in the first year of corona – and with it the demand for displays and point-of-sale

materials. In 2021, this sector recovered in line with the easing of restrictions but without reaching the level of previous years.

The construction sector brought positive effects during the pandemic: the global construction boom continued unaffected by the corona restrictions. Especially in the private sector, demand for construction elements made of PMMA, such as for kitchens and furniture, but also for transparent roofing continued unabated. The PMMA market for optoelectronic applications was also relatively robust. During the pandemic-related lockdowns, demand for consumer electronics increased again compared to previous years. As a result, the demand for optical components made of PMMA was also high.

The global automotive industry was very negatively impacted by the effects of the pandemic. Repeated lockdowns, short-time working as well as quarantine and illness of the workforce led to a decline in global vehicle production of almost 16 % in 2020 compared to the previous year. This also meant a harsh cut for the PMMA market, with its diverse automotive applications. The lighting industry also experienced declines due to lockdowns and production shutdowns but demand recovered relatively quickly here.

Worldwide, there were significant regional differences in PMMA sales. At the beginning of 2020, Asia was the first region to be affected by corona and its consequences. However, demand stabilized relatively quickly in the second half of the year. In Europe, on the other hand, but also in North, Central, and South America, the impact of the pandemic hit later but the effects lasted much longer. The Asia-Pacific region continues to be the largest market for PMMA molding compounds, due in particular to the high demand in the Chinese market, which has a share of some 40 % of the total market. Two-thirds of global demand comes from Asia, followed in equal parts by Europe and the Americas (North, Central and South).

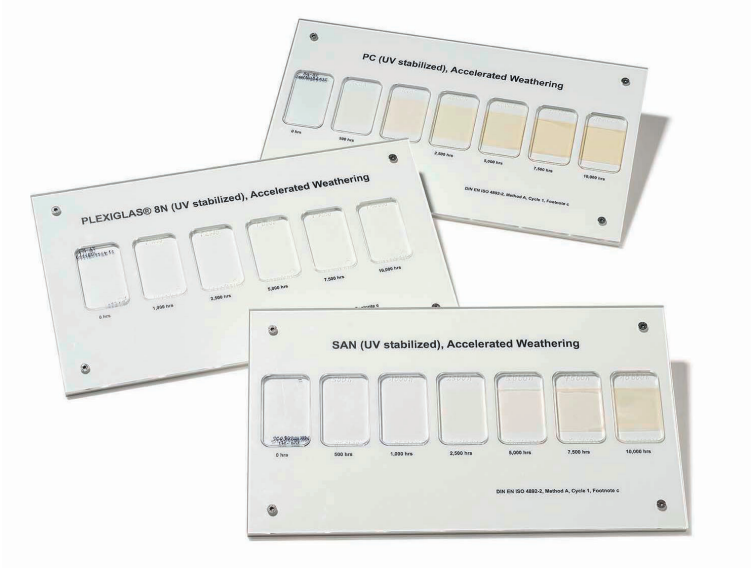


Fig. 1. Crystal-clear PMMA standard molding compounds of the Plexiglas brand show very good aging and weathering resistance in weathering tests. © Röhm GmbH

Positive Trend with Some Dark Clouds

Overall, the PMMA market is poised for growth. Since the end of 2020, economic development has been improving in many industries that had previously suffered setbacks. For example, sales of motor vehicles picked up again in 2021, although they remain below pre-pandemic levels. Despite subdued automotive production figures, a positive effect on the PMMA market can be seen. The average weight of PMMA per vehicle has increased significantly in recent years due to a constant stream of new applications and ever larger compo- »

Fig. 2. The company Algoliner has developed a mobile PMMA extrusion line that enables resource-saving photobioreactors to be installed at almost any location. © Algoliner

Info

Text

Monika Juda is employed in Global Market Intelligence Management,
Thomas Kern works in Global Communications,
Sven Schröbel is Head of Global Sustainability Management,
all three are in the Molding Compounds Business Unit of Röhm GmbH.

