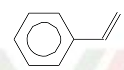
ABS poly(acrylonitrile-co-butadiene-co-styrene)

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	poly(acrylonitrile-co-butadiene-co-styrene)	
IUPAC name	-	buta-1,3-diene; prop-2-enenitrile; styrene	
CAS name	-	2-propenenitrile, polymer with 1,3-butadiene and ethenyl-benzene	
Acronym	-	ABS	
CAS number	-	9003-56-9	
RTECS number	-	AT6970000	
Linear formula		$[CH_2CH(CN)]_x(CH_2CH{=}CHCH_2)_y[CH_2CH(C_6H_5)]_z$	
HISTORY			
Details	-	ABS was patented in 1948 and introduced to commercial markets by the Borg-Warner Corporation in 1954	
SYNTHESIS			
Monomer(s) structure	-	$H_2C{=}CHC{\equiv}N$ $H_2C{=}CHCH{=}CH_2$ 	
Monomer(s) CAS number(s)	-	107-13-1 (acrylonitrile); 106-99-0 (butadiene); 100-42-5 (styrene)	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	53.06; 54.09; 104.15	
Monomer(s) expected purity(ies)	%	variable	
Monomer ratio	-	acrylonitrile: 15-50%; butadiene: 5-30%; styrene: 40-60%	
SAN/BP		90-40/10-60	
Formulation example	-	H_2O (solvent) 17,070, emulsifier 3558, polybutadiene latex 6384, tertdodecyl mercaptan 70, $FeSO_4$ 1610, styrene 8565, acrylonitrile 4236, cumene hydroperoxide 53	Hu, K-H; Kao, C-S; Duh, Y-S, J. Hazardous Matrer., 159, 25-34, 2008.
Method of synthesis	-	the most frequently used are emulsion, mass, and suspension polymerizations; styrene and acrylonitrile are being grafted onto rubber by chemical grafting, chemical grafting blending, or physical mixing; chemical grafting blending is the most frequently used method and specifically emulsion grafting-bulk SAN blending is a method of choice	Huang, P; Tan, D; Luo, Y, J. Env. Sci., Technol., 3, 3, 148-58, 2010.
Temperature of polymerization	^oC	62-75	
Heat of polymerization	$J\ g^{-1}$	styrene: 647; acrylonitrile: 2290; ABS: 890	
Number average molecular weight, M_n	dalton, g/mol, amu	30,000-200,000	
Mass average molecular weight, M_w	dalton, g/mol, amu	81,000-308,000	
Polydispersity, M_w/M_n	-	2.72-2.88	
STRUCTURE			
Domain size of rubber	nm	<1,000 (emulsion polymerization); 500-5,000 (mass polymerization)	Lucarini, M; Pedulli, G F; Motyakin, M V; Schlick, S, Prog. Polym. Sci., 28, 331–340, 2003.
Cis content	%	32.3-97.0 (polybutadiene); 1.5-51.6 (*trans* in polybutadiene)	Yu, Z; Li, Y; Zhao, Z; Wang, C; Yang, J; Zhang, C; Li, Z; Wang, Y, Polym. Eng. Sci., 49, 2249-56, 2009.

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PARAMETER	UNIT	VALUE	REFERENCES
COMMERCIAL POLYMERS			
Some manufacturers	-	BASF; Daicel; Denka; Formosa; Sabic	
Trade names	-	Lustran, Terluran; Cevian; Novodur; Tairilac; Cycolac	
PHYSICAL PROPERTIES			
Density at 20°C	g cm^{-3}	1.03-1.09; 0.93 (melt)	Terluran, BASF; Cevian, Daicel
Bulk density at 20°C	g cm^{-3}	0.6	
Refractive index, 20°C	-	1.540	
Transmittance	%	80-90	Cevian, Daicel
Haze	%	0.4-5	
Gloss, 60°, Gardner (ASTM D523)	%	85-95 (glossy); 1.8-6.6 (matt)	Arino, I; Kleist, U; Rigdahl, M, Polym. Eng. Sci., 45, 733-44, 2005.
