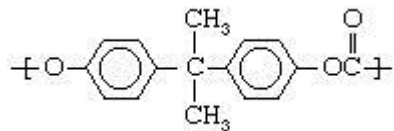


Lecture 4: Hetero chain inorganic polymers.

The other category of plastics is made up of heterochain polymers. These compounds contain atoms such as oxygen, nitrogen, or sulfur in their backbone chains, in addition to carbon. Most of the engineering plastics listed above are composed of heterochain polymers. An example would be polycarbonate, whose molecules contain two aromatic (benzene) rings:



The distinction between carbon-chain and heterochain polymers is reflected in the table, in which selected properties and applications of the most important carbon-chain and heterochain plastics are shown and from which links are provided directly to entries that describe these materials in greater detail. It is important to note that for each polymer type listed in the table there can be many subtypes, since any of a dozen industrial producers of any polymer can offer 20 or 30 different variations for use in specific applications. For this reason the properties indicated in the table must be taken as approximations.

Properties and applications of commercially important plastics

polymer family and type	density (g/cm ³)	degree of crystallinity	glass transition temperature (°C)	crystal melting temperature (°C)	deflection temperature at 1.8 MPa (°C)
Thermoplastics					
Carbon-chain					
high-density polyethylene (HDPE)	0.95–0.97	high	–120	137	—
low-density polyethylene (LDPE)	0.92–0.93	moderate	–120	110	—
polypropylene (PP)	0.90–0.91	high	–20	176	—

polystyrene (PS)	1.0–1.1	nil	100	—	—
acrylonitrile-butadiene-styrene (ABS)	1.0–1.1	nil	90–120	—	—
polyvinyl chloride, unplasticized (PVC)	1.3–1.6	nil	85	—	—
polymethyl methacrylate (PMMA)	1.2	nil	115	—	—
polytetrafluoroethylene (PTFE)	2.1–2.2	moderate-high	126	327	—
Heterochain					
polyethylene terephthalate (PET)	1.3–1.4	moderate	69	265	—
polycarbonate (PC)	1.2	low	145	230	—
polyacetal	1.4	moderate	–50	180	—
polyetheretherketone (PEEK)	1.3	nil	185	—	—
polyphenylene sulfide (PPS)	1.35	moderate	88	288	—
cellulose diacetate	1.3	low	120	230	—
polycaprolactam (nylon 6)	1.1–1.2	moderate	50	210–220	—
Thermosets*					
Heterochain					
polyester (unsaturated)	1.3–2.3	nil	—	—	200
epoxies	1.1–1.4	nil	—	—	110–250
phenol formaldehyde	1.7–2.0	nil	—	—	175–300
urea and melamine formaldehyde	1.5–2.0	nil	—	—	190–200

polyurethane	1.05	low	—	—	90–100
polymer family and type	tensile strength (MPa)	elongation at break (%)	flexural modulus (GPa)	typical products and applications	
Thermoplastics					
Carbon-chain					
high-density polyethylene (HDPE)	20–30	10–1,000	1–1.5	milk bottles, wire and cable insulation, toys	
low-density polyethylene (LDPE)	8–30	100–650	0.25–0.35	packaging film, grocery bags, agricultural mulch	
polypropylene (PP)	30–40	100–600	1.2–1.7	bottles, food containers, toys	
polystyrene (PS)	35–50	1–2	2.6–3.4	eating utensils, foamed food containers	
acrylonitrile-butadiene-styrene (ABS)	15–55	30–100	0.9–3.0	appliance housings, helmets, pipe fittings	
polyvinyl chloride, unplasticized (PVC)	40–50	2–80	2.1–3.4	pipe, conduit, home siding, window frames	
polymethyl methacrylate (PMMA)	50–75	2–10	2.2–3.2	impact-resistant windows, skylights, canopies	
polytetrafluoroethylene (PTFE)	20–35	200–400	0.5	self-lubricated bearings, nonstick cookware	
Heterochain					
polyethylene terephthalate (PET)	50–75	50–300	2.4–3.1	transparent bottles, recording tape	
polycarbonate (PC)	65–75	110–120	2.3–2.4	compact discs, safety glasses, sporting goods	
polyacetal	70	25–75	2.6–3.4	bearings, gears, shower heads, zippers	

polyetheretherketone (PEEK)	70–105	30–150	3.9	machine, automotive, and aerospace parts
polyphenylene sulfide (PPS)	50–90	1–10	3.8–4.5	machine parts, appliances, electrical equipment
cellulose diacetate	15–65	6–70	1.5	photographic film
polycaprolactam (nylon 6)	40–170	30–300	1.0–2.8	bearings, pulleys, gears
Thermosets*				
Heterochain				
polyester (unsaturated)	20–70	<3	7–14	boat hulls, automobile panels
epoxies	35–140	<4	14–30	laminated circuit boards, flooring, aircraft parts
phenol formaldehyde	50–125	<1	8–23	electrical connectors, appliance handles
urea and melamine formaldehyde	35–75	<1	7.5	countertops, dinnerware
polyurethane	70	3–6	4	flexible and rigid foams for upholstery, insulation

***All values shown are for glass-fibre-reinforced samples (except for polyurethane).**

For the purposes of this article, plastics are primarily defined not on the basis of their chemical composition but on the basis of their engineering behaviour. More specifically, they are defined as either thermoplastic resins or thermosetting resins.

Reference:

<http://www.britannica.com/science/plastic#ref625152>