Acrylonitrile butadiene styrene (ABS)

Description

Image

Caption

1. ABS pellets. © Shutterstock 2. ABS allows detailed moldings, accepts color well, and is non-toxic and tough enough to survive the worst that children can do to it. © Gettyimages

The material

ABS (Acrylonitrile-butadiene-styrene) is tough, resilient, and easily molded. It is usually opaque, although some grades can now be transparent, and it can be given vivid colors. ABS-PVC alloys are tougher than standard ABS and, in self-extinguishing grades, are used for the casings of power tools.

Compositional summary

Block terpolymer of acrylonitrile (15-35%), butadiene (5-30%), and styrene (40-60%).

General properties

Density		63.1	-	75.5	lb/ft^3
Price	*	1.13	-	1.36	USD/lb
Date first used		1937			

Mechanical properties

Young's modulus		0.16	-	0.421	10^6 psi
Shear modulus		0.0462	-	0.15	10^6 psi
Bulk modulus		0.551	-	0.58	10^6 psi
Poisson's ratio		0.391	-	0.422	
Yield strength (elastic limit)		2.68	-	7.4	ksi
Tensile strength		4	-	8.01	ksi
Compressive strength		4.5	-	12.5	ksi
Elongation		1.5	-	100	% strain
Hardness - Vickers		5.6	-	15.3	HV
Fatigue strength at 10^7 cycles		1.6	-	3.2	ksi
Fracture toughness		1.08	-	3.9	ksi.in^0.5

Mechanical loss coefficient (tan delta)	0.0138	-	0.0446	

Thermal properties

Glass temperature	190	-	262	°F
Maximum service temperature	143	-	170	°F
Minimum service temperature	-190	-	-99.7	°F
Thermal conductor or insulator?	Good insulator			
Thermal conductivity	0.109	-	0.194	BTU.ft/h.ft^2.F
Specific heat capacity	0.331	-	0.458	BTU/lb.°F
Thermal expansion coefficient	47	-	130	µstrain/°F

Electrical properties

Electrical conductor or insulator?	Good insulator			
Electrical resistivity	3.3e21	-	3e22	µohm.cm
Dielectric constant (relative permittivity)	2.8	-	3.2	
Dissipation factor (dielectric loss tangent)	0.003	-	0.007	
Dielectric strength (dielectric breakdown)	351	-	551	V/mil

Optical properties

Transparency	Opaque			
Refractive index	1.53	-	1.54	

Processability

Castability	1	-	2	
Moldability	4	-	5	
Machinability	3	-	4	
Weldability	5			

Durability: water and aqueous solutions

Water (fresh)	Excellent
Water (salt)	Excellent
Soils, acidic (peat)	Excellent
Soils, alkaline (clay)	Excellent
Wine	Excellent

Durability: acids

Acetic acid (10%)	Excellent
Acetic acid (glacial)	Unacceptable
Citric acid (10%)	Excellent
Hydrochloric acid (10%)	Excellent
Hydrochloric acid (36%)	Limited use
Hydrofluoric acid (40%)	

	Limited use
Nitric acid (10%)	Excellent
Nitric acid (70%)	Unacceptable
Phosphoric acid (10%)	Excellent
Phosphoric acid (85%)	Excellent
Sulfuric acid (10%)	Excellent
Sulfuric acid (70%)	Excellent

Durability: alkalis

Sodium hydroxide (10%)	Excellent
Sodium hydroxide (60%)	Excellent

Durability: fuels, oils and solvents

Amyl acetate	Unacceptable
Benzene	Unacceptable
Carbon tetrachloride	Unacceptable
Chloroform	Unacceptable
Crude oil	Excellent
Diesel oil	Excellent
Lubricating oil	Excellent
Paraffin oil (kerosene)	Excellent
Petrol (gasoline)	Excellent
Silicone fluids	Excellent
Toluene	Unacceptable
Turpentine	Unacceptable
Vegetable oils (general)	Excellent
White spirit	Excellent

Durability: alcohols, aldehydes, ketones

Acetaldehyde	Unacceptable
Acetone	Unacceptable
Ethyl alcohol (ethanol)	Unacceptable
Ethylene glycol	Excellent
Formaldehyde (40%)	Excellent
Glycerol	Excellent
Methyl alcohol (methanol)	Unacceptable

Durability: halogens and gases

Chlorine gas (dry)	Unacceptable
Fluorine (gas)	Excellent
O2 (oxygen gas)	Unacceptable

Sulfur dioxide (gas)	Unacceptable

Durability: built environments

Industrial atmosphere	Acceptable
Rural atmosphere	Excellent
Marine atmosphere	Excellent
UV radiation (sunlight)	Poor

Durability: flammability

Flammability	Highly flammable

Durability: thermal environments

Tolerance to cryogenic temperatures	Unacceptable
Tolerance up to 150 C (302 F)	Acceptable
Tolerance up to 250 C (482 F)	Unacceptable
Tolerance up to 450 C (842 F)	Unacceptable
Tolerance up to 850 C (1562 F)	Unacceptable
Tolerance above 850 C (1562 F)	Unacceptable

