Plastics Data File – PB

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1. Introduction

Polybutylene is a flexible linear polyolefin (as are PE and PP). The material is semi-crystalline and has excellent resistance to creep at high temperatures. The material can be readily processed by most conventional means using similar processes to other polyolefins.

PB is used either as a homopolymer of poly(1-butene) or as one of a series of copolymers of poly(1-butene/ethylene). This group of copolymers has quite wide-ranging properties and this information concentrates mainly on the homopolymer.

PB is not a high-volume polymer but the rapid development of the piping usage of PB may indicate some significant expansion in the market.

2. Typical applications

Pipes: Hot and cold water pipes for domestic water services, well piping, heat pump piping.

Building products: Liners for domestic water heaters.

Packaging: Film for food and meat packaging, packaging hot fill containers, fibres for heavy duty sacks.

Mechanical: Tank and chute liners.

Miscellaneous: Hot melt adhesives and sealants, carrier for products to be blended into other polyolefins such as PP.

3. Physical and mechanical properties

PB is has excellent resistance to creep at both room and elevated temperatures and has higher long term temperature resistance than other polyolefins. The material has good toughness properties and has high impact strength as well as excellent tear resistance.

PB undergoes crystallisation after the melt phase and full mechanical properties are only achieved after aging.

Mechanical properties

Property	Approximate Value
Tensile Strength	40 - 80 MN/m^2
Tensile Modulus	2 - 3 GN/m^2
Elongation at Break	50 - 100%
Flexural Strength	50 - 100 MN/m^2
Notched Impact Strength	>20 kJ/m^2
Specific Heat	2.15 - 2.6 kJ/kg˚C
Glass Transition Temperature	N/A
Heat Deflection Temperature	>100˚C
Coefficient of Thermal Expansion	10 - 20 x 10^{-5}/˚C
Long Term Service Temperature	>100˚C
Specific Gravity	0.91 - 0.95

Mould Shrinkage	0.025-0.05 m/m
Water Absorption	<1 % (50% rh)
Transparency	Opaque

4. Thermal, electrical and optical properties

Thermal properties

PB has good high temperature performance and many mechanical properties are retained to high temperatures. This is particularly true of creep resistance.

Fire behaviour

PB pipe grades have achieved a ‘slow -burning’ rating from Underwriters Laboratories (UL94-HB).

Electrical properties

PB has good electrical insulation properties.

Optical properties

Natural PB is milky-opaque but can be easily coloured in a wide variety of colours. PB has a refractive index which varies with the variant and for most types it is in the region of 1.52 to 1.53.

5. Chemical resistance properties

PB is generally resistant to acids, bases, solvents, paraffinic oils but as with most polymers, this resistance decreases with increasing temperature.

PB has good moisture barrier properties and this has led to applications in hot fill food packaging.

A detailed chemical resistance chart for PB is given in Section 11.

Weathering resistance:

Stress cracking resistance:

PB has excellent resistance to environmental stress cracking.

6. Advantages and limitations

Advantages	Limitations
1. Versatile resin capable of being adapted to a wide variety of processes and applications.	1.Low demand means price is higher than conventional polyolefins.
2. Excellent creep strength retention at high temperatures.	2.Crystallisation behaviour requires careful treatment immediately after processing.
3. Excellent retention of mechanical properties at high temperatures.	3. High die-swell can lead to concerns with extrusion calibration and accuracy.
4. Good moisture barrier properties.	4. Crystallisation behaviour changes product dimensions after production.
5. Excellent electrical insulation properties.	

6. Excellent chemical resistance, particularly to environmental stress cracking.	

7. Processing

PB can be processed on the same equipment used for processing PE-LD but after processing it crystallizes to various forms. The first crystallization is to a tetragonal crystal form and after 5-7 days (depending on the grade) there is a further transformation to a twined hexagonal crystal form. After crystallization the degree of crystallinity is in the region of 48 to 55% for the homopolymer grades. The crystallization process changes the tensile strength, hardness and density but does not generally give processing problems. PB is similar to PP where the crystallization process can change the product dimensions and some care needs to be taken in tooling design to ensure that product dimensions are suitable for fabrication after crystallization.

Injection moulding

Injection moulding is by conventional injection moulding machines using settings as for PE-LD.

Extrusion

Extrusion is by conventional single screw machines using vacuum calibrators for size control. Processing temperatures are in the range 160 to 240˚C. PB die swell and cooling shrinkage are larger than for PE materials. The initial material after cooling from the melt needs to be handled with care until the strength develops through crystallisation. This requires the use of sensitive haul-off equipment with minimal opportunities for draw-down in processing.

