Non-Metallic Materials

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PLASTICS

The word plastic has been derived from the Greek word 'Plastikos' which means fit for moulding.

What are Plastics?

"Plastics are basically, the synthetic organic materials of high molecular weight, which can be moulded into any shape by the application of heat and pressure in the presence of a catalyst".

The term 'plastics' is different from 'resins'. Resins are the basic binding materials, which forms a major part of plastics. Actually undergo polymerisation or condensation.

Polymerisation (Binding Materials)

"The process in which a large number of small molecules (monomers) link together to form a large molecule (polymer) under specific conditions of temperature, pressure and catalyst is known as polymerisation"
The higher polymer are known as plastics. "A high polymer is one in which

the number of repeating units is in excess of 100. This is termed as degree of polymerisation. (DP).

Formation of Plastics (Chain)

i) Addition Polymerisation:- "It is a process in which the monomers undergo repeated addition, resulting in the formation of long chain polymer without the elimination of simple molecules like H_2O, HCl, NH_3 etc."

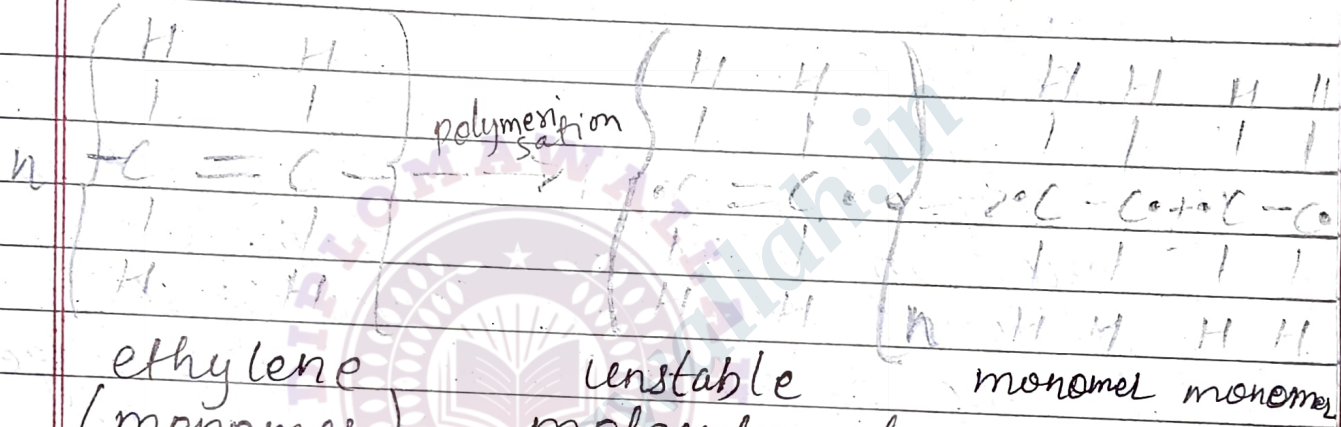
Examples:-

(a). Polymerisation of ethylene to form Polyethylene

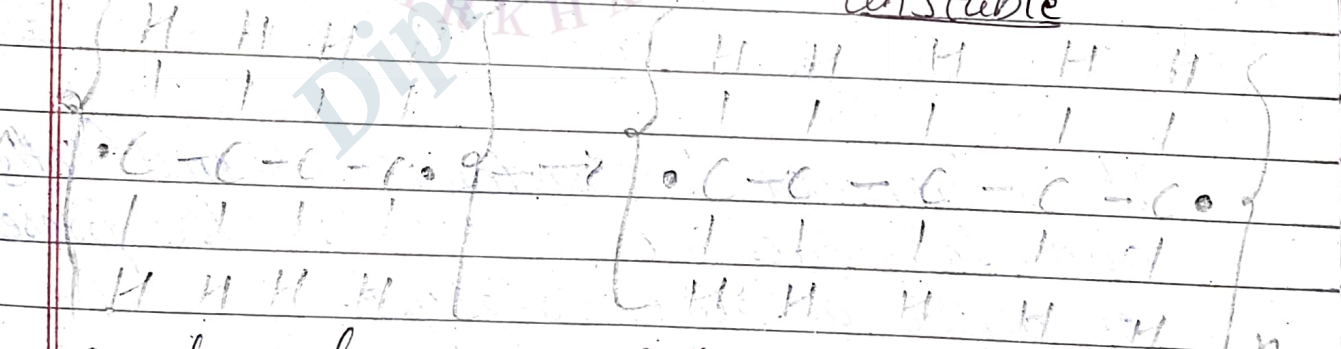
Monomers taking part in polymerisation should contain at least one double bond (=). In addition polymerisation, one of the two bonds between the two carbon atoms of ethylene molecule ($CH_2=CH_2$) is opened up and form an unstable molecule of ethylene ($-CH_2-CH_2-$). Due to opening of the bond, two valence electrons of C-atoms are made free. The resulting unstable molecule joins with similar molecule, by means of free valencies.