Melting temperature, DSC	°C	220-260	Terluran, BASF; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009.
Softening point	°C	>90	Terluran, BASF
Heat deflection temperature	°C	76.5-79.2	Basurto, F C; Garcia-Lopez, D; Villarreal-Bastardo, N; Merino, J C; Pastor, J M, Composites: Part B, 47, 42-7, 2013.
Onset temperature of thermal degradation	°C	385-407	Li, Y; Zheng, Y; Liu, J; Shang, H, J. Appl. Polym. Sci., 115, 957-62, 2010.
Thermal expansion coefficient, 23-80°C	$°C^{-1}$	0.6-1.1E-4	Terluran, BASF; Cevian, Daicel
Thermal conductivity, melt	W m^{-1} K^{-1}	0.16	Terluran, BASF
Glass transition temperature	°C	102-107 (acrylonitrile-styrene mesophase) and -58 (butadiene component); 103 (DSC) and 121 (DMA); 112-115 (DMA)	Terluran, BASF; Xue, M-L; Yu, Y-L; Rhee, J M; Kim, N H; Lee, J H, Eur. Polym. J., 43, 9, 3826-37, 2007; Santos, R M; Botelho, G L; Machado, A V, J. Appl. Polym. Sci., 2005-14, 2010; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009; Torrado, A R; Shemelya, C M; English, J D; Lin, Y; Wicker, R B; Roberson, D A, Addit. Manufac., 6, 16-29, 2015.
Specific heat capacity	J K^{-1} kg^{-1}	1,780-2,030 (88°C); 2,300-2,400 (melt)	Terluran, BASF
Maximum service temperature	°C	80	Terluran, BASF
Heat deflection temperature at 0.45 MPa	°C	89-113	Terluran, BASF
Heat deflection temperature at 1.8 MPa	°C	67-109	Terluran, BASF; Cevian, Daicel
Vicat temperature VST/A/50	°C	90-112	Terluran, BASF
Vicat temperature VST/B/50	°C	95-100	Terluran, BASF
Melting enthalpy peak	J g^{-1}	9.6	Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009.
Relative permittivity at 100 Hz	-	2.9	Terluran, BASF
Relative permittivity at 1 MHz	-	2.8	Terluran, BASF
Dissipation factor at 100 Hz	E-4	48-160	Terluran, BASF
Dissipation factor at 1 MHz	E-4	79-140	Terluran, BASF
Volume resistivity	ohm-m	1E+13; 1E+1 (with 0.18 vol fraction of Ni coated mica)	Terluran, BASF; Kandasubramanian, B; Gilbert, M, Macromol. Symp., 211, 185-95, 2005.

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PARAMETER	UNIT	VALUE	REFERENCES
Surface resistivity	ohm	1E+13 to 1E+15	Terluran, BASF
Electric strength K20/P50, d=0.60.8 mm	kV mm^{-1}	37-41	Terluran, BASF
Comparative tracking index, CTI, test liquid A	-	600	Terluran, BASF
Comparative tracking index, CTIM, test liquid B	(-)-	225	Terluran, BASF
Shielding effectiveness	dB	16-16.5	Kandasubramanian, B; Gilbert, M, Macromol. Symp., 211, 185-95, 2005.
Coefficient of friction	ASTM D1894	0.21-0.28 (chrome steel); 0.40 (aluminum)	Maldonado, J E, Antec, 3431-35, 1998.
Contact angle of water, 20^{o}C	degree	80.9; 89.7	Accu Dyne Test, Diversified Enterprizes; K. Fukuzawa, in Adhesion Science and Technology, H. Mizumachi, ed., International Adhesion Symposium, Yokohama, Japan, 1994.
Surface free energy	mJ m^{-2}	35-42	D.A. Markgraf, in Film Extrusion Manual, 2nd Ed., T.I. Butler, ed., TAPPI Press, Norcross, GA, 2005, p. 299.
Speed of sound	m s^{-1}	36.2-37.5	Alan R. Selfridge, IEEE Trans. Sonics Ultrasonics, SU-32, 3, 381-394, 1985.
