

Plastics parts 1-4

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PROPERTIES OF PLASTICS

The bonding properties and chemical versatility of carbon account for the great number of plastics. Although carbon is the backbone of polymer chains, other elements are included, to varying degrees, in the chemical structures of plastics. These include hydrogen, oxygen, nitrogen, chlorine, fluorine, and occasionally other elements, such as sulfur and silicon.

While progress in polymer technology makes it increasingly difficult to make general statements about these materials, the following properties are characteristic of most plastics:

1. Low strength--for the familiar plastics, about one-sixth the strength of structural steel
2. Low stiffness (technically, modulus of elasticity)--less than one-tenth that of metals, except for reinforced plastics
3. A tendency to creep, that is, to increase in length under a tensile stress
4. Low hardness (except formaldehyde plastics)
5. Low density, usually an advantage, the density of most plastics being close to that of water
6. Brittleness at low temperatures and loss of strength and hardness at moderately elevated temperatures (Thermal expansion of plastics is about ten times that of metals)
7. Flammability, although many plastics do not burn
8. Outstanding electrical characteristics, such as electrical resistance
9. Degradation of some plastics by environmental agencies such as ultraviolet radiation, although most plastics are highly resistant to chemical attack

Almost all of the deficiencies mentioned above can be overcome to some degree by the addition to a given plastic of suitable fillers or reinforcing fibres. For example, a number of plastics have been developed that can sustain elevated temperatures, including *Teflon and the silicones*. Addition of other materials to plastics generally reduces their property of electrical resistance. On the other hand, a number of plastics have more recently been developed for the specific purpose of making them electrically conductive. The aim of such research is to produce cheap and lightweight components for use in the electronics industry.

THERMOPLASTICS**Ethylene-Based Plastics**

The simplest structure among the many thermoplastics is that of *polyethylene*. *Addition polymerisation* is the name given to the process in which each ethylene monomer opens up at a double bond and joins to the end of the lengthening chain. The earliest thermoplastics to be developed had the basic structure of polyethylene and were made by addition polymerisation.

These polymers could be created simply by substituting other atoms or groups of atoms for one or more of the four hydrogen atoms in the ethylene monomer. Polyvinyl chloride is made from an ethylene monomer in which one chlorine atom has replaced one hydrogen atom. The result is a polymer that is nonflammable. Polyvinyl fluoride is made from an ethylene monomer in which a fluorine atom has replaced a hydrogen atom. The result is another polymer with improved heat resistance. Polyvinyl alcohol involves the substitution of an OH group, which causes the polymer to be water soluble. Polytetrafluoroethylene (Teflon) contains fluorine atoms in place of all hydrogen atoms. The well-known properties of this plastic include remarkable heat resistance as well as the inability to be softened by heat. In polypropylene a methyl group () replaces one hydrogen atom.

In the monomer of polystyrene a phenyl ring of six carbon atoms (as in benzene) is attached to the ethylene unit in place of one hydrogen atom. This bulky side group results in a brittle plastic. Except for the fluorinated polymers and the acrylic polymers, thermoplastics must be protected from destruction caused by ultraviolet radiation. Carbon black provides such protection in polyethylene pipe, but other additives must be used if the product must be white or pigmented.

The consumption of polyethylene exceeds that of any other plastic. This soft, flexible, waxy material is produced in five grades: low density, medium density, high density, ultra high molecular weight (UHMW), and irradiated (cross-linked by radiation). It is also made into a flexible foam. The differences in density result from differences in the degree of crystallinity.

When the long polymer chains are ordered in a parallel arrangement like the atoms in a metal crystal, the result is a higher density than would be possible in a random or disordered distribution. The branching of polymer chains also leads to lower densities. Although low-density polyethylene has the highest vapour transmission rate, it is the least expensive of the five grades and is used as a vapour barrier in buildings. High-density polyethylene is used in blown bottles and pipes. The UHMW grade is composed of very long chains and is suited to applications requiring a harder, stronger, and wear-resistant material.

Polypropylene is hard, strong, and has a higher useful temperature range than polyethylene, polyvinyl chloride, and polystyrene. It is highly crystalline. At low temperatures it becomes brittle, but this is overcome by *copolymerisation* with *ethylene* or other monomers.

THERMOSETS

The thermosets, such as wood, wool, Bakelite, epoxy, polyurethane, and paints, cannot be softened following polymerisation and cross-linking. Because the thermosets do not offer the wide range of properties found in the thermoplastics, fewer thermosets are in use. In general, they are harder and more brittle than thermoplastics.

The polymerisation of a thermoset is a more complex chemical process than the addition polymerisation of a thermoplastic. It frequently proceeds by the process called condensation polymerisation, in which a compound reacts with itself or another compound and in the reaction releases, or "condenses" some small molecule such as water. In the case of phenol-formaldehyde (Bakelite), phenol and formaldehyde molecules attach to each other in an alternating-chain fashion, releasing water molecules in the process.

