Polyphenylene sulfide (PPS) in review

HIGH-PERFORMANCE PLASTICS

by Ed Hallahan

Manufacturers often rely on polyphenylene sulfide (PPS) to meet demanding conditions. Not only is this high-performance thermoplastic extremely strong, rigid and tough (see Properties Table I below), but also it retains these attributes at temperatures well above 200°C (392°F).

PPS is inherently flame retardant, absorbs little moisture, and has exceptional chemical resistance, dimensional stability and creep resistance. In addition, its low ionic content makes it an excellent electrical insulator.

This polymer is commonly used in extruded and injection molded components. It is available in partially branched and linear forms. The branched version is more rigid, while the linear form has greater tensile, flexural and notched impact strength. Linear PPS also has fewer ionic impurities, better melt stability, a wider viscosity range and shorter cycle times, and provides for easier and more consistent extrusion and molding.

Meeting thermal and chemical stresses

PPS has striking thermal stability. Grades containing 30 to 40 percent glass reinforcement have deflection temperatures under load (DTUL) of more than 250°C (480°F) at a load of 264 PSI. Its continuous use temperature is as high as 220°C (428°F) and it can withstand excursions to 260°C (500°F). It melts at 285°C (545°F) and has a glass transition temperature of about 90°C (190°F).

PPS is inert to many chemicals and resists oxidation and hydrolysis. It does not dissolve in most common solvents below 200°C (392°F) and is virtually unaffected by acids, bases, alcohols, oxidizing bleaches and many other substances at elevated temperatures. It is relatively impermeable to liquids and gases, so emissions through PPS walls and linings are relatively low.

PPS is inherently flame retardant without additives and is rated UL 94 V-0/5V. Neat PPS has an oxygen index of 44 (the lowest oxygen concentration at which it burns on its own), while its compounds have indices up to 53.

Automotive thermostat housing molded from Ticona's Fortron® PPS.

Its hardness, abrasion resistance, weld line integrity and other properties are better than most high-temperature thermoplastics. Compared to higher-temperature polyesters, for instance, PPS offers greater dimensional stability and thermal, chemical and creep resistance. Also, since it absorbs little water, it swells less in moist environs than nylons, polyetherimides and polyesters.

Near universal application

Linear PPS is valued for its ability to master challenging situations, whether in new products or when replacing metals, thermosets and more expensive thermoplastics. It is often the material of choice for hot, corrosive environments in many industries, including the chemical, pharmaceutical, food and petroleum sectors, especially when superior mechanical integrity is needed. Some typical end uses for PPS include chemical tower packing, sensor and heater housings, pump components, aircraft wing elements, linings in oil and gas drill strings and fuel and chemical tanks, conveyor belts, fuel cell end plates, light sockets and reflectors, and coatings in industrial heat exchangers.

TABLE I: PROPERTIES OF SELECTED PPS GRADES

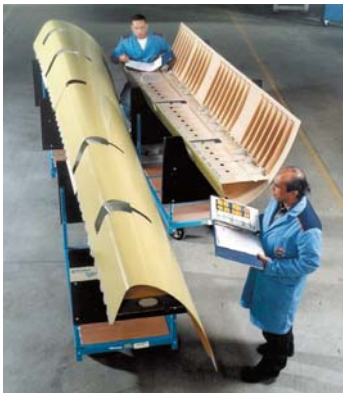
	Extrusion Grade*	40% Glass Grade**	65% Mineral/ Glass Grade***
Density, kg/m^3	1,350	1,650	1,950
Water absorption, % 24 hr. immersion	0.02	0.02	0.02
Tensile modulus, MPa	3,800	14,700	19,000
Tensile stress at break, MPa	90	195	130
Flexural modulus, MPa	3,750	14,500	18,800
Flexural stress at break, MPa	125	285	210
Notched Izod impact, kJ/m^2	3.5	10	6
Melting temperature °C	280	280	280
Deflection temperature under load, °C @ 1.8 MPa	110	270	270
Coefficient of thermal expansion, 1/°C parallel	0.52 x 10^{-4}	0.26 x 10^{-4}	1.9 x 10^{-4}

**Based on Fortron® 0214 PPS from Ticona, an unfilled extrusion grade having good melt strength.*
***Based on Fortron® 1140L4 PPS, an easy-flow, 40% glass-reinforced grade.*
****Based on Fortron® 6165L4 PPS, a tough, mineral/glass-fiber grade.*

In electronics, PPS is typically found in connectors, plug boards, coil formers, relays, switches and chip carriers. Its high heat deflection temperature (up to 270°C/520°F) enables it to withstand infrared and vapor phase soldering commonly used to attach components to printed circuit boards.

Automakers use PPS for precision parts exposed to lubricants, gasoline, coolants, and brake and transmission fluids at elevated temperature (to 200°C/390°F). These parts include fuel rails, seals, water pumps, valve covers, manifolds, clutch systems, engine sensors and exhaust gas feedback systems.

Its use in appliance applications encompasses switches, heater internals, electric motor end bells and brush holders. As a filter material, PPS is a good choice for the bag-house and flue-gas filters associated with coal-fired boilers, cogeneration units and cement kilns. It is also an excellent candidate for use in filtering many liquids, from water, amine and glycol to naphtha and potassium hydroxide at temperatures to 200ºC (392°F). In powdered form, it is used for heat-resistant binders, as additives to other polymers and in slurry coating and electrostatic spraying for food-contact elements and chemical processing equipment.



Airbus A340-500 and -600 planes use Ticona's Fortron® PPS thermoplastic composites in wing and other structural parts, replacing aluminum to decrease weight, improve impact resistance and ease fabrication.

