

CSP chlorosulfonated polyethylene

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	chlorosulfonated polyethylene	
CAS name	-	chlorosulfonated polyethylene rubber	
Acronym	-	CSP	
CAS number	-	9008-08-6; 68037-39-8	
HISTORY			
Person to discover	-	McQueen, D M, DuPont	McQueen, D M, US Patent 2,212,786, DuPont, 1940.
Date	-	1940	
Details	-	polyethylene is dissolved or suspended in hot carbon tetrachloride and reacted with SO ₂ and Cl ₂	
SYNTHESIS			
Monomer(s) structure	-	PE, SO ₂ , Cl ₂	
Monomer(s) CAS number(s)	-	9002-88-4; 7446-09-5; 7782-50-5	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	broad range; 64.07; 70.9	
Chlorine content	%	24-45	
Sulfur content	%	0.8-1.7	
Temperature of polymerization	°C	40-80	Zhao, R; Cheng, S; Shun, Y; Huang, Y, J. Appl. Polym. Sci., 81, 3582-88, 2001.
cure time	min	26.6	Malas, A; Das, C K; Composites Part B, 79, 639-48, 2015.
Mass average molecular weight, M _w	dalton, g/mol, amu	180,000-550,000	
STRUCTURE			
Crystallinity	%	16-21	Wang, Z; Ni, H; Bian, Y; Zhang, M; Zhang, H, J. Appl. Polym. Sci., 116, 2095-100, 2010.
Avrami constants, k/n	-	n=4	
COMMERCIAL POLYMERS			
Some manufacturers	-	Jiangxi HongRun Chemical	
Trade names	-	Acsum, HongRun, Hypalon	
PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	1.0-1.27	
Color	-	white to slightly yellow	
Odor	-	slight, ether-like	
Melting temperature, DSC	°C	87-140	
Decomposition temperature	°C	150-200	
Glass transition temperature	°C	7 to -27	
Activation energy of thermal degradation	kJ mol ⁻¹	106-116 (N ₂); 99-101 (air)	Sandelin, M J; Gedde, U W, Polym. Deg. Stab., 86, 331-38, 2004; Gilen, K T; Bernstein, R; Celina, M, Polym. Deg. Stab., 335-46, 2005.
Hansen solubility parameters, δ _D , δ _P , δ _H	MPa ^{0.5}	18.1, 3.4, 4.9; 18.2, 4.7, 2.0	

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Molar volume	kmol m ⁻³	3.6; 5.0	
Permeability to oxygen, 25°C	cm ³ mm m ⁻² day ⁻¹ atm ⁻¹	60-78	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	2.5-31.7	
Elongation	%	260-820	
Tear strength	kN m ⁻¹	2.5-44	
Abrasion resistance (ASTM D1044)	mg/1000 cycles	99-243	
Compression set, 22h 100°C	%	21-86	
Shore A hardness	-	40-75	
Shore D hardness	-	45-98	
Brittleness temperature (ASTM D746)	°C	8 to -44	
Mooney viscosity	-	28-94	
CHEMICAL RESISTANCE			
Alcohols	-	very good	
Aromatic hydrocarbons	-	poor	
Greases & oils	-	good	
Halogenated hydrocarbons	-	fair-poor	
Ketones	-	poor	
Good solvent	-	chlorinated hydrocarbons, MEK, THF, toluene	
FLAMMABILITY			
Limiting oxygen index	% O ₂	25; 26 (35 wt% Cl)	
Volatile products of combustion	-	HCl, CO, CO ₂	
WEATHER STABILITY			
Products of degradation	-	HCl, double bonds formation, crosslinking, yellowing	
Stabilizers	-	carbon black, tetrakis(methylene (3,5-di-tert-butyl-4-hydroxy-hydrocinnamate))methane, 2 antiacids	
TOXICITY			
Carcinogenic effect	-	IARC 2B, NTP X, ACGIH A2 (carbon tetrachloride present in concentration of 0.4%)	
Mutagenic effect	-	tests on bacterial or mammalian cell cultures did not show mutagenic effects	
Teratogenic effect	-	animal testing showed effects on embryo-foetal development at levels equal to or above those causing maternal toxicity	
TLV, ACGIH	ppm	2 (HCl)	
OSHA	ppm	5 (HCl)	
Oral rat, LD ₅₀	mg kg ⁻¹	>20,000	

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PROCESSING			
Typical processing methods	-	coating, extrusion, compounding, injection molding, vulcanization	
Additives used in final products	-	Acid acceptor (hydrotalcite, magnesia, calcium hydroxide); Fillers: aluminum powder, basic magnesium carbonate, calcium carbonate, carbon black, carbonyl iron powder, graphite, magnesium hydroxide, metal oxides (typically MgO) are used as curing agents, silica; Flame retardant (antimony oxide, hydrated alumina, halogenated hydrocarbons); Plasticizers: seldom used (e.g., polyethylene glycol, dioctyl sebacate, or dioctyl adipate used in small quantities as process oil); Processing aids (waxes, stearic acid, low MW PE, polyethylene glycol); Antistatics: glyceryl monostearate, trineoalkoxy amino zirconate, trineoalkoxy sulfonyl zirconate; Release: fluorocarbon, polydimethylsiloxane, silicone coated paper; Vulcanizing agent, sulfur, TMTD, MBTS, NBC. DOTG, peroxide plus coagent, HVA-2 plus coagent)	
Applications	-	adhesives, automotive components (high-temperature timing belts, power steering pressure hose, gaskets, spark plugs), boots, coated fabrics, industrial effluent pit liners and lining for chemical processing equipment, industrial products (hose, rolls, seals, gaskets, diaphragms), inflatable boats, microwave absorbing rubber, pool liners, radiator and heater hoses, roofing, wire and cable	
Outstanding properties	-	resistance to ozone, heat, weather, oxygen and oils and high tensile and abrasion resistance	
BLENDS			
Suitable polymers	-	EPDM, EPR, HNBR, NR, PVC	
ANALYSIS			
FTIR (wavenumber-assignment)	cm ⁻¹ /-	SO ₂ (asymmetric stretch) – 1369, SO ₂ (symmetric stretch) – 1160	O'Keefe, J F, Rubber World, June 2004, 27-37.