It was noted above that cross-linking reduces the freedom of movement of polymer chains under stress, resulting in brittleness. Rubbers, however, though cross-linked, are not brittle even though they are thermosets. Common cross-linking agents include sulfur for rubbers, styrene for polyesters, and oxygen for linseed oil and many paints and varnishes. Polymer paints are obtained in the thermoplastic condition. After paint is brushed onto a surface, it cross links by means of oxygen in the air or other agents, becoming thermosetting and brittle. To counter shrinkage that occurs during moulding and to improve properties such as impact resistance and tensile strength, thermosets are usually compounded with fillers such as wood flour, minerals, or glass fibre. The epoxies undergo very little shrinkage, however, and are rarely compounded with fillers.

Phenol-formaldehyde is commonly used in pot handles, bottle caps, wall switches, and other electrical hardware and as a plywood adhesive. It is available only in black and brown colours. When a differently colored formaldehyde is needed, as in counter tops and tabletops, urea-formaldehyde or melamine-formaldehyde are commonly chosen. Urea-formaldehyde is not suited to outdoor exposure, however.

The superior properties of the epoxy thermosets are in part accounted for by oxygen atoms and carbon rings in the polymer chains. Epoxies are usually supplied as two components to be mixed and set. These are strong, corrosion resistant materials that adhere well to most materials, including metals. Their low shrinkage and high strength make them the preferred filler-adhesive in demanding applications such as aircraft structures.

POLYESTERS are thermosetting plastics familiar as fiberglass-reinforced materials in boats, fishing rods, and furniture. There are also thermoplastic polyesters. Polyesters are synthesised in a wide range of reactions involving complex organic acids and alcohols. By suitable selection of the acid and alcohol, specific properties such as flexibility and heat resistance can be obtained.

Styrene is commonly used as a cross-linking agent for polyesters; methyl methacrylates is used when improved colour and weatherability are needed. Because neither heat nor pressure are required for the production of polyesters, there is almost no limit to the size of the part that may be produced. With glass as a reinforcement, polyesters can be created with strengths equal to those of metals.

Foams

The first of the foamed plastics to be developed was polystyrene (styrofoam). It is commonly used as building insulation and in flotation devices. Polystyrene foams are either extruded with a blowing agent or created in a mould by using expandable beads. The latter method is used to make the familiar white coffee cup. Like solid polystyrene, the foam version is low in cost, brittle, and attacked by solvents and ultraviolet radiation.

Although most plastics have been foamed, only polystyrene, ABS, polyethylene, polyvinyl chloride, urea-formaldehyde, and polyurethane have found extensive applications. These foams have three principal uses: thermal insulation, cushioning materials, and structural materials. Insulating foams must be of low density, whereas structural foams must have high density to obtain strength and hardness.

Plastic foams may be open-celled or closed-celled. An open-celled foam has interconnected gas cells and hence can absorb water and other liquids. The gas cells in a closed-cell foam are completely isolated from each other by thin walls of plastic. Closed-cell foams are required for flotation devices and are also preferred for building insulation. Polystyrene, polyurethane (for insulation), and ABS foams are closed-celled, while polyethylene, urea-formaldehyde, and other polyurethane foams are open-celled.

Low-density urethane insulating foams provide the best but also the most expensive insulation. These foams are poured or sprayed from a gun, and they bond well to clean, dry surfaces. In higher densities, urethane foam is used for cupboard doors, artificial limbs, and furniture, and will hold nails and screws. Strength and hardness increase with density. By using a chilled mould, an integral-skin foam can be produced, that is, a foam with a dense and hard surface. Polyvinyl chloride is commonly used as either a flexible foam or as a high-density rigid foam. The latter is used as a substitute for mouldings and other wood products and has the same weight as softwoods.

SUBCLASSIFICATIONS of Plastics

It has been stated that the first plastics were based on carbon chains and that improved properties resulted when other atoms such as oxygen were included in the chain. Incorporation of the phenyl ring within the chain, first achieved with polycarbonate and polyesters, also increased the possibilities.

The ladder type of polymer has two bonds between units in the chain, providing remarkable resistance to heat. The breaking of one bond does not result in depolymerisation. Rings in the chain also yield thermal stability at higher temperatures. As the number of cyclic units in the polymer chain increases, however, difficulties in polymerisation and in the moulding of these materials also increase. Many of these linear polymers of more complex structure must be condensation-polymerised.

Polymerisation

{pah'-li-mur-i-zay'-shuhn}

Polymerisation is a reaction in which small molecules react to form large molecules, called polymers, that contain many repeating units (poly = many, mer = units). Polymers find wide use as plastics, finishes, and fibres. For a molecule (called a monomer) to form a polymer, it must have at least two reactive sites; that is, it must be difunctional.

