Material Alternatives for Plastic Injection Molding

During material supply shortages, consider these resin substitutes for ABS, PC, PP, and other commonly molded thermoplastics

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Navigating supply chain issues is a constant challenge, especially in times of material shortages. So we looked at the more commonly used materials and compiled a list of substitution options that can serve well as replacements. Choosing which ones to use will depend on material properties and the intended functions of your parts. Each section delves into those material properties and reasoning behind the alternative recommendations to provide insight into additional resin options.

With these options in mind, this guide lists alternative materials for common injection-molded thermoplastics. Please be advised that we may not stock all of the materials discussed on this list. We are constantly evaluating our supply base, so feel free to contact us for up-to-date material availability.

In addition, 3D printing materials could potentially be an option, though not a 1:1 option of course. Materials must be suited to the application itself in order to have successful results.

For more information on materials generally, including detailed data sheets, visit our [Materials Comparison Guide].

Plastic Alternative: ASA (Acrylonitrile Styrene Acrylate)

ASA Trade Names: Gelov, Luran

ASA copolymers have excellent resistance to UV irradiation, moisture, heat, and cracking and probably have the best weathering resistance of all acrylonitrile elastomers. Its mechanical properties are similar to acrylonitrile butadiene styrene (ABS) elastomers.

For example, like ABS, ASA has good chemical resistance and high-impact strength. Due to its similar mechanical properties, ASA copolymers are used for similar applications as ABS.

However, ASA has superior weathering resistance which makes it more suitable for outdoor applications than ABS. One of the most important markets for ASAs are automotive body parts such as mirror housings and radiator grills.

ASA thermoplastics are also extensively used in a variety of other industries, including building and construction segments, appliance products, electrical and electronics, and sports goods.

Plastic Alternative: COC (Cyclic Olefin Copolymer)

COC Trade Names: Topas, Apel

These copolymers find growing use as a shatter-resistant substitute for glass in optical lenses and films, particularly in medical and electronic applications such as diagnostic tubes, touch screens (ITO film), light guides, and reflection films.

COC's excellent biocompatibility, chemical resistance, and superior water vapor barrier all make the material a good choice for primary packaging of pharmaceuticals and medical diagnostic disposables.

In addition, these copolymers exhibit a unique combination of properties including high light transmissivity, low birefringence, high refractive index, extremely low water absorption, excellent biocompatibility, good chemical resistance, and very low water vapor permeability as well as high rigidity, strength, and hardness.

These properties can be modified over a wide range by varying the proportions of norbornene and ethylene in the backbone and the overall structure of the copolymer.

Shipping container shortages, a blockage in the Suez Canal, and the on-going pandemic have all served to disrupt supply chains worldwide and trigger material shortages. With this shortage in mind, this guide compiles a list of alternative materials to use for molded parts.

Plastic Alternative:
PCT (Polycyclohexylenedimethylene Terephtalate)

PCT Trade Names: Thermx, Eastar

PCT is a high-performance, semi-crystalline thermoplastic polyester produced by polycondensation of cyclohexane dimethanol (CHDM) and terephthalic acid (TPA).

Its mechanical properties, including flexural, impact, and tensile strength (30% GF) are similar to those of polyethylene terephthalate (PET, 30% GF) whereas its resistance to hydrolysis and heat is superior.

It also has a noticeably higher melting point than PET, about 545 degrees F (285 degrees C) vs. 473 degrees F (245 degrees C).

Other important properties include low moisture absorption, excellent electrical properties, good chemical resistance (comparable to PET and PBT) as well as good long-term light and thermal stability.

Due to these properties, PCT finds uses in the electronic and automotive industries for products and parts such as plug connectors, relays, switches, and distribution boxes. In addition, in many cases, it can be used as a drop-in replacement for PBT where higher temperature resistance is required.