Digital Version

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

German Version

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

nents made of PMMA, as well as replacement of other plastics. However, the positive trend has been clouded by the shortage of raw materials, especially in the semiconductor industry. A bottleneck in the production of microchips (important components in many applications) slowed down the catch-up effect in some industries.

The prospects for the development of the PMMA market are quite positive due to the variety of industries and new applications – however, the war in Ukraine is currently making accurate forecasts difficult, especially for the European market. In addition to rising energy prices, the conflict is increasing existing raw material and supply bottlenecks. Corona has not yet been overcome either: bottlenecks in global supply chains are still to be feared – due to new lockdowns, for example as a result of the zero-Covid strategy in China. All this will continue to pose major challenges for the logistics industry and production companies in the future.

Continued Bottlenecks in Raw Materials

The additives and raw materials market was also subject to fluctuations in the first two years of the pandemic: the decline in demand in the MMA market and PMMA molding compound market in 2020 took the pressure off and ensured good availability of raw materials. However, 2021 was again marked by a large number of bottlenecks. Among other things, MMA and MMA precursors, such as acetone, as well as polymerization aids were affected. The result was once again massive cost increases: for example, the price of MMA as a raw material rose by 37 to 67 %, depending on the region (see ICIS MMA Index). Particularly in Europe and America, price increases were at the upper end of the scale.

In contrast, the PMMA market remains well positioned on the supply side, although there have been some changes in the competitive structure. Arkema S.A. sold its methacrylate business in Europe and America to Trinseo LLC. However, Arkema S.A.'s PMMA production site in Korea was not part of the sale and was closed in mid-2021. As a result, there have been slight shifts in the PMMA producer landscape: Mitsubishi Chemical Methacrylates Ltd., formerly Mitsubishi Chemicals Co., Ltd., continues to lead the ranking as a long-standing leader, followed by Röhm GmbH, and Sumitomo Chemical Co., Ltd. In total, these three providers account for around 40 % of global PMMA capacity.

Where Producers Are Expanding their Production Capacities

In order to respond to the expected increase in demand for PMMA, producers are further expanding their global capacities. In recent years, the expansion of capacities has focused on Saudi Arabia and China. Röhm GmbH is currently expanding its production facilities for PMMA molding compounds and impact-modified PMMA molding compounds at its sites in Germany (Worms) and China (Shanghai). A further expansion in production for China, the world's largest sales market, is expected in the coming years. More than half of China's demand is still covered by imports – despite massive capacity expansions for PMMA in recent years.

The strong demand for PMMA is based on the continually expanding diversity of applications. New market opportunities are currently emerging here in connection with the pursuit of a more sustainable and climate-neutral future. High efficient plastics can make an important contribution here. For example, light guides made of PMMA have been part of energy-saving LED lighting for many years and help reduce power consumption in supermarkets and sports arenas, for example. In these and many other applications, PMMA excels as an extremely durable material on account of its outstanding weather resistance (**Fig. 1**). With this longevity, the material enables applications with a long service life and so contributes to careful use of resources. For example, PMMA is ideal for the production of bioreactor tubes for algae cultivation, in which its unsurpassed light transmission of 92 % is maintained long-term, even outdoors (**Fig. 2**). If all components of the algae reactor are also made of PMMA molding compound, they could be recycled together at the end of the plant's life cycle. Such a sustainable product design significantly improves

recyclability, as no foreign plastics have to be sorted out before the recycling process.

In principle, when the component has reached the end of its life cycle, PMMA can be recycled several times without significant loss of properties. However, in mechanical recycling processes, homogeneous separation must be ensured.

Homogeneous Separation Remains a Major Challenge

Recycling processes have already established themselves in the post-industrial sector, for example the collection of edge trim and sprues. Here, manufacturers have recycled materials with different proportions of recyclates in their portfolio: for example, Plexiglas proTerra is a co-extruded sheet material with a core of PMMA recyclate and outer layers of virgin material. Consequently, the material has the proven properties of acrylic glass of the Plexiglas brand, such as high-gloss surface, light weight, and good processability.