Acoustic impedance		2.31-2.36	Alan R. Selfridge, IEEE Trans. Sonics Ultrasonics, SU-32, 3, 381-394, 1985.
Attenuation	dB cm^{-1}, 5 MHz	10.9-11.3	Alan R. Selfridge, IEEE Trans. Sonics Ultrasonics, SU-32, 3, 381-394, 1985.
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	25-65	Li, J; Cai, C L, Current Appl. Phys., 11, 50, 2011; Lee, J-W; Lee, J-C; Pandey, J; Ahn, S-H; Kang, Y J, J. Compos. Mater., 44, 1701-16, 2010.
Tensile modulus	MPa	1900-2700	Terluran, BASF
Tensile stress at yield	MPa	35-58	Terluran, BASF
Tensile creep modulus, 1000 h, elongation 0.5 max	MPa	1250	Terluran, BASF
Elongation	%	8-20	Terluran, BASF; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009.
Tensile yield strain	%	2.4-4	Terluran, BASF
Flexural strength	MPa	55-125	Jin, F-L; Lu, S-L, Song, Z-B; Pang, J-X; Zhang, L; Sun, J-D; Cai, X-P, Mater. Sci. Eng., A527, 3438-41, 2010; Terluran, BASF; Cevian, Daicel
Flexural modulus	MPa	2150-2300	Vitands, E, Antec, 2986-2991, 1996.
Elastic modulus	MPa	1208-1939	Lee, J-W; Lee, J-C; Pandey, J; Ahn, S-H; Kang, Y J, J. Compos. Mater., 44, 1701-16, 2010; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009.
Young modulus	MPa	1810-2390	Basurto, F C; Garcia-Lopez, D; Villarreal-Bastardo, N; Merino, J C; Pastor, J M, Composites: Part B, 47, 42-7, 2013.
Compressive strength	MPa	65-86; 120 (30% glass fiber)	

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PARAMETER	UNIT	VALUE	REFERENCES
Charpy impact strength, unnotched, 23°C	kJ m^{-2}	120-190 to NB	Terluran, BASF; Cevian, Daicel
Charpy impact strength, unnotched, -30°C	kJ m^{-2}	80-140	Terluran, BASF; Cevian, Daicel
Charpy impact strength, notched, 23°C	kJ m^{-2}	5-40	Terluran, BASF; Cevian, Daicel
Charpy impact strength, notched, -30°C	kJ m^{-2}	2-25	Terluran, BASF; Cevian, Daicel
Izod impact strength, notched, 23°C	J m^{-1}	30-450	Jin, F-L; Lu, S-L, Song, Z-B; Pang, J-X; Zhang, L; Sun, J-D; Cai, X-P, Mater. Sci. Eng., A527, 3438-41, 2010; Terluran, BASF; Cevian, Daicel
Izod impact strength, notched, -40°C	J m^{-1}	8-280	Terluran, BASF; Cevian, Daicel
Shear modulus	MPa	700-1,50	
Rockwell hardness	-	101; 102-124	(-); Jin, F-L; Lu, S-L, Song, Z-B; Pang, J-X; Zhang, L; Sun, J-D; Cai, X-P, Mater. Sci. Eng., A527, 3438-41, 2010.
Ball indention hardness at 358 N/30 S (ISO 2039-1)	MPa	97	
Shrinkage	%	0.4-0.7; 0.72 (across the flow), 1.11 (along the flow)	Terluran, BASF; Chang, T; Faison, E, Polym. Eng. Sci., 41, 5, 703-10, 2001.
Melt viscosity, shear rate=1000 s^{-1}	Pa s	140-250	Xue, M-L; Yu, Y-L; Rhee, J M; Kim, N H; Lee, J H, Eur. Polym. J., 43, 9, 3826-37, 2007.
Melt volume flow rate (ISO 1133, procedure B), 220°C/10 kg	cm^3/10 min	2-34	Terluran, BASF
Pressure coefficient of melt viscosity, b	G Pa^{-1}	33.7	Aho, J; Syrjala, S, J. Appl. Polym. Sci., 117, 1076–84, 2010.
