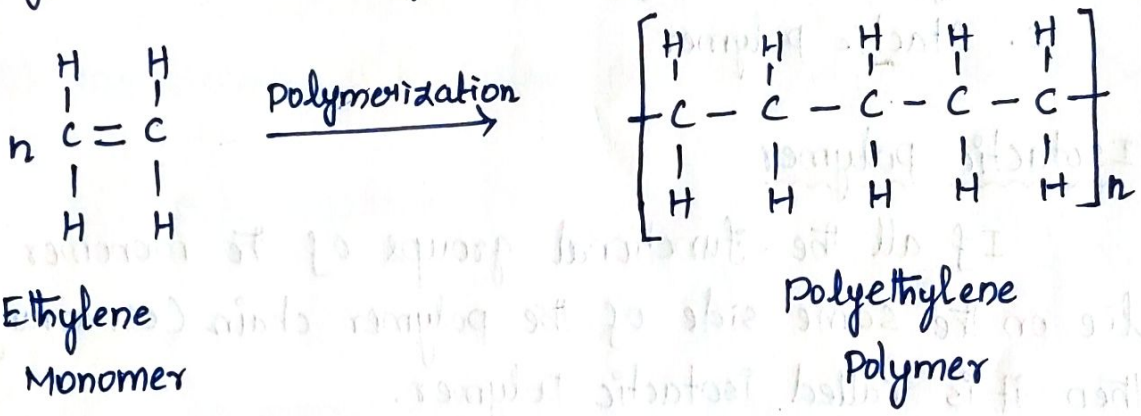
POLYMERS

Polymers are Macromolecules built-up by linking together of a large number of small molecules called monomers.
eg. polythene

Polythene is a polymer formed by linking together of a large number of ethylene.



Ethylene
Monomer

Polyethylene
Polymer

MONOMER

The smallest repeating unit in a long chain of polymer is known as a monomer

Polymer	Monomer
Polyethylene	Ethylene
Polyvinyl chloride	Vinyl chloride
Polystyrene	Styrene

TACTICITY

Tacticity is the relative stereochemistry of adjacent chiral centers within a macromolecule.

The orientation of monometric units in a polymer molecule can take place in an orderly fashion or disorderly fashion with respect to the main chain.

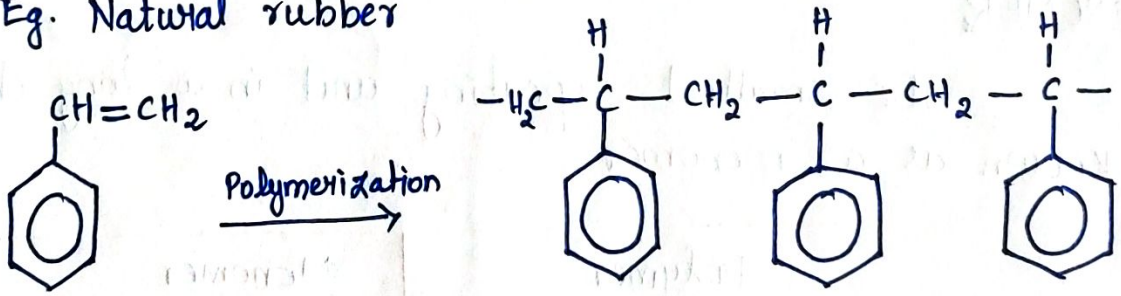
Depending on the arrangement, they are classified into

a. Isotactic polymer
b. Syndiotactic polymer
c. Atactic polymer

Isotactic Polymer

If all the functional groups of the monomer units lie on the same side of the polymer chain (cis arrangement) then it is called isotactic polymer.

