Polyoxymethylene (Acetal, POM)

Description

Image

Caption

Zips.

The material

POM was first marketed by DuPont in 1959 as Delrin. It is similar to nylon but is stiffer, and has better fatigue and water resistance - nylons, however, have better impact and abrasion resistance. It is rarely used without modifications: most often filled with glass fiber, flame retardant additives or blended with PTFE or PU. The last, POM/PU blend, has good toughness. POM is used where requirements for good moldability, fatigue resistance and stiffness justify its high price relative to mass polymers, like polyethylene, which are polymerized from cheaper raw materials using lower energy input.

Composition (summary)

(CH2-O)n

General properties

Density	86.8	-	89.3	lb/ft^3
Price	* 1.34	-	1.47	USD/lb
Date first used	1956			

Mechanical properties

Young's modulus	0.363	-	0.725	10^6 psi
Shear modulus	0.122	-	0.33	10^6 psi
Bulk modulus	0.638	-	0.667	10^6 psi
Poisson's ratio	0.33	-	0.407	
Yield strength (elastic limit)	7.05	-	10.5	ksi
Tensile strength	8.7	-	13	ksi
Compressive strength	10.9	-	18	ksi
Elongation	10	-	75	% strain
Hardness - Vickers	14.6	-	24.8	HV
Fatigue strength at 10^7 cycles	* 3.18	-	4.97	ksi
Fracture toughness	1.55	-	3.82	ksi.in^0.5
Mechanical loss coefficient (tan delta)	* 0.00638	-	0.017	

Thermal properties

Melting point	320	-	363	°F
Glass temperature	-0.67	-	17.3	°F
Maximum service temperature	170	-	206	°F
Minimum service temperature	-190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			

Thermal conductivity	0.128	-	0.203	BTU.ft/h.ft^2.F
Specific heat capacity	0.326	-	0.342	BTU/lb.°F
Thermal expansion coefficient	42.1	-	112	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e20	-	3e21	µohm.cm
Dielectric constant (relative permittivity)	3.6	-	4	
Dissipation factor (dielectric loss tangent)	9.5e-4	-	0.005	
Dielectric strength (dielectric breakdown)	384	-	521	V/mil

Optical properties

Transparency	Opaque

Processability

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

Durability: water and aqueous solutions

Water (fresh)	Excellent
Water (salt)	Excellent
Soils, acidic (peat)	Excellent
Soils, alkaline (clay)	Excellent
Wine	Excellent

Durability: acids

Acetic acid (10%)	Excellent
Acetic acid (glacial)	Unacceptable
Citric acid (10%)	Excellent
Hydrochloric acid (10%)	Limited use
Hydrochloric acid (36%)	Unacceptable
Hydrofluoric acid (40%)	Unacceptable
Nitric acid (10%)	Limited use
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Limited use
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Unacceptable
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

Sodium hydroxide (10%)	Excellent
Sodium hydroxide (60%)	Excellent

Durability: fuels, oils and solvents

Amyl acetate	Excellent
Benzene	Excellent
Carbon tetrachloride	Excellent
Chloroform	Limited use
Crude oil	Acceptable
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent

Silicone fluids	Limited use
Toluene	Excellent
Turpentine	Excellent
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Excellent
Acetone	Limited use
Ethyl alcohol (ethanol)	Excellent
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Excellent

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable
O2 (oxygen gas)	Unacceptable
Sulfur dioxide (gas)	Unacceptable

Durability: built environments

Industrial atmosphere	Acceptable
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Poor

Durability: flammability

Flammability	Highly flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Acceptable
Tolerance up to 250 C (482 F)	Unacceptable
Tolerance up to 450 C (842 F)	Unacceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 9.25e3	-	1.02e4	kcal/lb
CO2 footprint, primary production	* 3.85	-	4.26	lb/lb
Water usage	* 16.5	-	49.5	gal(US)/lb

Material processing: energy

Polymer extrusion energy	* 624	-	689	kcal/lb
Polymer molding energy	* 1.83e3	-	2.03e3	kcal/lb
Coarse machining energy (per unit wt removed)	* 135	-	150	kcal/lb
Fine machining energy (per unit wt removed)	* 891	-	984	kcal/lb
Grinding energy (per unit wt removed)	* 1.73e3	-	1.91e3	kcal/lb

Material processing: CO2 footprint

Polymer extrusion CO2	* 0.432	-	0.477	lb/lb
Polymer molding CO2	* 1.27	-	1.4	lb/lb
Coarse machining CO2 (per unit wt removed)	* 0.0937	-	0.104	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.616	-	0.681	lb/lb

Grinding CO_2 (per unit wt removed)	* 1.2	-	1.32	lb/lb

Material recycling: energy, CO_2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 3.6e3	-	3.98e3	kcal/lb
CO_2 footprint, recycling	* 2.61	-	2.88	lb/lb
Recycle fraction in current supply	* 0.5	-	1	%
Downcycle	✓			
Combust for energy recovery	✓			
Heat of combustion (net)	* 1.68e3	-	1.76e3	kcal/lb
Combustion CO_2	* 1.43	-	1.5	lb/lb
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Acetal, like most thermoplastics, is an oil derivative, but this poses no immediate threat to its use.

Recycle mark

Supporting information

Design guidelines

POM is easy to mold by blow molding, injection molding or sheet molding, but shrinkage on cooling limits the minimum recommended wall thickness for injection molding to 0.1mm. As manufactured, POM is gray but it can be colored. It can be extruded to produce shapes of constant cross section such as fibers and pipes. The high crystallinity leads to increased shrinkage upon cooling. It must be processed in the temperature range 190-230 C and may require drying before forming because it is hygroscopic. Joining can be done using ultrasonic welding, but POM's low coefficient of friction requires welding methods that use high energy and long ultrasonic exposure; adhesive bonding is an alternative. POM is a good electrical insulator. Without coPolymerization or the addition of blocking groups, POM degrades easily.

Technical notes

The repeating unit of POM is - $(CH_2O)_n$ and the resulting molecule is linear and highly crystalline. Consequently, POM is easily moldable, has good fatigue resistance and stiffness, and is water resistant. In its pure form, POM degrades easily by dePolymerization from the ends of the polymer chain by a process called 'unzipping'. The addition of 'blocking groups' at the ends of the polymer chains or coPolymerization with cyclic ethers such as ethylene oxide prevents unzipping and hence degradation.

Typical uses

POM is more expensive than commodity polymers such as PE, so is limited to high performance applications in which its natural lubricity is exploited. It is found in fuel-system; seat-belt components; steering columns; window-support brackets and handles; shower heads, ballcocks, faucet cartridges, and various fittings; quality toys; garden sprayers; stereo cassette parts; butane lighter bodies; zippers; telephone components; couplings; pump impellers; conveyor plates; gears; sprockets; springs; gears; cams; bushings; clips; lugs; door handles; window cranks; housings; seat-belt components; watch gears; conveyor links; aerosols; mechanical pen and pencil parts; milk pumps; coffee spigots; filter housings; food conveyors; cams; gears; TV tuner arms; automotive underhood components.

Tradenames

Acetron, Delrin, Fulton, Latan, Lupital, Plaslube, Tenac, Thermocomp, Ultraform

Links

Reference

ProcessUniverse

Producers