Polyvinyl Chloride (PVC): Specialties Lead to Improvements in Many Areas

Back on Growth Path

Following the demand slump in 2020 due to Covid 19, global PVC demand has picked up considerably. This is also predicted for the coming years – provided that the numerous worldwide crises are overcome. Product innovations, high infrastructure needs, and further alignment of the PVC value chain towards sustainability are the basis for successful development.

With a share of 26 %, PVC is the world's most widely used polymer in medical products [1]. © iStock; Sudok1

According to the Opis market research institute, worldwide production capacity for polyvinyl chloride (PVC) in 2022 is almost 61 million t – an increase of about 6 million t since 2018. With 56 % (+2 % compared with 2018), the largest share continues to be accounted for by North East Asia, with China as largest producer country. North America accounts for 16 % of worldwide capacity, followed by Western Europe with 10 %, meaning they have slightly lost ground. Both their shares dropped by some 1 % compared with 2018 (**Fig. 1**).

The first four places in the producer capacity ranking remain unchanged: first place goes to Shin-Etsu Chemical in Japan, followed by the US company Westlake with its European subsidiary Westlake Vinnolit. Place three goes to Formosa Plastics in Taiwan, and fourth place is held by Inovyn, which belongs to the Ineos Group. Orbia (previously Mexichem) in Mexico lost fifth place to the Chinese producer Xinjiang Huatai, putting it in place six (**Fig. 2**).

Six of the top ten producers come from Asia; three of them from China. With three companies, North America is also well represented. In terms of capacity, the only European company in the top group is raw materials producer Inovyn. However, the situation is completely different regarding research-intensive PVC specialties: with Inovyn, Westlake Vinnolit, Vestolit (part of Orbia), and Kem One, four European companies are represented in the top ten specialties producers [2].

Following a relatively weak year in 2020 due to the Covid 19 pandemic – with a worldwide PVC demand of 45.8 million t – sales picked up again considerably in 2021, and increased by

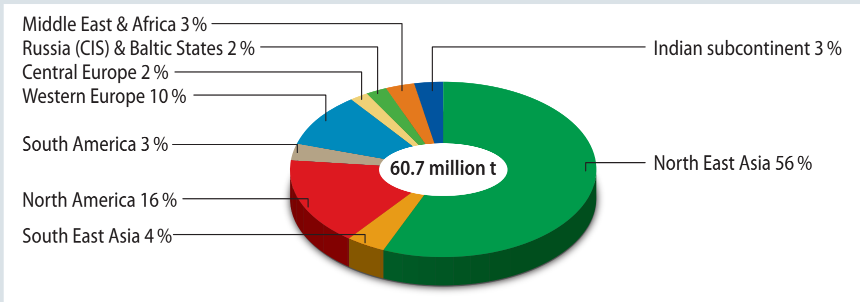

Fig. 1. Global PVC capacities in 2022 according to regions (total quantity 60.7 million t): with more than 50 %, North East Asia dominates the market. Source: Opis; graphic: © Hanser

5.5 % to 48.3 million t. However, average growth from 2018 to 2020 was only 1.3 %. With a market share of 45 %, pipes and fittings continued to be the largest application area, followed by rigid film and sheets (18 %) as well as profiles and tubes (16 %) (**Fig. 3**). Paste applications had a share of about 6 % of worldwide demand.

North East Asia Processes More than Half of Worldwide PVC

North East Asia has further increased its strong position, and once again was the largest demand driver in 2021, accounting for 51 % of worldwide PVC needs. With 12 %, North America had to settle for second place, while the Indian subcontinent and West Europe shared third place with 8 % each (**Fig. 4**).

Global PVC sales continue to have great importance. They amounted to 9.6 million t in 2021, corresponding to an increase of 2.4 % over the previous year [3]. With almost 3.9 million exported tons, North East Asia was able to exceed North America's 2.5 million t, and took top position. Also in the coming years, a fight for the pole position can be expected between these two regions, which could exceed an annual export volume of 4 million t each by 2026. With a total of 1.1 million t, West Europe again takes third place among exporters. The highest import demand was registered by the Indian subcontinent with 2.2 million t.

In 2021, the West European PVC market achieved a demand increase of 8.8 %, after just 0.2 % in 2020. After years of declining production capacities in West Europe, a positive trend can be seen since 2020, which will presumably continue in the next years. Also the utilization of production capacity increased from 79 % in 2020 to 82 % in 2021. Due to the high demand in Europe and the rising price level, West European exports shrunk from 1.4 million to 1.1 million t, with a simultaneous increase of imports by 37,000 t.