In the post-consumer sector, on the other hand, the collection infrastructure is currently being developed but is complicated by the long use phase and diversity of applications. There is potential here for single-polymer applications that are easy to collect – for example, the currently ubiquitous hygiene protection screens could be very suitable for the circular economy.

Greenhouse Gas (GHG) Protocol

The GHG protocol is a globally recognized standard for the measurement and management of greenhouse gas emissions by companies and their value chains. The GHG Protocol Corporate Accounting and Reporting Standard provides guidance to companies on how to quantify and report emissions.

Scope 1: Direct emissions from sources that are directly owned or controlled by the companies. These include emissions from energy sources such as natural gas and fuels as well as from coolants and the operation of boilers and furnaces. Scope 1 also includes emissions from the company's own fleet.

Scope 2: Indirect emissions from purchased energy such as electricity, steam, district heating or cooling, which are generated outside the company's own system boundaries but consumed by the company.

Scope 3: Indirect emissions generated along the value chain. Although these emissions are not controlled by the company, they may well account for the largest share of greenhouse gas emissions.

The GHG Protocol requires its users to record their company's emissions under Scope 1 and 2, while recording of emissions under Scope 3 is voluntary but recommended.

	Name of the program	Target by 2030	Target by 2050	Base year	Included scope
Mitsubishi Chemical Methacrylates Ltd.	Kaiteki Vision 2030	- 32 % GHG	Carbon neutral	2019	■ 1, 2
Röhm GmbH	Track 2030	- 30 % CO_2 per manufactured tonne	Net zero (all GHG)	2020	■ 1, 2, 3
Trinseo LLC	–	- 20 % GHG	No information	2017	■ 1, 2

Table. Targets for reducing CO_2 emissions. Source: Röhm

Where the Cycle Works Well: Backlight Units for Display Screens

A well-rehearsed process already exists, for example, for the collection and recycling of backlight units for display screens. These often consist of high-purity PMMA and are therefore suitable for chemical recycling. The MMA obtained in this way can be used again for the production of PMMA after purification and then has a significantly reduced CO_2 footprint compared to virgin material. This process clearly distinguishes PMMA from other materials from which precursors for monomer »

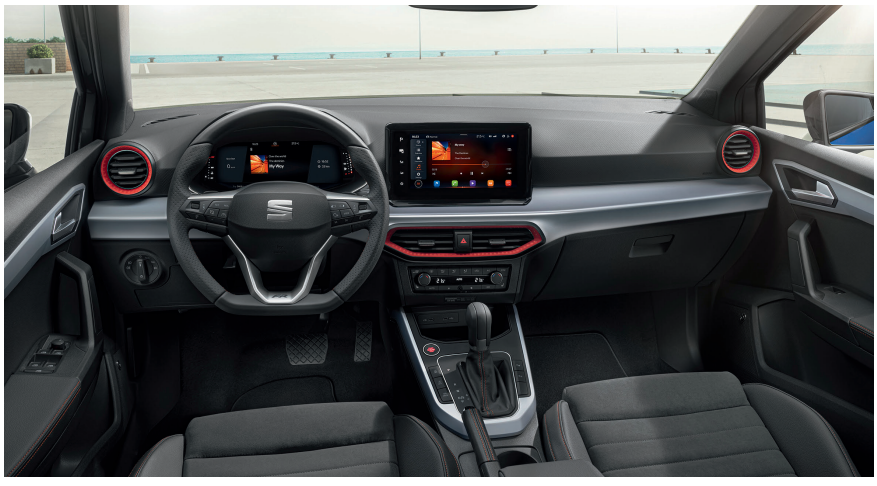


Fig. 3. The PMMA Plexiglas LED 8N LD12 provides luminous highlights in the interior of the new Seat Ibiza and Seat Arona. © Seat

production are produced in chemical recycling, such as pyrolysis oils.

