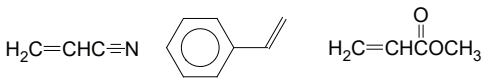
ASA poly(acrylonitrile-co-styrene-co-acrylate)

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	poly(acrylonitrile-co-styrene-co-acrylate)	
IUPAC name	-	2-propenoic acid, butyl ester, polymer with ethenylbenzene and 2-propenenitrile	
CAS name	-	2-propenoic acid, butyl ester, polymer with ethenylbenzene and 2-propenenitrile	
Acronym	-	ASA	
CAS number	-	9003-54-7; 26299-47-8; 26716-29-0	
HISTORY			
Person to discover	-	Herbig and Salyer; Siebel and Otto	
Date	-	1964; 1965	
Details	-	first patent; refined product	
SYNTHESIS			
Monomer(s) structure	-		
Monomer(s) CAS number(s)	-	107-13-1; 100-42-5; 96-33-3	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	104.15; 53.06; 86.09	
Monomer reactivity ratio		AN/ST=0.25/2	Badawy, S M; Dessouki, A M, J. Appl. Polym. Sci., 84, 268-75, 2002.
Method of synthesis	-	grafting rubber which is dispersed with a styrene acrylonitrile (SAN) phase	
Mass average molecular weight, M_w	dalton, g/mol, amu	60,000-200,000	
Rubber particle size	nm	100-1000	Hossain, M M; Moghbelli, E; Jahnke, E; Boeckmann, P; Guriyanova, S; Sander, R; Minkwitz, R; Sue, H-J, Polymer, 63, 71-81, 2015.
STRUCTURE			
Crystallinity	%	0	
COMMERCIAL POLYMERS			
Some manufacturers	-	BASF; Sabic	
Trade names	-	Luran S; Geloy	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.06-1.1; 1.18 (15% glass fiber)	
Bulk density at 20°C	g cm^{-3}	0.6	
Refractive index, 20°C	-	1.57-1.677	
Gloss, 60°, Gardner (ASTM D523)	%	93-94	
Odor	-	faint specific	
Melting temperature, DSC	°C	180-200	
Softening point	°C	>85 to >100	
Decomposition temperature	°C	320; 395(TGA onset)	

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Thermal expansion coefficient, -40 to 40°C	$^oC^{-1}$	0.95-1.2E-4; 0.3E-4	
Thermal conductivity, melt	W m^{-1} K^{-1}	0.16	
Glass transition temperature	°C	103-127; -46.5 to -50.9 (core) and 103.7 to 107.1 (shell)	Tolue, S; Moghbeli, M R; Ghafelebashi, S M, Eur. Polym. J., 45, 714-20, 2009.
Specific heat capacity	J K^{-1} kg^{-1}	1,860-2,000 (melt)	
Long term service temperature	°C	-40 to 75	
Heat deflection temperature at 0.45 MPa	°C	84-106; 115 (15% glass fiber)	
Heat deflection temperature at 1.8 MPa	°C	75-103; 110 (15% glass fiber)	
Vicat temperature VST/A/50	°C	80-104; 115 (15% glass fiber)	
Vicat temperature VST/B/50	°C	82-98	
Dielectric loss factor at 1 kHz	-	0.02-0.05	
Relative permittivity at 100 Hz	-	3.5-3.9	
Relative permittivity at 1 MHz	-	3.2-3.5	
Dissipation factor at 100 Hz	E-4	90-110	
Dissipation factor at 1 MHz	E-4	240-340	
Volume resistivity	ohm-m	1E12	
Surface resistivity	ohm	1E13	
Electric strength K20/P50, d=0.60.8 mm	kV mm^{-1}	35	
Comparative tracking index	-	600	
Coefficient of friction	-	0.4-0.5	Hossain, M M; Moghbelli, E; Jahnke, E; Boeckmann, P; Guriyanova, S; Sander, R; Minkwitz, R; Sue, H-J, Polymer, 63, 71-81, 2015.
Permeability to nitrogen, 25oC	cm^3 m^{-2} d^{-1} day^{-1}	60-100	
Permeability to oxygen, 25oC	cm^3 m^{-2} d^{-1} day^{-1}	150-560	
Permeability to water vapor, 25oC	g m^{-2} day^{-1}	30-35	
Contact angle of water, 20oC	degree	93.7-97.0	
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	29-51; 110 (15% glass fiber)	Chang, M C O; Garrett, P D, Antec, 2588-93, 1996.
Tensile modulus	MPa	1,870-2,600; 6,600 (15% glass fiber)	
Tensile stress at yield	MPa	38-56	Chang, M C O; Garrett, P D, Antec, 2588-93, 1996.
Tensile creep modulus, 1000 h, elongation 0.5 max	MPa	1,200-1,650	
Elongation	%	7-37	Chang, M C O; Garrett, P D, Antec, 2588-93, 1996.
Tensile yield strain	%	2.8-4.0; 2.5 (15% glass fiber)	
Tensile yield strength	MPa	55-57	Hossain, M M; Moghbelli, E; Jahnke, E; Boeckmann, P; Guriyanova, S; Sander, R; Minkwitz, R; Sue, H-J, Polymer, 63, 71-81, 2015.
Flexural strength	MPa	56-75	