Common Thermoplastics and Their Material Alternatives

Plastic: ABS (Acrylonitrile Butadiene Styrene)
Trade Names: Lustran, Cycolac, Polylac, RTP
Alternatives: PSU, ASA, COC, PPO
3DP Alternatives: ABS-Like stereolithography

Plastic: ABS/PC (Acrylonitrile Butadiene Styrene/Polycarbonate)
Trade Names: Bayblend, Cycoloy
Alternatives: PSU, ASA, PPO
3DP Alternatives: ABS-Like and PC-Like stereolithography

Plastic: HDPE (High-Density Polyethylene)
Trade Names: Marlex, Hostalen, Petrothene
Alternatives: PP, PPO
3DP Alternatives: PP selective laser sintering

Plastic: HIPS (High-Impact Polystyrene)
Alternatives: PMMA, ASA, PPO

Plastic: LCP (Liquid Crystal Polymer)
Trade Name: Vectra
Alternatives: PEEK, PEI, PCT, PPA, PPS, PESU, PPSU

Plastic: PA Nylon (Polyamide)
Trade Names: Hylon, Minion, RTP, Stanyl, Vydyne, Zytel
Alternatives: SPS, PSU, PESU, PPSU, PPA, PPO
3DP Alternatives: PA Nylon selective laser sintering and Multi Jet Fusion

Plastic: PBT (Polybutylene Terephthalate)
Trade Names: Valox, Crastin
Alternatives: SPS, PCT, PSU, PPO

Plastic: PC (Polycarbonate)
Trade Names: Hylex, Lexan, Makrolon, RTP
Alternatives: PSU, COC, PMMA
3DP Alternatives: PC-Like stereolithography

Plastic: PET (Polyethylene Terephthalate)
Trade Name: Rynite
Alternatives: SPS, PCT, PSU, PPO

Plastic: PP (Polypropylene)
Trade Names: Thermylene, Polyfort, Pro-fax, Hostacom
Alternatives: PE, PPO
3DP Alternatives: PP selective laser sintering

Plastic: PPA (Polyphthalmide)
Trade Names: Amodel, Zytel, HTN
Alternatives: PPS, PEEK, PEI, PSU, PESU, PPSU

Plastic: POM (Acetal)
Trade Names: RTP, Celcon, Delrin
Alternatives: PP
3DP Alternatives: PP selective laser sintering

Plastic Alternative: PEEK (Polyether Ether Ketone) and PAEK (Polyaryletherketones)

PEEK Trade Names: Victrex, Ketaspire, Thermocomp

Polyaryletherketones (PAEKs) are a class of semi-crystalline, high-performance engineering thermoplastics that have a unique combination of thermal stability, chemical resistance, and excellent mechanical properties over a wide temperature range.

This class of polymers has also good resistance to combustion and good electrical performance. The high thermal stability is provided by the diphenylene ketone groups, which impart high strength and high resistance to oxidation, but make the polymer rigid. Flexibility in the polymer backbone is provided by ether linkages which also add to the thermal stability.

Some types, like PEEK1, are extremely tough and have very high impact strength. Due to the semi-crystalline nature of these polymers, a high degree of mechanical properties is retained close to their melting temperature. They also have very low tendency to creep and good sliding and wear properties. These properties are retained over a wide temperature range.

Polyetherketones are known for excellent chemical resistance to many organic and inorganic chemicals and exceptionally good resistance to hydrolysis in hot water. However, they exhibit poor or only moderate resistance to weathering due to damage caused by UV radiation2, whereas resistance to beta, gamma, and X-rays is good. Some grades of PAEKs show good resistance to combustion, and when they burn, they produce fewer toxic and corrosive gases than many other high-performance polymers.

PAEKs and polyethersulfones are often used in similar applications. However, PAEKs have better solvent resistance than polyethersulfones because they are semi-crystalline, whereas the latter are amorphous polymers, which makes them more prone to solvent attack. The excellent solvent resistance can be a critical factor in many demanding applications.

Like polyethersulfones, polyetherketones are usually not attacked by prolonged exposure to (saltwater) sea or steam, which makes them ideal candidates for use in applications such as medical components, sub-sea equipment, and valve components. Because of their good wear resistance and mechanical properties, including high stiffness and long-term creep and fatigue properties, mechanical parts made of PAEKs can replace steel in many applications. Examples are high-speed rotors, intricate bearing shells, aircraft landing gear hubcaps, and aerospace P-clamps. Due to their semi-crystalline nature, PAEKs retain a high degree of their mechanical properties close to their melting temperature. Some PAEKs have a continuous service temperature rating of more than 480 degrees F (250 degrees C).

Plastic Alternative: PEI (Polyetherimide)

PEI Trade Names: Ultem, Extem, Thermocomp

Poly(ether)imides (PI, PEI) are high-performance engineering thermoplastics of amber to transparent color. They have outstanding thermal, mechanical, and chemical properties and are often the best choice for the most demanding applications where high mechanical strength in combination with high temperature, corrosion, and wear resistance is required.