Melt index, 230°C/3.8 kg	g/10 min	1.5; 2.5-7.0; 18-34	Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009; (-); Jin, F-L; Lu, S-L, Song, Z-B; Pang, J-X; Zhang, L; Sun, J-D; Cai, X-P, Mater. Sci. Eng., A527, 3438-41, 2010,
Water absorption, equilibrium in water at 23°C	%	0.7-1.03	Terluran, BASF
Moisture absorption, equilibrium 23°C/50% RH	%	0.21-0.35	Terluran, BASF
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	no resistance to concentrated; good resistance to dilute	Terluran, BASF
Alcohols	-	limited resistance; insoluble	Terluran, BASF
Alkalis	-	good resistance to dilute	Terluran, BASF
Aliphatic hydrocarbons	-	limited resistance; insoluble	Terluran, BASF
Aromatic hydrocarbons	-	no resistance	Terluran, BASF
Esters	-	no resistance	Terluran, BASF
Greases & oils	-	limited resistance; insoluble: mineral oil	Terluran, BASF
Halogenated hydrocarbons	-	no resistance; soluble: dichloromethane	Terluran, BASF
Ketones	-	no resistance; soluble: acetone, methyl-ethyl ketone	Terluran, BASF
Other	-	resistant: water, salt solutions; soluble: dimethylformamide, tetrahydrofuran, toluene	Terluran, BASF

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PARAMETER	UNIT	VALUE	REFERENCES
Good solvent	-	acetophenone, aniline, benzene, chlorobenzene, chloroform, dimethylformamide, dioxane, ethyl benzene	
Non-solvent	-	cyclohexane, diethanolamine, diethylene glycol, dipropylene glycol, petroleum ether	
Chemicals causing environmental stress cracking		nonionic surfactants	Kawaguchi, T; Nishimura, H; Kasahara, K; Kuriyama, T; Narisawa, I, Polym. Eng. Sci., 43, 2, 419-30, 2003.
Effect of EtOH sterilization (tensile strength retention)	%	105-110 (high gloss); 82-95 (low gloss)	Navarrete, L; Hermanson, N, Antec, 2807-18, 1996.
FLAMMABILITY			
Autoignition temperature	°C	>400	Terluran, BASF, MSDS
Limiting oxygen index	% O_2	18.1-20.5; 23-35 (with flame retardants)	Yan, I; Zheng, Y; Liu, J; Shang, H, J. Appl. Polym. Sci., 115, 957-62, 2010; Hourston, D J, Shreir's Corrosion, Elsevier, 2010, Chapter 3.31, 2369-2386; Li, Y; Zheng, Y; Liu, J; Shang, H, J. Appl. Polym. Sci., 115, 957-62, 2010; Ren, Y-y; Chen, L; Zhang, Z-y; Wang, X-l; Yang, X-s; Kong, X-j; Yang, L, Polym. Deg. Stab., 109, 285-92, 2014.
Heat release	kW m^{-2}	1037; 602-796 (with organoclays); 243-268 (with flame retardant	Du, X; Yu, H; Wang, Z; Tang, T, Polym. Deg. Stab., 95, 587-92, 2010; Yu, B; Liu, M; Lu, L; Dong, X; Gao, W; Tang, K, Fire Mater., 34, 251-61, 2010.
NBS smoke chamber	Ds	800	Padey, D; Walling, J; Wood A, Polymers in Defence and Aerospace 2007, Rapra, 2007, paper 15.
Char, 554°C	%	0-0.6; 9.4; 0.43-2.89	Yang, S; Castilleja, J R; Barrera, E V; Lozano, K, Polym. Deg. Stab., 83, 3, 383-88, 2004; Du, X; Yu, H; Wang, Z; Tang, T, Polym. Deg. Stab., 95, 587-92, 2010; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009; Lyon, R E; Walters, R N, J. Anal. Appl. Pyrolysis, 71, 27-46, 2004.
