

Polyphenylene Sulfide (PPS)

Capacity Expansion.

Polyphenylene sulfide is a high performance polymer that due to its properties is increasingly in demand, particularly in the electrical and electronics industry as well as automobile construction. The number of application areas for it is growing rapidly and accordingly also the demand. Manufacturers are investing and especially in China they are expanding their capacity in stages. PPS will in the future also help to shape electromobility.



The rudder and elevators for the Gulfstream G650 were manufactured from Fortron PPS
(photo: Gulfstream Aerospace Corporation)

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The semi-crystalline high performance polymer polyphenylene sulfide was first manufactured in 1972 in the United States and marketed under the brand name Ryton by the Phillips Petroleum Company (now Chevron Phillips Chemical Company LLC, The Woodlands, TX/USA). Today there are a large number of manufacturers serving the global market. The largest of these are Fortron Industries LLC, Wilmington, NC/USA (a joint venture between Ticona Technical Polymers, Kelsterbach, Germany, and Kureha Chemical Industries Co., Ltd, Tokyo/Japan) with Fortron, Chevron Phillips with Ryton and Xtel, Toray/J&A Plastics Inc., Tokyo, with

Torelina, DIC Corporation with DIC.PPS, Albis Plastic GmbH, Hamburg, Germany, with Tedur as well as Tosoh Co., Tokyo, with Petcoal. In the past few years the number of competitors, particularly in the Asian market, has increased rapidly.

Fundamentally there are two different forms of



Fig. 1. The AdBlue membrane pump P800 from Thomas Magnete with a valve block made from Fortron PPS 1140L4 (photo: Thomas Magnete)

polyphenylene sulfide. On the one hand there are the cross-linked grades such as Ryton, which has branched polymer chains that are irreversibly bonded with each other via chemical cross-linking points. On the other there linear PPS grades such as Fortron and Tedur. The linear molecules pack together to form highly ordered macrostructures. Due to these morphological structures linear PPS, unlike the brittle cross-linked polyphenylene sulfide, is characterized in particular by excellent toughness and elongation at break. Both types are in general very resilient polymers that, particularly in the case of the linear structure, have good mechanical properties as well as excellent shape and dimensional stability, which is retained even at temperatures well above 200°C. Depending on the loading, PPS is suitable for continuous service at up to 240°C as well as short term use

at up to 270°C, conditions that are increasingly being found under the hood or in electrical devices. This is one of the reasons why PPS has established itself in numerous applications in the automotive and electrical industry. In addition PPS has very low water absorption and very good chemical resistance to practically all solvents, many acids and bases as well as atmospheric oxygen, even at high temperatures. Further benefits of PPS are excellent electrical properties as an insulator, inherent flame retardancy, low creep as well as very low permeability for most liquids and gases.

The processing spectrum of PPS is very large; however, it is predominantly used for injection molding. Due to its very good flow behavior PPS is an ideal material for thin walled molded parts and complex tooling geometries. Processing techniques such as blow molding and extrusion are still com-

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paratively rare, but particularly for these applications products are currently increasingly being developed to better meet the special needs of these techniques. It can therefore be assumed that PPS will be found more often in these areas in the future.

The automotive industry has been using PPS for a long time and is the largest customer in Western Europe with an offtake of around 13,000 t/a. The breakdown of the remain-



Fig. 2. "Xenon" gas discharge lamps with PPS (photo: Ticona)



Fig. 3. The blow molded supercharger air pipe made from Fortron won the Automotive Award 2009 (photo: Ticona)

ing Western European consumption is electrical and electronics (5,000 t), industrial, predominantly domestic appliances (3,100 t), fibers and filaments (1,700 t) as well as composites and films (500 t). The world's largest consumer is Asia with its electrical and electronics industry (source: SRI/internal estimates 2010).

Further Expansion of Capacities

The continuously growing demand has also led to a continuous expansion of worldwide capacity. Particularly in 2009 and 2010 PPS consumption experienced a rapid growth spurt. Manufacturers have been increasingly building up their capacities to meet this large demand. Worldwide PPS polymer capacity is currently more than 60,000 t/a. This is an increase in capacity of

around 30 % since 2009, a clear sign that manufacturers are working flat out on expanding their capacities in order to meet worldwide demand. For the present no end to the increase is in sight as PPS consumption continues to boom.

In anticipation of this Fortron Industries increased its capacity at Wilmington in 2010. With a production capacity of 15,000 t/a the joint venture of Ticona and Kureha has the largest plant for the production of linear PPS in the world.

