Polybutylene Terephthalate (PBT)

On the Advance. Polybutylene terephthalate (PBT), as a semi-crystalline plastic with good dimensional stability and excellent mechanical properties, has become established in many different applications in the automotive industry and electrical/electronics sector. The global market volume for PBT, including PBT blends and the PET used as an engineering polymer, passed the 900 kt mark in 2006 and has grown at an above-average rate in recent years.

PBT, like PET (polyethylene terephthalate) or PTT (polytrimethylene terephthalate), belongs to the saturated polyester family. PBT is produced either by polycondensation of terephthalic acid (PTA: Purified Terephthalic Acid) with butanediol (BDO) or by transesterification of terephthalic acid dimethyl ester (DMT) with butanediol. The PBT base polymer obtained can then be reinforced with, for example, glass fibers or mineral fillers or modified by the addition of flame retardants in a subsequent compounding operation. The properties of PBT can also be modified by blending with other plastics such as PC, PET or ASA.

PBT offers a valuable combination of technical properties with its very good dimensional stability due to low water absorption, exceptionally high stiffness and good heat resistance. These advantages together with good processability give PBT a balanced property profile that make it highly suitable for injection molding technical parts. Among the engineering polymers, which have a total market of 8 million t, PBT is the second largest semi-crystalline material after polyamide (PA), which has global sales of 2.5 million t.

Market Development

The global market for PBT and PBT compounds totaled some 900 kt in 2006. Global growth, at over 6 %, is higher than for other engineering polymers.

Asia accounts for the largest share of demand and also shows the highest growth (Fig. 1 Table 1). In China, for...
example, there has been double-digit growth in consumption in recent years. The dynamic growth of PBT in Asia will continue over the next few years (Fig. 2).

The main applications for PBT are the automotive and electrical/electronics industries, which make up 48% and 22% of consumption in Europe respectively (Fig. 3). Consumption is growing in Europe because of the good order situation with European automotive component suppliers and the increasing provision of comfort and safety functions in vehicles. In the electrical industry, the significantly reduced share of sales accounted for by Europe, as compared with 2004, reflects the relocation of production plants to Asia.

In the slower-growing market of North America, the shift in automobile market shares to Japanese manufacturers has had a negative impact on PBT growth.

On the supply side, new capacities in base polymer manufacture and compounding have been created or announced in the last few years. New base polymer plants have often been built as continuous world-scale production joint ventures to reduce the risks and investment costs for the partners. A good example of this is the Dubay plant in Hamm-Uentrop, Germany, which has been operated since 2004 by Lanxess and DuPont. However, the main focus for the construction of new capacities is Asia because of the strong growth in that region. In 2006, BASF and Toray commissioned a joint venture for the production of PBT base polymer with a capacity of 60 kt/a in Malaysia. In June 2007, the Taiwanese PBT manufacturer Chang Chun started up a 60 kt plant in the People’s Republic of China. Other new polymer plants have already been announced by Chinese manufacturers.

It is also in Asia that most activity in relation to the installation of new compounding facilities can be seen. In 2006, in Wuxi, China, Lanxess commissioned its first plant in Asia for compounding PA and PBT (capacity of 20 kt). In the spring of this year (2007), BASF brought on stream a new plant in Shanghai (45 kt) that increases its compounding capacity in Asia to more than 100 kt.

But investment in compounding is also being made in Germany. Just recently, Lanxess and DuPont announced an investment in a jointly operated polymerization facility in Hamm-Uentrop to counter the growing margin pressure with PBT compounds.

In the slower-growing North American market, no significant capacity changes have been observed in recent years. One change that did take place was the sale by General Electrics (GE) of its plastics business. On account of shrinking margins and insufficient profitability, GE decided to sell its plastics business, GE Plastics, to the Saudi Arabian company Sabic. GE Plastics produces PBT in North America and also at Schwarzheide, Germany, in a joint production venture with BASF.

A survey of the most important PBT manufacturers is given in Table 2.