For example, some grades have continuous service temperatures of up to 700 degrees F (371 degrees C) and are suitable for short-term exposure up to 1,000 degrees F (538 degrees C) with minimal thermal degradation and minimal loss of mechanical properties. PEIs and PIs resist most chemicals including hydrocarbons, alcohols, and halogenated solvents and have excellent long-term creep resistance. In many cases, they can replace metals and other high-performance materials in structural applications. The electrical properties are of excellent stability under variable temperature, humidity, and frequency conditions.

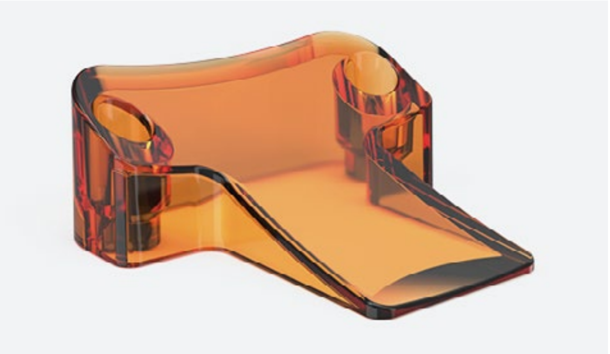
Other important performance properties include:

- High tensile strength over a wide temperature range of about -454 degrees F to + 572 degrees F (-270 degrees C to + 300 degrees C)
- High compression strength and high pressure and creep resistance
- Excellent resistance to wear under high pressure and sliding speeds
- Excellent resistance to stress cracking
- Good cold temperature properties
- High glass transition temperature up to 752 degrees F (400 degrees C) (amorphous resins)
- High melting temperature (semi-crystalline resins)
- Excellent long-term thermal-oxidative stability
- Inherently flame retardant
- Minimal thermal expansion
- High radiation resistance
- High purity and low outgassing in vacuum
- Good chemical resistance to acids, alcohols, fuels, oils, and halogenated solvents
- Excellent electrical insulation properties
- Low thermal conductivity
- Good processability (can be extruded, thermoformed, molded, etc.)

However, poly(ether)imides have also some limitations and shortcomings. For example, they are expensive and require high processing temperatures and they cannot be used above their glass transition temperature unless post annealed.

Poly(ether)imides are often an excellent choice for demanding applications in aerospace and transportation. They also find many applications in the electronic and integrated circuit industry because they meet the most demanding and strict materials specifications. Some other important applications include probe housing, digital card printer frames, coil springs, and cable guards. Because of their high price, polyimides and polyetherimides are usually only used when outstanding properties are required.

The typical service temperature range of polyetherimides is about -454 degrees F to +572 degrees F (-270 degrees C to + 300 degrees C).



The process of injection molding produces high-quality and superior-functioning parts, such as this component that fits into the end product of Triax Technologies Proximity Trace device, which provides distancing alerts and contact tracing in the workplace.

Plastic Alternative: PESU (Polyethersulfone)

PESU Trade Names: Ultrason, Veradel

Veradel PESU offers more toughness, strength, and hydrolytic stability than other transparent engineering plastics. It withstands prolonged exposure to water, chemicals, and temperatures—handling a range of end-use temperatures from -104 degrees F to 400 degrees F (-40 degrees C to 204 degrees C). Veradel PESU is recommended in applications where higher thermal capability, inherent flame resistance, better chemical resistance, and improved mechanical properties are required.

Important performance properties include:

- Heat deflection temperature of 399 degrees F (204 degrees C)
- Inherently flame retardant
- Good chemical resistance
- Excellent electric properties
- Transparency
- Dimensional stability

Veradel PESU is commonly used for electrical and electronics, membranes, health care applications, automotive industry, and in coatings and food-contact applications.

Of all the polyarylsulfones (PSU, PESU, PPSU), PESU has the highest values of temperature resistance and tensile modulus in elasticity. PESU properties are similar to those of PSU, although it exhibits a higher impact strength and better chemical resistance. Its stiffness and stability are high, and its notch sensitivity is low. Other elements to evaluate when considering PESU:

- High cost—applicable for highly demanding applications
- Processing at high temperature and pressure
- Attached by polar solvents such as ketones, chlorinated solvents, and aromatic hydrocarbons
- Low resistance to UV light

Being amorphous in nature, it furthermore suffers from a low stress crack resistance, especially during exposure to organic solvents. As discussed above, very high sales price is also among the major drawbacks as compared to engineering thermoplastics like polyamides, polyesters, and polycarbonates.

