Polychloroprene (Neoprene, CR)

Description

Image

Caption

1. Close-up of a wetsuit showing the texture of the material. © Yoruno at en.wikipedia - (CC BY-SA 3.0) 2. Surfer in a polychloroprene wetsuit. © Johntex at en.wikipedia - (CC BY-SA 3.0)

The material

Polychloroprenes (Neoprene, CR) – the materials of wetsuits – are the leading non-tire synthetic rubbers. First synthesized in 1930, they are made by a condensation polymerization of the monomer 2-chloro –1,3 butadiene. The properties can by modified by copolymerization with sulfur, with other chloro-butadienes and by blending with other polymers to give a wide range of properties. Polychloroprenes are characterized by high chemical stability, resistance to water, oil, gasoline and UV radiation.

Compositional summary

(CH2-CCl=CH-CH2)n

General properties

Density	1.23e3	-	1.25e3	kg/m^3
Price	* 5.36	-	5.96	USD/kg
Date first used	1931			

Mechanical properties

Young's modulus	7e-4	-	0.002	GPa
Shear modulus	2e-4	-	6.7e-4	GPa
Bulk modulus	* 1.2	-	1.3	GPa
Poisson's ratio	0.48	-	0.495	
Yield strength (elastic limit)	3.4	-	24	MPa
Tensile strength	3.4	-	24	MPa
Compressive strength	3.72	-	28.8	MPa
Elongation	100	-	800	% strain
Fatigue strength at 10^7 cycles	* 1.53	-	12	MPa
Fracture toughness	* 0.1	-	0.3	MPa.m^0.5

Mechanical loss coefficient (tan delta)	* 0.95	-	2.3	

Thermal properties

Glass temperature	-48.2	-	-43.2	°C
Maximum service temperature	102	-	112	°C
Minimum service temperature	-53.2	-	-48.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.1	-	0.12	W/m.°C
Specific heat capacity	* 2e3	-	2.2e3	J/kg.°C
Thermal expansion coefficient	575	-	610	µstrain/°C

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	1e19	-	1e23	µohm.cm
Dielectric constant (relative permittivity)	6.7	-	8	
Dissipation factor (dielectric loss tangent)	* 1e-4	-	0.001	
Dielectric strength (dielectric breakdown)	15.8	-	23.6	1000000 V/m

Optical properties

Transparency	Translucent			
Refractive index	1.55	-	1.57	

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)	Unacceptable
Citric acid (10%)	Excellent
Hydrochloric acid (10%)	Excellent
Hydrochloric acid (36%)	Excellent
Hydrofluoric acid (40%)	

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

Durability: alkalis

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

Durability: fuels, oils and solvents

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

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

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

Sulfur dioxide (gas)	Limited use

Durability: built environments

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

Durability: flammability

Flammability	Self-extinguishing

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Excellent
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	* 61.2	-	67.6	MJ/kg
CO2 footprint, primary production	* 1.61	-	1.78	kg/kg
Water usage	* 126	-	378	l/kg

Material processing: energy

Polymer molding energy	* 17.2	-	18.9	MJ/kg
Grinding energy (per unit wt removed)	* 3.53	-	3.91	MJ/kg

Material processing: CO2 footprint

Polymer molding CO2	* 1.37	-	1.51	kg/kg
Grinding CO2 (per unit wt removed)	* 0.265	-	0.293	kg/kg

Material recycling: energy, CO2 and recycle fraction

Recycle	✗			
Recycle fraction in current supply	* 1	-	2	%
Downcycle	✓			
Combust for energy recovery	✓			
Heat of combustion (net)	* 16.8	-	17.7	MJ/kg
Combustion CO2	* 1.39	-	1.46	kg/kg
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			

A renewable resource?	✗

Environmental notes

Chlorinated elastomers are thermosets, and thus cannot be recycled. Their disposal creates an environmental problem.

Supporting information

Design guidelines

Polychloroprenes are characterized by exceptional chemical resistance, ability to be colored, and useful properties up to 175 C. Some have low gas permeability and low hysteresis, minimize heating when cyclically loaded, and resist burning. They are exceptionally tough, having high tear resistance due to stress induced crystallization.
A number of other chlorinated hydrocarbons have similar properties and compete with Neoprene. Among them are chlorinated polyethylene (CPE or CM) and chlorosulfonated polyethylene (Hypalon, CSM).

Typical uses

Brake seals, diaphragms, hoses and o-rings, tracked-vehicle pads, footwear,

Links

Reference

ProcessUniverse

Producers