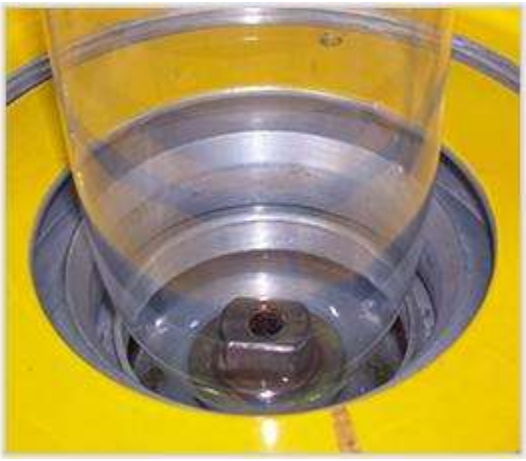
Description

Image





Caption

1. Shopping Bag made of PLA-Blend Bio-Flex © F. Kesselring, FKuR Willich at Wikimedia Commons (CC BY-SA 3.0) 2. Mulch Film made of PLA-Blend Bio-Flex © F. Kesselring, FKuR Willich at Wikimedia Commons (CC BY-SA 3.0) 3. Blow film PLA-Blend Bio-Flex © F. Kesselring, FKuR Willich at Wikimedia Commons (CC BY-SA 3.0)

The material

Polylactide, PLA, is a biodegradable thermoplastic derived from natural lactic acid from corn, maize or milk. It resembles clear polystyrene, provides good aesthetics (gloss and clarity), but it is stiff and brittle and needs modification using plasticizers for most practical applications. It can be processed like most thermoplastics into fibers, films, thermoformed or injection molded.

Composition (summary)

(CH(CH3)CO2)n. The lactic acid is produced from sugar (dextrose) with plant starch origins e.g. corn, wheat, sugar beets and sugar cane.

General properties

Density		1,2e3	-	1,29e3	kg/m^3
Price	*	2,85	-	3,62	EUR/kg
Date first used		1993			

Mechanical properties

Young's modulus		3,3	-	3,6	GPa
Shear modulus	*	0,902	-	1,35	GPa
Bulk modulus	*	2,35	-	3,53	GPa
Poisson's ratio	*	0,38	-	0,4	
Yield strength (elastic limit)		45	-	72	MPa
Tensile strength		45	-	72	MPa
Compressive strength	*	54	-	86,4	MPa
Elongation		2,2	-	6	% strain
Hardness - Vickers	*	16,3	-	17,9	HV
Fatigue strength at 10^7 cycles	*	18	-	28,8	MPa
Fracture toughness	*	3,38	-	4,09	MPa.m^0.5

Mechanical loss coefficient (tan delta)	*	0,0124	-	0,0164	

Thermal properties

Melting point		135	-	181	°C
Glass temperature		42,9	-	63	°C
Maximum service temperature	*	39,9	-	60	°C
Minimum service temperature	*	-45,2	-	-12	°C
Thermal conductor or insulator?		Good insulator			
Thermal conductivity	*	0,12	-	0,15	W/m.°C
Specific heat capacity		1,18e3	-	1,21e3	J/kg.°C
Thermal expansion coefficient	*	68	-	78	µstrain/°C

Electrical properties

Electrical conductor or insulator?		Good insulator			
Electrical resistivity	*	2,7e16	-	4,3e17	µohm.cm
Dielectric constant (relative permittivity)	*	3,1	-	3,2	
Dissipation factor (dielectric loss tangent)	*	0,00909	-	0,01	
Dielectric strength (dielectric breakdown)	*	3	-	6,2	MV/m

Optical properties

Transparency		Transparent			
Refractive index		1,44	-	1,46	

Critical Materials Risk

High critical material risk?		No			

Processability

Moldability		4	-	5	
Formability	*	4	-	5	
Machinability	*	4	-	5	
Weldability	*	3	-	4	

Durability: water and aqueous solutions

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

Durability: acids

Acetic acid (10%)	Unacceptable
Acetic acid (glacial)	Unacceptable
Citric acid (10%)	Acceptable
Hydrochloric acid (10%)	Acceptable
Hydrochloric acid (36%)	Unacceptable
Hydrofluoric acid (40%)	Unacceptable

