

The Periodic Table of the elements by Mendeleev was a historic achievement in chemistry and enabled chemists to see the relationship between structure and properties of the basic elements.

Polymers also have a strong relationship between structure and properties and this 'Periodic Table of Polymers' is a first attempt to provide a simple codification of the basic polymer types and structures.

The diversity of polymer types makes it impossible to include all of the variations in one simple table and this table only includes the most common polymers.

Tangram Technology Periodic Table of Thermoplastics

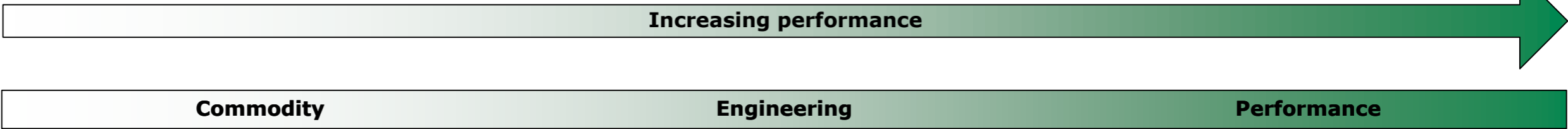


TANGRAM
TECHNOLOGY

Consulting
Engineers

KEY
TS = Tensile Strength at Yield @ 23°C
EAB = Elongation at break
TM = Tensile Modulus @ 23°C
LTST = Long Term Service Temperature
HDT = Heat Deflection Temperature @ 1.8 MPa
Cost = Relative Cost

All properties are for the natural injection moulding grade resin only and do not include polymers with reinforcements or other functional fillers.



Amorphous

Random molecular orientation in both molten and solid phases.

General Characteristics
 Soften gradually.
 Generally transparent.
 Lower Tensile Strength and Tensile Modulus.
 Lower Density.
 Low Creep Resistance.
 High Dimensional Stability.
 Low fatigue resistance.
 Easy to bond using adhesives and solvents (high surface energy).

Semicrystalline

Random molecular orientation in molten phase, densely packed crystallites in solid phase.

General Characteristics
 Sharp melting point.
 Generally translucent or opaque.
 Higher Tensile Strength and Tensile Modulus.
 Higher Density.
 High Creep Resistance.
 Low Dimensional Stability.
 High fatigue resistance.
 Difficult to bond using adhesives and solvents (low surface energy).

