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Environment

Information
for the
underwriter

apropos **Plastics**

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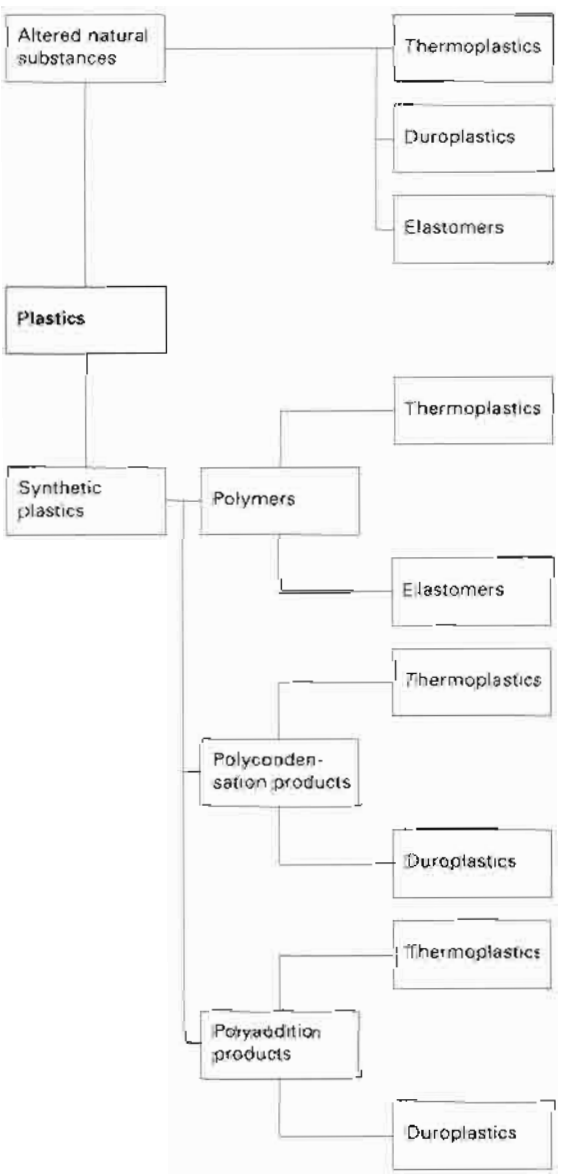
Nowadays, in what is truly the "age of plastic", it is difficult to imagine a life without plastics. Developed at the end of the last century as a low-cost substitute for natural substances, plastic has since established itself as a modern substance which can be adapted to fit specific applications in all areas of life.

Today there are almost 5000 different types of plastic, of which only about 50 are in frequent use. With a market share of around 90 %, the most important multi-purpose plastics are polythene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC).

Classification

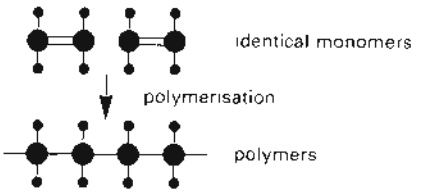
Plastics are generally classified according to how they are manufactured and how they react to heat, a property directly attributable to the plastic's chemical structure. In this way we can distinguish thermoplastics, duroplastics and elastomers.

As regards their manufacture, plastics can be divided into those produced through the chemical transformation of natural substances and those resulting from the linking (synthesis) of organic molecules (monomers) to form long linear molecule chains (polymers). This synthesis is achieved via the technical processes of polymerisation, polycondensation or polyaddition.



Polymerisation

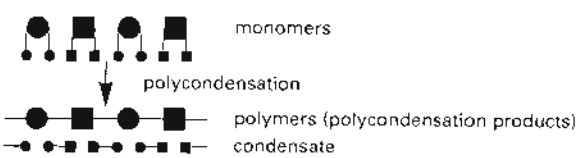
Polymerisation involves the joining together of identical simple molecules (monomers) to form gigantic molecules called high polymers.



The process of polymerisation is initiated by the addition of a catalyst and can be ended by adding an inhibitor once the desired molecule size has been reached. Polymerisation is an exothermic reaction. This means that energy is released in the form of heat, which has to be constantly removed in order to prevent damage due to rising temperatures and pressure build-up. Of the better known plastics, polyvinyl chloride and polythene are produced in this way.

Polycondensation

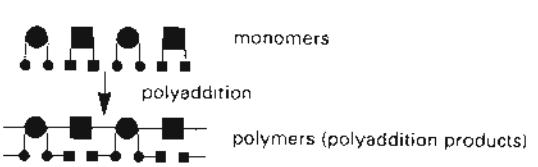
During polycondensation, molecules (monomers) of different types are joined together to form polymers, with smaller molecules such as water, alcohol, ammonia or hydrogen chloride being split off as by-products. Well-known polycondensation products are polyamides, polyester as well as polyester resins and phenolic resins.



Polyaddition

Polyaddition is a reaction between molecules (monomers) of different types to form polymers. In contrast to polycondensation, no by-products are generated; rather, certain atoms from one reactant are recombined with those of another. The reaction generates considerable amounts of heat.

Polyurethanes and epoxy resins are typical products of polyaddition.