Nitric acid (10%)	Unacceptable
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Acceptable
Phosphoric acid (85%)	Unacceptable
Sulfuric acid (10%)	Unacceptable
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

Sodium hydroxide (10%)	Unacceptable
Sodium hydroxide (60%)	Unacceptable

Durability: fuels, oils and solvents

Amyl acetate	Unacceptable
Benzene	Limited use
Carbon tetrachloride	Limited use
Chloroform	Unacceptable
Crude oil	Unacceptable
Diesel oil	Acceptable
Lubricating oil	Acceptable
Paraffin oil (kerosene)	Limited use
Petrol (gasoline)	Limited use
Silicone fluids	Excellent
Toluene	Unacceptable
Turpentine	Excellent
Vegetable oils (general)	Acceptable
White spirit	Limited use

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

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

Durability: built environments

Industrial atmosphere	Limited use
Rural atmosphere	Acceptable

Marine atmosphere	Acceptable			
UV radiation (sunlight)	Good			

Durability: flammability

Flammability	Slow-burning			

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	* 42,5	-	47,2	MJ/kg
CO2 footprint, primary production	* 2,15	-	2,4	kg/kg
Water usage	* 19,8	-	21,8	l/kg

Material processing: energy

Polymer extrusion energy	* 5,65	-	6,23	MJ/kg
Polymer molding energy	* 13,5	-	14,9	MJ/kg
Coarse machining energy (per unit wt removed)	* 0,969	-	1,07	MJ/kg
Fine machining energy (per unit wt removed)	* 5,41	-	5,96	MJ/kg
Grinding energy (per unit wt removed)	* 10,3	-	11,4	MJ/kg

Material processing: CO2 footprint

Polymer extrusion CO2	* 0,424	-	0,467	kg/kg
Polymer molding CO2	* 1,01	-	1,12	kg/kg
Coarse machining CO2 (per unit wt removed)	* 0,0727	-	0,0802	kg/kg
Fine machining CO2 (per unit wt removed)	* 0,406	-	0,447	kg/kg
Grinding CO2 (per unit wt removed)	* 0,774	-	0,853	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✓			
Embodied energy, recycling	* 14,6	-	16,1	MJ/kg
CO2 footprint, recycling	* 0,738	-	0,816	kg/kg
Recycle fraction in current supply	0,1	-	1,1	%
Downcycle	✓			
Combust for energy recovery	✓			
Heat of combustion (net)	* 18,9	-	19,9	MJ/kg
Combustion CO2	* 1,8	-	1,9	kg/kg
Landfill	✓			
Biodegrade	✓			
Toxicity rating	Non-toxic			

A renewable resource?	✓

Environmental notes

Biopolymers like PLA are made from renewable resources, although the processing involves non-renewable chemicals. PLA is biodegradable. If combusted, the CO2 footprint rises to 3.45 kg/kg.

Recycle mark

Supporting information

Design guidelines

PLA is a biopolymer that can be molded, thermoformed and extruded, much like any other thermoplastic. It is transparent and has FDA approval for food packaging. PLA film and sheet can be printed and laminated. Biopolymers are, however, expensive, costing 2 to 6 times as much as commodity plastics like polypropylene.

Technical notes

PLA is a thermoplastic derived primarily from annually renewable resources (maize, corn or milk). It is available in a number of grades, designed for ease of processing. In-line drying may be needed to reduce water content for extrusion and molding. The recommended molding temperature is 165 - 170 C.

Typical uses

Injection molded: pencil sharpeners, rulers, cartridges, toys, plant pots, plastic bones and other toys for pets, plastic cutlery, hair combs.
Thermo-formed: trays for fresh food packaging, especially fruit and vegetables.
Film extrusion: shopping bags, bubble film for wrapping, plastic laminates for paper cups and plates, bags for rubbish disposal, lining for baby nappies, mulching films for horticulture, wrapping for fruit, vegetables and sanitary products .

Tradenames

NatureWorks PLA, BOPLA

Further reading

See Reference link and Producer website.

Links

ProcessUniverse

Producers

Reference