From 2001 to 2004, European consumption of PVC rose from 6.4 million t to around 6.8 million t. Due to more dynamic market growth in Asia, Europe’s share of consumption fell from 26 % in 2001 to 23 % in 2004 (Fig. 1). The North American market has also ceded ground.

The pace of consolidation and restructuring on the part of European suppliers has eased during this period. In October 2005, Total restructured its chemicals business and outsourced its PVC activities (previously with Atofina) into a new company (Arkema). Smaller closures at Atofina/Arkema had already been made (Brignoud, St. Auban/France) and further restructuring measures were announced. Substantial expansion has been performed by Anwil and Oltchim in Vlocavlek in Poland and Rimnicu in Romania. As a result, Oltchim has climbed up the ladder of the major PVC producers in Europe to rank 8 (Fig. 2).

On balance, following closures, debottlenecking and expansions, the 300 kt growth in European PVC capacity in the last three years has somewhat lagged behind European consumption. Higher capacity growth is expected in the next few years, which will further exacerbate the existing capacity overhang (Table 1).

The European market for PVC processed by thermoplastic methods grew by over 3 % in 2004. Rigid profile applications performed most positively of all, with above-average growth rates. This extra consumption in the profile sector occurred almost exclusively in Central and Eastern Europe. So it is therefore not surprising that the major profile extruders already have their own production sites in Russia.

The Western European paste PVC market enjoyed a pleasing recovery in 2004. A growth rate of barely 2 %, relative to the prior year, stopped the gentle decline of recent years. This recovery was driven only to a small extent by higher consumer demand in Western Europe. It was fuelled predominantly by ongoing growth in exports by Western European processors to Central and East Europe. At the same time, local PVC-paste processing capacity – especially in the CIS states – was expanded or better utilised. This led to double-digit percentage growth in the market for PVC pastes in Central and Eastern Europe in 2004. This performance is typ-
TREND REPORT

COMMODITY PLASTICS

ical of the European paste PVC market of recent years and an end is not yet in sight. For this reason, it can be expected that the next few years will also see plant closures in Western Europe or relocation of plants from Western Europe and the founding of subsidiaries in Eastern Europe.

Process Improvements

By far the most PVC is produced by the discontinuous suspension method. This involves loading the polymerisation reactor with vinyl chloride, water, suitable suspension aids, and peroxide initiators. The polymerisation is then performed under agitation at elevated temperature. The resultant heat of reaction is dissipated by means of the chilled reactor wall or reflux condensers. The development of new, more heat-stable suspension agents, coupled with the use of improved initiator dispersions, has led not only to more uniform product quality but also to much shorter loading and heating times. Even large reactors holding 150 to 200 m³ only need preparation times of less than an hour. Substantial progress has also recently been made in the actual polymerisation process itself. For one thing, the use of the new smooth-wall or even corrugated internally-cooled reactors can generate virtually double the cooling efficiency of conventional reactors. For another, a new metering process for initiators makes it possible for the first time to selectively control the reaction rate in the suspension process and so to make better use of the cooling efficiency while maintaining high process safety.

Paste PVC is produced by either the continuous or batch emulsion or microsuspension methods. The popularity of the microsuspension method has increased slightly in recent years. For selective control over product properties, especially rheology, different variants of these two methods are to be found, such as predispersion, or a combination of emulsion and microsuspension methods for the manufacture of hybrid products. Further developments are headed in the direction of seed-swell methods for producing highly disperse and monodisperse particles. Overall, unlike the case for the suspension method, the situation is characterised by highly heterogeneous technologies: no one shop resembles another. Particular attention in the production of paste PVC has been paid to reducing vinyl chloride emission levels and to lowering the content of residual monomer in the sales product. Additionally, enormous efforts have been and are being taken to safeguard or extend the use of paste PVC in the foodstuffs and allied sectors through the use of polymerisation auxiliaries on the EU positive list.