A variety of high-performance engineering thermoplastics are available as alternatives to the more commonly used materials during times of supply shortages.

Plastic Alternative: PMMA (Polymethyl Methacrylate)

PMMA Trade Names: Plexiglas, Delpet, Acrylite, Sumipex, Acrypet

Polymethacrylates are amorphous commodity thermoplastics of high transparency that can be easily processed and converted into many semi-finished products like films, rods, tubes, and sheets. The most commercially important methacrylate polymer is poly(methyl methacrylate) (PMMA) also known as Plexiglas, Lucite, Acrylite, and Altuglas. It is a high-volume, amorphous thermoplastic with high Tg (398 K), good mechanical properties, and excellent weatherability. It is resistant to oils, alkanes, and (diluted) acids but is not resistant to many (polar) solvents such as alcohols, organic acids, and ketones. It is also rather brittle and has low-impact strength and fatigue resistance. To increase its toughness, PMMA is often modified with core-shell rubber or other impact modifiers. These resins offer up to 10 times the impact resistance of standard PMMA while maintaining high clarity. Because of their high transparency (92% transmission), toughened acrylics are often used as a lightweight and shatter-resistant replacement for regular glass.
These resins have sufficient impact resistance to be machined.

PMMA is an economical alternative to polycarbonate (PC) when high toughness and impact strength is not required. It comes in a variety of forms, such as sheets, rods, and tubes, and is used for signs, optical fibers for light transmission, architectural structures, tail lights for cars, bathtubs, and sanitary fixtures, to name only a few products.

A prime benefit of injection molding is having hundreds of material choices, including a range of alternative material options to choose from during supply shortages.

Plastic Alternative: PPA (Polyphthalmide)

PPA Trade Names: Amodel, Zytel, HTN

Another important class of polyamides are semi-aromatic polyamides, also knowns as polyphthalamides (PPA). They are melt-processible, semi-crystalline thermoplastic resins made from the condensation of an aliphatic diamine such as hexametylene diamine with terephthalic acid and/or isophthalic acid. The aromatic portion typically comprises at least 55 molar percent of the repeat units in the polymer chain. The combination of aromatic and aliphatic groups greatly reduces moisture absorption which results in little dimensional changes and much more stable properties. Thus, PPAs fill the performance gap between aliphatic nylons such as PA6.6 and PA6, and the much more expensive polyaramids. They are mostly crystalline and offer high strength and stiffness at elevated temperatures. However, these resins are more expensive than aliphatic amides and are more difficult to process due to their higher melting point. To improve processability and to lower cost, they are sometimes blended with aliphatic polyamides such as Nylon 66. The two most common semi-aromatic amides are poly(hexamethylene teraphthalamide) (PA 6T) and poly(hexamethylene isophthalamide) (6I). These resins have a very high melting point (6T: $T_m \approx 595$ K) and glass transition temperature (6T: $T_g \approx 410$ k). They are known for their excellent dimensional stability, low creep at elevated temperatures and good chemical resistance comparable to many high-performance engineering plastics.

Semi-aromatic polyamides are often a cost-effective alternative to the more expensive fully aromatic aramids.

Semi-aromatic polyamides are often a cost-effective alternative to the more expensive fully aromatic aramids. They fill the performance gap between aliphatic nylons and the much more expensive polyaramids. They are often a good choice when the products have to withstand prolonged exposure to harsher chemicals and/or higher temperatures. Common applications include motor parts, fuel line connectors, coolant pumps, bushings, bearing pads in aircraft engines, charge air coolers, resonators, engine cover components and heat shields, fuel cutoff and water heater manifold valves, connectors, high voltage bushings, motor housings, and headlight components.

Plastic Alternative: PPO (Polyphenylene Oxide)

PPO Trade Names: Noryl, Tecanyl

PPO has high tensile and impact strength and is resistant to many chemicals including steam and hot water as well as mineral and organic acids but is sensitive to stress cracking. Despite its many attractive properties, PPO and its derivatives have found only limited commercial use.

The susceptibility of PPO to thermal oxidation in relation to its high glass transition temperature poses a significant problem for melt processing. For this reason, commercial resins are often blended with high-impact polystyrene (HIPS) with which it is fully compatible or with polyamide (PA). Some filled grades of PPO find uses in the automotive and electronic industry. Examples include pump parts, fan impellors, catalyst supports, plugs, insulators, and household articles. Commercial grades of (modified) polyphenylene ethers are available from Ensinger Ltd. (Tecanyl), and SABIC (Noryl).

