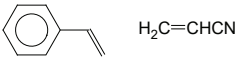


# SAN poly(styrene-co-acrylonitrile)

PARAMETER	UNIT	VALUE	REFERENCES
<b>GENERAL</b>			
Common name	-	poly(styrene-co-acrylonitrile)	
CAS name	-	2-propenenitrile, polymer with ethenylbenzene	
Acronym	-	SAN	
CAS number	-	9003-54-7	
RTECS number	-	AT6978000	
<b>HISTORY</b>			
Person to discover	-	Fikentscher, H; Heuck, C	Fikentscher, H; Heuck, C, US Patent 2,140,048, IG Farben, Dec. 13, 1938.
Date	-	1938	
Details	-	production of polymerization products	
<b>SYNTHESIS</b>			
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	100-42-5; 107-13-1	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	104.15; 53.06	
Acrylonitrile content	%	25-40	Liu, M; Zhang, X; Zammarano, M; Gilman, J W; Kashiwagi, T, Polym. Deg. Stab., 96, 1000-8, 2011.
Formulation example	-	water – 180-40, peroxidic catalyst – 0.1-0.5, styrene – 85-50, acrylonitrile – 15-50, emulsifying agent – 0.5-150, modifier – 0-1	Daly, L E, US Patent 2,439,202, US Rubber Company, Apr. 6, 1948.
Temperature of polymerization	°C	60	Wang, W P; Pan, C Y, Wu, J S, J. Phys. Chem. Solids, 66, 1695-1700, 2005.
Time of polymerization	h	24	
Mass average molecular weight, $M_w$	dalton, g/mol, amu	165,000-185,000	
Van der Waals volume	cm <sup>3</sup> mol <sup>-1</sup>	calc.=53.8	
Molecular cross-sectional area, calculated	cm <sup>2</sup> x 10 <sup>-16</sup>	33.8	
<b>STRUCTURE</b>			
Entanglement molecular weight	dalton, g/mol, amu	calc.=5030, 7005, 8716, 9154, 9536	
<b>COMMERCIAL POLYMERS</b>			
Some manufacturers	-	BASF; DOW; Polimeri Europa	
Trade names	-	Luran; Tyril; Kostil	
<b>PHYSICAL PROPERTIES</b>			
Density at 20°C	g cm <sup>-3</sup>	1.07-1.09; 0.97 (melt); 1.36 (35% glass fiber)	
Color	-	colorless	
Refractive index, 20°C	-	1.5700	Sultaanova, N G; Nikolov, I D; Ivanov, C D, Optical Quantum Electronics, 35, 21-34, 2003.

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PARAMETER	UNIT	VALUE	REFERENCES
Transmittance	%	85-92	
Odor	-	odorless	
Decomposition temperature	°C	260	
Thermal expansion coefficient, 23-80°C	°C <sup>-1</sup>	0.7E-4; 0.25E-4 (35% glass fiber)	
Thermal conductivity, melt	W m <sup>-1</sup> K <sup>-1</sup>	0.17 (melt); 0.21 (melt, 35% glass fiber)	
Glass transition temperature	°C	calc.=111; exp.=103-112	Silva, A L A; Takase, I; Pereira, R P; Rocco, A M, Eur. Polym. J., 44, 1462-74, 2008.
Specific heat capacity	J K <sup>-1</sup> kg <sup>-1</sup>	1,300 (25°C); 2,300-2,400 (melt); 1,900 (melt, 35% glass fiber)	
Heat deflection temperature at 0.45 MPa	°C	99-110; 108 (35% glass fiber)	
Heat deflection temperature at 1.8 MPa	°C	86-104; 104 (35% glass fiber)	
Vicat temperature VST/A/50	°C	105-120; 109 (35% glass fiber)	
Relative permittivity at 100 Hz	-	2.9-3; 3.5 (35% glass fiber)	
Relative permittivity at 1 MHz	-	2.7-2.8; 3.2 (35% glass fiber)	
Dissipation factor at 100 Hz	E-4	40-50; 70 (35% glass fiber)	
Dissipation factor at 1 MHz	E-4	70-80; 100 (35% glass fiber)	
Volume resistivity	ohm-m	>1E13	
Surface resistivity	ohm	>1E15	
Comparative tracking index, CTI, test liquid A	-	400-550	
Speed of sound	m s <sup>-1</sup>	41.8	
Acoustic impedance		2.68	
Attenuation	dB cm <sup>-1</sup> , 5 MHz	5.1	
<b>MECHANICAL &amp; RHEOLOGICAL PROPERTIES</b>			
Tensile strength	MPa	61-79; 110 (35% glass fiber)	
Tensile modulus	MPa	3,600-3,900; 12,000 (35% glass fiber)	
Tensile creep modulus, 1000 h, elongation 0.5 max	MPa	2,800; 7,500 (35% glass fiber)	
Elongation	%	2.5-4	
Young's modulus	MPa	22-171 (core-shell particles)	Canche-Rscamilla, G; Duarte-Aranda, S; Rabelero_Velasco, M; Mendizabal-Mijares, E, Antec, 334-37, 2006.
Charpy impact strength, unnotched, 23°C	kJ m <sup>-2</sup>	14-21; 17 (35% glass fiber)	
Charpy impact strength, unnotched, -30°C	kJ m <sup>-2</sup>	16-21; 17 (35% glass fiber)	
Charpy impact strength, notched, 23°C	kJ m <sup>-2</sup>	1.5-2.5; 4 (35% glass fiber)	
Poisson's ratio	-	0.366	
Shrinkage	%	0.3-0.7; 0.1-0.4 (glass fiber reinforced)	
Melt viscosity, shear rate=1000 s <sup>-1</sup>	Pa s	120-200	
Melt volume flow rate (ISO 1133, procedure B), 220°C/10 kg	cm <sup>3</sup> /10 min	7-23; 4 (35% glass fiber)	

