Polyethylene terephthalate (PET)

Description

Image

Caption

PET drinks containers, pressurized and unpressurized. © Tee design and printing

The material

The name polyester derives from a combination of 'Polymerization' and 'esterification'. Saturated polyesters are thermoplastic - examples are PET and PBT; they have good mechanical properties to temperatures as high as 175 C. PET is crystal clear, impervious to water and CO2, but a little oxygen does get through. It is tough, strong, easy to shape, join and sterilize - allowing reuse. When its first life comes to an end, it can be recycled to give fibers and fleece materials for clothing and carpets. Unsaturated polyesters are thermosets; they are used as the matrix material in glass fiber/polyester composites. Polyester elastomers are resilient and stretch up to 45% in length; they have good fatigue resistance and retain flexibility at low temperatures.

Compositional summary

(CO-(C6H4)-CO-O-(CH2)2-O)n

General properties

Density		80.5	-	87.4	lb/ft^3
Price	*	0.658	-	0.803	USD/lb
Date first used		1941			

Mechanical properties

Young's modulus		0.4	-	0.6	10^6 psi
Shear modulus	*	0.144	-	0.216	10^6 psi
Bulk modulus		0.718	-	0.754	10^6 psi
Poisson's ratio	*	0.381	-	0.396	
Yield strength (elastic limit)		8.19	-	9.04	ksi
Tensile strength		7.01	-	10.5	ksi
Compressive strength		9.01	-	9.94	ksi
Elongation		30	-	300	% strain
Hardness - Vickers		17	-	18.7	HV

Fatigue strength at 10^7 cycles	*	2.8	-	4.2	ksi
Fracture toughness		4.1	-	5.01	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.00966	-	0.0145	

Thermal properties

Melting point		413	-	509	°F
Glass temperature		154	-	176	°F
Maximum service temperature		152	-	188	°F
Minimum service temperature	*	-190	-	-99.7	°F
Thermal conductor or insulator?		Good insulator			
Thermal conductivity		0.0797	-	0.0872	BTU.ft/h.ft^2.F
Specific heat capacity	*	0.339	-	0.352	BTU/lb.°F
Thermal expansion coefficient		63.7	-	66.3	µstrain/°F

Electrical properties

Electrical conductor or insulator?		Good insulator			
Electrical resistivity		3.3e20	-	3e21	µohm.cm
Dielectric constant (relative permittivity)		3.5	-	3.7	
Dissipation factor (dielectric loss tangent)	*	0.003	-	0.007	
Dielectric strength (dielectric breakdown)		419	-	551	V/mil

Optical properties

Transparency		Transparent			
Refractive index		1.57	-	1.58	

Processability

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

Eco properties

Embodied energy, primary production	*	8.76e3	-	9.7e3	kcal/lb
CO2 footprint, primary production	*	3.76	-	4.15	lb/lb
Recycle		✓			

Recycle mark

Supporting information

Design guidelines

There are four grades of thermoplastic polyesters: unmodified, flame retardant, glass-fiber reinforced and mineral-filled. Unmodified grades have high elongation; flame retardant grades are self -extinguishing; glass-fiber reinforced grades (like Rynite) are some of the toughest polymers but there are problems with dimensional stability; and mineral-filled grades are used to counter warping and shrinkage although some strength is lost. The PET used in carbonated drink containers is able to withstand pressure from within, it is recyclable and lighter than glass. The limits of the material's permeability to oxygen is overcome by sandwiching a layer of polyethylvinylidene-alcohol between two layers of PET giving a multi-layer material that can still be blow molded. Polyester can be optically transparent, clear, translucent, white or opaque; the resin is easily colored.

Technical notes

Polyesters are made by a condensation reaction of an alcohol like ethyl alcohol (the one in beer) and an organic acid like acetic acid (the one in vinegar). The two react, releasing water, and forming an ester. PET, PBT and PCT are not cross-linked and thus are thermoplastic. The polyesters that are used as the matrix polymer in bulk and sheet molding compounds are thermosets

Typical uses

Electrical fittings and connectors; blow molded bottles; packaging film; film; photographic and X-ray film; audio/visual tapes; industrial strapping; capacitor film; drawing office transparencies; fibers. Decorative film, metallized balloons, photography tape, videotape, carbonated drink containers, ovenproof cookware, windsurfing sails, credit cards

Tradenames

Arnite, Eastabond, Eastapak, Ektar, Grilpet, Impet, Kodapak, Melinar, Petra, Plenco, Polyclear, Rynite, Selar, Techster, Valox

Links

Reference

ProcessUniverse

Producers