

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 | 1.01e3 | - | 1.21e3 | kg/m ³ |
| Price | * 2.5 | - | 3 | USD/kg |
| Date first used | 1937 | | | |

Mechanical properties

| | | | | |
|--|-------|---|-------|----------------------|
| Young's modulus | 1.1 | - | 2.9 | GPa |
| Shear modulus | 0.319 | - | 1.03 | GPa |
| Bulk modulus | 3.8 | - | 4 | GPa |
| Poisson's ratio | 0.391 | - | 0.422 | |
| Yield strength (elastic limit) | 18.5 | - | 51 | MPa |
| Tensile strength | 27.6 | - | 55.2 | MPa |
| Compressive strength | 31 | - | 86.2 | MPa |
| Elongation | 1.5 | - | 100 | % strain |
| Hardness - Vickers | 5.6 | - | 15.3 | HV |
| Fatigue strength at 10 ⁷ cycles | 11 | - | 22.1 | MPa |
| Fracture toughness | 1.19 | - | 4.29 | MPa.m ^{0.5} |

| | | | |
|---|--------|---|--------|
| Mechanical loss coefficient (tan delta) | 0.0138 | - | 0.0446 |
|---|--------|---|--------|

Thermal properties

| | | | | |
|---------------------------------|----------------|---|--------|------------|
| Glass temperature | 87.9 | - | 128 | °C |
| Maximum service temperature | 61.9 | - | 76.9 | °C |
| Minimum service temperature | -123 | - | -73.2 | °C |
| Thermal conductor or insulator? | Good insulator | | | |
| Thermal conductivity | 0.188 | - | 0.335 | W/m.°C |
| Specific heat capacity | 1.39e3 | - | 1.92e3 | J/kg.°C |
| Thermal expansion coefficient | 84.6 | - | 234 | µstrain/°C |

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) | 13.8 | - | 21.7 | 1000000 V/m |

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 |
| O ₂ (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 | * 5.6e6 | - | 5.7e6 | tonne/yr |
| Reserves, principal component | * 1.48e8 | - | 1.5e8 | tonne |

Primary material production: energy, CO2 and water

| | | | | |
|-------------------------------------|--------|---|------|----------------|
| Embodied energy, primary production | * 90.3 | - | 99.9 | MJ/kg |
| CO2 footprint, primary production | * 3.64 | - | 4.03 | kg/kg |
| Water usage | * 167 | - | 185 | l/kg |
| Eco-indicator 95 | 400 | | | millipoints/kg |
| Eco-indicator 99 | 352 | | | millipoints/kg |

Material processing: energy

| | | | | |
|---|--------|---|------|-------|
| Polymer extrusion energy | * 5.86 | - | 6.47 | MJ/kg |
| Polymer molding energy | * 19.7 | - | 21.7 | MJ/kg |
| Coarse machining energy (per unit wt removed) | * 1 | - | 1.11 | MJ/kg |
| Fine machining energy (per unit wt removed) | * 5.76 | - | 6.37 | MJ/kg |
| Grinding energy (per unit wt removed) | * 11 | - | 12.2 | MJ/kg |

Material processing: CO2 footprint

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

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

Material recycling: energy, CO2 and recycle fraction

| | | | | |
|------------------------------------|-----------|---|------|-------|
| Recycle | ✓ | | | |
| Embodied energy, recycling | * 44 | - | 48.6 | MJ/kg |
| CO2 footprint, recycling | * 3.46 | - | 3.82 | kg/kg |
| Recycle fraction in current supply | 0.5 | - | 1 | % |
| Downcycle | ✓ | | | |
| Combust for energy recovery | ✓ | | | |
| Heat of combustion (net) | * 37.6 | - | 39.5 | MJ/kg |
| Combustion CO2 | * 3.06 | - | 3.22 | kg/kg |
| 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

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, Cycles, Hanalac, Lastilac, Lupos, Lustran ABS, Magnum, Multibase, Novodur, Polyfabs, Polylac, Porene, Ronfalin, Sinkral, Terluran, Toyolac, Tufrex, Ultrastyr

Links

Reference

ProcessUniverse

Producers