The overall market outlook predicts a growing PVC demand also for the coming years. The demand is there, but inevitably, all forecasts are subject to the reservations due to a global economy currently threatened by multiple crises. Should it be possible to overcome these crises step by step, the large global trends will continue to influence growth of the global PVC market – a growing global middle class with higher requirements and living standards, an increasing urbanization coupled with high infrastructure requirements, plus a more sustainable resource management and changed consumer behavior. For all of this, PVC is basically very well positioned as a resource-efficient, long-lasting, safe, and recyclable material – also in an increasingly circular economy.

The correlation between development of gross domestic product (GDP) and PVC growth still applies. An annual average GDP growth of 3.2 % is expected up to 2026, which should even be exceeded by an average increase of PVC demand of 3.5 % during the same period [3]. Consequently, PVC demand would grow by an average of 1.7 million t every year. In contrast, an average annual growth of only 2.7 % was achieved between 2014 and 2019. Increasing demand will continue to be influenced primarily by North East Asia and the Indian subcontinent. Both regions account for about 75 % of the growth. A comparatively low growth of 0.4 % for primary PVC is expected for West Europe. Hereby, part of the market growth will be covered by recyclates.

The thermoplastic material PVC is mainly processed as a polymer melt in common molding processes. Of particular importance hereby are » formulations ranging from hard to soft for extrusion into profiles, pipes, sheets, tubes, seals, and cables, as well as processing via calender into foils and films (e.g. pharmaceutical films, roofing sheets, etc.). As a major raw material, the processing mixtures used frequently contain suspension PVC types as well as a range of special PVC-based polymers for process modification or the final product properties. In addition, PVC processing offers the possibility of supplying special shaping processes with the liquid phase dispersed in plasticizers – so-called pastes or plastisols. Examples for this are dipping, spraying, brushing, or centrifuging. The PVC products used for this are specially produced, finely particled polymers, mostly based on an emulsion.

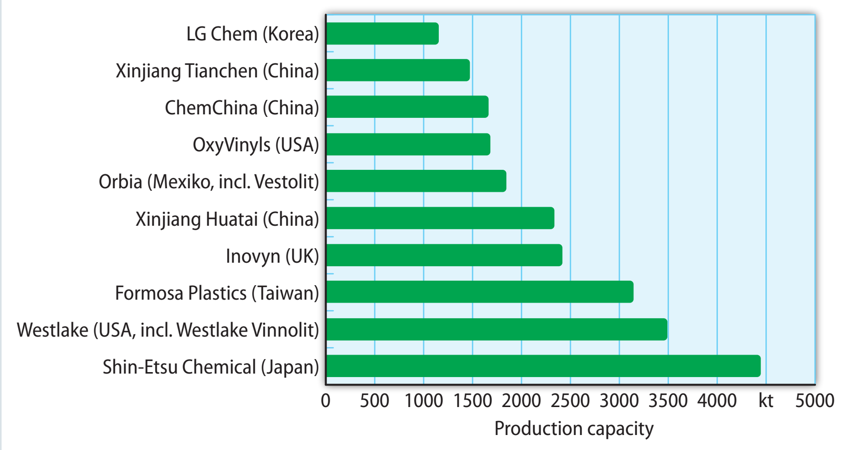

Fig. 2. Production capacities of the world's largest producers (as of September 2022): the first four places are unchanged since 2019, but things are moving in the background.
Sources: Opis, Westlake Vinnolit; graphic: © Hanser

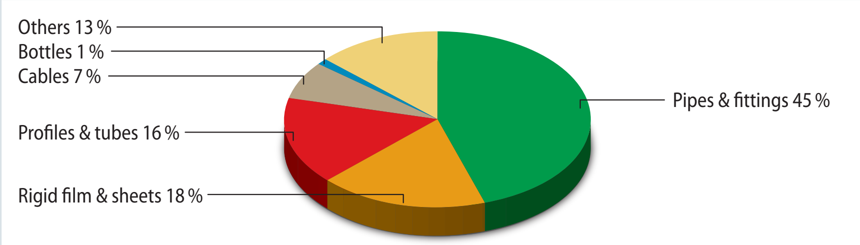

Fig. 3. Global PVC application areas in 2021 (total consumption 48.3 million t): almost half of worldwide PVC is used to produce pipes and fittings. Source: IHS Markit; graphic: © Hanser