Condensation Polymerisation

An example of a difunctional molecule is hydroxy acid. The hydroxyl (OH) group of one hydroxyl acid monomer reacts with the carboxyl group (COOH) of another hydroxyl acid monomer to form an ester (a dimer). The ester dimer is also difunctional and may react further to form a polyester, where n is the number of repeating units in the polymer chain. Polyesters may also be formed by reacting a dihydric alcohol (glycol) with a dicarboxylic acid.

The production of Dacron is an example of reaction (2) in which ethylene glycol is the dialcohol and terephthalic acid is the dicarboxylic acid. The above reactions are condensation reactions because a smaller molecule is split off, and the polymers are called condensation polymers. Another important class of condensation polymers is the polyamides, which are produced by the reaction of AMINO ACIDS or by the reaction of a diamine with a dicarboxylic acid. The product of the amino acid reaction is polyalanine, the protein in wild silk, and the product of the reaction of a diamine with a dicarboxylic acid is Nylon 66, a commercial fibre.

Polymers have useful mechanical properties only if they are of sufficiently high molecular weight. Only four condensation reactions give sufficiently high yields to ensure reliably high-molecular-weight polymers:

- (a) esterification by ester interchange,
- (b) esterification and amidation by the Schotten-Baumann reaction of acyl chlorides,
- (c) amidation by thermal dehydration of ammonium salts, and
- (d) formation of urethanes from isocyanates and alcohols, and ureas from isocyanates and amines;

Petrochemicals

Petrochemicals are chemicals produced from natural gas, natural-gas liquids, or refinery products derived from crude oil distillation, or cracking. First-stage petrochemicals, including ethylene, propylene, butylenes, benzene, toluene, and xylenes, the "building blocks"--are produced as a starting point for a number of secondary petrochemicals that, in turn, are transformed into a variety of petrochemicals and products: PLASTICS, SOLVENTS, SYNTHETIC FIBRES, ELASTOMERS, and other essential commodities.

THE RISE OF THE PETROCHEMICAL INDUSTRY

Some of the products referred to as "petrochemicals" were in the past produced from charcoal, coal-tar distillation by-products, ACETYLENE, or fermentation alcohol. Industrial ORGANIC CHEMISTRY, upon which the science of petrochemicals is based, was originally the domain of German, British, and other European firms. The growth of the refining industry in the United States, based on abundant petroleum and natural gas resources as well as on the development of sophisticated thermal and catalytic oil-cracking processes, created the conditions for the present petrochemical industry. Although the main focus of the refining industry has always been the supply of motor and heating fuels, the oil-transformation processes that were developed in the 1920s and 1930s also provided by-products in the form of highly reactive hydrocarbons--the petrochemical "building blocks"--that were quickly seen to be better and less expensive feedstocks than coal or alcohol for the production of many organic chemicals.

World War II greatly accelerated the rise of the U.S. petrochemical industry. First, the suddenly increased demand for high-octane aviation gasoline led to a surge in refinery capacity, with a concomitant increased production of reactive hydrocarbons. Second, the need for synthetic rubber required the development of a large-scale technology for producing BENZENE, styrene, butylenes, butadiene, and ACRYLONITRILE. The war was also responsible for creating a demand for many other petrochemical products: NYLON for parachutes, cumene for rich aviation gasoline, and polyethylene to shield electric cables in radar equipment. At the end of the war, pent-up consumer demand kept plants running, and petrochemical sales enjoyed more than 10% annual growth rates for well over two decades.

By the late 1960s, growth in the European industry had narrowed the U.S. lead in petrochemicals, and Japan's industry also began to develop. In the 1970s, oil-rich nations such as Saudi Arabia, Iran, Canada, Algeria, and Norway began building their own petrochemical plants. By the early 1980s, world trade in petrochemicals had greatly expanded. Today few countries are without some petrochemical production units.

The ACETYLENE family of chemicals also provide material for the petrochemical industry. Obtained from METHANE, the main component of natural gas, acetylene and its derivatives are used to make acetate fibre, vinyl acetate, and vinyl chloride used in adhesives, plastics, and coatings. Petroleum-derived aromatic compounds such as benzene and toluene are also important starting points for the production of end products.

The range of petrochemical use is enormous. Major needs met by the petrochemical industry include almost every consumer field, some of which follow.

Agriculture and Food

The most important petrochemical product here is ammonia, for which natural gas is the preferred feedstock and which is now produced literally all over the world. Ammonia is used to make nitrogen fertilisers. Other products include crop-protection chemicals, single-cell proteins, polyethylene films for agricultural use, and feed and food additives.

Housing

Polyvinylchloride siding, polystyrene and polyurethane insulation, seal and caulking materials, vinyl and acrylate adhesives, furniture fabrics, carpeting, paints and wallpapers are major products.

Clothing

Of the 20 major synthetic fibres, only three--acetate, rayon, and acetic anhydride--are not based on petrochemicals.