Process selector

Processing Method	Applicable
Injection Moulding	Yes
Extrusion	Yes
Extrusion Blow Moulding	Yes
Injection Blow Moulding	Yes
Rotational Moulding	Yes
Thermoforming	Yes
Casting	Yes
Bending and joining	Yes

8. Finishing

Machining

PB can be easily machined and the use of coolants allows high cutting speeds whilst still producing a good surface finish. Tools should be sharp and have good clearance and cutting angle.

Surface treatment

PB is a polyolefin similar to PE and PP and the low surface energy makes surface treatments such as printing or painting difficult.

Welding

All processes suitable for thermoplastics can be used, e.g., ultrasonic, friction, hotplate, high frequency and heat impulse welding. Pipe applications use thermal fusion to join pipe sections and joints and packaging applications use films that are easily heat sealable.

Bonding

PB can be difficult to bond without appropriate surface pre-treatment. Treatment for bonding is as per PE and PP, i.e., corona or flame pre-treatment.

9. Health and safety

PB does not constitute a health hazard and can be used in domestic hot and cold water supply and in food contact applications. Care must be taken in the choice of additives used for food contact applications.

10. Other Information

Identification

PB is recognisable as a polyolefin from the 'greasy' feel and can be differentiated form other polyolefins be the improved strength and stiffness.

11. Detailed chemical resistance

Important Note:

Whilst we try to ensure that this table is as accurate as possible, we cannot guarantee that the data contained in the tables is accurate for all blends and grades. In all cases the supplier of the material should be contacted to determine the exact chemical resistance of the material.