Manufacturers are currently developing further processes for PMMA recycling, such as depolymerization of PMMA in twin-screw extruders. A well-known example here is the MMA-two project, in which 13 companies along the value chain are involved. The aim of the project is to convert post-industrial PMMA waste and end-of-life waste into high-quality raw materials, so contributing to the circular economy. PMMA industry leader Mitsubishi Chemical Methacrylates Ltd also plans to open a pilot plant for the thermal depolymerization of PMMA by 2023 with the American recycling company Agilyx Corporation.

In addition, PMMA manufacturers are working to significantly reduce their carbon dioxide emissions. For example, Röhm GmbH has set itself the goal of reducing the CO_2 footprint of the products it makes and sells by 30 % per manufactured tonne by 2030 compared to 2020. By 2050, Röhm wants to eliminate direct greenhouse gas emissions (Scope 1), indirect emissions from the purchase of energy (Scope 2), and indirect emissions along the value chain (Scope 3), so achieving climate-neutral production (**see Info Box p. 59**). Similar targets can also be found at other PMMA manufacturers such as Trinseo or Mitsubishi Chemical Methacrylates. Trinseo has set itself the goal of reducing its greenhouse gas emissions by 20 % by 2030 compared to 2017 levels. Mitsubishi Chemical Methacrylates, on the other hand, aims to achieve carbon neutrality by 2050 as part of its "Kaiteki Vision 2030". As an intermediate step, a reduction in greenhouse gas emissions of at least 32 % compared to 2019 is mentioned here (**Table**).

In many industries, the demand for resource-saving and recyclable materials is currently increasing. PMMA is a sought-after material in applications where weather resistance, color fastness, high brilliance and transparency as well as surface hardness and scratch resistance are paramount requirements. The material also offers particular advantages in terms of its optical behavior: PMMA has unique light transmission and light guidance. However, advances in lighting technology increase the thermal requirements for the materials used – various trends in product design also contribute to this, for example the use of high-performance LEDs in conjunction with smaller component depths. Until now, the higher heat deflection resistance required has often been achieved at the expense of optical quality.