Geo-economic data for principal component

Annual world production, principal component	* 5.51e6	-	5.61e6	ton/yr
Reserves, principal component	* 1.46e8	-	1.48e8	l. ton

Primary material production: energy, CO2 and water

Embodied energy, primary production	* 9.78e3	-	1.08e4	kcal/lb
CO2 footprint, primary production	* 3.64	-	4.03	lb/lb
Water usage	* 20	-	22.2	gal(US)/lb
Eco-indicator 95	400			millipoints/kg
Eco-indicator 99	352			millipoints/kg

Material processing: energy

Polymer extrusion energy	* 635	-	701	kcal/lb
Polymer molding energy	* 2.13e3	-	2.35e3	kcal/lb
Coarse machining energy (per unit wt removed)	* 108	-	120	kcal/lb
Fine machining energy (per unit wt removed)	* 624	-	690	kcal/lb
Grinding energy (per unit wt removed)	* 1.19e3	-	1.32e3	kcal/lb

Material processing: CO2 footprint

Polymer extrusion CO2	* 0.439	-	0.485	lb/lb
Polymer molding CO2	* 1.47	-	1.63	lb/lb
Coarse machining CO2 (per unit wt removed)	* 0.0753	-	0.0832	lb/lb
Fine machining CO2 (per unit wt removed)	* 0.432	-	0.477	lb/lb

Grinding CO2 (per unit wt removed)	*	0.828	-	0.916	lb/lb

Material recycling: energy, CO2 and recycle fraction

Recycle	✓				
Embodied energy, recycling	*	4.77e3	-	5.27e3	kcal/lb
CO2 footprint, recycling	*	3.46	-	3.82	lb/lb
Recycle fraction in current supply		0.5	-	1	%
Downcycle	✓				
Combust for energy recovery	✓				
Heat of combustion (net)	*	4.07e3	-	4.28e3	kcal/lb
Combustion CO2	*	3.06	-	3.22	lb/lb
Landfill	✓				
Biodegrade	✗				
Toxicity rating	Non-toxic				
A renewable resource?	✗				

Environmental notes

The acrylonitrile monomer is nasty stuff, almost as poisonous as cyanide. Once polymerized with styrene it becomes harmless. ABS is FDA compliant, can be recycled, and can be incinerated to recover the energy it contains.

Recycle mark

Supporting information

Design guidelines

ABS has the highest impact resistance of all polymers. It takes color well. Integral metallics are possible (as in GE Plastics' Magix.) ABS is UV resistant for outdoor application if stabilizers are added. It is hygroscopic (may need to be oven dried before thermoforming) and can be damaged by petroleum-based machining oils. ASA (acrylic-styrene-acrylonitrile) has very high gloss; its natural color is off-white but others are available. It has good chemical and temperature resistance and high impact resistance at low temperatures. UL-approved grades are available. SAN (styrene-acrylonitrile) has the good processing attributes of polystyrene but greater strength, stiffness, toughness, and chemical and heat resistance. By adding glass fiber the rigidity can be increased dramatically. It is transparent (over 90% in the visible range but less for UV light) and has good color, depending on the amount of acrylonitrile that is added this can vary from water white to pale yellow, but without a protective coating, sunlight causes yellowing and loss of strength, slowed by UV stabilizers. All three can be extruded, compression molded or formed to sheet that is then vacuum thermo-formed. They can be joined by ultrasonic or hot-plate welding, or bonded with polyester, epoxy, isocyanate or nitrile-phenolic adhesives.

Technical notes

Acrylonitrile butadiene styrene (ABS)

ABS is a terpolymer - one made by copolymerizing 3 monomers: acrylonitrile, butadiene and styrene. The acrylonitrile gives thermal and chemical resistance, rubber-like butadiene gives ductility and strength, the styrene gives a glossy surface, ease of machining and a lower cost. In ASA, the butadiene component (which gives poor UV resistance) is replaced by an acrylic ester. Without the addition of butyl, ABS becomes, SAN - a similar material with lower impact resistance or toughness. It is the stiffest of the thermoplastics and has excellent resistance to acids, alkalis, salts and many solvents.

Typical uses

Safety helmets; camper tops; automotive instrument panels and other interior components; pipe fittings; home-security devices and housings for small appliances; communications equipment; business machines; plumbing hardware; automobile grilles; wheel covers; mirror housings; refrigerator liners; luggage shells; tote trays; mower shrouds; boat hulls; large components for recreational vehicles; weather seals; glass beading; refrigerator breaker strips; conduit; pipe for drain-waste-vent (DWV) systems.

Tradenames

Claradex, Comalloy, Cycogel, Cycolac, Hanalac, Lastilac, Lupos, Lustran ABS, Magnum, Multibase, Novodur, Polyfabs, Polylac, Porene, Ronfalin, Sinkral, Terluran, Toyolac, Tufrex, Ultrastyr

Links

Reference

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Producers