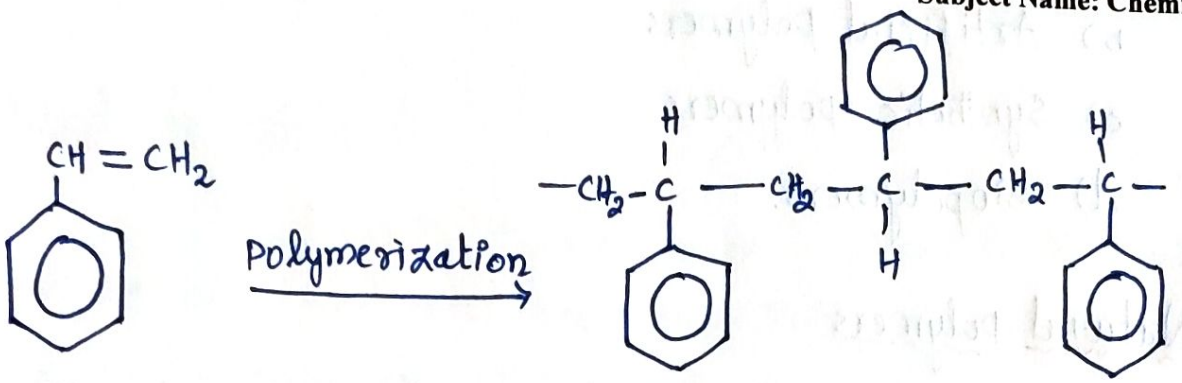
Eg. Natural rubber



Syndiotactic Polymer

If the arrangement of side groups is in an altenating fashion (trans arrangement), it is called syndiotactic polymer.

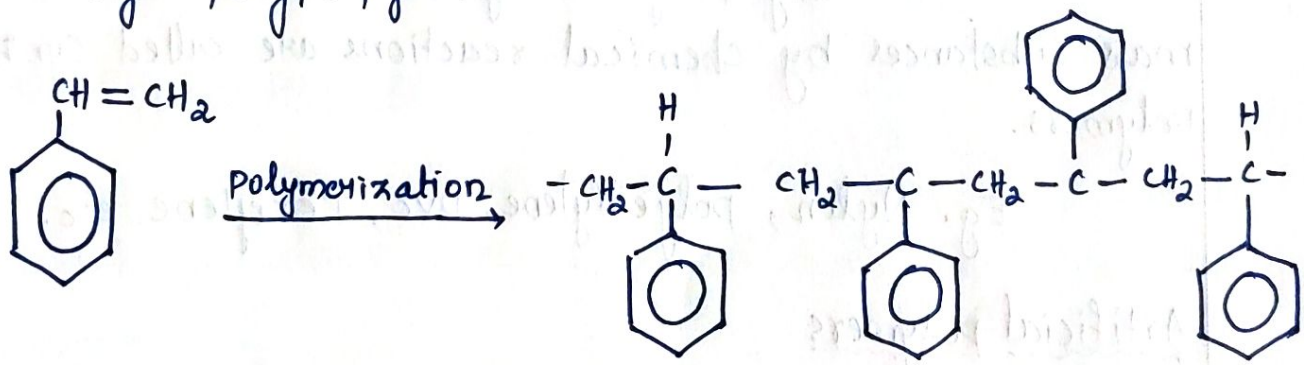
Eg. Guttapercha (polyterpene)



Atactic polymer

If the arrangement of side groups are at random around the main chain, it is called Atactic polymer (or) Heterotactic polymer.

Eg. Polypropylene



CLASSIFICATION OF POLYMERS

Based on the origin and applications, polymers are classified into various types. They are given below:

i) Based on origin

Based on the origin, polymers are classified into four types. They are

a) Natural polymers
b) Artificial polymers
c) Synthetic polymers
d) Biopolymers.

Natural polymers

The polymers derived from naturally occuring materials are called natural polymers.

Eg. Cotton, silk, wool, Rubber etc.

Synthetic polymers

They polymers synthesized from low molecular mass substances by chemical reactions are called synthetic polymers.

Eg. Nylon, polyethylene, PVC, Terylene, etc.

Artificial polymers

The polymers obtained by chemical modification of natural polymers are called artificial polymers.

Eg. Rayon, cellulosic etc.

Biopolymers

Natural polymers having biological activities are called biopolymers

Eg. Nucleic acids, polysaccharides etc.

ii) Based on nature

Based on the type of atoms present in the polymer, Polymers are classified into three types. They are a) organic polymer b) Hetero organic polymer c) Inorganic polymer

a) organic Polymers

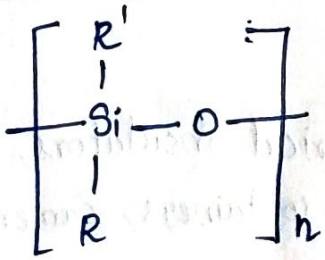
Polymers whose backbone is made up of carbon atoms are called organic polymers.