Besides pure PPO, also blends of PPO and polystyrene and polyolefins (PP) are available that offer a wide range of flexibility, toughness, and flame retardant capabilities. The resins are available in injection-moldable, extrudable and foamable grades.

Plastic Alternative: PPS (Polyphenylene Sulfide)

PPS Trade Names: Fortron, Ryton, Torelina

The most widely used polyphenylthioether is poly(para-phenylene sulfide) (PPS), also called polyphenylene sulfide (PPS). It is a semi-crystalline engineering thermoplastic with a relatively high melting point of about 560 K. Because of its high melting point and its poor solubility, special processing methods have to be used to manufacture products from this resin. For example, PPS can be compression molded at temperatures between 550 and 650 K, at which PPS softens and undergoes crosslinking reactions to yield a totally insoluble plastic. PPS has outstanding heat and chemical resistance, good dimensional stability as well as high tensile and flexural strength due to the aromatic ring structure of the polymer backbone. Although the mechanical properties drop somewhat with increasing temperature, they level off at approximately 395 K, and moderately high mechanical properties can be expected up to 530 K. PPS is typically reinforced with glass fibers or mineral fillers. These grades have improved mechanical strength, are noticeably stiffer (higher modulus), and exhibit better strength retention at elevated temperature (higher heat deflection temperature, HDT). They also exhibit improved flame retardant capabilities and exceptional electrical and electronic properties, including outstanding dielectric strength, which is exceptionally stable over a wide range of temperatures and frequencies.

Poly(p-phenylene sulfide) is the most widely used polythioether. This semi-crystalline engineering thermoplastic has many attractive mechanical and electrical properties. For example, it offers high thermal stability and outstanding dielectric strength, which is exceptionally stable over a range of temperatures and frequencies. Because of these properties, it is extensively used for electrical and electronic parts such as plugs, connectors, relays, switches, and encapsulation of electronic parts. Other applications include mechanical parts in automobiles and precision engineering like air intake systems, pump parts, gaskets, valves, bushings, and bearings, particularly for service in corrosive environments.

Some materials for molding may be in short supply. At Protolabs, we stock more than 100 different thermoplastic resins, though, at any given time, we may not stock all of the materials on this list. Feel free to contact us for up-to-date material availability. We also accept customer-supplied materials.

Plastic Alternative: PPSU (Polyphenylensulfone)

PPSU Trade Names: Ultrason, Radel

PPSU is the highest-performing polysulfone. It is known for its high toughness, high flexural and tensile strength, excellent hydrolytic stability, and good resistance to chemicals and heat. Compared to the two other polyethersulfones, PSU and PES, it has superior mechanical properties, but it is also more expensive, and thus, less widely used. It also has the best chemical resistance of all polyethersulfones. For example, it is highly resistant to aqueous mineral acids, bases, and oxidizing agents and most solvents. However, aromatic solvents and oxygenated solvents, such as ketones and ethers, might cause some stress cracking. PPSU is often an excellent choice for components that are exposed to high temperatures and corrosive media because it has exceptional chemical resistance. Examples include pipe fittings, battery containers, medical device parts, and sterilizable products for health care and nursing. Polyphenylsulfone is also used in the automotive and aerospace industries for applications where superior thermal and mechanical properties relative to conventional resins are required. However, most (unfilled) grades are not suitable for outdoor uses because of poor weathering, ozone, and UV resistance.

Plastic Alternative: PSU (Polysulfone)

PSU Trade Names: Ultrason, Udel

Polysulfone (PSF, PSU) is an amorphous, transparent, and pale amber high-performance thermoplastic produced by nucleophilic aromatic substitution between dichlorodiphenyl sulfone and disodium salt of bisphenol A with elimination of sodium chloride. The resulting resin exhibits good melt stability, which permits fabrication by conventional thermoplastic processing methods including injection molding, extrusion, and thermoforming. Due to its low mold shrinkage, it can be formed into small parts with tight dimensional tolerances.