Commodity	Engineering	Performance
<p>PS-HI High Impact Polystyrene TS: 19 - 33 MPa EAB: 40 - 50% TM: 1.8 GPa LTST: 55 - 60°C HDT = 60 - 80°C Cost: ◆</p> <p>PS-GP General Purpose Polystyrene TS: 40 - 50 MPa EAB: < 3% TM: 3.2 - 3.5 GPa LTST: 70 - 85°C HDT: 72 - 82°C Cost: ◆</p> <p>ABS Acrylonitrile Butadiene Styrene (Copolymer) TS: 40 - 60 MPa EAB: 3 - 20% TM: 2.0 - 2.6 GPa LTST: 80 - 95°C HDT = 90 - 100°C Cost: ◆</p> <p>SAN Styrene Acrylonitrile (Copolymer) TS: 47 - 72 MPa EAB: 2.0 - 10% TM: 2.3 - 4.1 GPa LTST: 55 - 60°C HDT = 84 - 95°C Cost: ◆◆</p> <p>PVC-P Plasticised Polyvinylchloride TS: 6 - 20 MPa EAB: 50 - 460% TM: 0.002 - 0.020 GPa LTST: 50°C HDT: 20 °C Cost: ◆</p> <p>SBS Styrene-Butadiene-Styrene (Copolymer) TS: 35 - 40 MPa EAB: 40% TM: 1.8 - 2.0 GPa LTST: 60°C HDT = 67°C Cost: ◆◆</p> <p>SMA Styrene-Maleic Anhydride (Copolymer) TS: 40 - 52 MPa EAB: 1.8% TM: 2.0 GPa LTST: 100°C HDT = 105°C Cost: ◆◆</p> <p>ASA Acrylonitrile Styrene Acrylate (Copolymer) TS: 38 - 70 MPa EAB: 15 - 45% TM: 2.3 - 2.9 GPa LTST: 82 - 120°C HDT = 82 - 120°C Cost: ◆◆</p> <p>SB Styrene-Butadiene (Copolymer) TS: 26 - 30 MPa EAB: 20 - 80% TM: 1.8 GPa LTST: 65 - 77°C HDT = 70 - 77°C Cost: ◆◆</p> <p>PVC-U Unplasticised Polyvinylchloride TS: 45 - 55 MPa EAB: 25 - 60% TM: 2.50 - 3.02 GPa LTST: 60 - 70 °C HDT: 64 - 70°C Cost: ◆</p> <p>CA Cellulose Acetate TS: 30 - 55 MPa EAB: 5 - 55% TM: 1.6 GPa LTST: 45 - 70°C HDT: 48 - 65°C Cost: ◆◆</p> <p>CAB Cellulose Acetate Butyrate TS: 26 - 50 MPa EAB: 8 - 80% TM: 0.7 - 1.5 GPa LTST: 75 - 100°C HDT: 45 - 75°C Cost: ◆◆</p> <p>CAP Cellulose Acetate Propionate TS: 26 - 47 MPa EAB: 30 - 100% TM: 0.7 - 1.5 GPa LTST: 75 - 100°C HDT: 45 - 75°C Cost: ◆◆</p> <p>CP Cellulose Propionate TS: 30 - 45 MPa EAB: 45 - 65% TM: 0.8 - 1.5 GPa LTST: 68 - 100°C HDT: 61 - 73°C Cost: ◆◆</p> <p>PET-G Glycolised Polyethylene terephthalate TS: 55 MPa EAB: 300% TM: GPa LTST: 60°C HDT: 70°C Cost: ◆◆◆</p> <p>PVC-UX Crosslinked Unplasticised PVC TS: 28 - 40 MPa EAB: 150% TM: 2.5 - 3.0 GPa LTST: 70 - 95°C HDT: 120°C Cost: ◆◆◆</p> <p>PVC-C Chlorinated Polyvinylchloride TS: 53 - 58 MPa EAB: 25 - 45% TM: 2.6 - 2.7 GPa LTST: 90 - 110°C HDT: 105°C Cost: ◆◆◆</p> <p>PA 6/3/T Amorphous polyamide TS: 60 - 100 MPa EAB: > 50% TM: 1.4 - 2.3 GPa LTST: 125°C HDT = 102 - 123°C Cost: ◆◆◆</p> <p>PAR Polyarylate TS: 68 - 71 MPa EAB: 50 - 100% TM: 2.0 - 2.2 GPa LTST: 130 - 150°C HDT = 165 - 175°C Cost: ◆◆◆</p> <p>PSU Polysulphone TS: 70 - 76 MPa EAB: 10 - 80% TM: 1.5 - 2.7 GPa LTST: 150 - 180°C HDT = 160 - 174°C Cost: ◆◆◆</p> <p>PES Polyethersulphone TS: 70 - 95 MPa EAB: 40 - 80% TM: 2.4 - 2.6 GPa LTST: 180 - 220 °C HDT = 200 - 210°C Cost: ◆◆◆</p> <p>PPSU Polyethersulphone (Block copolymer) TS: 83 MPa EAB: 40 - 80% TM: 2.65 GPa LTST: 180°C HDT = 204°C Cost: ◆◆◆◆</p> <p>PEI Polyetherimide TS: 100 - 105 MPa EAB: 40 - 60% TM: 2.7 - 4.5 GPa LTST: 170 - 215°C HDT = 275 - 280°C Cost: ◆◆◆◆</p> <p>PAI Polyamideimide TS: 90 - 150 MPa EAB: 2.6 - 12% TM: 2.5 - 8.8 GPa LTST: 220 - 280°C HDT = 275 - 280°C Cost: ◆◆◆◆</p> <p>PI Polyimide TS: 72 - 90 MPa EAB: 6 - 8% TM: 1.3 - 4 GPa LTST: 260 - 300°C HDT = 