Polycarbonate (PC)

Description

Image

Caption

1. Personal computer casing made of polycarbonate. © Chris Lefteri 2. Polycarbonate is tough and impact-resistant: hence its use in hard hats and helmets, transparent roofing and riot shields.

The material

PC is one of the 'engineering' thermoplastics, meaning that they have better mechanical properties than the cheaper 'commodity' polymers. The family includes the plastics polyamide (PA), polyoxymethylene (POM) and polytetrafluorethylene (PTFE). The benzene ring and the -OCOO- carbonate group combine in pure PC to give it its unique characteristics of optical transparency and good toughness and rigidity, even at relatively high temperatures. These properties make PC a good choice for applications such as compact disks, safety hard hats and housings for power tools. To enhance the properties of PC even further, it is possible to co-polymerize the molecule with other monomers (improves the flame retardancy, refractive index and resistance to softening), or to reinforce the PC with glass fibers (giving better mechanical properties at high temperatures).

Compositional summary

(O-(C6H4)-C(CH3)2-(C6H4)-CO)n

General properties

Density	71.2	-	75.5	lb/ft^3
Price	* 1.69	-	1.84	USD/lb
Date first used	1958			

Mechanical properties

Young's modulus	0.29	-	0.354	10^6 psi
Shear modulus	0.114	-	0.126	10^6 psi
Bulk modulus	0.537	-	0.566	10^6 psi
Poisson's ratio	0.391	-	0.408	
Yield strength (elastic limit)	8.56	-	10.2	ksi
Tensile strength	8.7	-	10.5	ksi
Compressive strength	10	-	12.6	ksi
Elongation	70	-	150	% strain

Hardness - Vickers	17.7	-	21.7	HV
Fatigue strength at 10^7 cycles	3.21	-	4.47	ksi
Fracture toughness	1.91	-	4.19	ksi.in^0.5
Mechanical loss coefficient (tan delta)	0.0164	-	0.0181	

Thermal properties

Glass temperature	287	-	401	°F
Maximum service temperature	214	-	291	°F
Minimum service temperature	-190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.109	-	0.126	BTU.ft/h.ft^2.F
Specific heat capacity	0.367	-	0.39	BTU/lb.°F
Thermal expansion coefficient	66.7	-	76	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e20	-	1e21	µohm.cm
Dielectric constant (relative permittivity)	3.1	-	3.3	
Dissipation factor (dielectric loss tangent)	8e-4	-	0.0011	
Dielectric strength (dielectric breakdown)	399	-	487	V/mil

Optical properties

Transparency	Optical Quality			
Refractive index	1.54	-	1.59	

Processability

Castability	1	-	2	
Moldability	4	-	5	
Machinability	3	-	4	
Weldability	5			

Eco properties

Embodied energy, primary production	* 1.12e4	-	1.24e4	kcal/lb
CO2 footprint, primary production	* 5.74	-	6.35	lb/lb
Recycle	✓			

Recycle mark

Supporting information

Design guidelines

The optical transparency and high impact resistance of PC make it suitable for bullet-resistant or shatter-resistant glass applications. It is readily colored. PC is usually processed by extrusion or thermoforming (techniques that impose constraints on design), although injection molding is possible. When designing for extrusion with thermoplastics, the wall thickness should be as uniform as possible to prevent warping, and projections and sharp corners avoided- features like hollows and lone unsupported die sections greatly increase the mold cost. The stiffness of the final part can be improved by the incorporation of corrugations or embossed ribs. PC can be reinforced using glass fibers to reduce shrinkage problems on cooling and to improve the mechanical performance at high temperatures.

Technical notes

The combination of the benzene ring and carbonate structures in the PC molecular structure give the polymer its unique characteristics of high strength and outstanding toughness. It can be easily blended with ABS or polyurethane. ABS/PC gets its flame retardance and UV resistance from polycarbonate at a lower cost than that of ABS. PU/PC gets its rigidity from polycarbonate and flexibility and ease of coating from polyurethane.

Typical uses

Safety shields and goggles; lenses; glazing panels; business machine housing; instrument casings; lighting fittings; safety helmets; electrical switchgear; laminated sheet for bullet-proof glazing; twin-walled sheets for glazing; kitchenware and tableware; microwave cookware, medical (sterilizable) components.

Tradenames

Calibre, FR-PC, Latilon, Lexan, Lupilon, Makrolon, Naxell, Nyloy, Panlite, Sinvet, Star-C, Starglas, Triex, Xantar

Links

Reference

ProcessUniverse

Producers