Thermoplastics	These are non-resilient plastics that, when heated, soften into a viscous molten mass which can then be processed. After cooling, thermoplastics return to a non-elastic state. This process can be repeated any number of times; any residues can be easily melted and reprocessed. Polythene, polyvinyl chloride, polystyrene and polypropylene are typical thermoplastics. About 80 % of all plastics produced are thermoplastics.
Duroplastics	These are noted for their thermal stability; even at high temperatures they retain their external form. This property is attributable to their cross-linked molecular structure. Thus duroplastics cannot be melted and, unlike thermoplastics, their processing residues cannot be re-used. The class of thermoplastics includes epoxy resins, polyurethane and silicones.
Elastomers	These are elastic thermoplastics that deform under mechanical forces. Once these forces cease, the elastomers revert to their original form. Unlike thermoplastics, elastomers cannot be reworked under heat input, as heating alters and ultimately breaks down their molecular structure. The elastomer class of plastics includes both natural and synthetic rubber.
Production of plastics	The most work-intensive stage in the production of plastics is isolation of the monomers, which are products won from the cracking of crude oil, coal and natural gas. The monomers are then bonded together as already described to form polymers. Polymers are the basic input material for further processing.
Processing of plastics – Conditioning of the polymers	The plastic polymers must first undergo a number of operations – drying, crushing, mixing, granulating – to make them suitable for mechanical processing. Additives and process materials are used to ensure that the finished product has the desired properties and to prevent any unwanted changes in the plastic during processing.
Lubricants	Additives such as waxes and metallic salts enhance the ductility of the plastic when heated. These are generally used in the moulding of thermoplastics.
Stabilisers	Various additives which help retain certain material properties. Examples are metallic compounds that ensure that the plastic does not decompose during processing, ultra-violet absorbers that protect the plastic from ultra-violet radiation, and antioxidants that prevent premature ageing of the plastic from reaction with atmospheric oxygen.
Emollients	These are added to brittle polymers to make the finished products more flexible and pliant.
Fillers	These are either additives used to improve material properties such as hardness, strength and elasticity, or substitutes, the addition of which will not alter the material properties of the finished product, but which, because of their low price, help reduce production costs. Examples: chalk, silicates and ground slate.

Pigments and dyes

Organic and inorganic agents used to change the colour of plastics.

Flame retardants

Additives used to lower the flammability of plastics. These are usually metallic salts, metallic oxides or compounds of chlorine or bromide.

– Shaping

The polymers are amorphous base materials (granulates, powder, fibres, paste, liquid, etc.) which must be given a certain shape.

The main processing methods are:

Moulding

An exact amount of plastic material, either as a powder or in pellet form, is inserted into a heated compression mould. The plastic material melts to completely fill the compression mould. After setting, the moulded part is removed from the mould.

Injection moulding

The plastic material is melted in the heated section of the injection moulding machine and then forced through a heated nozzle into the cooled mould. The plastic sets within a few seconds and the finished product is ejected from the machine.

Extrusion

Plastic polymers in granulated or powder form are melted in a heated worm extruder, compressed by means of a continuously turning endless screw and then pressed through an extruder die to give them their form. The plastic parts then cool off and set in a water bath. This method allows continuous production and is used in the manufacture of tubes, sheets, sections and thread.

Extrusion blowing is a more advanced form of extrusion. The tubular plastic film leaving the extruder is placed in a two-part steel mould and bonded at one end when the mould is closed. The plastic sac is then pumped full of air and pressed against the inside of the steel mould. The plastic sets against the cooled steel mould. This process is used to manufacture hollow plastic forms, tubular film and thin sheeting.

Calendering

Calendering is a process used for the continuous manufacture of plastic sheeting and coatings. A calender consists of three or more rollers that can be heated and cooled, with a narrow adjustable gap between pairs of rollers. The plastic is rolled out and shaped into the desired width and thickness. After it leaves the calender, the sheet plastic is transported across chilling rollers to the winder.

Foaming

Foam plastic can be manufactured by mechanical, physical or chemical processes.

Mechanical foaming

The plastic polymers are mixed with foam stabilising agents and then agitated or blown through with compressed air. The resulting foam sets by means of chemical cross-linking.

Physical foaming

The plastic polymers are mixed with sponging agents which at processing temperature either evaporate (hydrocarbons) or expand strongly (nitrogen). The plastic foam usually sets by cooling.

	Chemical foaming Chemical components are added to the polymers. The ensuing chemical reaction generates a gas which foams the polymer and links and stabilises the foam plastic.
Casting	This process is mainly used with polyester and epoxy resins. The resins are mixed with the necessary fillers and hardeners and poured into the casting mould. An exothermic chemical reaction takes place between the hardener and the resin, so that the moulds have to be cooled during the hardening process.
Coating	Paper, textiles, metals, etc. are often coated with a plastic film. This is generally done by means of extrusion using either a sheet die or subsequent processing in a calender. Another process is coating with polyester, polyurethane or epoxy resins, which are applied to the workpieces by means of brushing, spraying or dipping. The polymers for the coating are usually present as liquids, powders or dispersed in water or solvents.
Tips for the underwriter	See the following apropos brochure on "Combustion/disposal of plastics".

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