PPS for extrusion and molding

PPS encompasses a broad range of grades that are used in extrusion, injection molding, blow molding and other processes. Its extrusion and injection molding grades span a wide range of melt viscosities, including high-flow grades for thin-walls and those capable of fiber and specialized extrusion use. PPS resin can carry up to 70 percent filler and reinforcement loadings, so its basic properties can be enhanced to meet specific situations.

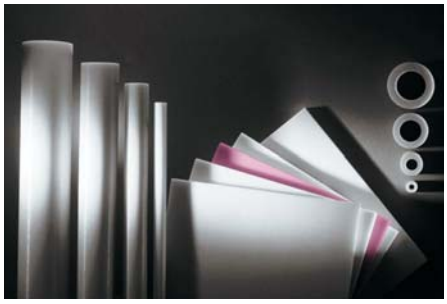
PPS resin is often extruded into stock shapes, films, piping and fibers. Extruded rod, sheet and plate are available with up to 40 percent glass reinforcement. ➡

One line of 40 percent glass-filled PPS offers rods having diameters of 0.25" to 4" and plates with thicknesses of 0.25" to 2". These offer considerable cost savings vs. more expensive polymers. They can, for example, replace 30 percent glass-reinforced polyetheretherketone at approximately one-third the price. Typical applications of these sheets, rods, tubes, films and fibers include insulators, housings, connectors, semiconductor polishing rings, and chain guides, pump parts and other industrial components.

Another extruded line involves thermoformable PPS sheet and roll-stock that are used in interior panels and other large, thin-walled elements in buses, planes and trains. They can replace fluoropolymers in chemical tank linings at an estimated material saving of 30 percent or more. Sheets and rolls are available at thicknesses of 0.01" to 0.25" and may be thermoformed between 550° and 600°F (288° and 315°C) or more. They include neat, glass-filled and modified grades, as well as those with optional backings of glass fiber, polyester fabric and other materials that aid adhesion in multilayer structures.

Linear PPS can be meltblown for filter media over a broad processing window to create a wide range of fiber diameters and fabrics ranging from lofty to stiff. It also can be spunbond for filter media backing, used as netting in filter supports to replace stainless steel mesh, and spun into staple fibers in various deniers and cross sections for felt substrates, such as needlepunched composites. In addition, its monofilaments can be woven to produce forming fabrics for paper machines.

PPS is often used to fabricate injection molded components in conventional screw injection molding machines. Its high melt-flow rate makes it a candidate for long, thin and complex sections. It typically yields parts with excellent dimensional stability and high-quality surface finishes. In blow molding, PPS has good melt strength and allows the formation of complex shapes having high strength-to-weight ratios, such as automotive fuel rails and intake manifolds.



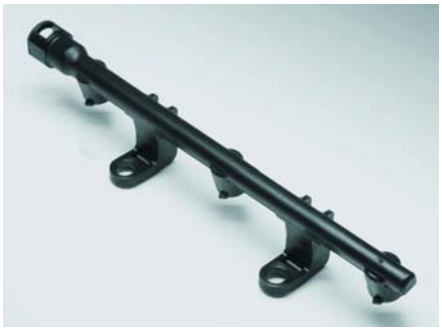
Ensifide® GF 40 rods and plates from ENSINGER, extruded from 40 percent glass fiber-reinforced Fortron® PPS.

Lamp holder by Kania Lichtsysteme for high intensity lights. Fortron® PPS thermoplastic maintains structural integrity over a wide range of ambient temperatures and conditions.

The advances continue

Although linear PPS is a well-established polymer, it continues to be pushed to ever greater versatility and levels of performance. Here's a summary of some relatively new PPS products that offer advanced capabilities:

- A line of PPS certified for medical, pharmaceutical and repeated-use food contact applications. The line includes unreinforced grades that are excellent candidates for extrusion as tube, profiles and fibers, as well as reinforced grades for medical devices and diagnostic equipment and for food and beverage processing.
- An impact-modified PPS that is a good choice for extruded and blow molded use in monolayers or multilayer structures in tube, pipe and film. It has unusual ductility and flexibility, a high melt strength and improved adhesion to nylons and polyolefins
- A nonwoven grade that creates fine-to-coarse meltblown fibers having textures ranging from soft and flexible to stiff. It can be processed on polypropylene meltblown machines and can replace more expensive polymers in tough environments.
- A special grade that is an excellent candidate for high-density fiber optic connectors that offers better flow, cycle time and dimensional stability vs. competing resins.
- A grade that should be considered for auto and light truck cooling systems for use in thermostat housings, crossover pipes and water pump impellers. It has high dimensional and thermal stability, strength and low creep and withstands aggressive long-life coolants.
- A PPS compound having exceptionally low wear and coefficient of friction that is a good choice for parts that move against other parts or surfaces, such as bearings, shafts, gears and chain links.
- A blow-moldable grade having 15 percent glass reinforcement that is an excellent candidate for such uses as hot-side air ducts in auto turbo-diesel engines, auto engine cooling ducts and residential furnace ducts.
- New grades that are good choices for reflective surfaces in headlamp and fog lamp reflectors. These grades retain reflector focus over a wide temperature range and can be metallized without a base coating.



Fortron® PPS fuel rail for DaimlerChrysler 2.7 liter V-6 engines used in U.S. vehicles.

In summary

Polyphenylene sulfide is a versatile material that gives extruded and molded components the ability to meet exceptionally demanding criteria. This semicrystalline, engineering thermoplastic has outstanding thermal stability, superior toughness, inherent flame resistance and excellent chemical resistance. It also has high mechanical strength, impact resistance and dimensional stability, as well as good electrical properties. Although it is a well-known polymer with a long application history, suppliers continue to push it to new levels of performance to meet the expanding needs of designers and manufacturers in nearly all industries. ■

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