280 - 360°C Cost: ◆◆◆◆</p> <p>PBI Polybenzimidazole TS: 120 - 160 MPa EAB: 2.6 - 3.0% TM: 4.0 - 6.5 GPa LTST: 260 - 400°C HDT = 220°C Cost: ◆◆◆◆</p>	<p>PMMA Polymethylmethacrylate (Acrylic) TS: 56 - 70 MPa EAB: 3.0 - 3.5% TM: 3.0 GPa LTST: 90°C HDT = 85 - 95°C Cost: ◆◆◆</p> <p>PPO (Modified) Polyphenylene Oxide TS: 40 - 90 MPa EAB: 10 - 60% TM: 2.0 - 5.4 GPa LTST: 80 - 260°C HDT = 129°C Cost: ◆◆</p> <p>PC Polycarbonate TS: 55 - 75 MPa EAB: 110 - 120% TM: 1.6 - 2.4 GPa LTST: 95 - 154°C HDT = 135 - 140°C Cost: ◆◆</p> <p>PET-G Glycolised Polyethylene terephthalate TS: 55 MPa EAB: 300% TM: GPa LTST: 60°C HDT: 70°C Cost: ◆◆◆</p> <p>PVC-UX Crosslinked Unplasticised PVC TS: 28 - 40 MPa EAB: 150% TM: 2.5 - 3.0 GPa LTST: 70 - 95°C HDT: 120°C Cost: ◆◆◆</p> <p>PVC-C Chlorinated Polyvinylchloride TS: 53 - 58 MPa EAB: 25 - 45% TM: 2.6 - 2.7 GPa LTST: 90 - 110°C HDT: 105°C Cost: ◆◆◆</p> <p>PA 6/3/T Amorphous polyamide TS: 60 - 100 MPa EAB: > 50% TM: 1.4 - 2.3 GPa LTST: 125°C HDT = 102 - 123°C Cost: ◆◆◆</p> <p>PPA Polyphthalamide (Amorphous) TS: 85 MPa EAB: 2.6% TM: 3.7 GPa LTST: 140°C HDT = 138°C Cost: ◆◆◆◆</p> <p>PARA Polyaryl amide TS: 60 MPa EAB: 100% TM: 24 GPa LTST: 150°C HDT = 150°C Cost: ◆◆◆◆</p>	<p>PPA Polyphthalamide (Amorphous) TS: 85 MPa EAB: 2.6% TM: 3.7 GPa LTST: 140°C HDT = 138°C Cost: ◆◆◆◆</p> <p>PARA Polyaryl amide TS: 60 MPa EAB: 100% TM: 24 GPa LTST: 150°C HDT = 150°C Cost: ◆◆◆◆</p> <p>PA 12 Polyamide 12 (Nylon 12) TS: 50 MPa EAB: 200% TM: 1.2 - 1.6 GPa LTST: 70 - 80°C HDT = 55°C Cost: ◆◆◆</p> <p>PPA Polyphthalamide TS: 85 MPa EAB: 2.6% TM: 3.7 GPa LTST: 140°C HDT = 138°C Cost: ◆◆◆</p> <p>PA 4/6 Polyamide 4/6 (Nylon 4/6) TS: 100 MPa EAB: 40% TM: 3.3 GPa LTST: 130°C HDT = 190°C Cost: ◆◆◆</p> <p>PEK Polyetherketone TS: 52 - 214 MPa EAB: 1.3 - 330% TM: 1.5 - 18.6 GPa LTST: 93 - 334°C HDT = 93 - 334°C Cost: ◆◆◆◆</p> <p>PEEK Polyetheretherketone TS: 90 - 110 MPa EAB: 2.5 - 100% TM: 3.1 - 8.3 GPa LTST: 154 - 315°C HDT = 154 - 295°C Cost: ◆◆◆◆</p> <p>LCP Liquid Crystal Polymer (Aromatic copolyester) TS: 55 - 165 Mpa EAB: 175% TM: 2 - 20 GPa LTST: 260°C HDT: 200°C Cost: ◆◆◆◆</p> <p>PFA Perfluoroalkoxy TS: 15 - 30 MPa EAB: 300% TM: 0.60 GPa LTST: 140 - 166°C HDT = 48 - 60°C Cost: ◆◆◆◆</p> <p>ECTFE Ethylene-chlorotrifluoroethylene TS: 42 - 48 MPa EAB: 175% TM: 1.4 GPa LTST: 140 - 166°C HDT = 63 - 67°C Cost: ◆◆◆◆</p> <p>PCTFE Polychlorotrifluoroethylene TS: 30 - 40 MPa EAB: 175% TM: 1.3 GPa LTST: 140 - 150°C HDT = 67 - 75°C Cost: ◆◆◆◆</p> <p>PTFE Polytetrafluoroethylene TS: 17 - 21 MPa EAB: 140 - 400% TM: 0.35 - 0.75 GPa LTST: 250 - 260°C HDT = 50 - 60°C Cost: ◆◆◆</p> <p>EVOH Ethylene-vinyl Alcohol TS: 37 - 205 MPa EAB: 100 - 330% TM: 1.9 - 3.5 GPa LTST: 80 - 100°C HDT = 70 - 90°C Cost: ◆◆◆◆</p> <p>PPS Polyphenylene Sulphide TS: 69 - 124 MPa EAB: 1 - 5% TM: 2.2 - 5.5 GPa LTST: 190 - 260°C HDT = 174°C Cost: ◆◆◆</p> <p>FEP Fluorinated ethylene-propylene TS: 15 - 21 MPa EAB: 240 - 350% TM: 0.35 - 0.50 GPa LTST: 160 - 204°C HDT = 48 - 60°C Cost: ◆◆◆◆</p> <p>ETFE Ethylene-tetrafluoroethylene TS: 35 - 45 MPa EAB: 200 - 500% TM: 1.00 GPa LTST: 150°C HDT = 90°C Cost: ◆◆◆◆</p> <p>PVDF Polyvinylidene fluoride TS: 30 - 55 MPa EAB: 50% TM: 1.3 GPa LTST: 150°C HDT = 75 - 82°C Cost: ◆◆◆</p> <p>PE-LD Low Density Polyethylene TS: 7.0 - 25 MPa EAB: 50 - 400% TM: 0.15 - 0.35 GPa LTST: 40 - 70°C HDT = 35°C Cost: ◆</p> <p>PE-LLD Linear Low Density Polyethylene TS: 8.0 - 20 MPa EAB: 50 - 500% TM: 0.2 - 1.0 GPa LTST: 44 - 50°C HDT = 37 - 44°C Cost: ◆</p> <p>PE-MD Medium Density Polyethylene TS: 14 - 25 MPa EAB: 50 - 300% TM: 0.25 - 0.70 GPa LTST: 38 - 70°C HDT = 38 - 43°C Cost: ◆◆</p> <p>PMP Polymethyl pentene TS: 25 - 28 MPa EAB: 15 - 30% TM: 1.0 - 2.2 GPa LTST: 55 - 60°C HDT = 40 - 50°C Cost: ◆◆◆</p> <p>EVA Ethylene-vinyl Acetate (12% VA) TS: 10 - 19 MPa EAB: 50 - 750% TM: 0.04 - 0.14 GPa LTST: 50°C HDT = 20 - 23°C Cost: ◆◆◆</p> <p>PE-X Crosslinked Polyethylene TS: 18 MPa EAB: 350% TM: 0.6 GPa LTST: 90°C HDT = 60°C Cost: ◆◆◆</p> <p>PB Polybutene-1 (Polybutylene) TS: 12 - 17 MPa EAB: 300 - 380% TM: 0.21 - 0.26 GPa LTST: 110°C HDT = 54 - 60°C Cost: ◆◆◆</p> <p>PE-UHMW Ultra-high Molecular Weight Polyethylene TS: 35 MPa EAB: 500% TM: 0.5 GPa LTST: 55°C HDT = 42°C Cost: ◆◆◆</p> <p>PA 11 Polyamide 11 (Nylon 11) TS: 20 - 60 MPa EAB: 30 - 400% TM: 1.0 - 2.0 GPa LTST: 74 - 147°C HDT = 38 - 55°C Cost: ◆◆◆</p> <p>PE-Chlorinated Chlorinated Polyethylene TS: 12.5 MPa EAB: 700% TM: 0.002 GPa LTST: 60°C HDT = 25°C Cost: ◆◆◆◆</p> <p>PE-VLD Very Low Density Polyethylene TS: 34 - 400 MPa EAB: 400 - 700% TM: 0.10 - 0.20 GPa LTST: 60°C HDT = 75 - 95°C Cost: ◆◆◆</p> <p>EMA Ethylene-methyl Acrylate TS: 9 - 12 MPa EAB: 750 - 800% TM: 0.03 GPa LTST: 55°C HDT = 59°C Cost: ◆◆◆</p> <p>PP Polypropylene (Homopolymer) TS: 33 MPa EAB: 150% TM: 1.5 GPa LTST: 100°C HDT = 65°C Cost: ◆</p> <p>PP Polypropylene (Copolymer) TS: 25 MPa EAB: 300% TM: 1.2 GPa LTST: 90°C HDT = 60°C Cost: ◆</p> <p>PE-HD High Density Polyethylene TS: 10 - 50 MPa EAB: 400 - 800% TM: 0.18 - 1.6 GPa LTST: 55°C HDT = 46°C Cost: ◆</p>

KEY TO MAJOR POLYMER FAMILIES: Styrenes Polyolefins Vinyls Cellulosics Polyesters Polyamides Acrylics Polycarbonates Acetals Polysulphones Imides Fluoropolymers

Other skills				Markets				Commercial				Sustainability				Processing						Materials and design																
Project management	Recruitment	Training	Trouble shooting	Packaging	Medical	General	Electrical/Electronic	Automotive	Mergers and acquisitions	Market research	Legislative and regulatory	Export and Import	Expert witness	Waste management	Sustainability management	Recycling and recovery	Plastics degradation	Energy management	Eco-product design	Bioplastics	Tooling	Thermoforming	Quality	Injection moulding	Lean/Health & safety	Extrusion	Equipment	Compounding	Blow moulding	Testing and analysis	Thermoplastics	Product design	Polyurethanes	Materials selection	Additives			
						●				●	●	●																			●						Graham Chetwood	
				●											●	●	●				●								●									Terence Cooper
		●		●								●														●												Peter Cox
		●			●																	●			●										●			Peter Cracknell
				●		●																		●	●	●												Gerhard Crossman
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