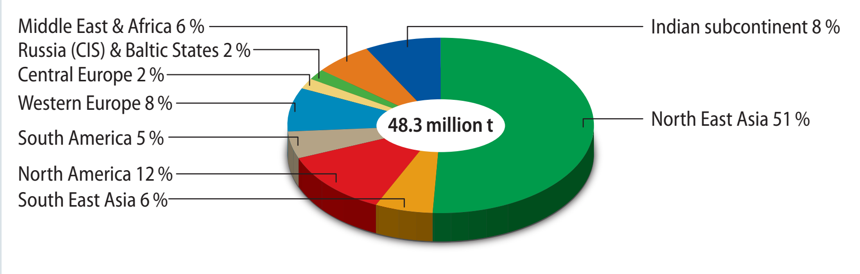

Fig. 4. Worldwide PVC demand in 2021 according to regions (total consumption 48.3 million t): slightly more than half of worldwide PVC is processed in North East Asia. Source: IHS Markit; graphic: © Hanser

Improved Properties with Thermoplastic Specialties

In thermoplastic processes for the manufacture of soft films, PVC copolymers make an important contribution for improving product properties. Their use or the use of polymer plasticizers that do not or hardly migrate helps to prevent material embrittlement as well as sticky surfaces. The higher durability and longer service life of these products make a contribution towards the manufacture of more sustainable products.

Permanent elasticity, flexibility, low-temperature resistance, and weather and UV resistance are the decisive properties of high-grade seals. Compared with elastomer seals, the main advantages of rubber-elastic seals made of high-molecular PVC types are that they are inexpensive, very durable, and in addition completely recyclable. This permits end products with hardnesses up to 30 Shore A to be made. What is more, the use of special PVC copolymers enables seals to be made with few or even without monomer plasticizers.

Apart from standard PVC cable sheaths, high-molecular PVC types are preferred for special cable sheathing applications with high mechanical requirements or for high-temperature areas. Existing requirements regarding flexibility, weather, temperature, oil, and media resistance are supplemented by additional challenges from the fields of electromobility, energy transition, and applications from Industry 4.0. Hereby, constructively reinforced, multi-core systems and materials are used as sheathing for weight and volume reduction. For this, thermoplastic PVC special products play an increasingly important role.

Meanwhile, design PVC flooring and so-called luxury vinyl tiles (LVT) have a significant share in the extensive flooring market. Among other reasons, this is due to their enormous design varieties, simple installation, and very good usage properties. An increasing use of recyclate material for hard extrusion of PVC into profiles and pipes can be observed – also thanks to the continuously improving recyclate purity.

What Makes Vinyl Record Discs Better

The trend for pressed vinyl record discs persists. In 2021, some 4.5 million of these records were sold in Germany alone, compared with just 700,000 in 2011. For the growing collector community, the selection criteria include the warmer sound of a vinyl record disc compared with that of CDs or MP3 files, as well as the increasing individualization of designs (e.g. geometric shapes, luster and glitter effects, and transparent, crystal clear or bright colors).

Special copolymers have opened up a new application in the field of color masterbatches. The use of PVC copolymers instead of e.g. the frequently used vinyl acetate copolymer (EVA) achieves higher masterbatch compatibility, clearly improved thermal deformation (Vicat), and a considerably higher color yield (lower pigment concentrations). Also the common and undesirable effect of EVA masterbatches that creates a shinier surface is eliminated with masterbatches based on PVC copolymers.

Special copolymers permit the production of soft artificial leathers with extraordinary properties. Hereby, products can be manufactured with little or no plasticizer, which are extremely oil, grease, and sweat repellent, exhibit very good weathering resistance, and do not show any signs of embrittlement.

Apart from numerous applications in the field of thermoplastic processing, liquid plastisol processing open up many additional application areas. In the textile coating segment, the high demand for PVC tarpaulin fabric, e.g. for banners, façade claddings, textile roof constructions, and truck tarpaulins is unbroken. The fabric is usually manufactured by means of plastisol brush coating.

New application areas such as building façade greening in line with sustainable construction have also emerged. For this purpose, and thanks to their very good UV resistance, net-like tarpaulin fabrics with special pockets for the plants are used. Green façades reduce the emission of harmful substances and CO_2, thereby supporting the building's climate management.

New challenges have also emerged for materials in automobile interiors – not only resulting from electromobility, but also from autonomous driving. Large changes in design towards increasing individualization and multifunctionality lead to special demands for surfaces, which must also meet high requirements in terms of very low emissions (**Fig. 5**). In Asia, for example, in addition to great freedom in design – often with very bright colors – a neutral smell is essential, because the olfactory perception differs clearly from that of Europeans. The typical "new car smell" is not perceived as neutral or pleasant in the Asian region, but as disturbing. Therefore, numerous adaptations are necessary in the plastisol formulations, i.e. changed stabilizers and plasticizer, which can also influence processability. Optimum tuning of recipe components becomes a central issue.

