

UP unsaturated polyester

PARAMETER	UNIT	VALUE	REFERENCES
GENERAL			
Common name	-	unsaturated polyester	
CAS name	-	1,3-benzenedicarboxylic acid, polymer with 1,4-cyclohexanedi-methanol, 2,2-dimethyl-1,3-propanediol and 2,5-furandione	
Acronym	-	UP	
CAS number	-	92230-55-2; 654641-87-9	
HISTORY			
Person to discover	-	Carleton Ellis	
Date	-	1936	
Details	-	discovered that product of reaction of glycol and maleic anhy-dride can be cured with peroxide	
SYNTHESIS			
Monomer(s) structure	-	neopentyl glycol; isophthalic acid; maleic anhydride; 1,4-cyclohexanedimethanol	
Monomer(s) CAS number(s)	-	126-30-7; 121-91-5; 108-31-6; 105-08-8	
Monomer(s) molecular weight(s)	dalton, g/mol, amu	104.15; 166.13; 98.06; 144.24	
COMMERCIAL POLYMERS			
Some manufacturers	-	Reichhold	
Trade names	-	Polylite	
PHYSICAL PROPERTIES			
Density at 20°C	g cm ⁻³	1.1-1.12	
Thermal expansion coefficient, 23-80°C	10 ⁻⁴ °C ⁻¹	0.31	
Thermal conductivity, melt	W m ⁻¹ K ⁻¹	0.17	
Glass transition temperature	°C	-61 (before cure); 94-125 (after cure)	Wacker, M; Ehrenstein, G W, Antec, 836-41, 2001.
Maximum service temperature	°C	170	
Contact angle of water, 20°C	degree	62-66	Li, G; Wei, X; Wang, W; He, T; Li, X, Appl. Surf. Sci., 257, 290-95, 2010.
Surface free energy	mJ m ⁻²	47	Jia, Z; Li, Z; Zhao, Mater. Chem. Phys., 121, 193-97, 2010.
MECHANICAL & RHEOLOGICAL PROPERTIES			
Tensile strength	MPa	22-85	
Tensile modulus	MPa	3,200-3,900	
Elongation	%	1.2-5.0	
Flexural strength	MPa	67-113	
Flexural modulus	MPa	3,500-4,600	
Compressive strength	MPa	104-131	
Young's modulus	MPa	1,970	Jasso-Gastinel, C F; Vivero-Marin, J M; Manero-Brito, O, Antec, 1615-19, 2005.

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Water absorption, equilibrium in water at 23°C	%	0.2	
CHEMICAL RESISTANCE			
Acid dilute/concentrated	-	good	
Alcohols	-	good	
Alkalis	-	good (dilute)	
Aliphatic hydrocarbons	-	poor	
Aromatic hydrocarbons	-	poor	
Greases & oils	-	poor	
Halogenated hydrocarbons	-	poor	
FLAMMABILITY			
Heat release	kW m ⁻²	202-720	Tibiletti, L; Longuet, C; Ferry, L; Coutelen, P; Mas, A; Robin, J-J; Lopez-Cuesta, J-M, Polym. Deg. Stab., 96, 67-75, 2011; Pereira, C M C; Herrero, M; Labajos, F M; Marques, A T; Rives, V, Polym. Deg. Stab., 94, 939-46, 2009.
Char at 500°C	%	1.5-4	Tibiletti, L; Longuet, C; Ferry, L; Coutelen, P; Mas, A; Robin, J-J; Lopez-Cuesta, J-M, Polym. Deg. Stab., 96, 67-75, 2011; Pereira, C M C; Herrero, M; Labajos, F M; Marques, A T; Rives, V, Polym. Deg. Stab., 94, 939-46, 2009.
Volatile products of combustion	-	CO, CO ₂ , styrene, phthalic anhydride	
PROCESSING			
Typical processing methods	-	bulk molding, casting, compression molding, encapsulation, injection molding, printed circuit board, pultrusion, resin transfer molding, sheet molding	
Additives used in final products	-	Fillers: aluminum hydroxide, antimony trioxide, calcium carbonate, carbon black, chopped glass fiber, crashed marble, flyash, glass fiber, hollow glass spheres, kaolin, marble, montmorillonite, nano-TiO ₂ , polymeric bubbles, quartz, saw dust, silica, talc, wood flour	
Applications	-	automotive, boats, buttons, chairs, coatings, construction, ducts, electrical components, gel coats, marine laminates, pipes, sheet molding compounds, shower stalls, synthetic marble, tanks, wind turbine blades	
Outstanding properties	-	balance of toughness and other mechanical properties, renewable content (some), simple processing methods	
BLENDS			
Suitable polymers	-	EP, PCL, PEO, PLA, PMMA, PU	
ANALYSIS			
FTIR (wavenumber-assignment)	cm ⁻¹ /-	C-H – 2918, 1453; C=O – 1721; C-O-C – 1259, 1124, 1071	Zhao, Q; Jia, Z; Li, X; Ye, Z, Mater. Design, 31, 4457-60, 2010.
Raman (wavenumber-assignment)	cm ⁻¹ /-	vinyl – 1632, 1661; C=CH ₂ – 1413; C=O – 1732	Cruz, J C; Osswald, T A; Kemper, M, Antec, 2828-32, 2006.
NMR (chemical shifts)	ppm	H NMR: CH ₂ -O – 3.8; CH ₂ -OH – 3.5; CH ₂ – 4.3; aromatic proton – 7.3-7.8	Alemdar, N; Erciyas, A T; Bicak, N, Polymer, 51, 5044-50, 2010.