Polypropylene (PP)

Description

Image

Caption

1. Polypropylene samples showing texture and transparency. © Chris Lefteri 2. Polypropylene glasses. © Thinkstock

The material

Polypropylene, PP, first produced commercially in 1958, is the younger brother of polyethylene - a very similar molecule with similar price, processing methods and application. Like PE it is produced in very large quantities (more than 30 million tons per year in 2000), growing at nearly 10% per year, and like PE its molecule-lengths and side-branches can be tailored by clever catalysis, giving precise control of impact strength, and of the properties that influence molding and drawing. In its pure form polypropylene is flammable and degrades in sunlight. Fire retardants make it slow to burn and stabilizers give it extreme stability, both to UV radiation and to fresh and salt water and most aqueous solutions.

Compositional summary

(CH2-CH(CH3))n

General properties

Density		55.6	-	56.8	lb/ft^3
Price	*	0.889	-	1.02	USD/lb
Date first used		1957			

Mechanical properties

Young's modulus		0.13	-	0.225	10^6 psi
Shear modulus		0.0458	-	0.0795	10^6 psi
Bulk modulus		0.363	-	0.377	10^6 psi
Poisson's ratio		0.405	-	0.427	
Yield strength (elastic limit)		3	-	5.4	ksi
Tensile strength		4	-	6	ksi
Compressive strength		3.64	-	8.01	ksi
Elongation		100	-	600	% strain

Hardness - Vickers	6.2	-	11.2	HV
Fatigue strength at 10^7 cycles	1.6	-	2.4	ksi
Fracture toughness	2.73	-	4.1	ksi.in^0.5
Mechanical loss coefficient (tan delta)	0.0258	-	0.0446	

Thermal properties

Melting point	302	-	347	°F
Glass temperature	-13.3	-	4.73	°F
Maximum service temperature	212	-	239	°F
Minimum service temperature	-190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0653	-	0.0965	BTU.ft/h.ft^2.F
Specific heat capacity	0.447	-	0.467	BTU/lb.°F
Thermal expansion coefficient	68	-	100	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e22	-	3e23	µohm.cm
Dielectric constant (relative permittivity)	2.1	-	2.3	
Dissipation factor (dielectric loss tangent)	3e-4	-	7e-4	
Dielectric strength (dielectric breakdown)	577	-	625	V/mil

Optical properties

Transparency	Translucent			
Refractive index	1.48	-	1.5	

Processability

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

Eco properties

Embodied energy, primary production	*	8.2e3	-	9.07e3	kcal/lb
CO2 footprint, primary production	*	2.96	-	3.27	lb/lb
Recycle		✓			

Recycle mark

Supporting information

Design guidelines

Standard grade PP is inexpensive, light and ductile but it has low strength. It is more rigid than PE and can be used at higher temperatures. The properties of PP are similar to those of HDPE but it is stiffer and melts at a higher temperature (165 - 170 C). Stiffness and strength can be improved further by reinforcing with glass, chalk or talc. When drawn to fiber PP has exceptional strength and resilience; this, together with its resistance to water, makes it attractive for ropes and fabric. It is more easily molded than PE, has good transparency and can accept a wider, more vivid range of colors. PP is commonly produced as sheet, moldings fibers or it can be foamed. Advances in catalysis promise new co-polymers of PP with more attractive combinations of toughness, stability and ease of processing. Mono-filaments fibers have high abrasion resistance and are almost twice as strong as PE fibers. Multi-filament yarn or rope does not absorb water, will float on water and dyes easily.

Technical notes

The many different grades of polypropylene fall into three basic groups: homopolymers (polypropylene, with a range of molecular weights and thus properties), co-polymers (made by co-Polymerization of propylene with other olefines such as ethylene, butylene or styrene) and composites (polypropylene reinforced with mica, talc, glass powder or fibers) that are stiffer and better able to resist heat than simple polypropylenes.

Typical uses

Ropes, general polymer engineering, automobile air ducting, parcel shelving and air-cleaners, garden furniture, washing machine tank, wet-cell battery cases, pipes and pipe fittings, beer bottle crates, chair shells, capacitor dielectrics, cable insulation, kitchen kettles, car bumpers, shatter proof glasses, crates, suitcases, artificial turf, thermal underwear.

Tradenames

Adpro, Amoco, Appryl, Aqualoy, Astryn, Cefor, Comalloy, Comshield, Dypro, EA36NA, Eltex P, Empee, Escorene, Ferrex, Ferrolene, Fortilene, Fotilene, Hifax, Hostalen PP, Latene, Marlex, Moplen, Multi-Flam, Multi-Pro, Nortuff, Novalen, Novolen, Nyloy, Petrothene, Polyfort, Polypro, Precolor, Pro Fax, Propak, Rexflex, Stamylyn, Starlylen, Statoil, Technoprene, Thermocomp, Vestolen, WPP, Washpen

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Reference

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