Transportation

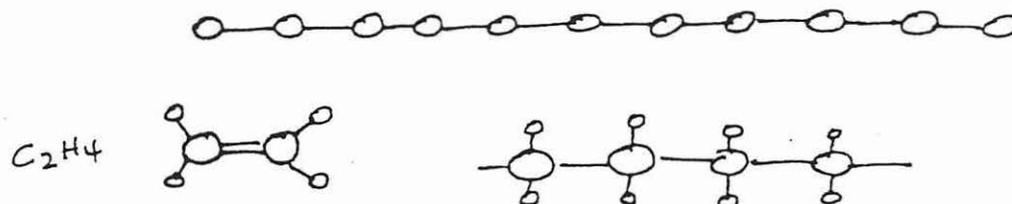
These products include polyester car and truck bodies, acrylic automobile finish coats, styrenic car bumpers, synthetic elastomers for tires, tire treads and hoses, vinyl seat covers, methacrylate traffic lights and road signs, and vinyl road paints. (Many automobile models use several hundred pounds of plastic, which is strong but much lighter than metal.)

Medicine

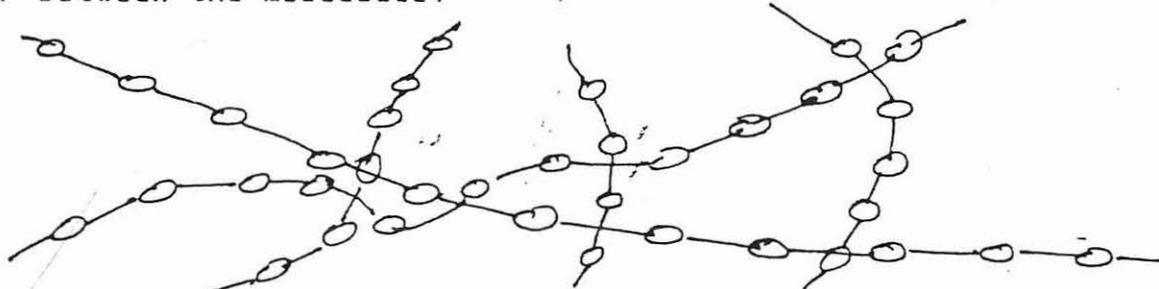
A large number of medicines are the products of petrochemicals, including many antihistamines, decongestants, anti-hypertensives, and analgesics such as aspirin, acetaminophen, and phenacetin.

Plastics

Organic materials made from petrochemicals or coal. Consist of very long molecules made up of individual components (mers) linked repeatedly to each other (polymers).



The molecules become entangled with each other and cross-linking may occur between the molecules.



Two groups - 1. Thermosets - harden on exposure to temperature. After setting do not soften on being reheated.

2. Thermoplastics - soften and flow under heat and pressure. Harden when cooled. Can repeat this cycle indefinitely.

Examples of Thermoplastics:

Polyethylene - Excellent resistance to corrosion. Tough, flexible, high electrical resistance, light, easily moulded, cheap. Used for containers for foodstuffs, plastic film, pipes for acids (flexible and rigid), electrical insulators.

Polypropylene - Similar properties to polyethylene but better heat resistance. Used for electrical insulators, car parts.

Polyamides (nylon) - Strong, hard wearing, high softening temperature, resistant to oils and greases, good electrical insulator. Used for ropes, tyre fabric, small bearings, small gears.

A.B.S. - Outstanding impact resistance and high tensile strength. Resistant to acids and alkalis. Used for many automotive panels, telephones, helmets.

P.T.F.E. (Teflon) - Highly resistant to all solvents and corrosive chemicals. High temperature resistance. High electrical resistance. Low coefficient of friction. Expensive and difficult to mold. Used for bearings, sealing rings, gaskets.

Polyacetal - High tensile strength, tough, rigid, resistant to many solvents. Used for replacement of many metal die-castings - bearings, cams, gears, shafts.

Other Thermoplastics - Cellulose and cellulose based plastics, vinyl based plastics, polystyrene, polyester, acrylics.

Examples of Thermosets:

Phenol formaldehyde (Bakelite) - Hard, rigid, good electrical resistance. Used for electrical switches and plugs, knobs.

Urea formaldehyde - Similar to phenol formaldehyde but better colour range.

Melamine formaldehyde - Harder, more heat resistant, resistant to water. Used for cups, saucers etc.

Epoxy - Outstanding adhesion, flexible, hard, abrasion resistant, resistant to water and chemicals. May be cured by heat or by a catalyst. Used as a coating to line tinplate, drums and vessels, in paint, and as an adhesive (Araldite). In cast form many applications including those in which it is reinforced with glass fibre.

Other thermosets - Alkyd, Furan, polyurethane, polyester (glass fibre reinforced).

Additives Used in Plastics:

1. Fillers - substances used to extend thermosets and improve impact strength, heat and chemical resistance, electrical properties and reduce cost. Some used are wood flour, mica, cellulose, cotton flock, paper.
2. Plasticisers - Used in thermoplastics to make the resin softer, more flexible and more workable.
3. Lubricants - Prevents molten plastics sticking to moulds.
4. Colouring agents - Dyes and pigments.
5. Catalysts - Used to induce or speed setting of thermosets.
6. Stabilisers - Retard hardening to give longer working time, prevent colour change and prevent ageing.