Product Developments and Applications

The pipe sector has now been overtaken by the profile sector as the largest market sector for PVC in Western Europe, but it is still important nonetheless (Figs. 3 and 4). In Western Europe alone, some 1.4 million t are needed primarily for sewerage and drainage systems as well as for potable water supplies. The cost squeeze on the processors’ side has led to further growth of foam extrusion in pressureless pipes. This manufacturing method utilises low-molecular PVC grades with a K-value of 57 to 60. In the case of pressure pipes or pipes exposed to high mechanical stress, substantial materials savings are made by extruding twin-wall chamber pipes and also through in-line or off-line molecular orientations in the pipes. The high molecular PVC grades employed here have K-values of around 67. To meet the piping sector’s requirements for high...
### Table 1. Breakdown of capacity and demand in Europe by region in 2004

<table>
<thead>
<tr>
<th>Regions</th>
<th>Capacity</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1000 t/a</td>
<td>1000 t/a</td>
</tr>
<tr>
<td>Germany</td>
<td>2100</td>
<td>1620</td>
</tr>
<tr>
<td>France</td>
<td>1400</td>
<td>710</td>
</tr>
<tr>
<td>Benelux</td>
<td>910</td>
<td>570</td>
</tr>
<tr>
<td>Great Britain</td>
<td>520</td>
<td>760</td>
</tr>
<tr>
<td>Spain</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>Italy</td>
<td>470</td>
<td>990</td>
</tr>
<tr>
<td>Scandinavia</td>
<td>315</td>
<td>230</td>
</tr>
<tr>
<td>Central and Eastern Europe</td>
<td>2400</td>
<td>1150</td>
</tr>
<tr>
<td>Others</td>
<td>385</td>
<td>250</td>
</tr>
<tr>
<td>Total</td>
<td>9000</td>
<td>6830</td>
</tr>
</tbody>
</table>

The extraordinary versatility of PVC is reflected in the very wide range of compact and foamed profiles for the construction industry and also for the furni-
ture, automotive and electrical/electronics industries. The PVC raw materials that are used for rigid extrusion employ suspension products having a wide K-value ranging from 57 to 68 as well as emulsion PVC with a K-value of 70. Specifically in the case of the compact profiles, the fast-
melting emulsion PVC facilitates processing while simultaneously increasing output, surface quality and antistatic properties.

By far the greatest application area in the profile sector is that of window pro-
files. Nowadays, 55 % of all window frames made in Germany are of PVC. Ap-
pealing design, good heat insulation, long-term stability and low maintenance are the decisive purchasing reasons. In particular, good impact modification of the profiles is needed for the working processes of assembly and installation. In addition to blends of PVC with K-values ranging from 65–68 and impact modi-
fiers of acrylate-PMMMA and acrylate-PVC, PVC graft copolymers have mainly become established in Germany. In this, a highly disperse acrylate dispersion is grafted onto the vinyl chloride during the PVC polymerisation. This technology yields a highly homogeneous distribution of the rubber particles in the PVC matrix and, through the grafting reaction, also an ideal connection between the PVC and the impact modifier. These products re-
commend themselves furthermore to the processor on account of their high bulk densities and very uniform plastication.

Extrusion of plasticised PVC profiles, tubes and cables is performed with dry blends of plasticisers containing highly porous PVC grades having a K-value ranging from 65 to 70. High molecular PVC improves the mechanical strength and heat resistance. Such PVC grades therefore find application in new high-
temperature cables for the automotive sector. For higher demands on elastic re-
covery, the very high molecular PVC grades with K-values greater than 90 and, especially, PVC graft copolymers with an acrylate content of about 50 % are used. Outdoor and indoor window seals have evolved into an important application area for these special products in recent years. Aside from the processing advan-
tages offered by their thermoplasticity, these raw materials yield seals that are weatherable, pigmentionable in any colour and moreover may be welded to the frame profile by means of coextrusion or the new PCE method.

Far and away the greatest need for dif-
ferent PVC grades is that experienced by the highly diverse market segment for PVC rigid film. This sector utilises not only suspension PVC with K-values ranging from 57 to 60, but especially copolymers of vinyl chloride with vinyl acetate, emul-
sion PVC with a K-value of around 60, and a series of other specialty products. The copolymers substantially improve the thermoformability of packaging and pharmaceutical film (Fig. 5) and the lam-
inating properties of credit card and com-
posite films. The addition of emulsion PVC accelerates plastification, leads to greater melt homogeneity and also boosts the antistatic properties. Highly disperse and high molecular PVC grades serve as antiblocking agents and also for matting and texturising the surfaces. Given the correct choice of PVC raw materials and processing technology, modern large-
scale calenders can now produce up to 5 t an hour, even in the case of high-quality rigid film.

