

## Description

### Image



### Caption

Butyl rubber is one of the most important materials for inner tubes. © Granta

### 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.

### Compositional summary

$(CH_2-C(CH_3)-CH-(CH_2)_2-C(CH_3)_2)_n$

## General properties

Density	900	-	920	kg/m <sup>3</sup>
Price	* 3.94	-	4.55	USD/kg
Date first used	1937			

## Mechanical properties

Young's modulus	0.001	-	0.002	GPa
Shear modulus	3e-4	-	6e-4	GPa
Bulk modulus	* 1.35	-	1.45	GPa
Poisson's ratio	0.499	-	0.5	
Yield strength (elastic limit)	2	-	3	MPa
Tensile strength	5	-	10	MPa
Compressive strength	2.2	-	3.3	MPa
Elongation	400	-	500	% strain
Fatigue strength at 10 <sup>7</sup> cycles	* 0.9	-	1.35	MPa
Fracture toughness	0.07	-	0.1	MPa.m <sup>0.5</sup>
Mechanical loss coefficient (tan delta)	* 0.89	-	2.1	

### Thermal properties

Glass temperature	-73.2	-	-63.2	°C
Maximum service temperature	96.9	-	117	°C
Minimum service temperature	-51.2	-	-43.2	°C
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.08	-	0.1	W/m.°C
Specific heat capacity	1.8e3	-	2.5e3	J/kg.°C
Thermal expansion coefficient	120	-	300	µstrain/°C

### 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)	16	-	23	1000000 V/m

### Optical properties

Transparency	Translucent			
Refractive index	1.5	-	1.52	

### 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
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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	1.03e7	-	1.06e7	tonne/yr
Reserves, principal component	* 2.9e8	-	2.95e8	tonne

### Primary material production: energy, CO2 and water

Embodied energy, primary production	* 112	-	124	MJ/kg
CO2 footprint, primary production	* 6.29	-	6.95	kg/kg
Water usage	* 63.7	-	191	l/kg
Eco-indicator 99	309			millipoints/kg

### Material processing: energy

Polymer molding energy	* 15.4	-	17	MJ/kg
Grinding energy (per unit wt removed)	* 1.68	-	1.85	MJ/kg

### Material processing: CO2 footprint

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

### 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)	* 43.2	-	45.3	MJ/kg
Combustion CO2	* 3.11	-	3.27	kg/kg

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