

Description

Image



Caption

1. Rubber trees in Kerala, India © M.arunprasad at en.wikipedia - (CC BY-SA 3.0) 2. Rubber bands in different colors. © Bill Ebbesen at en.wikipedia - (CC BY-SA 3.0)

The material

Natural Rubber was known to the natives of Peru many centuries ago, and is now one of Malaysia's main exports. It made the fortune of Charles Macintosh who, in 1825, devised the rubber-coated waterproof coat the still bears his name. Latex, the sap of the rubber tree, is cross-linked (vulcanized) by heating with sulfur; the amount of the cross-linking determines the properties. It is the most widely used of all elastomers - more than 50% of all produced.

Composition (summary)

$(CH_2-C(CH_3)-CH-CH_2)_n$

General properties

Density	57.4	-	58.1	lb/ft ³
Price	* 0.671	-	0.676	USD/lb
Date first used	1751			

Mechanical properties

Young's modulus	2.18e-4	-	3.63e-4	10 ⁶ psi
Shear modulus	8.7e-5	-	1.16e-4	10 ⁶ psi
Bulk modulus	* 0.203	-	0.218	10 ⁶ psi
Poisson's ratio	0.499	-	0.5	
Yield strength (elastic limit)	2.9	-	4.35	ksi
Tensile strength	3.19	-	4.64	ksi
Compressive strength	3.19	-	4.79	ksi
Elongation	500	-	800	% strain
Fatigue strength at 10 ⁷ cycles	0.609	-	0.653	ksi
Fracture toughness	0.137	-	0.228	ksi.in ^{0.5}
Mechanical loss coefficient (tan delta)	* 0.8	-	1.9	

Thermal properties

Glass temperature	-109	-	-81.7	°F
Maximum service temperature	156	-	224	°F
Minimum service temperature	-69.1	-	-45.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0578	-	0.0809	BTU.ft/h.ft ² .F
Specific heat capacity	0.43	-	0.597	BTU/lb.°F
Thermal expansion coefficient	83.3	-	250	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e15	-	1e16	µohm.cm
Dielectric constant (relative permittivity)	3	-	4.5	
Dissipation factor (dielectric loss tangent)	7e-4	-	0.003	
Dielectric strength (dielectric breakdown)	406	-	584	V/mil

Optical properties

Transparency	Translucent			
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Critical Materials Risk

High critical material risk?	No			
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Processability

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

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)	Limited use			
Citric acid (10%)	Excellent			
Hydrochloric acid (10%)	Limited use			
Hydrochloric acid (36%)	Limited use			

Hydrofluoric acid (40%)	Limited use
Nitric acid (10%)	Limited use
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Unacceptable

Durability: alkalis

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

Durability: fuels, oils and solvents

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

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Limited use
Acetone	Excellent
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
O ₂ (oxygen gas)	Unacceptable

Sulfur dioxide (gas)	Unacceptable
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Durability: built environments

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

Durability: flammability

Flammability	Highly flammable
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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

Geo-economic data for principal component

Annual world production, principal component	7.64e6	-	7.68e6	ton/yr
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Primary material production: energy, CO2 and water

Embodied energy, primary production	* 6.96e3	-	7.69e3	kcal/lb
CO2 footprint, primary production	* 1.97	-	2.18	lb/lb
Water usage	* 1.8e3	-	2.4e3	gal(US)/lb
Eco-indicator 95	360			millipoints/kg
Eco-indicator 99	23.7			millipoints/kg

Material processing: energy

Polymer molding energy	* 1.66e3	-	1.83e3	kcal/lb
Grinding energy (per unit wt removed)	* 683	-	754	kcal/lb

Material processing: CO2 footprint

Polymer molding CO2	* 1.23	-	1.35	lb/lb
Grinding CO2 (per unit wt removed)	* 0.472	-	0.522	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✗		
Recycle fraction in current supply	0.1		%
Downcycle	✓		
Combust for energy recovery	✓		

Heat of combustion (net)	* 4.6e3	-	4.84e3	kcal/lb
Combustion CO2	* 3.15	-	3.31	lb/lb
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✓			

Environmental notes

Natural rubber is a biopolymer. Once vulcanized, natural rubbers are thermosets, and thus cannot be recycled. Their disposal creates an environmental problem.

Supporting information

Design guidelines

Natural rubber is an excellent, cheap, general-purpose elastomer with large stretch capacity and useful properties from -50 C to 115 C, but with poor oil, oxidation, ozone and UV resistance. It has low hysteresis - and is thus very bouncy.

Typical uses

Gloves, Car tires, seals, belts, anti-vibration mounts, electrical insulation, tubing, rubber lining pipes and

Links

Reference

ProcessUniverse

Producers