Fig. 5. Very high requirements regarding freedom of emissions are placed on PVC for automobile interiors. Challenging for manufacturers is that customer expectations vary in the different world regions. © Adobe Stock; Kayros Studio

Saving Entire Fusing Ovens

In the field of plastisols for vehicle underbody protection and seam sealing, focus is aimed at lower fusing temperatures and eliminating entire fusing ovens for ecological reasons. Moreover, high interest also exists for multiple wet coatings and plastisols with lower density for weight reduction in electric and internal combustion vehicles.

In various consumer areas (e.g. balls, toys, lid seals) and also with medical products, a trend towards natural, » renewable plasticizers such as citric acid esters or epoxidized natural oils is clearly noticeable. Because of their other properties, a conversion to these plasticizers involves formulation adaptations and optimizations.

On the whole, regulatory requirements for end products and manufacturing are increasing continuously. Additives for producing PVC and recipe components in the processing mixtures are subject to continuous change. Therefore, formulation adaptations in PVC production as well as processing are permanently necessary.

PVC Circular Economy Picks up Momentum

The transition to a circular economy for plastics has already started, and is gaining in momentum. More and more companies are getting involved in plastic recycling with the aim of reaching their sustainability targets. Nonetheless, when seen globally, the PVC industry is still at a very early stage regarding this subject: Currently, with some 1.7 million t per year, only a small part of worldwide PVC is being recycled. And yet, the predicted growth of 4.3 % from 2021 to 2026 is higher than that for PVC demand [3]. In the long term, however, the increase in post-consumer and pre-consumer recycling could have an effect of the demand for virgin PVC, and higher PVC prices could lead to further investments in recycling capacities.

Also in the global view, the European PVC industry with its voluntary VinylPlus self-commitment is seen as a pioneer. Within the scope of VinylPlus, a total of about 7.3 million t PVC were recycled and reused in new products since the year 2000. This also means a CO_2 saving of more than 14.5 million t [4]. The 811,000 t of recyclate achieved in 2021 correspond roughly to 26.9 % of total PVC waste accumulated in the EU, or about 13 % when referred to PVC demand in 2021. The clear difference between PVC demand and waste accumulated in the same year results mainly from the long utilization periods of PVC products and components. About 70 to 80 % are long-lasting products, which only end up as waste after many years, and are therefore only available for recycling after a time delay.

In its new ten-year program VinylPlus 2030, the PVC industry has confirmed its pledge to the EU Commission in 2018 to produce at least 900,000 t of PVC recyclate annually starting in 2025, and at least 1 million t of PVC recyclate from 2030 onwards. With VinylPlus 2030, the European PVC industry intends to push the material's sustainable development. In this way, a proactive contribution to the European and global sustainability aims is to be made. For this, a stakeholder meeting identified three so-called pathways and twelve action areas. These cover the suitability for circular economy of the PVC added value chain, its further development towards carbon neutrality, and minimizing the ecological footprint of PVC production and products, as well as the further inclusion of interest groups and global coalitions.

Scalable Pyrolysis for Mixed Plastic Waste

Apart from recycling-compatible product design, continued expansion of waste collecting systems, and further development of sorting, separating, and preparation technologies, the aimed-for transition to a circular economy also requires the development of new chemical recycling processes for contaminated and mixed PVC-containing plastic wastes and compound materials. These processes will be used for wastes that cannot be recycled mechanically or with solvents, but are currently recycled thermally or used as supplementary fuel. Hereby, mechanical and chemical recycling must be viewed as complementary – the material circuit can only be closed with an intelligent recycling mix.

This is also the aim of ChemRecPolymer, a multi-stakeholder project coordinated by BKV, VCI, and Plastics-Europe Deutschland. Within the scope of the project – also promoted by the German Federal Ministry of Education and Research (BMBF) – and under scientific guidance of the Karlsruhe Institut für Technologie (KIT), a scalable, flexible pyrolysis technology is being developed for residual mixed plastic fractions that previously could not be recycled mechanically.

The circular economy of plastics is an important precondition for the CO_2 neutrality targeted by the plastics industry. Mechanical recycling of PVC saves about 2 kg CO_2 per kg of PVC. In the medium and long term – and in addition to the use of biomass and direct CO_2 utilization (CCU) – also the raw material generated by chemical recycling processes such as pyrolysis or gasification is seen as a contribution for the de-fossilization and carbon neutrality of primary plastic.

Due to limited availability of raw materials and the high costs, the share of bio-based and chemically recycled raw materials for PVC production is presently still very low. Hereby, the use of bioethylene permits significant CO_2 savings of about 90 %. An intermediate step and important lever towards carbon-reduced PVC products is the use of renewable electric power in the production chain, particularly for chlor alkali electrolysis without changing the raw material base. Such PVC products permit notable CO_2 savings of some 25 % for comparatively low additional costs, and are featured by very good availability. ■

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