Rubber

There is no sharp distinction between rubber and plastic. Some synthetics fit into both categories. The rubber molecules are kinked and folded so they possess elasticity similar to that of a coiled spring.

Natural rubber stretches like dough when stressed because the molecules slide past each other. When it is vulcanised links are formed between the molecules so that they are anchored to each other and the rubber returns to its original shape after being stressed.

Classes of Rubber:

- | | |
|-------------------------------|---|
| 1. Non-oil resistant | - Natural
Styrene-butadiene (SBR)
Butyl |
| 2. Oil Resistant | - Nitrile
Polysulphide
Neoprene |
| 3. High temperature resistant | - Silicone
Acrylic |
| 4. Specialty | Hypalon
Urethane
Fluoroelastomers. |

Natural Rubber:

Obtained as a finely divided dispersion of latex in water from the rubber tree.

This latex is usually dried to about 1% moisture content to coagulate it and mixed with vulcanising agents (e.g. sulphur), softeners or plasticisers, fillers and pigments. It is then formed by rolling, extrusion or moulding and vulcanised. The process of curing rubber is called vulcanisation and is carried out by heating, either steam or dry, depending on the type of product desired, degree of vulcanisation, etc. The effects of vulcanising on the properties of natural rubber are

1. reduction of heat sensitivity - less plastic when hot, less brittle when cold.
2. rubber no longer dissolves in benzene.
3. improved elasticity.
4. improved resistance to abrasion.

Hard Rubber:

Highly vulcanised natural rubber. "Ebonite". Rigid and brittle. Contains about 50% sulphur. Same chemical resistance as natural rubber but better resistance to oxidation and acids and to attack by strong acids and alkalis. Used for battery casings, tank linings, valves, etc.

Styrene-Butadiene:

First synthetic rubber. Used in car tyres and blended with natural rubber in light truck tyres. Low resilience means heat is generated because of rapid flexing during service. Loses strength at elevated temperature but has reasonable low temperature properties. Poor resistance to oil, strong oxidising agents, ozone, petrol, chlorinated hydrocarbons, benzene. Blends of SBR and natural rubber are used to overcome some of the disadvantages of straight SBR.

Butyl:

Outstanding impermeability to gases, excellent dielectric properties, good resistance to tearing after ageing and at elevated temperatures and fairly good chemical stability. Excellent resistance to ultraviolet light and ozone. Swells in the presence of hydrocarbon solvents. Used in tyre tubes and inflatable goods, steam hose, conveyor belts used for carrying hot materials and automobile parts subject to flexing.

Nitrile:

"Buna-N" Extremely good oil resistance, low swelling and good tensile strength after immersion in gases and oils. Used in oil seals, o-rings, etc. Often used in the form of a latex as an adhesive.

Polysulphide:

"Thiokol". Excellent resistance to oil and water and very low permeability to gases. Good ageing characteristics and excellent resistance to ozone. Used in petrol hoses, printer rollers, cable coverings, diaphragms. Liquid polymers are used in protective coatings and adhesives.

Neoprene:

Good resistance to oils, oxidation, ageing, sunlight, ozone and chemicals. Resists abrasion and will not support combustion. On exposure to heat, becomes brittle. Used in heavy duty conveyor belts, V-belts, gaskets, brake diaphragms.

Silicone rubber:

Extremely resistant to high and low temperatures, ozone, oils and chemicals. Used in oil seals working in extreme temperature conditions.

Acrylic Rubber:

Good resistance to high temperatures and resistance to swelling and deterioration in oils. Resistance to water, alcohol and some solvents is poor. Not recommended for applications below -10 deg F. Used in car transmission seals, oil hose, gaskets, o-rings.

Hypalon:

Chlorosulphonated polyethylene. Good resistance to oxidation, ozone, chemicals and high temperatures. Not recommended for continuous contact with refrigerant gases, petrol and benzene.

Urethane:

"Duralon". Extremely good tensile strength, hardness and resistance to abrasion. Used for shock absorption pads on heavy machinery, friction wheels and drive belts.

Fluoroelastomers:

Includes "Viton". Resistant to chemicals and high and low temperatures. Good mechanical properties.

Rubber additives:

1. Vulcanising agents - mainly sulphur, form cross-links between molecules.
2. Accelerators - speed up vulcanisation and reduce sulphur required.