Heat of combustion	J g^{-1}	39,840	Walters, R N; Hacket, S M; Lyon, R E, Fire Mater., 24, 5, 245-52, 2000.
CO yield	%	13	
UL 94 rating	-	HB	
THERMAL STABILITY			
Activation energy under nitrogen	kJ mol^{-1}	134.5-242.4	Yang, S; Castilleja, J R; Barrera, E V; Lozano, K, Polym. Deg. Stab., 83, 3, 383-88, 2004; Polli, H; Pontes, L A M; Araujo, A S; Barros, J M F; Fernandes, V J, J. Therm. Anal. Calorimetry, 95, 1, 131-34, 2009.
Activation energy under air	kJ mol^{-1}	156.3	Yang, S; Castilleja, J R; Barrera, E V; Lozano, K, Polym. Deg. Stab., 83, 3, 383-88, 2004.
Temperature of maximum degradation (air)	°C	428-445 (1st step); 554 (2nd step)	Yang, S; Castilleja, J R; Barrera, E V; Lozano, K, Polym. Deg. Stab., 83, 3, 383-88, 2004; Karahaliou, E K; Tarantili, P A, Polym. Eng. Sci., 49, 2269-75, 2009.
Weight loss	%	85.6 (1st step); 13.8 (2nd step)	Yang, S; Castilleja, J R; Barrera, E V; Lozano, K, Polym. Deg. Stab., 83, 3, 383-88, 2004.

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PARAMETER	UNIT	VALUE	REFERENCES
Onset temperature of oxidation	^oC	80 (isothermal test); 120 (dynamic scanning)	Duh, Y-S; Ho, T-C; Chen, J-R; Kao, C-S, Polymer, 51, 2, 171-84, 2010.
Heat of oxidation	J g^{-1}	2,800; 4,720 (polybutadiene)	
WEATHER STABILITY			
Activation wavelengths	nm	320, 385	
Depth of UV penetration	μm	110-150	Jouan, X; Gardette, J L, J. Polym. Sci., Polym. Chem., 29, 685, 1991; Bokria, J G; Schlick, S, Polymer, 43, 3239-46, 2002.
Products of degradation	-	hydroperoxides, carboxylic acids, andydrides, gamma lactones, chain scission	Santos, R M; Botelho, G L; Machado, A V, J. Appl. Polym. Sci., 2005-14, 2010.
Stabilizers	-	UVA: 2-hydroxy-4-octyloxybenzophenone; 2-hydroxy-4-methoxybenzophenone; 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-di-tert-butyl-6-(5-chloro-2H-benzotriazole-2-yl)-phenol; 2-[4,6-bis(2,4-dimethylphenyl)-1,3,5-triazin-2-yl]-5-(octyloxy) phenol; ethyl-2-cyano-3,3-diphenylacrylate; 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; N,N'-bisformyl-N,N'-bis-(2,2,6,6-tetramethyl-4-piperidinyl)-hexamethylendiamine; alkenes, C20-24-.alpha.-, polymers with maleic anhydride, reaction products with 2,2,6,6-tetramethyl-4-piperidinamine; 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 antioxidants: ethylene-bis(oxyethylene)-bis(3-(5-tert-butyl-4-hydroxy-m-tolyl)-propionate); 2,6,-di-tert-butyl-4-(4,6-bis(octylthio)-1,3,5,-triazine-2-ylamino) phenol; pentaerythritol tetrakis(3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate); 2-(1,1-dimethylethyl)-6-[[3-(1,1-dimethylethyl)-2-hydroxy-5-methylphenyl] methyl-4-methylphenyl acrylate; isotridecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate; 2,2'-ethylidenebis (4,6-di-tert-butylphenol); 2,2'-methylenebis(4-ethyl-6-tertbutylphenol); 3,5-bis(1,1-dimethyethyl)-4-hydroxy-benzenepropanoic acid, C13-15 alkyl esters; phenol, 4-methyl-, reaction products with dicyclopentadiene and isobutene; Phosphite: trinonylphenol phosphite; isodecyl diphenyl phosphite	
BIODEGRADATION			
Colonized products		bathroom fixtures, health care products, pipes	
Stabilizers	-	Microban, nanosilver	
TOXICITY			
NFPA: Health, Flammability, Reactivity rating	-	1/1/0	
Carcinogenic effect	-	not listed by ACGIH, NIOSH, NTP	
MAK/TRK	mg m^{-3}	styrene: 86; acrylonitrile: 7; 1,3-butadiene: 11	
Oral rat, LD_{50}	mg kg^{-1}	>5,000	

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PARAMETER	UNIT	VALUE	REFERENCES
ENVIRONMENTAL IMPACT			
Cradle to grave non-renewable energy use	MJ/kg	92-95	
PROCESSING			
Typical processing methods	-	calendering, casting, electroplating, extrusion, film lamination, injection molding, rotational molding, thermoforming, vacuum forming, vacuum metallization	Sarkar, K; Gomez, C; Zambrano, S; Ramirez, M; de Hoyos, E; Vasquez, H; Lozano, K, Mater. Today, 13, 11, 12-14, 2010.