The flexible-film sector is dominated by porous PVC grades with a K-value of 70. Technical progress in this area is impressively illustrated by the production of blown cling-film. Nowadays, wall thick-

nesses of just 10 µm are already being achieved. For low-migration, weatherable and chemically resistant container linings, sealing film and roofing sheet (title picture), the raw materials employed also in-
clude internally plasticised polymers of PVC and EVA or PVC and acrylate. These products additionally increase the melt

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**Fig. 4.** The piping sector is among the largest market segments for PVC
viscosity. Due to the high pressure build-up, plasticised films can be calendered in thicknesses exceeding 1 mm in one pass.

Paste processing enjoys a roughly 10% share of the total market in Europe. Analysis of the product portfolio and the portfolio performance of Western European paste producers shows that the proportion of new paste products less than five years old makes up some 27% of the 125 PVC paste grades sold on the market. These are frequently “improvement innovations.” By this is meant that existing products are developed further in order that the market demands for increasingly higher coating speeds for plastisols may be met (low dilatancy, low paste viscosity). On the other hand, new paste products are offering better functionality of the end products and in some cases new application areas have been tapped.

Examples from recent years are new tarpaulin and sign grades that permit direct printing of support materials coated with plasticised PVC for large advertising posters without the need for prior coating. Modern PVC floorings with a strong design focus (e.g. mechanical embossing and metallic effects) have additional attributes with the result that sound-absorbing floorings, non-slip safety flooring and easy-clean flooring with reduced dirt retention are now available. New anti-drumming and acoustic insulation compounds made from PVC improve car interior acoustics. PVC-coated fabrics lead to improved sound insulation in buildings. New UV stabilisers double the life-time of plasticised PVC outdoors. This is a flanking measure for the trend towards using PVC-coated polyester membranes for textile building (e.g. roof membranes for lightweight structures). A new material for protective suits that is embedded in PVC fabric promises protection against alpha-, beta- and gamma-radiation, with total freedom of movement and 80-per-cent weight savings. Extra-fine paste grades ensure reliable screen printing of very fine designs with PVC plastisols and thus increasingly sophisticated wallpaper patterns. Specific foaming methods for paste PVC (Fig. 6) facilitate the production of ultra-lightweight parts for use in aeroplane building, shipbuilding and wind-power plants.

Apart from these examples, further basic trends are discernible in paste processing:

- The plasticisers DINP/DIDP are increasingly supplanting the standard plasticiser DOP (DEHP; this applies to plasticised-PVC applications generally). In 2003, DINP/DIDP already enjoyed 56% of the total plasticiser market.
- Paste PVC is once again finding increasing use in automotive interiors on account of its favourable price-performance ratio.

**PVC and the Environment**

The long-awaited communiqué from the EU commission on future PVC strategy has so far failed to materialise. On one hand, prioritisation by the EU Commission in the face of the planned realignment of the EU chemicals policy has changed. On the other, numerous studies of PVC have shown that there are no grounds for regulating PVC products since candidate substitutes offer no advantages over PVC. For this reason, there are no use restrictions on PVC. Instead, the discussion has shifted to the additives, such as phthalate plasticisers and heavy-metal-containing stabilisers.

The European PVC industry – raw materials producers, additives producers and PVC processors – has meanwhile submitted its 5th progress report on its voluntary commitment to sustainable industry. In 2000, the sector’s 10-year Vinyl 2010 program committed it to quantitative targets, deadlines and an annual review aimed at further reducing the environmental impact during production, processing and disposal of PVC. Once again, substantial progress was made in 2004, e.g. in recycling and switching over to leadfree stabiliser systems. This progress report can be downloaded from www.vinyl2010.org. The voluntary commitment is up for review from 2006 on. All fundamental suppositions, activities and goals will be examined and adjusted as necessary.

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