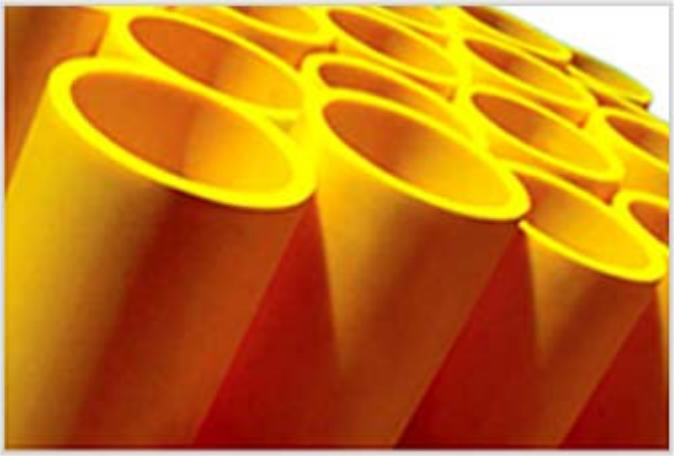
Polyethylene (PE)

Description

Image



Caption

1. Low-density PE bottle. © Granta Design 2. Medium-density PE pipe. © Granta Design

The material

POLYETHYLENE, (-CH2-)n, first synthesized in 1933, looks like the simplest of molecules, but the number of ways in which the - CH2 - units can be linked is large. It is the first of the polyolefins, the bulk thermoplastic polymers that account for a dominant fraction of all polymer consumption. Polyethylene is inert, and extremely resistant to fresh and salt water, food, and most water-based solutions. Because of this it is widely used in household products, food containers like Tupperware and chopping boards. Polyethylene is cheap, and particularly easy to mold and fabricate. It accepts a wide range of colors, can be transparent, translucent or opaque, has a pleasant, slightly waxy feel, can be textured or metal coated, but is difficult to print on.

Compositional summary

(-CH2-CH2-)n

General properties

Density		58.6	-	59.9	lb/ft^3
Price	*	0.903	-	1.1	USD/lb
Date first used		1936			

Mechanical properties

Young's modulus		0.0901	-	0.13	10^6 psi
Shear modulus	*	0.0316	-	0.0456	10^6 psi
Bulk modulus		0.312	-	0.326	10^6 psi
Poisson's ratio	*	0.418	-	0.434	
Yield strength (elastic limit)		2.6	-	4.21	ksi
Tensile strength		3	-	6.5	ksi
Compressive strength		2.86	-	4.63	ksi
Elongation		200	-	800	% strain
Hardness - Vickers		5.4	-	8.7	HV

Fatigue strength at 10^7 cycles	3.05	-	3.34	ksi
Fracture toughness	* 1.31	-	1.57	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.0446	-	0.0644	

Thermal properties

Melting point	257	-	269	°F
Glass temperature	-13.3	-	4.73	°F
Maximum service temperature	* 194	-	230	°F
Minimum service temperature	* -190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.233	-	0.251	BTU.ft/h.ft^2.F
Specific heat capacity	* 0.432	-	0.449	BTU/lb.°F
Thermal expansion coefficient	70	-	110	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e22	-	3e24	µohm.cm
Dielectric constant (relative permittivity)	2.2	-	2.4	
Dissipation factor (dielectric loss tangent)	* 3e-4	-	6e-4	
Dielectric strength (dielectric breakdown)	450	-	500	V/mil

Optical properties

Transparency	Translucent			
Refractive index	1.5	-	1.52	

Processability

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

Eco properties

Embodied energy, primary production	* 8.34e3	-	9.22e3	kcal/lb
CO2 footprint, primary production	* 2.64	-	2.92	lb/lb
Recycle	✓			

Recycle mark

Supporting information

Design guidelines

PE is commercially produced as film, sheet, rod, foam and fiber. Drawn PE fiber has exceptional mechanical stiffness and strength, exploited in geo-textile and structural uses. PE is a good electrical insulator with low dielectric loss, so suitable for containers for microwave cooking. It has poor resistance to aromatics and chlorine; it is slow burning in fire. PE is cheap, easy to form, biologically inert and recyclable; it is one of the materials of the next 20 years.

Technical notes

Low density polyethylene (LDPE), used for film and packaging, has branched chains which do not pack well, making it less dense than water. Medium (MDPE) and High (HDPE) density polyethylenes have longer, less branched chains, making them stiffer and stronger; they are used for containers and pipes. Modern catalysis allows side-branching to be suppressed and molecular length to be controlled precisely, permitting precise tailoring both of the processing properties critical for drawing, blow molding, injection molding or extrusion and the use-properties of softening temperature, flexibility and toughness. Linear low-density polyethylene (LLPDE) is an example. In its pure form it is less resistant to organic solvents, but even this can be overcome by converting its surface to a fluoro-polymer by exposing it to fluorine gas. Treated in this way (when it known is known as 'Super PE') it can be used for petrol tanks in cars and copes with oil, cleaning fluid, cosmetics and that most corrosive of substances: cola concentrate. Very low density polyethylene (VDLPE) is similar to EVA and plasticized PVC.

Typical uses

Oil container, street bollards, milk bottles, toys, beer crate, food packaging, shrink wrap, squeeze tubes, disposable clothing, plastic bags, paper coatings, cable insulation, artificial joints, and as fibers - low cost ropes and packing tape reinforcement.

Tradenames

Alathon, Aquathene, Bapolene, Dowlex, Eltex, Empee, Eraclene, Ferrene, Fortiflex, HiVal, Hid, Kemcor, Lacqtene, Lupolen, Marlex, Nortuff, Novapol, Paxon, Petrothene, Polyfort, Rigidex, Sclair, Stamylyn, Statoil, Unival, Zemid

Links

Reference

ProcessUniverse

Producers