Butyl rubber (IIR)

Description

Image

Caption

1. Butyl rubber is one of the most important materials for inner tubes. © Granta Design 2. Butyl Rubber (Viton®) Gloves © Ansell

The material

Butyl Rubbers (IIR) are synthetics that resemble natural rubber (NR) in properties. They have good resistance to abrasion, tearing and flexing, with exceptionally low gas permeability and useful properties up to 150 C. They have low dielectric constant and loss, making them attractive for electrical applications.

Composition (summary)

(CH2-C(CH3)-CH-(CH2)2-C(CH3)2)n

General properties

Density		56.2	-	57.4	lb/ft^3
Price	*	0.88	-	0.98	USD/lb
Date first used		1937			

Mechanical properties

Young's modulus		1.45e-4	-	2.9e-4	10^6 psi
Shear modulus		4.35e-5	-	8.7e-5	10^6 psi
Bulk modulus	*	0.196	-	0.21	10^6 psi
Poisson's ratio		0.499	-	0.5	
Yield strength (elastic limit)		0.29	-	0.435	ksi
Tensile strength		0.725	-	1.45	ksi
Compressive strength		0.319	-	0.479	ksi
Elongation		400	-	500	% strain
Fatigue strength at 10^7 cycles	*	0.131	-	0.196	ksi
Fracture toughness		0.0637	-	0.091	ksi.in^0.5
Mechanical loss coefficient (tan delta)	*	0.89	-	2.1	

Thermal properties

Glass temperature	-99.7	-	-81.7	°F
Maximum service temperature	206	-	242	°F
Minimum service temperature	-60.1	-	-45.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.0462	-	0.0578	BTU.ft/h.ft^2.F
Specific heat capacity	0.43	-	0.597	BTU/lb.°F
Thermal expansion coefficient	66.7	-	167	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Poor insulator			
Electrical resistivity	1e15	-	1e16	µohm.cm
Dielectric constant (relative permittivity)	* 2.8	-	3.2	
Dissipation factor (dielectric loss tangent)	0.001	-	0.01	
Dielectric strength (dielectric breakdown)	406	-	584	V/mil

Optical properties

Transparency	Translucent			
Refractive index	1.5	-	1.52	

Critical Materials Risk

High critical material risk?	No

Processability

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

Durability: water and aqueous solutions

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

Durability: acids

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

Durability: alkalis

Sodium hydroxide (10%)	Limited use
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)	Limited use
Silicone fluids	Acceptable
Toluene	Unacceptable
Turpentine	Unacceptable
Vegetable oils (general)	Unacceptable
White spirit	Unacceptable

Durability: alcohols, aldehydes, ketones

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

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Unacceptable

O2 (oxygen gas)	Unacceptable
Sulfur dioxide (gas)	Unacceptable

Durability: built environments

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

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

Geo-economic data for principal component

Annual world production, principal component	1.01e7	-	1.04e7	ton/yr
Reserves, principal component	* 2.85e8	-	2.9e8	l. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 1.21e4	-	1.34e4	kcal/lb
CO2 footprint, primary production	* 6.29	-	6.95	lb/lb
Water usage	* 7.63	-	22.9	gal(US)/lb
Eco-indicator 99	309			millipoints/kg

Material processing: energy

Polymer molding energy	* 1.67e3	-	1.84e3	kcal/lb
Grinding energy (per unit wt removed)	* 182	-	200	kcal/lb

Material processing: CO2 footprint

Polymer molding CO2	* 1.23	-	1.36	lb/lb
Grinding CO2 (per unit wt removed)	* 0.126	-	0.139	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✗			
Recycle fraction in current supply	2	-	4.1	%
Downcycle	✓			

Combust for energy recovery	✓			
Heat of combustion (net)	* 4.68e3	-	4.91e3	kcal/lb
Combustion CO2	* 3.11	-	3.27	lb/lb
Landfill	✓			
Biodegrade	✗			
Toxicity rating	Non-toxic			
A renewable resource?	✗			

Environmental notes

Butyl elastomers 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

Inner tubes, seals, belts, anti-vibration mounts, electrical insulation, tubing, brake pads, rubber lining pipes and pumps.

Links

Reference

ProcessUniverse

Producers