*etc
etc*

		COMMON NAME
ABS	acrylonitrile-butadiene-styrene	
CA	cellulose acetate	acetate
CAB	cellulose acetate butyrate	butyrate
CAP	cellulose acetate propionate	propionate
CPVC	chlorinated polyvinyl chloride	
DMC	dough-moulding compound (unsaturated polyester)	
EC	ethyl cellulose	
EP	epoxy, epoxide	
FEP	fluoroethylene propylene	
FRP	fibre reinforced polyester	fibreglass
MF	melamine-formaldehyde	melamine
PA	polyamide	nylon
PAN	polyacrylonitrile	
PC	polycarbonate	
POLYETHYLENES		
LDPE	low-density polyethylene	
HDPE	high-density polyethylene	
UHMWPE	ultra-high molecular weight polyethylene	
LLDPE	linear low-density polyethylene	
PET	polyethylene terephthalate	
PBT	polybutylene terephthalate	
PF	phenol-formaldehyde	phenolic
PIB	poly isobutylene	
PMMA	polymethyl methacrylate	acrylic (Perspex) *
POM	polyoxymethylene	acetal polyacetal polyformaldehyde
PP	polypropylene	
PS	polystyrene	general purpose polystyrene
HIPS	high-impact polystyrene	
PTFE	polytetrafluorethylene	Teflon *
PU	polyurethane	
PVAC (PVA)	polyvinyl acetate	
PVA	polyvinyl alcohol	
PVC	polyvinyl chloride (plasticised)	vinyl (flexible)
PVDC	polyvinylidene chloride	
SAN	styrene-acrylonitrile	
SB	styrene-butadiene	
SI	silicone	
SMC	sheet-moulding compound	
UF	urea-formaldehyde	urea
UP	unsaturated polyester (thermoset)	polyester/FRP
UPVC	unplasticised polyvinyl chloride	vinyl (rigid)
OTHER ABBREVIATIONS		
TPR (TPE)	thermoplastic rubber (elastomer)	
SE	self-extinguishing	
GR	glass-fibre reinforced	
GP	general purpose	

GRID

Note 1: Transpose your observations to the grid by ticking circles in same line;
After a deduction only tick those circles which fall under the deduced heading.

Note 2: Different results may be obtained using filled plastics other than those supplied in kit.

Name of student

TEST METHOD OBSERVED RESULTS

		UNKNOWN SAMPLE													
1. CUTTING PRODUCES	sliver	.....												
	powder	<input type="checkbox"/>												
2. HEAT	softens	.....												
	remains rigid	<input type="checkbox"/>												
		DEDUCE	<input type="checkbox"/>												
			THERMOSET	THERMOPLASTIC											
3. LISTEN	metallic	.....												
	dull	.....												
4. DENSITY	sinks	<input type="checkbox"/>												
	floats	.....												
		DEDUCE	<input type="checkbox"/>												
				STYRENICS	CHLORINATED	or	ACRYLIC	EPS	or	POLYOLEFIN					
5. IGNITES	with difficulty	<input type="checkbox"/>												
	readily	.....												
6. COLOUR OF FLAME	yellow	<input type="checkbox"/>												
	yellow/blue	.....												
	almost colourless	.....												
7. COLOUR OF SMOKE	black	<input type="checkbox"/>												
	grey/white	.....												
	little or none	<input type="checkbox"/>												
		DEDUCE	<input type="checkbox"/>												
					CHLORINATED		ACRYLIC								
8. ODOUR OF FUMES	candlewax	.....												
	irritating	<input type="checkbox"/>												
	fruity	.....												
	styrene		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
	rubber-like	.....												
		DEDUCE	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
			MF/UF	FRP	PS	ABS			EPS	POLYOLEFIN					
9. FEEL	rigid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>									
	flexible	.....												
	indents	.....												
	waxy	.....												
	scratches*	.....												
10. WHEN BURNING	drips	.....												
		DEDUCE	<input type="checkbox"/>												
			MF/UF	FRP	PS	ABS	UPVC	PVC	MMA	EPS	LDPE	HOPE	PP		

Name Unknown
Confirmatory Tests — see notes at Page of Manual.
*Compare with known samples.