• IUPAC NAME of ethylene : Ethyene

The compound molecule formed by joining the two ethylene molecules, it turn join with one or more molecules of ethylene and the process is continued, ultimately forming a large molecule of polythene.



ethylene (monomer) — unstable molecule of Polyethylene



compound molecule (dimmer) — Polythylene (trimmer) (polymer)

⇒ $n(C_2H_4) \xrightarrow[\text{Heat, light, pressure and catalyst}]{\text{Polymerisation}} (C_2H_4)_n$ Polythene.

(b). Formation of polyvinyl chloride (PVC):- It is produced by the addition polymerisation of vinyl chloride ($CH_2=CH-Cl$) using Hydrogen peroxide (H_2O_2) as a catalyst.

$$n(CH_2=CH-Cl) \xrightarrow[(H_2O_2)]{\text{Polymerisation}} (CH_2-CH-Cl)_n$$

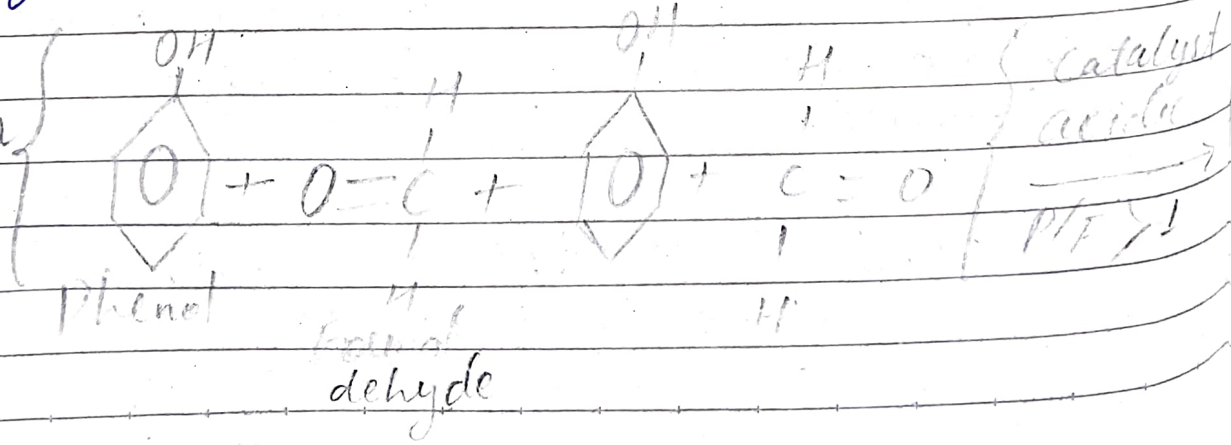
vinyl chloride → PVC

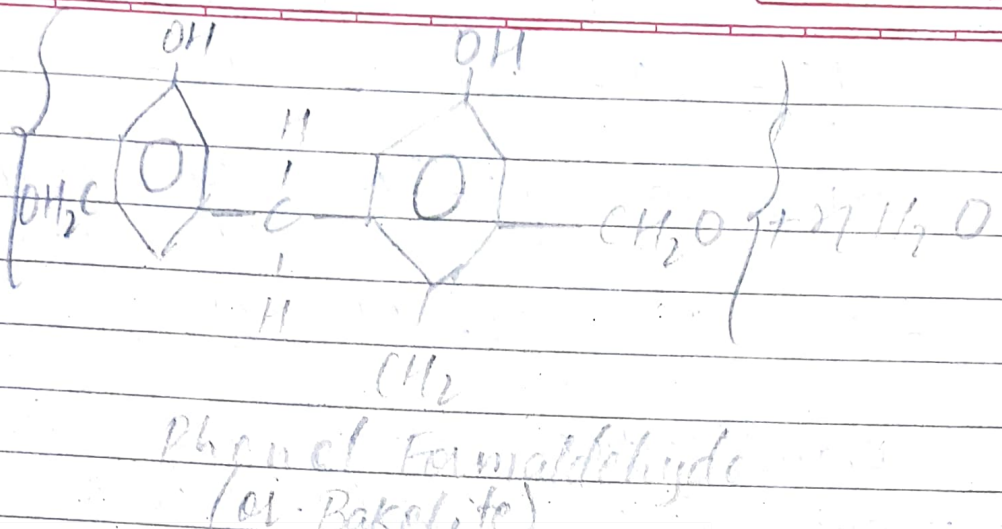
ii). Condensation Polymerisation:- "It is a process in which the monomers of different types are joined together by the condensation forming a large polymer with the elimination of simple molecules like H_2O, HCl, CH_3OH etc."

