Plastics

All plastics are Polymers, i.e. they consist of long chain molecules, composed of a large number of identical groups of atoms joined end to end. These small groups of atoms are called Monomers.

There are two major divisions of plastics, *thermosetting* and **thermoplastic**.

Thermosetting: these consist of polymers which are cross linked and are incapable of reforming once final curing is complete. When a product is made further heating does not produce plasticity.

(a) Phonolics: tough and strong- amber to dark brown in colour- good electrical insulator.

Uses: industrial and motor car moldings, electrical equipment, pump impellers, washing machine agitators, and toilet seats.

(b) Aminos: Similar properties to the above but colour cream or white.
Uses: As above but in addition, laminated sheet, cutlery handles, buttons.

(c) Polyesters: Mainly used when reinforced with glass fibre it is then strong, surface hard, an electrical insulator, transmits light, but resists water and weather.

Uses: Boat hulls, car and truck bodies, tanks, roofing materials, toys, repair outfits, paints and varnish

(d) Epoxides: Strong, tough, resists abrasion, electrical insulators, resists chemical attack and bonds well with other materials.
Uses: Paints, varnish, press tools, embedded electrical circuitry, laminates involving fibre glass for piping, aircraft bodies.

(e) Silicones: Stable for good temperature range. Water repellent.
Uses: Coatings on jet engine castings, bakery moulds, shoe polish, building for waterproofing, textiles and human implants

(f) Polyurethanes: High tensile strength, good abrasion and shock resistance.
Uses: As expanded (foamed) plastic for use in upholstery (soft) or insulation (rigid). Varnishes

Thermoplastics: there is no cross linking of the polymers with the result of reheating produces plasticity and reforming is possible

(a) Polylefine: Tough transparent materials they are divided into three types. 1, polyethylene high density, 2, polyethylene low density, 3, polypropylene.
Uses: Bottles and containers, water goods including tanks, hoses, hose connections. Insulation coating for wires.

(b) Polyvinylchloride (PVC) hard tough good electrical insulator. Resists chemical attack. Non-inflammable. Can be thermoformed, extruded, laminated or produced in sheet form.

(c) Polystyrene. Different grades have different molecular weights. Normally brittle it can be toughened by the Addition of rubber. Softens around 90ºC, melts around 140ºC. It can be injection molded, thermo formed and expanded.
Uses. Domestic goods such as cups. Radio and TV components and cases. Refrigerator linings. Drawing set squares, in foam form used as an insulator, wall paper and protective lining.

(d) Polymaides: Usually called Nylon. Tough, high tensile strength, abrasion resistant. High melting point 200ºC. can be molded, drawn or spun. Machines well.
Uses: Bushings, cams, bearings, gears, nuts, bolts, rollers. Self lubricating and chemical resistant, lab fittings.

(e) Acrylics: Best known of these is polymethylmethacrylate (Perspex). Good mechanical and electrical properties. Resistant to many chemicals. Excellent transparency. May be cast molded or extruded and thermoformed.
Uses: Sheets, for glazing windshields, face masks, machine guards, contact lens, shop signes. Emulsified it forms the base for emulsion paint.

(f) Polytetraflueroethylene: (PTFE) Smooth waxy material. It has great heat resistance. Chemically inert. Cold molding of powder, followed by sintering at 330ºC produces a material which can be machined etc.
Uses: Heat resistant jointing, gaskets and tubes. Coating on food processing plant and household cooking utensils. Teflon non-stick frying pans.

(g) Cellulosics: two types, First type (i) Cellulose Nitrate (ii) Cellulose Acetate. The first is highly flammable the second in non-flammable.
Uses: Cell. Nit. Table tennis balls, cycle mudguards

Cell. Acet. Combs, toys, spectacle frames, fountain pen bodies. Photographic film base and oxy-acetylene welding goggles.

(h) Acetals and Polycarbonates: These are similar materials. Both have excellent mechanical properties.
Uses: Engineering components pump impellers, bearings cams and small machine housings.

At present the use of plastics continues to increase rapidly. As new materials are developed plastics can be divided into three groups.

Thermoplastic Materials

Thermoplastic materials are substances which loose their rigidity whenever they are heated, so they can be molded repeatedly.

Thermosetting Materials

Thermosetting plastics are one which undergo a chemical change during molding process, causing them to become permanently rigid, and incapable of being softened again.

Cold setting Plastics

Cold setting plastics which become permanently hard due to a chemical reaction which occurs at ordinary room temperature. Materials used in conjunction with glass-fibre for the repair of the bodywork of old motor cars fall into this class.

The raw materials used in the manufacture of plastics can be divided into three main elements.

(a) animal or vegetable products:-

Animal or vegetable by products which include casein obtained from cows milk, and cellulose obtained principally from cotton fibre too short for spinning, and from wood pulp.

(b) Coal by-products:-

These are obtained during the distillation of coal to produce gas.