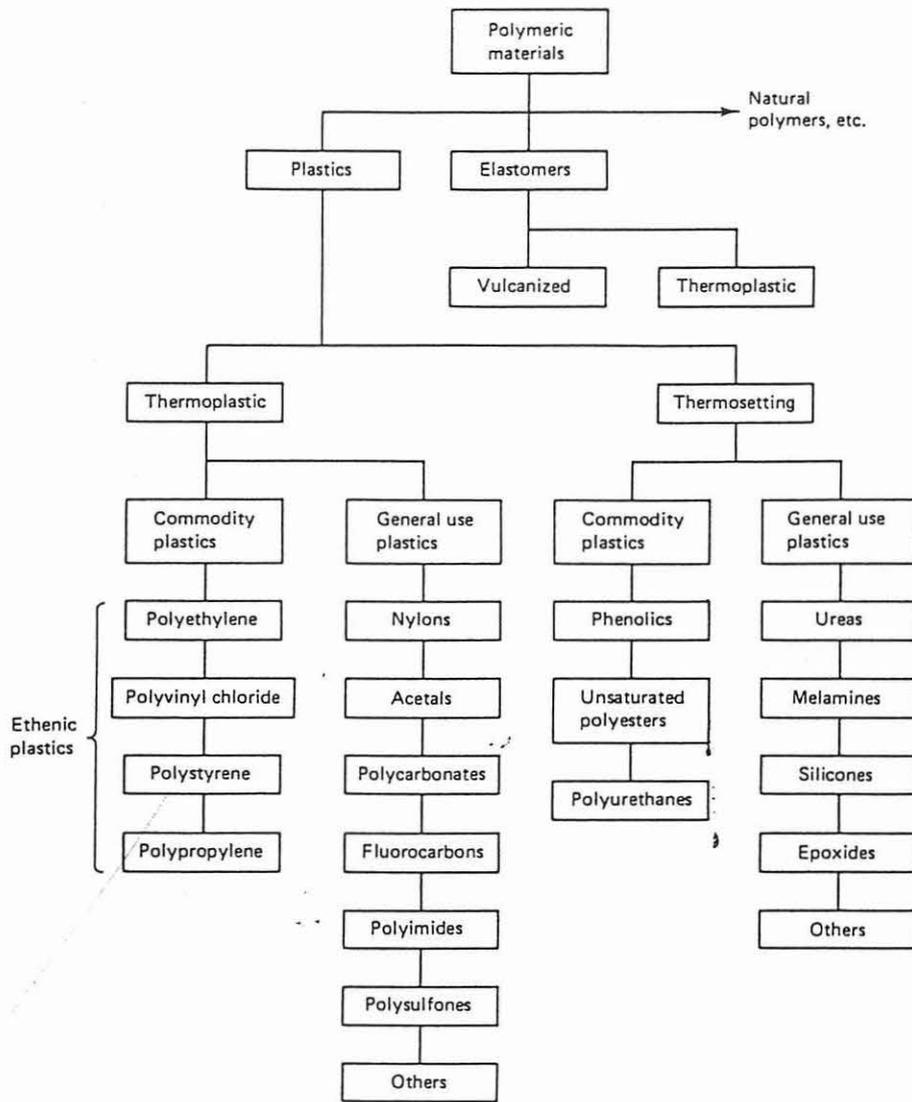


Figure 4-1 Thermoplastic and thermosetting plastics categorized as commodity and general-use plastics.

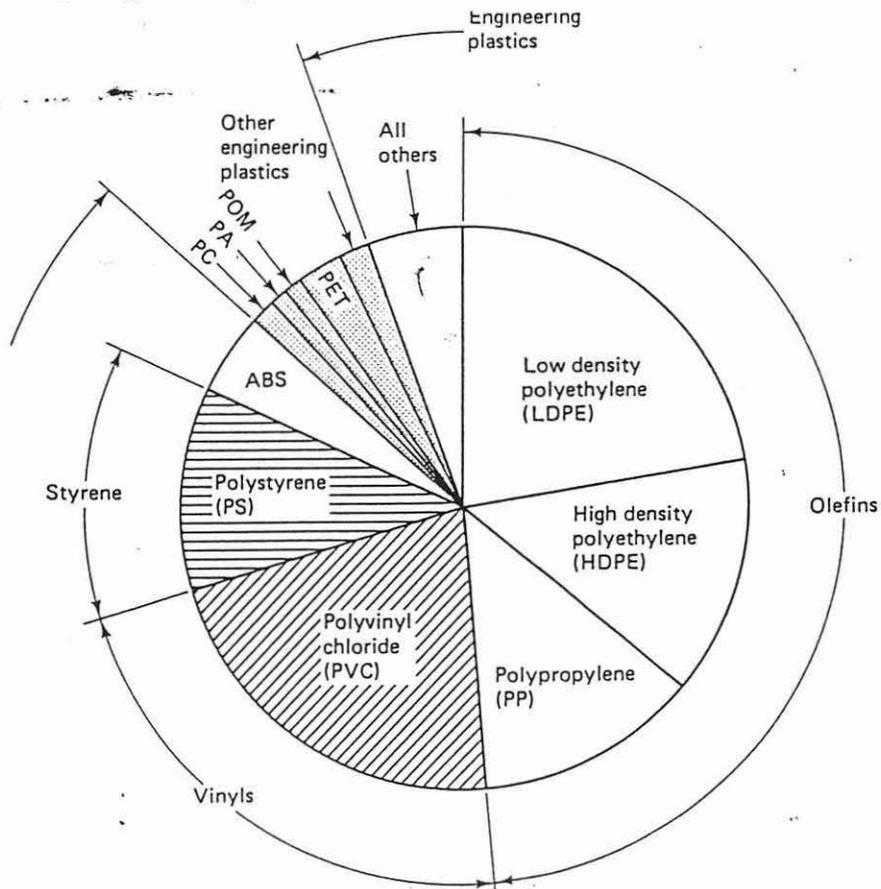


Figure 3-5 Predicted use of thermoplastics in 1995 (over 2 billion pounds)