E.g:-

(a). Formation of Bakelite (or phenol formaldehyde)

It is prepared by condensing phenol (C_6H_5OH) and formaldehyde ($HCHO$) in the presence of acidic/alkaline catalyst.





Phenol Formaldehyde
(or Bakelite)

Thus, Condensation polymerisation is an intermolecular combination, and it takes place through the different functional groups (OH - hydroxyl, NH_2 - amino, COOH - carboxyl) etc, in the monomers having affinity with each other.

TYPES OF PLASTICS

The plastics are classified into two classes according to their manner of setting and structures as:-

i. Thermosoftening Plastics (or Thermoplastics):-
Thermoplastics are formed by addition polymerisation and consist of a long chain linear polymers with little or no cross linking.

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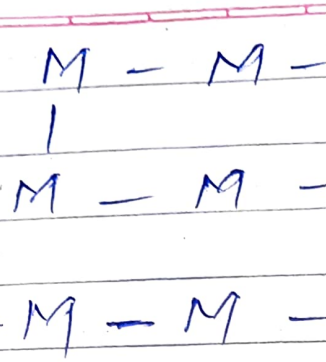
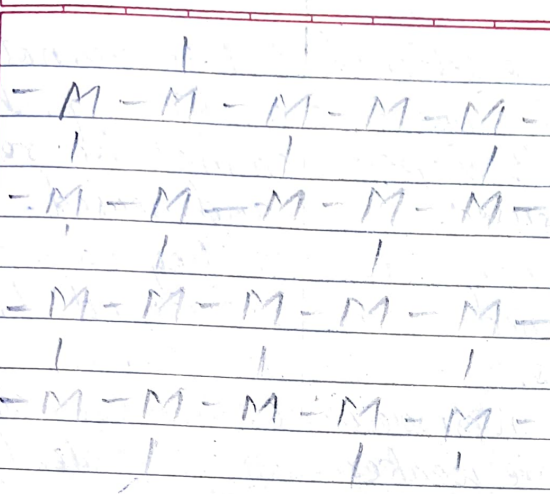


where 'M' represents constituent monomers.

- Thermoplastics soften on heating and regain their original properties on cooling.
- Their hardness is a temporary property subject to change with increase or decrease in temperature. They regain their original hardness and rigidity on cooling.
- Thermoplastics are usually soft, weak and less brittle and can be reclaimed from the wastes. These are soluble in some organic solvents, as their intermolecular bonds are weak.

Example:- Polyethylene, polypropylene, polystyrene, cellulose nitrate, cellulose acetate, PVC etc.

ii) Thermosetting Plastics:- These are formed by condensation polymerisation and consist of three dimensional network structure joined by strong covalent bonds.



where 'M' represents constituent monomers.

Examples:- Bakelite, Polyesters, Silicone plastics, urea formaldehyde etc.

Distinction between Thermoplastics & Thermosetting Plastics

	Thermoplastics	Thermosetting plastics
1. Formation	1. They are formed by addition polymerisation.	1. They are formed by condensation polymerisation.
2. Structure	2. They consist with linear long-chain polymers with limited cross-links	2. They consist of 3-dimensional network structure joined by strong covalent bonds.
3. Molecular weight	3. They consist of polymers of smaller molecular weight.	3. They consist of polymers of higher molecular weight.