Preprocess drying: temperature/ time/residual moisture	^{o}C/h/%	80-95/2-4/0.01	
Processing temperature	^{o}C	190-275; 220-260 (injection molding)	
Processing pressure	MPa	5 (backpressure); 53 (holding pressure)	Ingnell, S; Kelist, U; Rigdahl, M, Polym. Eng. Sci., 50, 2114-21, 2010.
Additives used in final products	-	Fillers: antimony oxide, carbon black, glass beads, magnesium hydroxide, nickel or copper coated carbon fibers, talc; Plasticizers: hydrocarbon processing oil, phosphate esters (e.g., triphenyl phosphate, resorcinol bis(diphenyl phosphate), or oligomeric phosphate), long chain fatty acid esters, and aromatic sulfonamide; Antistatics: ethanol,2,2'-iminobis-,N-coco alkyl derivatives, glycerol monostearate, polyaniline, polyesteramide, sodium alkyl sufonate; Antiblocking: talc; Release: cetyl palmitate, fluorocarbon, methyl behenate, paraffin wax; Slip: bis-stearamide wax	
Applications	-	appliance (refrigerator liners, kitchen appliance housings, vacuum cleaners, power tools), automotive (instrument panels, consoles, door parts, knobs, trim, wheel covers, mirror and headlight housing, front radiator grilles), business machines (computers, discs, phones), furniture, hot tubs, lawn and garden equipment, luggage, lunch and tool boxes, medical applications, military, packaging, pipes and fittings, recreation (snowmobiles, boats, vehicles), toys	
Outstanding properties	-	combination of 3 monomers gives specific advantages: styrene gives rigidity, electrical properties, easy processability and surface gloss, butadiene improves low temperature toughness, and acrylonitrile improves ABS' chemical, weathering and heat resistance and increases tensile strength	Huang, P; Tan, D; Luo, Y, J. Env. Sic., Technol., 3, 3, 148-58, 2010.
BLENDS			
Suitable polymer	-	chitosan, EPDM, ground rubber, PA6, PANI-EB, PC, PLA, PTT, PVC, SAN	
Compatibilizers	-	SBM	
ANALYSIS			
FTIR (wavenumber-assignment)	cm^{-1}/-	hydroxy – 3460; carbonyl – 1646, 1718, 1722, 1730, 1785; C=N – 2237; C-O – 1450, 950; styrene – 700, 765, 1028, 1449, 1456-1495, 1582-1601; poly-1,2-butadiene – 910-911; poly-*trans*-1,4-butadiene – 966-967; C=C of 1,2 structures – 1640	Jouan, X; Gardette, J-L, J. Polym. Sci., Polym. Chem., 29, 685, 1991; Motyakin, M V; Schlick, S, Poly. Deg. Stab., 91, 7, 1462-70, 2006; Santos, R M; Botelho, G L; Machado, A V, J. Appl. Polym. Sci., 2005-14, 2010.