Plastics Abbreviations with Chemical Names and Trade Names

Code	Chemical name	Trade names
ABS	Acrylonitrile butadiene styrene	Cycolac, Novodur, Ronfalin, Terluran
ACM	Polyacrylate rubber	Cyanacryl, Hycar
ANM	Modified polyacrylate	Vamac
APE ¹⁾	Ethylene propylene rubber	Arylef
Aramid	Aromatic polyester corresponds to aromatic polyamide	Kevlar, Nomex
ASA	Acrylate styrene acrylonitrile	Luran S
AU	Polyurethane elastomers	Urepan
CA	Cellulose acetate	Cellidor
CAB	Cellulose acetate butyrate	
CM	Chlorinated polyethylene	Bayer CM, CPE
CR	Chloroprene rubber	Baypren, Neoprene
CSM	Chlorosulphonated polyethylene	Hypalon
ECO	Epichlorohydrin rubber	Herclor, Hydrin
EP	Epoxy	Araldit
EPDM	Ethylene propylene rubber	Buna AP, Dutral, Keltan, Nordel, Vistalon
EU	Polyurethane elastomers	Adiprene C
FPM	Fluorcarbon rubber	DAI-EL, Fluorel, Tecnoflon, Viton
MF	Melamine formaldehyde	Bakelite, resinol, supraplast
MPF	Melamine/phenol formaldehyde	Resipas, supraplast
IR	Isoprene rubber	Cariflex IR, Natsyn
MVQ	Silicone rubber	Rhodorsil, Silastic, Silopren
NBR	Nitrile butadiene rubber	Buna N, Chemigum, Hycar, Perbunan
PA	Polyamide	Trogamid T
PA 6	Polyamide 6 (polymers of caprolactam)	Durethan B, Grilon, Perlon, Renyl, Sniamid, Technyl, Ultramid B, Wellamid
PA 66	Polyamide 66 (polymers of hexamethylene diamide and adipic acid)	Akulon, Durethan A, Minlon, Nylon, Sniamid, Technyl, Ultramid A, Wellamid, Zytel
PA 11	Polyamide 11 (polymers of 11-aminoundecanoic acid)	Rilsan B
PA 12	Polyamide 12 (polymers of 12-dodecalactam)	Grilamid, Rilsan A, Vestamid
PAI ¹⁾	Polyamide imide	Torlon
PAN ₂	Polyacrylonitrile	Dralon, Orlon
PBTP	Polybutylene terephthalate	Crastin, Pocan, Ultradur, Vestodur
PC	Polycarbonate	Makrolon, Orgalan, Sinvet, Lexan

Code	Chemical name	Trade names
PC-PBTP	—	Makroblend PR, Xenoy
PE	Polyethylene	Hostalen, Lupolen, Stamyran, Vestolen
PEEK ¹⁾	Polyether ether ketone	Victrex „PEEK“
PEI ¹⁾	Polyether imide	Ultem
PES ¹⁾	Polyether sulphone	Victrex „PES“
PETFE ¹⁾	Ethylene tetrafluorethylene copolymer	Hostafion ET, Tefzel
PETP	Polyethylene terephthalate	Arnite, Crastin, Mylar, Rynite, Trevira
PF	Phenol formaldehyde	Bakelite, supraplast, vincolyte
PFA ¹⁾	Perfluoralkoxyethylene	Teflon PFA
PFEP ¹⁾	Fluorinated ethylene-propylene copolymer	Teflon FEP
PI	Polyimide	Kapton, Kerimid, Kinel, Vespel
PMMA	Polymethyl methacrylate	Degalan, Diakon, Perspex, Plexiglas, Resarit, Vedril
POM	Acetal (polyoxymethylene)	Delrin, Hostaform C, Ultraform
PP	Polypropylene	Daplen, Hostalen PP, Moplen, Stamyran P, Starpylen, Vestolen
PPO	Polyphenylene oxide (modified)	Noryl
PPS	Polyphenylene sulphide	Ryton
PPVC	Plasticized polyvinyl chloride	Trosiplast
PS	Polystyrene	Edistir, Hostyren, Lustrex
PSU	Polysulphone	Udel
PTFE	Polytetrafluorethylene	Fluon, Hostafion, Teflon
PUR	Polyurethane	Desmopan, Elastollan, Lycra, Vulkollan
PVC	Polyvinyl chloride	Hostalit, Mipolam, Vestolit
PVDF	Polyvinylidene fluoride	Dyflor, Kynar, Solef
PVF	Polyvinyl fluoride	Tedlar
SAN	Styrene acrylonitrile	Kostil, Luran, Tyril
SB	Styrene butadiene	Hostyren, Lustrex
SBR	Styrene butadiene rubber	Buna Hüls, Buna S, Cariflex S
TPE ¹⁾	Thermoplastic rubber	Hytrell, Kraton, Solpren, TPR
UF	Urea formaldehyde	Bakelite, pölopas
UP	Unsaturated polyester	Keripol, Leguval, Palatal
UPVC	Unplasticized polyvinyl chloride	Trovidur

¹⁾ Code not yet standardized.