The most important drivers of PPS demand are the European automotive industry and the Asian electrical and electronics industry. The Asian automobile market has, however, grown rapidly over the past few years and experts expect further increases in the short and medium term. However, positive growth numbers are also

predicted for the electrical and electronics industries. Asia is already the largest consumer ahead of Europe. It is to be expected that the Asian market will drive demand for PPS even more strongly in the future. For this reason additional capacity expansions are currently being planned in Asia.

For example Thenardit Lumen Resources Corp in Hong Kong, who according to their own figures are the second largest worldwide producer of sodium sulfate, announced in 2010 that they would acquire between 89 and 95 % of the Chinese PPS market leader Sino Polymer New Materials Co Ltd. Via its subsidiaries Sichuan Deyang Chemical and Sichuan Deyang Special New Material, Sino Polymer New Materials, previously Haton Polymer & Fibre, runs two PPS production plants which according to its information have a capacity of 30,000 t/a of PPS from which they produce 30,000 t/a of compounded material and 5,000 t/a of fibers. Thus from the capacity side at least the company has attacked the long standing market domination of the two leading PPS manufacturers Chevron Phillips and Ticona.

Toray Industries Inc. is also planning to expand in Asia. According to unconfirmed Japanese media reports Toray is also planning a significant expansion of its compounding capacity for PPS in Japan and China. In addition its subsidiary company Toray Plastics

Ltd., which expanded in 2010, is to set up a plant in Suzhou with a capacity of 1,500 t/a. It is envisaged that this will produce PPS grades with low chlorine content for the East Chinese market. If this happens then their total compounding capacity in China will be increased from around 9,000 to 10,000 t/a. In parallel in 2012 a new compounding line with a capacity of 3,000 t/a is to be added at the Japanese plant in Nagoya. Even though the Japanese name plate capacity of Toray was increased from 11,500 to 14,000 t/a last year, it is today running at full stretch. Samsung Chemicals is also offering a PPS grade as part of its product portfolio.

It is hardly surprising that this boom in worldwide markets for PPS has led to cloned PPS materials being seen on the European market. Manufacturers are increasingly recommending that material quality should be checked to avoid inferior quality material clones being processed.

Wide Ranging Application Areas

Polyphenylene sulfide is mainly used where molded parts in the electronics and vehicle sectors as well as aerospace technology and other industrial applications are subjected to high mechanical, electrical, thermal and chemical loadings. The automotive industry uses PPS because of its resistance to fuels, anti-freeze, various oils and brake fluids as well as for its high temperature resistance in under the hood and fuel system applications. Areas of use are found amongst others in pumps, air intake systems, valves, seals and components for exhaust recirculation systems, cooling pumps, electric parking brakes, water pumps, air intake modules and supercharger pipes. The examples given show clearly how wide ranging the application areas are just in respect of automobile construction (Fig. 1 and 2). →

Fig. 4. The rudder and elevators for the Gulfstream G650 were manufactured from Fortron PPS and won the JEC Award in 2010

(photo: Stork Fokker)



rudder and elevators of the Gulfstream G650 business jet were awarded the JEC innovation prize. What is special about these is that they represent the first use of inductively welded thermoplastic primary structural components. KVE Composites Group, Den Haag, Netherlands, has developed a special welding process which allows cost effective highly resilient PPS composite materials, such as the ones here made from Fortron, to resist heavy mechanical loads and aggressive media (**Title photo and Fig. 4**).

The electrical and electronics industry uses PPS primarily for precision

components and sensors. PPS is predestined for welding processes where high temperature demands are placed on the material. It is also very suitable for applications in solar panel technology.

In addition flame retardant fibers can be manufactured by extrusion. They are suitable for instance for fabric in transport straps and protective clothing against chemicals, heat or fire. However, fabrics made from PPS are also used in smoke filters for aggressive exhaust fumes.

PPS that is certified for potable water applications is used in hot water systems such as classic gas and oil boilers, but finds particular use in modern solar thermal or geothermal systems (**Fig. 5**). In addition materials such as brass and castings can be replaced to ensure "lead free" drinking water.