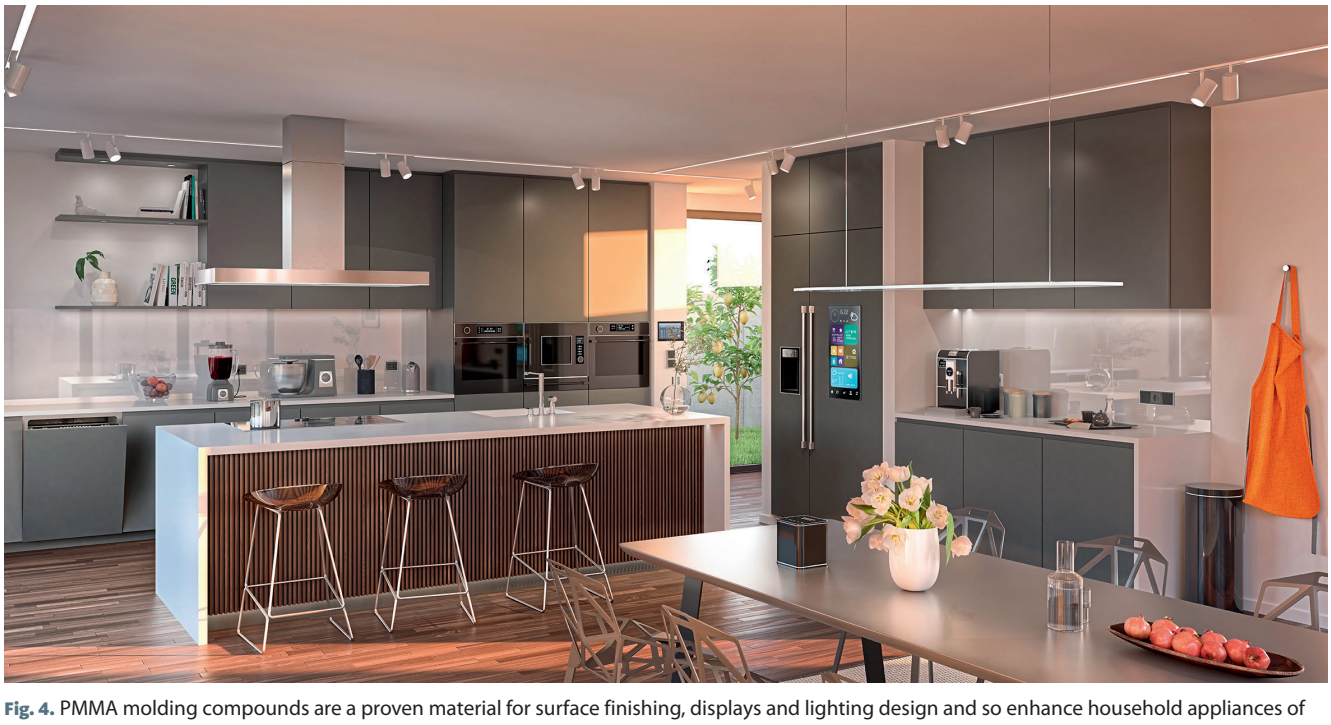


Fig. 4. PMMA molding compounds are a proven material for surface finishing, displays and lighting design and so enhance household appliances of all kinds. © Röhm GmbH

With Plexiglas Optical HT, Röhm offers an option here. The material withstands temperatures up to 105 °C – as evidenced by the RTI rating in accordance with the UL 746B standard – and permits a 15 °C higher long-term service temperature compared to the industry standard. This special molding compound was developed for applications with high-performance LEDs and for light guides with longer light path distances.

In Both Vehicle Interiors and the Home, Light Remains a Design Trend

Light as a design element is currently an omnipresent design trend: in vehicle interiors, illuminated trim strips, buttons or functional elements contribute to an atmospheric ambience (**Fig. 3**). In vehicle fronts, illuminated elements replace the usual chrome strips. However, this requires particularly robust, impact-modified PMMA molding compounds, such as Plexiglas Resist AG 100, as these components are exposed to increased mechanical stresses.

In household appliances, too, control elements such as knobs or buttons can be illuminated and symbols, logos or decorative surfaces can be backlit in color. PMMA variants with enhanced light scattering properties produce a homogeneous light here – without creating undesirable fluctuations in brightness or requiring additional scattering films or microstructures to be provided in the component. The household appliances then communicate with their users via light signals. A good example is the coffee machine, which indicates with a flashing symbol that it is currently preparing coffee.

However, light should not always be obtrusive. Even sophisticated Total Internal Reflection Lens Systems (TIR) can be produced from special PMMA molding compounds (**Title figure**), thanks to the high mold surface reproduction accuracy of these materials. Such lighting systems are installed almost invisibly in ceiling elements. The light from the LEDs is focused in the lens and then selectively directed depending on the chosen beam angle – for example, in a restaurant from a high ceiling down into a small area. However, it can also be spread pleasantly glare-free throughout the room.

Aesthetic Demands Are Increasing

Aesthetic demands are also increasing for household appliances. The kitchen is increasingly becoming a living area, so reinforcing the desire for high-end appliances that are technically state-of-the-art and look good (**Fig. 4**). PMMA molding compounds can contribute to this in a variety of ways – such as by enhancing the surfaces of household appliances with, for example, high-gloss or velvety matt effects. Because these molding compounds are also very suitable for co-extrusion, other materials can be provided with a top layer of PMMA, which creates a fascinating 3D depth effect. At the same time, the surfaces are robust, easy to clean, resistant to many cleaning agents and do not discolor when in contact with food. PMMA contributes to sustainable product design because it is an extremely durable plastic that permanently retains its high-quality appearance without yellowing or embrittlement. It goes without saying that household appliances should work well and continue to look good for a long time. So PMMA is a material for modern, sustainable design. ■