POLYMERS

1. INTRODUCTION

A polymer may be defined as a high molecular weight compound formed by the combination of a large number of one or more types of small molecular weight compounds.

The small unit(s) of which polymer is made is (are) known as monomer.

The polymerisation may be defined as a chemical combination of a number of similar or different molecules to form a single large molecule.

A polymer which is obtained from only one type of monomer molecules is known as homopolymer. Example: polythene, PVC, PAN, teflon, Buna rubber etc.

A polymer which is obtained from more than one type of monomer is known as a co-polymer. For example: Buna-S, Dacron, Nylon-66, Bakelite etc.

2. CLASSIFICATION

2.1 Origin (Source)

2.1.1 Natural Polymers

These are of natural origin or these are found in plants and animals. Natural polymers also called as biopolymers.

Example Proteins (Polymers of amino acids), Polysaccharides (Polymers of mono saccharides), rubber (Polymers of isoprene) silk, wool, starch, cellulose, enzymes, natural rubber, haemoglobin etc.

2.1.2 Synthetic Polymers

These are artificial polymers. For example Polythene, nylon, PVC, bakelite, dacron.

2.1.3 Semi-Synthetic Polymers

Natural polymers modified according to human needs.

Examples Nitro cellulose, cellulose acetate, cellulose xanthate, etc.

2.2 Synthesis

2.2.1 Addition Polymers

These are polymers formed by the addition together of the molecules of the monomers to form a large molecule without elimination of any thing.

The process of the formation of addition polymers is called addition polymerisation.

Example–1

$$\underset{\text{Ethene}}{nCH_2{=}CH_2} \xrightarrow{\text{Polymerisation}} \underset{\text{Polythene}}{[-CH_2-CH_2-]_n}$$

2.2.2 Condensation Polymers

Condensation polymers are formed by the combination of monomers with the elimination of simple molecules such as water or alcohol. This process is called condensation polymerisation. Proteins, starch, cellulose etc. are the example of natural condensation polymers.

Two main synthetic polymers of condensation types are polyesters (Terylene or dacron) and polyamides (Nylon-66).

2.3 Mechanism

2.3.1 Chain Growth Polymerization

These polymers are formed by the successive addition of monomer units to the growing chain having a reactive intermediate (Free radical, carbocation or carbanion). Chain growth polymerisation is an important reaction of alkenes and conjugated dienes.

Polythene, polypropylene, teflon, PVC, polystyrene are some examples of chain growth polymers.

2.3.2 Step Growth Polymerization

These polymers are formed through a series of independent steps. Each step involves the condensation between two monomers leading to the formation of smaller polymer.

e.g. Nylon, terylene, bakelite etc.

2.4 Structure

2.4.1 Linear Polymers

These consist of extremely long chains of atoms and are also called one dimensional polymers. Examples - Polyethylene, PVC, Nylon, Polyester.

2.4.2 Three-Dimensional Polymers

Those polymers in which chains are cross linked to give a three dimensional network are called three dimensional polymers. Example - Bakelite.

2.5 Molecular Forces

2.5.1 Elastomers

These are the polymers having very weak intermolecular forces of attraction between polymer chains.

Elastomers posseses elastic character.

Vulcanised rubber is very important example of an elastomer.

2.5.2 Fibres

These are the polymers which have bit strong intermolecular forces such as hydrogen bonding. Ex. Nylon - 6, 6, Nylon-6, 10, Terylene.

Nylon - 6, 6 is obtained by condensation polymerisation of hexamethylene diamine (six carbon) and adipic acid (a dibasic acid having six carbon).

$$nHOOC(CH_2)_4COOH + nH_2N(CH_2)_6NH_2 \xrightarrow{\text{high pressure}} [—OC(CH_2)_4CONH(CH_2)_6NH—]_n$$

Nylon-6, 6

Nylon-6, 10 is obtained by condensation polymerisation of hexamethylene diamine (6C) and sebasic acid (10C).

Terylene (Dacron, teron, cronar, mylar) is a polyester fibre made by the esterification of terephthalic acid with ethylene glycol.

2.5.3 Thermoplastics

A thermo plastic polymer is one which softens on heating and becomes hard on cooling. Polyethylene, polypropylene, polystyrene are the example of thermo plastics.

2.5.4 Thermo Setting Polymers or Resin

A thermo setting polymer becomes hard on heating. Bakelite, Aniline aldehyde resin, urea formaldehyde polymer.

3. MONOMERS AND POLYMERS

S.N.	Monomer	Polymer	Type of Polymers
1.	$CH_2=CH_2$ (Ethylene)	Poly ethene	Addition polymer
2.	$CH_2=CHCH_3$ (Propylene)	Poly propylene or koylene	Addition homo polymer
3.	$CH_2=CHCl$ (Vinyl chloride)	Polyvinyl chloride (PVC)	Homopolymer, chain growth
4.	$CH_2=CH-C_6H_5$ (Styrene)	Polystyrene (styron)	Addition homo polymer, linear chain
5.	$CH_2=CH-CN$ (Acrylonitrile)	Polyacrylonitrile (PAN) or Orlon	Addition homopolymer
6.	$CH_2=CH-CH=CH_2$ (1,3 Butadiene)	BUNA rubbers	Addition copolymer
7.	$CH_2=CHOCOCH_3$ (Vinyl acetate)	Poly vinyl acetate (PVA)	Addition homopolymer
8.	$CF_2=CF_2$ (Tetrafluoro ethylene)	Teflon	Chain growth homopolymer (Nonstick cookwares)
9.	$CH_2=\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}-CH=CH_2$ (Isoprene)	Natural Rubber	Addition homopolymer
10.	$CH_2=\underset{\displaystyle Cl}{\overset{\displaystyle |}{C}}-CH=CH_2$ (Chloroprene)	Neoprene (Artificial Rubber)	Addition homopolymer
11.	Ethylene Glycol + dimethyl terephthalate	Terylene or Dacron (Polyester)	Copolymer, step growth
12.	Hexamethylene diamine + adipic acid	Nylon-6,6 (Polyamide)	Copolymer, step growth linear
13.	Formaldehyde + urea	Urea formaldehyde resin	Copolymer, step growth
14.	Formaldehyde + Phenol	Bakelite	Copolymer, step growth thermo setting polymer
15.	Maleic anhydride + methylene glycol	Alkyl plastic	
16.	Methyl methacrylate	Poly methyl meth acrylate (PMMA)	Addition homopolymer
17.	Ethylene Glycol + Phthalic acid	Glyptal	Copolymer, linear step growth, thermo plastic
18.	Melamine + formaldehyde	Melamine formaldehyde resin	Copolymer, step growth thermosetting polymer
19.	Hexamethylene diamine + sebasic acid	Nylon - 6,10	Copolymer, step growth linear
20.	6-Aminohexanoic acid	Nylon - 6	Homopolymer, step growth linear