Ever more often PPS is also replacing metal in drive train applications. With innovative manufacturing techniques and modified compounds complex parts can be cost effectively manufactured. What is possible even today has been shown by Gebr. Röchling KG, Mannheim, Germany, and Ticona using the example of a blow molded supercharger air pipe made from Fortron 1115L0, for which they received the "Automotive Award 2009" (**Fig. 3**). The modified blow molding process, a combination of blowing, injection and joining, means that functional elements can be integrated during blow molding. In this way multiple production steps are brought together into a single process, which leads to a substantial increase in efficiency.

However, PPS is also finding increasing use in the aviation industry. For instance the

Innovations from Product Development

Development in the last few years has mainly been in the direction of easier to process, more cost effective PPS grades.

Today however, it is innovation in automobile construction that is driving product development. For example Ticona is offering the new mineral and glass filled Fortron 6162XF alongside Fortron 6165A6 specially for applications around aggressive new fuels. Alongside good dimensional stability and temperature resistance it has an even lower swelling behavior and 45% less fuel absorption than standard grades. It was specially optimized for the demands of future innovative fuel systems. In the future materials will need to resist fuels containing methanol, bio-fuels with ethanol content, aggressive additives as well as much higher service temperatures. Alongside dimensional stability Fortron 6162XF also has very good creep resistance. Typical applications are pump rotors, valve flaps or components in injection valves. Some Fortron grades already contain halogen free linear PPS.

Chevron Phillips Chemical Company is also marketing new low chlorine Ryton grades to the electronics industry alongside its low halogen, cross-linked standard PPS grades. Ryton PPS R-4-280 is a 40 % glass fiber filled PPS specially developed for the electrical and electronics industry. It is suitable amongst other things for plugs, coil cores and hard drives. Ryton PPS R-7-190 is a glass and mineral filled PPS for applications where particular dimensional stability, stiffness as well as electrical properties are required. With a new

polymerization and process technique Chevron Phillips Chemical is able to achieve the desired low chlorine content. On top of that the material has excellent flow properties and low shrinkage for precision molding of plugs and sockets, but also the necessary stiffness and strength for reliable assembly. In addition many PPS compounds have UL94 V-0 fire ratings without the use of flame retardant additives. Ticona is also marketing Fortron PPS 1140LC6, a polyphenylene sulfide with low viscosity and reduced chlorine content.

Opportunities for PPS in Electromobility

As well as supporting "lead free" potable water supply and environmentally friendly fuels PPS is also making a contribution to sustainability in the field of electromobility. Innovative and demanding technologies, cost savings as well as the substitution of metals demand suitable materials. The automotive industry is facing a huge challenge that it can only solve using polymers. Lighter and smaller automobiles are the way to an environmentally friendly and resource saving future. The trend to lightweight construction can only be realized with thermoplastic, flexible moldable polymers. PPS is a high-performance polymer with ideal prerequisites for the new technological developments. For instance in fuel cells



Fig. 5. Thermostat valve made from PPS which contributes to a "lead free" potable water supply (photo: Ticona)

this high-performance polymer is already replacing conventional materials such as gold coated stainless steel, aluminum, graphite or thermoset/graphite blends (Fig. 6). This not only leads to weight reduction, but also to cost savings. Due to its low weight and expansion coefficient, which is constant over a wide temperature range, it is suitable for coil cores as well as valve and pump casings. Even today the development of electric cars is the subject of intense development work. Polymer manufacturers also have a role to play in this.



Fig. 6. Weight reduction through metal substitution with PPS in fuel cells

(photo: Ticona)

With its “BamBoo” concept car Rinspeed in partnership with Ticona has shown how the future could look. In Asia as well electromobility is being pushed forwards with massive government support. For example the Japanese automobile manufacturer Nissan has already launched the first mass produced electric car. The options are still open and PPS has all the properties, especially in the area of batteries, electrical drive systems as well as high voltage

motors, in order to make a decisive contribution to shaping the future.

Conclusion

PPS consumption is booming and it is to be expected that this demand will continue to grow. PPS producers are expanding their capacities worldwide in order to meet this growing demand. Due to its good property profile potential applications for PPS are wide ranging

and the number of applications for it is expanding continuously. The growing demand is being driven in particular by the Asian electrical and electronics industry as well as the European automotive industry. The rate of growth in both markets, but particularly in Asia, is expected to increase over the next few years. It can be assumed that PPS consumption will benefit from this. New fuel systems and electromobility offer an enormous potential for PPS applications. Even today producers are making their mark on the future with their developments and concepts. ■

NOTE

All market information is based on press releases of the companies, literature research and/or our own investigations and estimates.

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