Polymethyl methacrylate (Acrylic, PMMA)

Description

Image

Caption

1. Car rear light casing. © Chris Lefteri 2. PMMA chair. © Chris

The material

When you think of PMMA, think transparency. Acrylic, or PMMA, is the thermoplastic that most closely resembles glass in transparency and resistance to weathering. The material has a long history: discovered in 1872, first commercialized in 1933, its first major application was as cockpit canopies for fighter aircraft during the second World War.

Compositional summary

(CH2-C(CH3)COOCH3)n

General properties

Density		72.4	-	76.2	lb/ft^3
Price	*	1.42	-	1.7	USD/lb
Date first used		1933			

Mechanical properties

Young's modulus		0.325	-	0.551	10^6 psi
Shear modulus		0.116	-	0.198	10^6 psi
Bulk modulus		0.609	-	0.638	10^6 psi
Poisson's ratio		0.384	-	0.403	
Yield strength (elastic limit)		7.8	-	10.5	ksi
Tensile strength		7.01	-	11.5	ksi
Compressive strength		10.5	-	19	ksi
Elongation		2	-	10	% strain
Hardness - Vickers		16.1	-	21.9	HV
Fatigue strength at 10^7 cycles	*	2.2	-	4.74	ksi
Fracture toughness		0.637	-	1.46	ksi.in^0.5

Mechanical loss coefficient (tan delta)	* 0.0105	-	0.0179	

Thermal properties

Glass temperature	185	-	329	°F
Maximum service temperature	107	-	134	°F
Minimum service temperature	-190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0484	-	0.145	BTU.ft/h.ft^2.F
Specific heat capacity	0.355	-	0.384	BTU/lb.°F
Thermal expansion coefficient	40	-	90	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e23	-	3e24	µohm.cm
Dielectric constant (relative permittivity)	3.2	-	3.4	
Dissipation factor (dielectric loss tangent)	0.05	-	0.06	
Dielectric strength (dielectric breakdown)	399	-	551	V/mil

Optical properties

Transparency	Optical Quality			
Refractive index	1.49	-	1.56	

Processability

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

Eco properties

Embodied energy, primary production	* 1.15e4	-	1.28e4	kcal/lb
CO2 footprint, primary production	* 6.46	-	7.14	lb/lb
Recycle	✓			

Recycle mark

Supporting information

Design guidelines

Acrylic, PMMA, is hard and stiff as polymers go, easy to polish but sensitive to stress concentrations. It shares with glass a certain fragility, something that can be overcome by blending with acrylic rubber to give a high-impact alloy (HIPMMA). PVC can be blended with PMMA to give tough, durable sheets. Acrylic is available as a sheet, rod or tube and can be shaped by casting or extrusion. Cell casting uses plates of glass and gasketing for a mold; it allows clear and colored panels up to 4 inches thick to be cast. Extrusion pushes melted polymer pellets through a die to give a wide variety of shapes, up to 0.25 inches thick for sheet. Clear and colored PMMA sheet lends itself to thermoforming, allowing inexpensive processing. A hybrid sheet manufacturing process, continuous casting, combines the physical benefits of cell casting and the cost efficiency of extrusion. Extruded and continuous cast sheet have better thickness tolerance than cell-cast sheet. PMMA can be joined with epoxy, alpha-cyanoacrylate, polyester or nitrile-phenolic adhesives. It scratches much more easily than glass, but this can be partially overcome with coatings.

Technical notes

Polymers are truly transparent only if they are completely amorphous - that is, non-crystalline. The lumpy shape of the PMMA molecule ensures an amorphous structure, and its stability gives good weathering resistance. PMMA is attacked by esters, ketones, acids and hydrocarbons, and has poor resistance to strong acids or bases, solvents and acetone.

Typical uses

Lenses of all types; cockpit canopies and aircraft windows; signs; domestic baths; packaging; containers; electrical components; drafting equipment; tool handles; safety spectacles; lighting, automotive tail lights, chairs, contact lenses, windows, advertising signs, static dissipation products; compact disks.

Tradenames

Acrive, Acrylite, Acryrex, Altuglas, Cyrolite, Diakon, Glasflex, Goldrex, Lucite, Lucryl, Optix, Oroglas, Perspex, Plexiglas, Plexit, Sumiplex

Links

Reference

ProcessUniverse

Producers