### Manufacturers and Capacities

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<th>Manufacturer</th>
<th>Trade name</th>
<th>Company headquarters</th>
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<tr>
<td>BASF</td>
<td>Ultradur</td>
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<td>Chang Chun</td>
<td>Chang Chun PBT</td>
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<td>DSM</td>
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<td>WinTech</td>
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Table 2. The world’s top ten PBT manufacturers (in alphabetical order)

In the automotive industry, which is the main application segment, vehicles will increasingly be equipped with electrically controlled comfort functions, electronic safety functions and electrified auxiliary units such as power steering or oil pumps. Now, even lower vehicle classes are being supplied with a considerable level of comfort as standard, which is leading to above-average...
growth in this sector. PBT is used in electronic components for air conditioning systems, control units, electronic brake regulation (ABS), electronic stability programs (ESP), electric window lifters, seat adjustment systems and housing parts for electric motors. In addition, mainly through replacement of metals, PBT is opening up new applications with high potential. Examples include front headlamp bezels, wiper arms and accessories and sunroofs. This trend is leading to PBT market growth that will continue above the general rate for the automotive market.

Besides automotive manufacture, there also continues to be sharply increasing demand for PBT in the electrical/electronics industry. In this sector, good dimensional stability and flame retardancy are particularly important. PBT is proving an excellent material for electric plugs, connectors for cable harnesses, switches and lamp bases. With its balanced thermomechanical properties, PBT can be used to produce extremely small components (miniaturization) characterized by thin walls and reduced weight.

In household applications, too, where surface quality and heat resistance are required, PBT is the material of choice. Here it is used in components such as oven knobs or cover strips, electric irons, toasters, deep fryers and fan heaters.

In addition to these applications as a compounded product in the injection molding process, PBT is also finding markets in extrusion, for example in fiber optic cable coating and for bristles and toothbrushes. PBT is also used in technical nonwovens and as an elastic component in fibers with high chlorine and UV resistance. However, the polyester fiber market is dominated by PET, while PTT is also used for carpets. The only film applications are in small specialized segments.

**New Products**

To counteract cost pressure and so strengthen the competitiveness of automotive component suppliers, various manufacturers have developed grades with improved flowability in recent years. The pioneers in this field were BASF, who succeeded in significantly improving the existing PBT and reducing system costs in injection molding through the use of nanotechnology. Up to 30 % cycle time can be saved, thereby also cutting both energy consumption and emissions. The improved flowability also makes it possible to mold thinner, smaller parts or alternatively to produce more parts per shot. As a result of the lower injection pressure, investment in new plants costs less because the pressure requirements for the machines are not so high. These so-called high-speed grades are now being supplied in a widely diverse range of products: At K 2007, BASF is launching a dozen new product grades.

For visible parts such as rear windshield wipers, door handles or roof frames, PBT+PET blends are being used, with high glass fiber content in some cases. They have good UV resistance and exceptional surface properties. These products can also be employed to produce hollow parts by gas/water assist molding, in order to reduce component weight still further. Other blends, such as PBT+PC or PBT+ASA, have been developed to achieve lower warpage and improved impact strength. For example, DuPont in collaboration with MAN has developed an exterior component for trucks produced from a PBT+SAN blend.

In the electrical/electronics industry, flammability behavior is extremely important. For this market, which is constrained by numerous regulations and test methods, manufacturers supply a range of flame-retardant products. These include, for example, grades that achieve a UL94 V0 rating at a wall thickness of 0.4 mm. Flame-retardant materials are also available from different producers to meet the high requirements for unattended household appliances. Halogen- and antimony-free flame-retardant PBT grades are now also available as special solutions. At K 2007, Ticona will be featuring interesting new products of this type based on a new halogen-free flame retardant system.

Other PBT innovations include materials that can be laser marked and laser welded or are suitable for laser direct structuring of MIDs (Molded Interconnect Devices). One of the latest product innovations is a heat-conductive PBT from BASF with a thermal conductivity value of 1 W/mK which is intended to replace metals in housing covers.

**Outlook**

In view of the increasing demand for comfort and electronics in vehicles and the home, PBT will continue to be one of the fastest-growing engineering polymers. The latest developments, such as very easyflowing grades, are attracting considerable interest from end customers and provide good grounds for optimism. The need for processors to cut system costs and ever higher and more complex performance specifications will continue to be the main innovation drivers.

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