4. Heating effect	4. They are softened on heating and hence can be reshaped and reused.	4. They do not soften on heating, hence cannot be reshaped and reused.
5. Reclaiming	5. They can be reclaimed from wastes.	5. They cannot be reclaimed from wastes.
6. Chemical bonding	6. Their intermolecular bonds are weaker.	6. They are joined by strong covalent bonds.
7. Natural	7. They are softer, weaker and less brittle.	7. They are harder, stronger and more brittle.
8. Solubility	8. They are soluble in suitable organic solvents, as their bonds are weaker.	8. They are insoluble in organic solvents, as their bonds are stronger.

COMPOUNDING OF PLASTICS

Generally, plastics are compounded with other substances during their manufacturing process which impart certain definite properties to the finished products.

1. Resins (or binders) :- Thermosetting plastics are usually supplied as linear polymers of comparatively low molecular weight, because at this stage they are fusible and

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hence, easily mouldable. The fubid foun gets converted into cross-linked infusible form during moulding, in the presence of catalyst.

Fillers :- Fillers are added to give the plastic better hardness, tensile strength, opacity, finish and workability or to impart special properties to the final finished of plastics.
It also reduce the cost, shrinkage on setting and brittleness of plastics.

Quartz, mica and carborundum are added to provide extra hardness to the plastic.
The addition of abestos provides heat and corrosions resistance to the plastic materials.

Fillers may be either of organic or inorganic fillers :-

Organic origin fillers :- These include wood flour, cotton, paper-pulp, graphite, powdered rubber, etc.

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2. Inorganic fillers:- These include abestos, powdered mica, silicate clays, talc, oxides of zinc and Lead, sulphides of barium and cadmium and metals like Fe, Pb, Cu and Al in powdered form.

- The percentage of fillers can be as high as 50% of the total moulding mixture.
- Those fillers which are added to increase the mechanical strength, are called reinforcing fillers. E.g:- Addition of Carbon black increases the tensile strength of natural rubber about 40% and also the abrasion resistance.

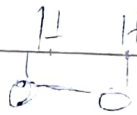
3. Plasticizers:- These are the substances/materials added to increase the plasticity and flexibility of thermosetting plastics.
- They decrease the tensile strength and chemical resistance. Most commonly used plasticizers are:- Camphor, tributyl phosphate, triphenyl phosphate and triacetin and non-drying vegetable oils.

- Camphor:- It increase the surface hardness of plastics. Tributyl and Triphenyl phosphates are used for flame-proofing.

- Triacetin:- It improves the toughness property of plastics.

4. Catalyst or Accelerators:- These are only used in thermosetting plastics. The function of these catalyst or accelerators is to accelerate the polymerisation of fusible plastic into cross-linked into cross-linked infusible form during moulding operation.
- In general, catalysts used for compounding are H_2O_2, benozyl peroxide, metals such as Pb, Ag, Cu and metallic oxide such as ZnO, ammonia and its salt etc.

5. Colouring matter (or pigments):- The colouring matter used in plastics should be resistant to the action of sunlight.
- The various coloured pigments are added to the plastics to impart the desired colours to the plastic articles.
e.g:- Organic dyestuffs and inorganic pigments are used as colouring materials.



PROPERTIES OF PLASTICS

1. They are light in weight as their specific gravity varies from 1 to 2.4
2. They possess low thermal and electrical conductivities.
3. They are highly resistant to corrosion, abrasion, and chemicals.
4. They can readily moulded, drilled, machined.
5. They have low coefficient of thermal expansion.
6. They are not attacked by fungi, insects etc
7. They have low melting points but high refractive index.
8. Their shades or colours do not fade easily.
9. It have better shock absorption capacity even better than steel.
10. They have very good tensile strength. ($550\ kg/cm^2$).
11. It has low maintenance cost and do not require any protective covering such as that of paints.
12. They possess good optical clarity and smoothness like glasses.

APPLICATIONS OF PLASTICS

1. They are used in aircrafts, motor cars and structural industries due to low specific gravity. ~~and high tensile strength.~~
2. It is used for manufacturing steering wheels and plastic dashboards by combining plastic with metals.
3. It also used in machinery to reduce noise and vibrations in machines due to being property of hard and shock-absorption.
4. It also used in chemical industries for manufacturing tubes, pipes etc. due to their high resistance towards chemicals and corrossive agents.
5. It is used for making handles in electric irons, kettles, soldering irons, pressure cookers, etc. due to bad conductor of heat.
6. They can easily and cheaply moulded, with accurate dimensions due to low cost of fabrication.
7. It is suitable for making wind screens for automobiles, aircrafts etc. due to optical clarity ~~and smoothness.~~