

IIR isobutylene-isoprene rubber

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	butyl rubber, isobutylene-isoprene rubber	
CAS name	-	1,3-butadiene, 2-methyl-, polymer with 2-methyl-1-propene	
Acronym	-	IIR	
CAS number	-	9010-85-9; 308063-42-5	
HISTORY			
Person to discover	-	William J. Sparks and Robert M. Thomas	
Date	-	1937; 1943	
Details	-	butyl rubber was invented in 1937 by William J. Sparks and Robert M. Thomas of Standard Oil; it was commercialized in 1943	
SYNTHESIS			
Monomer(s) structure	-	$\text{CH}_2=\text{C}(\text{CH}_3)_2$ (isobutylene) and $\text{CH}_2=\text{C}(\text{CH}_3)\text{CH}=\text{CH}_2$ (isoprene)	
Monomer(s) CAS number(s)	-	115-11-7, 78-79-5	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	56.11; 68.12	
Monomer ratio	-	isobutylene:isoprene=98:2	
Formulation example	-	calcium stearate, butylated hydroxy toluene, and epoxidized soybean oil are added to prevent dehydrohalogenation and oxidation during finishing and storage	
Method of synthesis	-	cationic polymerization of high purity isobutylene and isoprene is used to produce butyl rubber in the presence of complex systems of catalysts; polymerization is terminated by irreversible destruction of the propagating carbenium ion by the collapse of the ion pair, by hydrogen abstraction from the comonomer, by formation of stable allylic carbenium ions, or by reaction with nucleophilic species such as alcohols or amines	
Catalyst	-	aluminum trichloride, alkyl aluminum dichloride, boron trifluoride, tin tetrachloride, and titanium tetrachloride are used as co-initiators and water, hydrochloric acid, organic acid are used as initiators	
Heat of polymerization	J g ⁻¹	1042-1101 (isoprene)	Joshi, R M, Makromol. Chem., 55, 35, 1962.
Mass average molecular weight, M_w	dalton, g/mol, amu	350,000-4,500,000	
Polydispersity, M_w/M_n	-	3-5	
Unsaturation	mol%	0.9-2.25	
STRUCTURE			
Cell type (lattice)	-	orthorhombic	
Cell dimensions	nm	a:b:c=0.694:1.196:1.863	
Chain conformation	-	2*8/3	
Entanglement molecular weight	dalton, g/mol, amu	710	
Rapid crystallization temperature	°C	-34	
COMMERCIAL POLYMERS			
Some manufacturers	-	Exxon; Lanxess	
Trade names	-	Butyl Rubber; Butyl	

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PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	0.917-0.92	
Color	-	white to off-white	
Refractive index, 20°C	-	1.5081-1.5092	
Odor	-	none to mild	
Melting temperature, DSC	°C	1.5	
Decomposition temperature	°C	>200	
Storage temperature	°C	<35	
Thermal expansion coefficient, 23-80°C	°C ⁻¹	1.3-7.5E-4	
Thermal conductivity, melt	W m ⁻¹ K ⁻¹	0.13; 0.25-0.40 (with different carbon blacks)	Wang, W; Lamba, R; Herd, C; Tandon, D; Edwards, C, Rubber World, 27-48, Sept., 2005.
Glass transition temperature	°C	-71 to -65	
Specific heat capacity	J K ⁻¹ kg ⁻¹	1950	
Maximum service temperature	°C	150	
Long term service temperature	°C	120	
Hildebrand solubility parameter	MPa ^{0.5}	15.9-16.47	
Surface tension	mN m ⁻¹	33.6	
Dielectric constant at 1 Hz/1 MHz	-	2.38	
Dielectric loss factor at 1 kHz	-	0.003	
Permeability to nitrogen, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	0.0243	
Permeability to oxygen, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	0.0977	
Permeability to water vapor, 25°C	cm ³ cm cm ⁻² s ⁻¹ Pa ⁻¹ x 10 ¹²	36.7	
Diffusion coefficient of nitrogen	cm ² s ⁻¹ x10 ⁶	0.045	
Diffusion coefficient of oxygen	cm ² s ⁻¹ x10 ⁶	0.081	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	8.4-19	
Tensile stress at yield	MPa	7-9	
Elongation	%	670-800	
Tear strength	kN m ⁻¹	31-50	
Rebound	%	12-15	
Poisson's ratio	-	0.49	
Compression set, 105°C/24 h	%	72	
Shore A hardness	-	36-90	
Brittleness temperature (ASTM D746)	°C	-60	

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Mooney viscosity	-	32-75	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	very good	
Alcohols	-	good	
Alkalis	-	very good	
Aliphatic hydrocarbons	-	poor	
Aromatic hydrocarbons	-	poor	
Esters	-	good	
Greases & oils	-	poor	
Halogenated hydrocarbons	-	poor	
Ketones	-	poor	
FLAMMABILITY			
Ignition temperature	°C	>300	
Autoignition temperature	°C	560	
Volatile products of combustion	-	CO, CO ₂ , smoke	
BIODEGRADATION			
Typical biodegradants	-	<i>Actinomycetes</i>	Morton, L H G; Surman, S B, Int. Biodet. Biodeg., 34, 3-4, 203-21, 1994.
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	1/1/0; 1/1/0 (HMIS)	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
OSHA	mg m ⁻³	5 (respirable), 15 (total)	
PROCESSING			
Typical processing methods	-	mixing, molding, vulcanization	
Additives used in final products	-	Fillers: carbon black, clay, ferrites, silica, vermiculite, zinc oxide; in EMI shielding field: carbon black, nickel, silver, silver coated glass spheres, silver plated copper, silver plated aluminum, silver plated nickel; Antioxidants;	
Applications	-	adhesives, automotive vibration damping, belting, chewing gum, curing bladders, gas-metering diaphragms, innertubes for tires and bicycles, O-rings, protective clothing, roof coatings, shock and vibration products, sport ball bladders, steam hose, structural caulks and sealants, tire curing bladders, tire curing envelopes, water-barrier applications	
Outstanding properties	-	impermeability, resistance to heat, resistance to ozone, energy absorption	
BLENDS			
Suitable polymers	-	bromobutyl rubber, chlorobutyl rubber, ionomers, natural rubber, EPDM, NBR, PA12, PP, PS, SBR	