PSU has outstanding mechanical, electrical, and thermophysical properties. Many commercial grades can tolerate high temperatures for a long period of time and have very high and tensile strength and impact strength comparable to polycarbonate. Polysulfone also exhibits excellent chemical and hydrolytic stability. For example, it is highly resistant to aqueous mineral acids, bases, and oxidizing agents and is fairly resistant to many solvents. However, PSU is not resistant to aromatic and several moderate polar solvents such as benzene, toluene, methyl ethyl ketone, and chlorinated hydrocarbons.

Polysulfone is often an excellent choice for components that are exposed to steam and hot water. Examples include faucet components, internal components of coffee machines, sterilizable plastic parts like medical devices, hot water fittings, and plumbing manifolds, as well as membranes for water treatment, gas separation, hemodialysis, food, and beverage. However, (unprotected) polysulfone is not recommended for outdoor uses because most (unfilled) grades have poor weathering and UV resistance.

A range of alternative plastic materials—seen in raw resin form here—are available. Choosing which ones to use will depend on material properties and the intended functions of your parts.

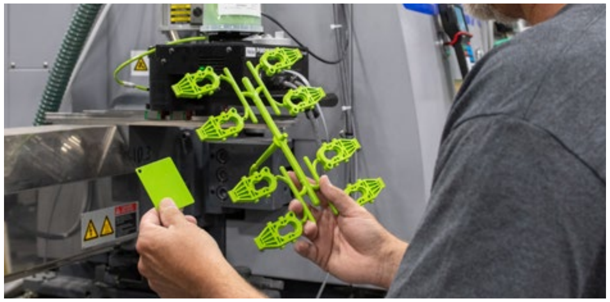
Plastic Alternative: SPS (Syndiotactic Polystyrene)

SPS Trade Name: Xarec

XAREC is the world's first syndiotactic polystyrene (SPS) resin. Idemitsu created this unique SPS product at its central research laboratories by combining a metallocene catalyst with a styrene monomer. The metallocene catalyst gives flexibility to the structure of the crystallized polystyrene SPS, allowing a variety of benzene ring arrangements. In addition, researchers applied advanced alloying and composite technology to greatly expand the commercial potential of SPS as an engineering plastic.

Highlights of SPS include:

- Resistance to hydrolysis: Compared to polyester- and polyamide-based resins, SPS offers a superior hydrolysis resistance, comparable to polyphenylene sulfide.
- Chemical resistance: SPS is highly resistant to corrosion by various acids and alkalis, and can withstand automobile oils and antifreeze.
- Low specific gravity: With one of the lowest specific gravities of all engineering plastics on the market, SPS reduces the weight and cost of parts.
- Heat resistance: With a long-term heat resistance of 266 degrees F (130 degrees C), a heat-distortion temperature of 482 degrees F (250 degrees C), and a melting point of 518 degrees F (270 degrees C), SPS can be used for wave and reflow soldering. SPS is also moisture resistance, and useful for surface mount chip parts and connectors.
- Electrical properties: SPS' electrical properties, including its dissipation factor and dielectric constant, are similar to those of fluororesins. Because it is electrically stable over a wide range of frequencies and temperatures, SPS is suitable for high-frequency components.
- Dimensional stability: Because the flow and transversal direction of the molten resin changes little during mold shrinkage, SPS offers good dimensional performance when compared to other glass-fiber-reinforced crystalline resins.
- Processability: SPS can easily be molded on any standard specification injection molding machine. It possesses high-flow properties, close to those of liquid crystal plastic, and degradation due to heating is minimal. It is also ground easily, making SPS easy to recycle.



Beyond the materials listed in this guide, injection molding's mold-making method also includes using a single-cavity or multi-cavity mold (pictured).

Owing to its desirable heat resistance, electrical properties, chemical resistance and low specific gravity, SPS is well suited for the manufacture of electronic components for various hybrid electric vehicles. SPS is also a sound environmental choice, and is compatible with lead-free solder processes.

Because SPS performs well even when subjected to temperature changes, or exposed to water chemicals and electrical contact, it has become an essential component of many everyday home appliances. SPS' dielectric properties, including its low dissipation factor and dielectric constant, are close to those known for fluororesins, making SPS ideal for use in high-frequency components.

Ultimately, as mentioned at the beginning of this guide, supply chain issues will remain a constant challenge, especially in times of material shortages. That's why it's helpful to be armed with a list of alternative materials for common injection-molded thermoplastics.

PROTOLABS

Contact Us

Proto Labs, Inc.
5540 Pioneer Creek Dr.
Maple Plain, MN 55359
United States

P 877-479-3680
F 763-479-2679
E customerservice@protolabs.com