Polyvinyl Chloride (PVC)

Continuing on a Growth Trajectory

Global PVC demand has increased further. This is also forecast for the coming years. Besides product innovations, growth is mainly driven by infrastructure expansion. As a resource-efficient, durable and recyclable material, PVC could, in addition, benefit from growing environmental awareness.

According to the market research institute IHS Markit, the global production capacity for polyvinyl chloride (PVC) in 2018 was 55 million t. The biggest share of this, namely 54%, is attributed to North East Asia. China, the biggest producer country, alone has 24 million t; North America provides 17% of global capacity, and Western Europe some 11% (Fig. 1). The highest growth rates in recent years can be seen in the USA and China. The USA, in particular, has an outstandingly good cost position thanks to its exploitation of shale gas, and exports around 37% of its PVC production.

As in previous years, the manufacturers’ capacity ranking is led by Shin-Etsu Chemical, Tokyo. Westlake Chemical, Houston, TX/USA, with its European subsidiary Vinnolit, has advanced to second place, with Formosa Plastics, Taipei, Taiwan, following hard on its heels. In fourth place comes Inovyn, London, UK, which is part of the Ineos Group, Mexichem, Mexico City, comes fifth (Fig. 2).

In general, many of the major market players are originally from Asia. North America, too, is strongly represented. In terms of capacity, Inovyn is the only European raw materials manufacturer among the leaders. The picture looks entirely different for the research-intensive PVC specialties: with Vinnolit (which belongs to Westlake), Vestolit (part of Mexichem), Inovyn and Kem One, there are four European companies among the top ten specialties manufacturers (sources: IHS Markit/Vinnolit).

Almost 50 Percent Pipes and Fittings

Overall global demand for PVC is growing. In 2018, it was 45.6 million t. The average growth from 2016 to 2018, according to IHS Markit, was 3.5%. It was therefore 0.6 percentage points higher than from 2013 to 2015.

With a share of 45% (+2), pipes and fittings were the biggest field of application by far. Rigid films and sheets also saw growth, with their share increasing by 1 to 18%. In third place came profiles and hoses again, with 17% (Fig. 3). The special field of paste applications makes up 6% of total demand. Global PVC growth is supported by the developing economies in North and South-East Asia (demand in 2018: 47 and 6% respectively) and India (demand in 2018: 8%) (Fig. 4). They are investing in expanding their infrastructure.

Large Differences in Per Capita Consumption

On average, the annual per capita consumption of PVC last year was 6 kg. In first
place comes North East Asia, with 13 kg, followed by North America, with 12 kg, Western Europe, with 10 kg, and Central Europe, with 7 kg (Fig. 5). Global PVC trade continues to play an important role. In 2018, almost 10 million t were traded, according to IHS Markit. The biggest net PVC exporter in 2018 was North America, with 2.5 million t. It was closely followed by North East Asia, with 2.1 million t. Europe only plays an important role in the export of PVC specialties. The Indian subcontinent was the biggest net PVC importer last year, taking 2.2 million t.

The European PVC market recorded an average growth in demand of only 0.8% from 2015 to 2018. The capacity of the European producers declined between 2013 and 2018. That led to increased utilization of the remaining plants. A comparatively high price level in Western Europe made imports more attractive. From 2016 to 2018, therefore, over 1 million t PVC was imported, mostly from North America. The average increase of imports to Western Europe in the period, at 1.3% per year, was slightly above the average increase of exports, which was 1.2% per year. However, Western Europe remains a net exporter (source: IHS Markit).

**Strong Growth in India**

The prospects for the overall PVC market are generally positive – at least provided that the current trade tensions are resolved. The market researchers from IHS Markit expect that global demand for PVC will grow by an average of 3.5% by 2023. It is thus significantly higher than the forecast global BIP growth of 2.1% for this period. The strongest growth, at 6.8%, is to be expected on the Indian subcontinent, followed by Africa, with 5.3%, North East Asia, with 3.7% and the Middle East, with 2.7%. For Western Europe, primary PVC is expected to show a low growth rate of 0.8%. One reason for this is the increasing use of PVC recyclates. In Central Europe, a growth of 2.9% is forecast. The differences in demographic development will continue to be the main driver of regionally different growth in the future. Whereas, in many regions, the population is growing strongly, it is declining in the developed markets due to increasing aging.

In the future, the global growth of the PVC market will continue to be determined by the major global trends: a growing global middle class with high demands and living standards, increasing urbanization accompanied by high infrastructure needs, as well as more sustainable resource management and changing consumption behavior. PVC, as a resource-efficient, durable, safe and recyclable material – including in an increasingly circular economy – is well positioned here. In the long term, the market researchers from IHS Markit therefore forecast an overall higher trade volume of 2.4 million t until 2028 for PVC. First and foremost, North America will profit from this due to the advantageous cost situation resulting from shale gas. For 2028, it is expected that the USA will export up to 50% of its production volume.

For the production of PVC articles, the traditional thermoplastic techniques of extrusion, calendering and injection molding will continue to predominate. Depending on the process and requirements, different suspension PVCs, as well as special grades, including high-molecular PVC, copolymers, emulsion-based processing aids and surface modifiers are used. They allow processing and end product properties to be modeled to a large extent.

**The Renaissance of the Vinyl Record**

Cables, e.g. for electromobility and autonomous driving, are subject to significantly changing demands on the sheathing. Ever more cable bundles and higher data volumes require high-performance cables that combine good heat dissipation with mechanical properties and good shielding.

