

Description

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.

Composition

$(\text{CH}_3\text{-CH}_2\text{-C-CO-OCH}_3)_n$

Image



General properties

Density	1160	-	1220	kg/m ³
Price	* 1.75	-	1.925	EUR/kg

Mechanical properties

Young's modulus	2.24	-	3.8	GPa
Shear modulus	0.8027	-	1.365	GPa
Bulk modulus	4.2	-	4.4	GPa
Poisson's ratio	0.384	-	0.4031	
Yield strength (elastic limit)	53.8	-	72.4	MPa
Tensile strength	48.3	-	79.6	MPa
Compressive strength	72.4	-	131	MPa
Elongation	2	-	10	%
Hardness - Vickers	16.1	-	21.9	HV
Fatigue strength at 10 ⁷ cycles	* 15.2	-	32.7	MPa
Fracture toughness	0.7	-	1.6	MPa.m ^{1/2}
Mechanical loss coefficient	* 0.01053	-	0.01786	

Thermal properties

Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0837	-	0.251	W/m.K
Thermal expansion coefficient	72	-	162	μstrain/°C
Specific heat	1485	-	1606	J/kg.K
Glass temperature	84.85	-	164.9	°C
Maximum service temperature	41.85	-	56.85	°C
Minimum service temperature	-123.2	-	-73.15	°C

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) 15.7 - 21.7 1000000 V/m

Optical properties

Transparency Optical Quality
Refractive index 1.49 - 1.56

Eco properties, material production

Embodied energy * 93.8 - 104 MJ/kg
CO2 footprint * 3.4 - 3.76 kg/kg

Eco properties, processing

Polymer molding energy 10.76 - 13.16 MJ/kg
Polymer extrusion energy 3.767 - 4.605 MJ/kg

Eco properties, recycling and disposal

Recycle ✓
Downcycle ✓
Combust for energy recovery ✓
Biodegrade ✗
Landfill ✓
A renewable resource? ✗

Recycle mark

Other less
common
polymers



Environmental notes

Acrylics are non-toxic and recyclable.

Processability

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

Durability

Flammability Flammable
Fresh water Very good
Salt water Very good
Weak acids Good
Strong acid Poor
Weak alkalis Good
Strong alkalis Average
Organic solvents Poor
Sunlight (UV radiation) Very good
Oxidation at 500C Very poor

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