Description

Image

Caption

1. Leather hat. 2. Leather armchair. © John Fernandez

The material

Leather is a natural fabric. It is made by the tanning of animal hide, a smelly process in which the hide is soaked in solutions of tannins for weeks or months, making it pliable and resistant to decay. It has high tensile strength and is exceptionally tough and resilient, yet it is flexible and - as suede - is soft to touch. Leather is used for belts, gaskets, shoes, jackets, handbags, linings and coverings. It can be injection molded by placing a piece in the mold prior to injected the polymer resin.

Composition (summary)

Collagen (protein)/12% H2O

General properties

Density		50.6	-	65.5	lb/ft^3
Price	*	7.53	-	9.39	USD/lb
Date first used		-10000			

Mechanical properties

Young's modulus		0.0145	-	0.0725	10^6 psi
Shear modulus	*	0.00435	-	0.0145	10^6 psi
Bulk modulus	*	0.145	-	0.29	10^6 psi
Poisson's ratio		0.05	-	0.48	
Yield strength (elastic limit)		0.725	-	1.45	ksi
Tensile strength		2.9	-	3.77	ksi
Compressive strength		0.145	-	0.29	ksi
Elongation		18	-	75	% strain
Hardness - Vickers	*	2	-	3	HV
Fatigue strength at 10^7 cycles		0.653	-	1.31	ksi
Fracture toughness	*	2.73	-	4.55	ksi.in^0.5

Mechanical loss coefficient (tan delta)	* 0.1	-	0.5	

Thermal properties

Glass temperature	* 224	-	260	°F
Maximum service temperature	* 224	-	260	°F
Minimum service temperature	* -118	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0901	-	0.0924	BTU.ft/h.ft^2.F
Specific heat capacity	0.366	-	0.413	BTU/lb.°F
Thermal expansion coefficient	* 22.2	-	27.8	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Poor insulator			
Electrical resistivity	* 1e8	-	1e10	µohm.cm
Dielectric constant (relative permittivity)	* 5	-	10	
Dissipation factor (dielectric loss tangent)	* 0.01	-	0.05	
Dielectric strength (dielectric breakdown)	* 12.7	-	25.4	V/mil

Optical properties

Transparency	Opaque

Critical Materials Risk

High critical material risk?	No

Processability

Moldability	3	-	4	
Machinability	4			

Durability: water and aqueous solutions

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

Durability: acids

Acetic acid (10%)	Limited use
Acetic acid (glacial)	Limited use
Citric acid (10%)	Limited use
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%)	Limited use
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

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

Durability: fuels, oils and solvents

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

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

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

Durability: built environments

Industrial atmosphere	Limited use
Rural atmosphere	Acceptable
Marine atmosphere	Acceptable
UV radiation (sunlight)	Fair

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		1.11e4	-	1.22e4	kcal/lb
CO2 footprint, primary production		4.08	-	4.5	lb/lb
Water usage	*	1.31e3	-	1.44e3	gal(US)/lb
Eco-indicator 99		158			millipoints/kg

Material recycling: energy, CO2 and recycle fraction

Recycle		✗			
Recycle fraction in current supply		0.5	-	1	%
Downcycle		✓			
Combust for energy recovery		✓			
Heat of combustion (net)	*	2.1e3	-	2.21e3	kcal/lb
Combustion CO2	*	1.39	-	1.46	lb/lb
Landfill		✓			
Biodegrade		✓			
Toxicity rating		Non-toxic			
A renewable resource?		✓			

Environmental notes

The processing of leather involves oak tannin or tanning with chromium salts, giving wastes that are toxic and difficult of disposal. Prior to 1900 mercury salts were used, with ill effects on the tanner -- the origin of the problems of the Mad Hatter at Alice (in Wonderland's) tea party.

Supporting information

Design guidelines

The quality of leather depends on the animal. Most comes form cattle, but some also from sheep, goat, deer, alligator, seal, shark and even snake. 'Top grade' leather is the outside layer, and is the best quality: durable, close fibers, with the highest strength and flexibility. 'First split' leather comes from the next layer; it has lower quality. 'Second split', from the inside, has the lowest quality. 'Patent leather' is an old name for glossy black leather for shoes and handbags.

Technical notes

Leather for drive belts (and those that hold up trousers) is soaked in oils or waxes to make if flexible; it has a density of 0.95 Mg/m^3 and a tensile strength up to 26 MPa. Leather is remarkable for having a tensile stiffness and strength that is much greater than that in bending, allowing it to flex easily yet carry tensile loads. It is a consequence of the fibrous nature of the material: the fibers all lie in the plane of the skin.

Typical uses

Drive belts and seals, shoes, bags, jackets, cases and luggage, briefcases hats, clothing, fancy goods, handbags and linings.

Links

Reference

ProcessUniverse