Carbon black reinforced styrene butadiene rubber (SBR)

Description

Image

Caption

Styrene Butadiene Rubber is the most popular synthetic rubber in tyres.

The material

Styrene Butadiene Copolymer Rubber (SBR) is the synthetic rubber that is most widely used and has the highest production volume. It is nearly always compounded with reinforcing fillers such as carbon black.
Strengths: When filled, its strength approaches natural rubber (NR) and polychloroprene. Similar chemical and physical properties to NR and somewhat better abrasion resistance.
Limitations: Weaker and lower fatigue resistance than natural rubber (it does not undergo strain-induced crystallation) especially when unfilled. Like NR: prone to oxidation, degrades in ozone, swells readily in hydrocarbon fluids with loss of properties.

Composition (summary)

Copolymer of 23% styrene (CH2CH(C6H5))n and 77% butadiene (CH2CH=CHCH2)m reinforced with typically 30% Carbon Black

General properties

Density	1.13e3	-	1.15e3	kg/m^3
Price	* 1.94	-	2.16	USD/kg
Date first used	1932			

Mechanical properties

Young's modulus	0.0038	-	0.006	GPa
Shear modulus	* 0.0012	-	0.002	GPa
Bulk modulus	* 1.5	-	2	GPa
Poisson's ratio	0.48	-	0.496	
Yield strength (elastic limit)	16	-	26	MPa
Tensile strength	16	-	26	MPa
Compressive strength	* 19.2	-	31.2	MPa

Elongation		320	-	550	% strain
Fatigue strength at 10^7 cycles	*	6.4	-	10.4	MPa
Fracture toughness	*	0.98	-	1.08	MPa.m^0.5
Mechanical loss coefficient (tan delta)	*	0.08	-	0.14	

Thermal properties

Glass temperature		-64	-	-52	℃
Maximum service temperature		70	-	110	℃
Minimum service temperature		-50	-	-40	℃
Thermal conductor or insulator?		Poor insulator			
Thermal conductivity		0.4	-	0.9	W/m.℃
Specific heat capacity		1.45e3	-	1.6e3	J/kg.℃
Thermal expansion coefficient		160	-	180	µstrain/℃

Electrical properties

Electrical conductor or insulator?		Poor insulator			
Electrical resistivity		1e10	-	1e16	µohm.cm

Optical properties

Transparency		Opaque			

Critical Materials Risk

High critical material risk?		No			

Processability

Moldability		3	-	4	

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%)		Excellent			
Hydrochloric acid (36%)		Limited use			
Hydrofluoric acid (40%)		Acceptable			
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%)	Excellent

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	Excellent

Durability: alcohols, aldehydes, ketones

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

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	1.03e7	-	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	342			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	0.1			%
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

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

Supporting information

Design guidelines

SBR is much weaker than NR if unfilled, but gains similar strength by compounding with 30-50 wt% carbon black.

Typical uses

Car and truck tires, belt, hose,

Links

Reference
ProcessUniverse
Producers