R = Resistant, LR = Limited Resistance, NR = Not Recommended, ND = No Data

Chemical	Resistance		
	20°C	60°C	100°C
Acetaldehyde	NR	NR	ND
Acetic acid (10%)	R	R	ND
Acetic acid (glac./anh.)	R	NR	ND
Acetic anhydride	NR	NR	ND
Aceto-acetic ester	ND	ND	ND
Acetone	R	R	ND
Other ketones	NR	ND	ND
Acetonitrile	ND	ND	ND
Acetylene	R	NR	ND
Acetyl salicylic acid	ND	ND	ND
Acid fumes	ND	ND	ND
Alcohols	R	R	ND
Aliphatic esters	NR	NR	ND
Alkyl chlorides	ND	ND	ND
Alum	R	NR	ND
Aluminium chloride	R	R	ND
Aluminium sulphate	R	NR	ND
Ammonia, anhydrous	R	R	ND
Ammonia, aqueous	R	R	ND
Ammonium chloride	R	R	ND
Amyl acetate	R	ND	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Aniline	R	R	ND
Antimony trichloride	R	R	ND
Aqua regia	NR	NR	ND
Aromatic solvents	NR	NR	ND
Ascorbic acid	ND	ND	ND
Beer	R	R	ND
Benzaldehyde	ND	ND	ND
Benzene	NR	NR	ND
Benzoic acid	R	R	ND
Benzoyl peroxide	ND	ND	ND
Boric acid	R	R	ND
Brines, saturated	R	R	ND
Bromide (K) solution	R	ND	ND
Bromine	NR	NR	ND
Bromine liquid, tech.	NR	NR	ND
Bromine water, saturated aqueous	R	NR	ND
Butyl acetate	ND	ND	ND
Calcium chloride	R	R	ND
Carbon disulphide	ND	ND	ND
Carbonic acid	R	R	ND
Carbon tetrachloride	NR	NR	ND
Caustic soda & potash	R	R	ND
Cellulose paint	ND	ND	ND
Chlorates of Na, K, Ba	R	R	ND
Chlorine, dry	NR	NR	ND
Chlorine, wet	NR	NR	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Chlorides of Na, K, Ba	R	R	ND
Chloroacetic acid	NR	NR	ND
Chlorobenzene	NR	NR	ND
Chloroform	R	NR	ND
Chlorosulphonic acid	ND	NR	ND
Chromic acid (80%)	R	R	ND
Citric acid	R	R	ND
Copper salts (most)	R	R	ND
Cresylic acids (50%)	NR	NR	ND
Cyclohexane	ND	ND	ND
Detergents, synthetic	ND	ND	ND
Emulsifiers, concentrated	ND	ND	ND
Esters	ND	ND	ND
Ether	NR	NR	ND
Fatty acids (>C_6)	R	R	ND
Ferric chloride	R	R	ND
Ferrous sulphate	R	R	ND
Fluorinated refrigerants	R	R	ND
Fluorine, dry	R	NR	ND
Fluorine, wet	R	NR	ND
Fluorosilic acid	R	R	ND
Formaldehyde (40%)	R	R	ND
Formic acid	R	R	ND
Fruit juices	R	R	ND
Gelatine	R	R	ND
Glycerine	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Glycols	R	R	ND
Glycol, ethylene	R	R	ND
Glycolic acid	ND	ND	ND
Hexamethylene diamine	ND	ND	ND
Hexamine	ND	ND	ND
Hydrazine	ND	ND	ND
Hydrobromic acid (50%)	R	R	ND
Hydrochloric acid (10%)	R	R	ND
Hydrochloric acid (conc.)	R	R	ND
Hydrocyanic acid	R	R	ND
Hydrofluoric acid (40%)	R	R	ND
Hydrofluoric acid (75%)	R	R	ND
Hydrogen peroxide (30%)	R	R	ND
Hydrogen peroxide (30 - 90%)	NR	NR	ND
Hydrogen sulphide	R	R	ND
Hypochlorites	R	R	ND
Hypochlorites (Na 12-14%)	R	R	ND
Iso-butyl-acetate	ND	ND	ND
Lactic acid (90%)	R	R	ND
Lead acetate	R	R	ND
Lead perchlorate	ND	ND	ND
Lime (CaO)	R	R	ND
Maleic acid	R	R	ND
Manganate, potassium (K)	R	R	ND
Meat juices	ND	ND	ND
Mercuric chloride	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Mercury	R	R	ND
Methanol	R	R	ND
Methylene chloride	ND	ND	ND
Milk products	R	R	ND
Moist air	R	R	ND
Molasses	R	R	ND
Monoethanolamine	ND	ND	ND
Naptha	R	NR	ND
Napthalene	R	NR	ND
Nickel salts	R	R	ND
Nitrates of Na, K and NH_3	R	R	ND
Nitric acid (<25%)	NR	NR	ND
Nitric acid (50%)	NR	NR	ND
Nitric acid (90%)	NR	NR	ND
Nitric acid (fuming)	NR	NR	ND
Nitrite (Na)	ND	ND	ND
Nitrobenzene	ND	ND	ND
Oils, diesel	R	R	ND
Oils, essential	R	R	ND
Oils, lubricating + aromatic additives	ND	ND	ND
Oils, mineral	R	NR	ND
Oils, vegetable and animal	R	R	ND
Oxalic acid	R	R	ND
Ozone	ND	ND	ND
Paraffin wax	R	R	ND
Perchloric acid	R	NR	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Petroleum spirits	ND	ND	ND
Phenol	R	R	ND
Phosphoric acid (20%)	R	R	ND
Phosphoric acid (50%)	R	R	ND
Phosphoric acid (95%)	ND	ND	ND
Phosphorous chlorides	ND	ND	ND
Phosphorous pentoxide	ND	ND	ND
Phthalic acid	ND	ND	ND
Picric acid	R	R	ND
Pyridine	ND	ND	ND
Salicyl aldehyde	ND	ND	ND
Sea water	R	R	ND
Silicic acid	R	R	ND
Silicone fluids	ND	ND	ND
Silver nitrate	R	NR	ND
Sodium carbonate	R	R	ND
Sodium peroxide	ND	ND	ND
Sodium silicate	R	R	ND
Sodium sulphide	R	R	ND
Stannic chloride	R	R	ND
Starch	ND	ND	ND
Sugar, syrups & jams	R	R	ND
Sulphamic acid	ND	ND	ND
Sulphates (Na, K, Mg, Ca)	R	R	ND
Sulphites	R	R	ND
Sulphonic acids	R	R	ND

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Chemical	Resistance		
	20°C	60°C	100°C
Sulphur	R	R	ND
Sulphur dioxide, dry	R	R	ND
Sulphur dioxide, wet	R	NR	ND
Sulphur dioxide (96%)	R	R	ND
Sulphur trioxide	R	NR	ND
Sulphuric acid (<50%)	R	NR	ND
Sulphuric acid (70%)	R	NR	ND
Sulphuric acid (95%)	R	R	ND
Sulphuric acid, fuming	NR	NR	ND
Sulphur chlorides	ND	ND	ND
Tallow	R	R	ND
Tannic acid (10%)	R	R	ND
Tartaric acid	R	R	ND
Trichlorethylene	NR	NR	ND
Urea (30%)	R	R	ND
Vinegar	R	R	ND
Water, distilled.	R	R	ND
Water, soft	R	R	ND
Water, hard	R	R	ND
Wetting agents (<5%)	ND	ND	ND
Yeast	ND	ND	ND
Zinc chloride	R	R	ND