Vinyl audio media are currently experiencing a renaissance; the global growth is estimated at 5 to 7% annually. Suspension copolymers play a major role for the optimum impression during press molding, and the resulting sound quality. Modern PVC window profiles are extremely weather resistant, dimensionally stable, easy care and available in various designs. Ever more complex profile->
geometries require better thermal insulation and more stable designs, which make metal reinforcements unnecessary, even for relatively large windows. Profile cores made from recyclate are increasingly being used. The post-coextrusion process allows seals to be durably bonded to the profile in one operation.

In the case of flexible products, such as tubes and gaskets, high-molecular S-PVC with a special grain morphology permits faster mixing with plasticizers. It also permits the more efficient absorption of alternative plasticizers that are more difficult to mix with PVC, and the absorption of significantly larger quantities. The latter possibility allows rubber-like properties to be achieved, which would otherwise be the reserve of elastomers. Recyclability, thermoplastic processability and the specific advantages of the material PVC, for example its chemical and weathering resistance, provide additional benefits.

**Flooring: Combining Pastes with Thermoplastic Processing**

In the flooring sector, luxury vinyl tiles (LVT) are becoming increasingly popular and gaining significant market shares compared to traditional floorings such as laminate. LVT products are available in a variety of designs, which can be freely combined, e.g. stone, wood, geometrical forms and with personalization for professionals, but also in the do-it-yourself product range. They are very resistant, scratch proof and easy care, show even more delicate embossing, can be made to feel warm underfoot, and can even be laid in damp rooms. The design possibilities are becoming ever more versatile, for example paste technology can be combined with thermoplastic processing. In addition, more and more variations, for example with hard to soft carrier structures, click or bonded, as well as tiles or planks.

Besides standard processing by thermoplastic processes, particular PVC types can also be processed as liquids or pastes in the form of a plastisol. They are mixtures of paste PVC and plasticizers, with further formulation components such as fillers, stabilizers, biocides, pigments and additives. These PVC pastes are usually spread, dip or spray coated onto backings, such as paper, textile and metal, and gelled at elevated temperatures to form a film. In this manner, floor covering, special artificial leathers, tarpaulins, wall coverings or body seals can be produced. These are usually complex multilayer designs in which the main component PVC is crucially important for the processing and end-product properties.

**Integrating LEDs and Displays**

Current trends in the field of wallpaper are, e.g. digital printing, for example for personalized designs, and embedded sensors or LEDs for active light management. In public rooms or health institutions, there is a demand for resistant, scratch-proof and easily washable compact wallpapers (anti-vandal treatment).

In the challenging automotive sector (interior trim and body seals), alongside mechanical, tactile and optical aspects, an increasing role is being played by emissions (VOCs, fogging). In vehicle interiors, there are trends towards individualization, more complex surface embossing and sensors as well as display technologies integrated into artificial leather (smart surfaces). In Asia, the trend toward lighter colors with stricter requirements in the field of color stability continues uninterrupted. In the case of underbody seals and sealing compounds, more ecological, energy-saving processing methods, such as wet-on-wet and low-temperature stoving, are becoming ever more important.

**PVC in Architecture**

PVC-coated textiles, such as tarpaulins, are subdivided into the standard cover tarpaulins for trucks, trains and boats, printed surfaces, such as advertising banners, as well as products for membrane structures and textile architecture. (Title figure) The latter is subject to very high technical requirements, but is nevertheless growing strongly. The trends in this area include alternative plasticizers, water-based and therefore more lightweight coatings, high weathering stability for architectural textiles, and cost reduction for standard tarpaulins.

In general, regulatory requirements are playing an ever bigger role, for example potential restrictions on key ingredients or auxiliaries, such as the white pigment titanium oxide or the blowing agent ADCA. The increasing internationalization of the goods streams in addition leads to further requirements due to different national regulations. The manufacturers are responding to consumers’ increased environmental awareness by adapting formulations and using additives based on renewable resources.

**One Million Tons of PVC-Recyclate Per Year by 2030**

At least since the publication of the EU plastics strategy in early 2018, the theme of the circular economy has been at the top of the political agenda, and has gradually entered the awareness of consumers. In this area, the European PVC industry acts as a forerunner with its voluntary commitment, VinylPlus. Since 2000,
over 5 million t PVC has been recycled within VinylPlus. In 2018, the program set a new record, with 740,000 t recyclate, representing a saving of 1.5 million t CO₂. This brings the 800,000 t recycled PVC per year promised for 2020 within reach. In the future, the amount is set to increase substantially. In September 2018, VinylPlus promised the EU Commission that it would contribute at least 900,000 t PVC recyclate per year by 2025, and at least 1 million t by 2030 to the manufacture of new products in the EU.

In the long term, by 2040, VinylPlus together with five other organizations in the European plastics supply chain, has committed itself to contributing to the aim of recycling or reusing 50% of all plastics wastes, and even 70% of all plastics packaging wastes. A challenging goal, which, besides design for recycling, and the further development of sorting and separating technologies also requires the development of new chemical or raw materials recycling processes.

One such process is advanced as part of the Circular Flooring project for recycling PVC flooring. It is based on the CreaSolv process of the Fraunhofer Institute IVV. This solvent-based process in particular involves separating undesirable plasticizers and thereby obtaining a recyclate in virgin quality. If it proves successful, it could also be interesting for recycling other PVC composite waste.

Of course, there are also contaminated and mixed PVC-containing plastics wastes that do not come into consideration for mechanical or solvent recycling. They are currently thermally recovered or used as substitute fuels. Industry currently develops feedstock recycling processes to convert such wastes into synthesis gases in the long term, and ultimately converting them into basic chemicals, and thereby closing the material loop.

Malte Bahls, Dr. Oliver Mieden, Kathrin Mühlischlegel, Dr. Frank Riedmiller, Edmund Vogel, all Ismaning/Burghausen, Germany

Fig. 4. Global PVC demand in 2018 by regions (total consumption 45.6 million t) (source: IHS Markit)