(c) Petroleum by-products:-

These are obtained during the refining and cracking of crude oil.

All materials mentioned under our present meaning of the term “plastic” are actually “organic” compounds, based on the carbon element. Organic compounds are associated mainly with living matter and those which occur naturally are of animal or vegetable nature. Cellulose fibre can be regarded as the material which makes up the skeleton of most plants, whilst petroleum and coal, form the bye-products of which most of our

plastics are derived, were produced by the decay and fossilization of vegetable matter, millions of years ago.

Important properties of plastics

1. Resistant to atmospheric corrosion and to the corrosion by many elements
2. Low relative density, some may float in water.
3. Many are reasonably tough and strong, but the strength is less than that of steel, science the relative density of plastics is low, this means that many have an excellent strength/weight ratio.
4. Most of the thermoplastic materials begin to soften at quite low temperatures, and few are useful for services at temperatures much above 100ºC. strength falls rapidly as the temperature increases.
5. Most plastics have a pleasing appearance, and can be colored if necessary. Some are transparent and completely colorless.

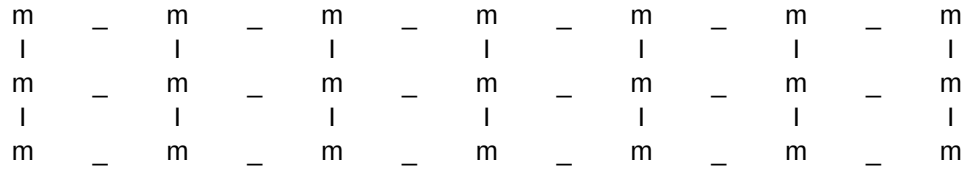
Thermoplastic Materials

The materials consist of a basic unit (or units) called a MONOMER which is a substance that is capable of joining up with other monomers to form chains of great length, to produce a polymer. The diagram below represents the structure of a thermo-plastic material.

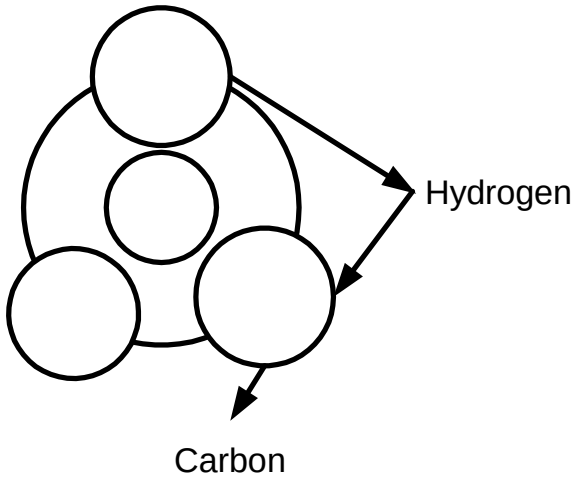
When a thermoplastic material is heated, the chains move apert, and under pressure, slide past each other, to take up new positions which are retained after the heat and pressure is removed. They can be formed or shaped with very little force, at temperatures slightly above that of boiling water. They can be joined together with a suitable solvent and in some cases by applying heat a pressure only.

Thermosetting materials

In the case of thermosetting materials we know that they undergo a chemical change when they are subjected to heat and pressure, after which they cannot be changed by additional heat and pressure. The diagram shows the structure of a *thermosetting* material.



All organic substances exist in the form of molecules. In these molecules, atoms are bound together by strong forces of attraction. A simple example is the molecule methane (north sea gas) which consists of four atoms of hydrogen bound to an atom of carbon as shown below. In addition to strong binding forces between the atoms in the molecules, a weaker force of attraction exists between the molecules themselves. However in plastics we will be dealing with very large molecules, hence even greater amounts of atoms so the forces of attraction overall will be considerable. The actual shape of the molecule also affects the properties of the plastic. In thermoplastic materials the carbon atoms are attached to each other in the form of a long chain, thus in polyethylene a chain of about 1200 carbon atoms exist with the hydrogen atoms being attached to individual carbon atoms. When they lie close and parallel to each other this force of attraction is even greater because they are so large. It is easy to imagine the amount of entanglement which will also exist among this long chain like molecules.



These strong binding forces between these molecules will give us solids possessing both strength and rigidity. When the solid is heated, the distances between the aligned molecules become greater, so the force of attraction between them decrease. This leaves the material weaker and less rigid so that it can be molded more easily. Such a substance is said to be **thermoplastic**.

In some plastics a chemical change occurs during the application of heat and pressure which forms “cross linking” in the form of strong chemical bonds which are formed between adjoining molecules. The forces associated with these chemical bonds is a lot stronger than those of the thermoplastic material. Hence the molecules are not able to slide past over each other and a strong rigid three-dimensional network is formed. Such a substance is said to be ***thermosetting***.