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PARAMETER	UNIT	VALUE	REFERENCES
Melt index, 230°C/3.8 kg	g/10 min	7.5	
Water absorption, equilibrium in water at 23°C	%	0.25-0.35	
Moisture absorption, equilibrium 23°C/50% RH	%	0.2-0.3	
<b>CHEMICAL RESISTANCE</b>			
Acid dilute/concentrated	-	good	
Alcohols	-	good	
Alkalis	-	very good	
Aliphatic hydrocarbons	-	good	
Aromatic hydrocarbons	-	poor	
Esters	-	poor	
Greases & oils	-	poor	
Halogenated hydrocarbons	-	poor	
Ketones	-	poor	
⊖ solvent, ⊖-temp.=43.2°C	-	ethyl acetate	
Good solvent	-	acetone, acetophenone, butyl acetate, chlorobenzene, cyclohexanone, diethyl ether, MEK, THF	
Non-solvent	-	acetamide, acetic acid, cetyl alcohol, diethylene glycol, formic acid	
Effect of EtOH sterilization (tensile strength retention)	%	63-88	Navarrete, L; Hermanson, N, Antec, 2807-18, 1996.
Chemicals causing environmental stress cracking	list	anionic and nonionic surfactants, sugar solution and fatty acids	Kawaguchi, T; Nishimura, H; Kasahara, K; Kuriyama, T; Narisawa, I, Polym. Eng. Sci., 43, 2, 419-30, 2003.
<b>FLAMMABILITY</b>			
Flammability according to UL-standard; thickness 1.6/0.8 mm	class	HB	
Ignition temperature	°C	380	
Autoignition temperature	°C	450	
Limiting oxygen index	% O <sub>2</sub>	18; 20 (35% glass fiber)	
<b>WEATHER STABILITY</b>			
Spectral sensitivity	nm	<360	
Activation wavelengths	nm	305	
Products of degradation	-	amide, aldehyde, acids	Mailhot, B; Gardette, J-L, Polym. Deg. Stab., 44, 237-47, 1994.
<b>TOXICITY</b>			
HMIS: Health, Flammability, Reactivity rating	-	0/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
Oral rat, LD <sub>50</sub>	mg kg <sup>-1</sup>	1,800	
Skin rabbit, LD <sub>50</sub>	mg kg <sup>-1</sup>	2,000	

# SAN poly(styrene-co-acrylonitrile)

PARAMETER	UNIT	VALUE	REFERENCES
<b>ENVIRONMENTAL IMPACT</b>			
Aquatic toxicity, <i>Daphnia magna</i> , LC <sub>50</sub> , 48 h	mg l <sup>-1</sup>	13	
Aquatic toxicity, <i>Bluegill sunfish</i> , LC <sub>50</sub> , 48 h	mg l <sup>-1</sup>	28	
Aquatic toxicity, <i>Fathead minnow</i> , LC <sub>50</sub> , 48 h	mg l <sup>-1</sup>	10	
Cradle to grave non-renewable energy use	MJ/kg	90	
Cradle to pellet greenhouse gasses	kg CO <sub>2</sub> kg <sup>-1</sup> resin	3.5	
<b>PROCESSING</b>			
Typical processing methods	-	blow molding, casting, extrusion, injection molding, thermoforming	
Preprocess drying: temperature/time/residual moisture	°C/h/%	80/2-4/	
Processing temperature	°C	220-260 (injection molding); 220-240 (extrusion)	
Additives used in final products	-	Fillers: aluminum borate whiskers, barium sulfate, glass fiber, montmorillonite, PTFE, zinc oxide, zirconium oxide	
Applications	-	appliances (housings, air conditioner parts, refrigerator shelves, blenders, lenses), automotive (dashboard, battery cases), bottles, high-density molding composition, housewares (eating utensils, beverage/food containers, display boxes), housings for electronic and electrical applications, instrument lenses packaging for high barrier properties	
Outstanding properties	-	outstanding transparency, good chemical resistance and stability in dishwashers together with high strength, rigidity, dimensional stability and thermal shock resistance	
<b>BLENDS</b>			
Suitable polymers	-	EPDM, PC, PCL, PMMA, PPE, PS; incompatible with most thermoplastics; small amounts of admixtures lower mechanical properties and cause streaking	Luran Brochure KSEL 1001 BE, BASF, 2010.
<b>ANALYSIS</b>			
FTIR (wavenumber-assignment)	cm <sup>-1</sup> /-	CN – 2220, C=O – 1725	Mailhot, B; Gardette, J-L, Polym. Deg. Stab., 44, 237-47, 1994.