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PARAMETER	UNIT	VALUE	REFERENCES
Flexural modulus	MPa	1,880-2,570	
Compressive strength	MPa	35-65	
Compressive modulus	MPa	1,600-1,900	Hossain, M M; Moghbelli, E; Jahnke, E; Boeckmann, P; Guriyanova, S; Sander, R; Minkwitz, R; Sue, H-J, Polymer, 63, 71-81, 2015.
Young's modulus	MPa	1,900-2,600	Chang, M C O; Garrett, P D, Antec, 2588-93, 1996.
Charpy impact strength, unnotched, 23°C	kJ m^{-2}	160-270; 28 (15% glass fiber)	
Charpy impact strength, unnotched, -30°C	kJ m^{-2}	70-180; 17 (15% glass fiber)	
Charpy impact strength, notched, 23°C	kJ m^{-2}	10-40; 7 (15% glass fiber)	
Charpy impact strength, notched, -30°C	kJ m^{-2}	3-9; 6 (15% glass fiber)	
Izod impact strength, unnotched, 23°C	J m^{-1}	260	
Izod impact strength, notched, 23°C	J m^{-1}	65-210	
Izod impact strength, notched, -30°C	J m^{-1}	24-35	
Shear modulus	MPa	700-900	
Rockwell hardness	-	R100-103	
Shrinkage	%	0.45 (parallel); 0.9 (normal)	
Melt viscosity, shear rate=1000 s^{-1}	Pa s	150-200	
Melt volume flow rate (ISO 1133, procedure B), 220°C/10 kg	cm^3/10 min	4-25	
Melt index, 220°C/10 kg	g/10 min	5.2-15	
Water absorption, equilibrium in water at 23°C	%	0.55-1.65; 1.42 (15% glass fiber)	
Moisture absorption, equilibrium 23°C/50% RH	%	0.15-0.35; 0.3 (15% glass fiber)	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	resistant	
Alcohols	-	resistant-fair	
Alkalis	-	resistant	
Aliphatic hydrocarbons	-	resistant	
Aromatic hydrocarbons	-	non-resistant	
Esters	-	non-resistant	
Greases & oils	-	resistant	
Halogenated hydrocarbons	-	non-resistant	
Ketones	-	non-resistant	
Good solvent	-	chloroform, dichlorobenzene, diethyl ether, DMF, ethyl benzoate, ethyl chloride, mesityl oxide, methyl chloride, methyl propyl ketone, xylene	
Non-solvent	-	acetamide, ethylene glycol, glycerin, triethanolamine	

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PARAMETER	UNIT	VALUE	REFERENCES
FLAMMABILITY			
Flammability according to UL-94 standard; thickness 1.6/0.8 mm	class	HB	
Ignition temperature	°C	>400	
Autoignition temperature	°C	>400	
Limiting oxygen index	% O_2	19	
Char at 500°C	%	1.12	
Volatile products of combustion	-	CO, CO_2, cyanides, ammonia, acrylonitrile, styrene, nitrogen	
WEATHER STABILITY			
Tensile strength retention	%	104 (40 months outdoors)	
Erosion rate (exposure for 10 years)	m $year^{-1}$	8.8E-10 (Florida) 12.0E-10 (Arizona)	
Stabilizers	-	UV absorbers: 2-(2H-benzotriazol-2-yl)-p-cresol; 2-(2H-benzotriazole-2-yl)-4,6-di-tert-pentylphenol; 2-(2H-benzotriazole-2-yl)-4-(1,1,3,3-tetraethylbutyl)phenol; 2-[4,6-bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-(octyloxy) phenol; HAS: 1,3,5-triazine-2,4,6-triamine, N,N'''[1,2-ethane-diyl-bis[[[4,6-bis[butyl(1,2,6,6-pentamethyl-4-piperidinyl) amino]-1,3,5-triazine-2-yl]imino]-3,1-propanediyl]-bis[N',N''-dibutyl-N',N''-bis(1,2,2,6,6-pentamethyl-4-piperidinyl)-; bis(2,2,6,6-tetramethyl-4-piperidyl) sebacate; 2,2,6,6-tetramethyl-4-piperidinyl stearate; 1, 6-hexanediamine, N, N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-, polymers with 2,4-dichloro-6-(4-morpholinyl)-1,3,5-triazine; 1,6-hexanediamine, N,N'-bis(2,2,6,6-tetramethyl-4-piperidinyl)-, polymers with morpholine-2,4,6-trichloro-1,3,5-triazine reaction products, methylated; Phenolic antioxidant: phenol, 4-methyl-, reaction products with dicyclopentadiene and isobutene; Screener: carbon black	
BIODEGRADATION			
Stabilizers		silver compound is added to Luran S BX 13042 to impart its surface with germicidal effect	Anon., Plast. Addit. Compounding, Nov/Dec., p. 19, 2008.
TOXICITY			
HMIS: Health, Flammability, Reactivity rating	-	1/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
PROCESSING			
Typical processing methods	-	extrusion, injection molding, thermoforming	
Preprocess drying: temperature/ time/residual moisture	oC/h/%	80-90/2-6/0.02-0.04	
Processing temperature	oC	225-280 (injection molding); 200-230 (pipe extrusion); 200-250 (sheet extrusion)	
Processing pressure	MPa	0.3-1 (back); 5-10 (injection)	
Additives used in final products	-	Fillers: carbon black, glass beads; release agents; thermal stabilizers	
Applications	-	exterior cable enclosures, impact modifier for PC, large screen displays, marine applications, mirrors for personal watercraft, pool accessories, profiles, recreational vehicle antennas, sheet outdoor furnishings, ski bindings, skylights, spas	

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PARAMETER	UNIT	VALUE	REFERENCES
Outstanding properties	-	high service temperature, low thermal conductivity, weather resistant	
BLENDS			
Suitable polymers	-	AES, PBT, PC, PET, PMMA, PVC	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	C=O – 1733, C-O-C – 1169, CH_3 – 1387, 1456	Tomar, N; Maiti, S N, J. Appl. Polym. Sci., 113, 1657-63, 2009.