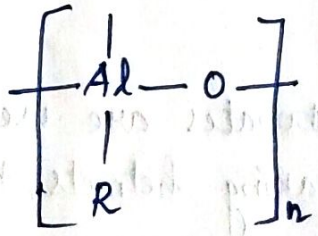
Eg. Polyethylene, polyvinyl alcohol, PVC etc.

b) Hetero - organic polymer

polymers whose backbone is made up of carbon atoms and hetero atoms like N, S and O are known as hetero-organic polymers

Eg. Polysiloxanes, Polyalumoxanes

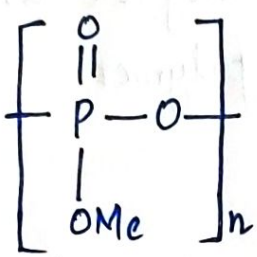




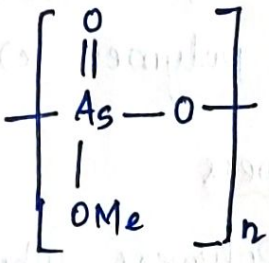
c) Inorganic polymers

Polymers whose backbone do not contain carbon atoms, but contain inorganic atoms like Si, Na, B etc are called inorganic polymers.

Eg. Polyphosphates and polyarsenates



Polyphosphate



Polyarsenate

iii) Based on applications

Based on the application, polymers are classified into

1) Polycarbonates
2) Poly amides
3) Polyurethene
4) Polyacetals
5) Epoxy resin
6) Teflon
7) Polycarbonates are used as electrical insulators, and for making helmets, transparent containers, camera body etc.
8) Polyamides are used for making tyres, gears, high tensile ropes etc.
9) Polyurethanes are used in defence, oceanic rese

Types of plastics

plastics are classified into two different types. They are

1. Theranoplastics
2. Thermosetting plastics

Thermoplastics

(i) Thermoplastics are made up of linear polymers.

(ii) The polymers chains are held together by weak intermolecular forces

(iii) on applying heat and pressure, these weak intermolecular forces become weaker.

(ir) These plastics can be moulded into any desired shape

(v) They soften on heating and remain so as long as they are hot.

(vi) They harden on cooling.

(vii) Repeated heating and cooling donot alter the chemical nature of these materials, because the changes involved are purely physical in nature.

(viii) Examples for thermoplastics are vinyl chlorides, nylon, polyethylene polystyrene, etc.

Thermosetting plastics

(i) Thermosetting plastics are made up of cross-linked polymers.

(ii) These plastics are formed by condensation polymerization.

(iii) The main chain in these polymers are held together by strong covalent bonds.

(iv) Thermosetting plastics set into a given quickly when it is manufactured.

(v) On heating, they donot soften

(vi) On continued heating, charring occurs.

(vii) These plastics are usually harder, stronger and more brittle.

TYPES OF POLYMERISATION

These are two types of polymerisation, namely (i) Addition (or) chain polymerisation (ii) condensation (or) step-polymerisation.

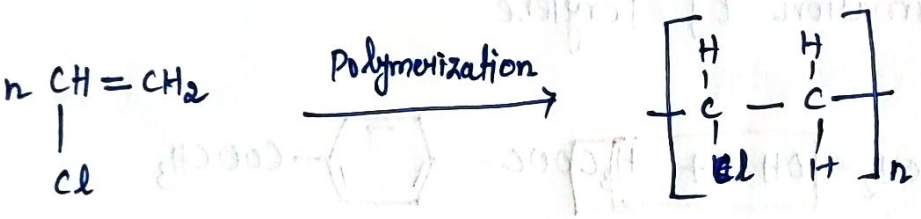
Addition or chain polymerisation

Addition or chain polymerisation is a reaction by which the polymer is formed from the monomer without the loss of any material. The polymer formed is an exact multiple of the original monomeric molecule.

Eg. 1 Formation of polythene

Ethylene Polyethylene

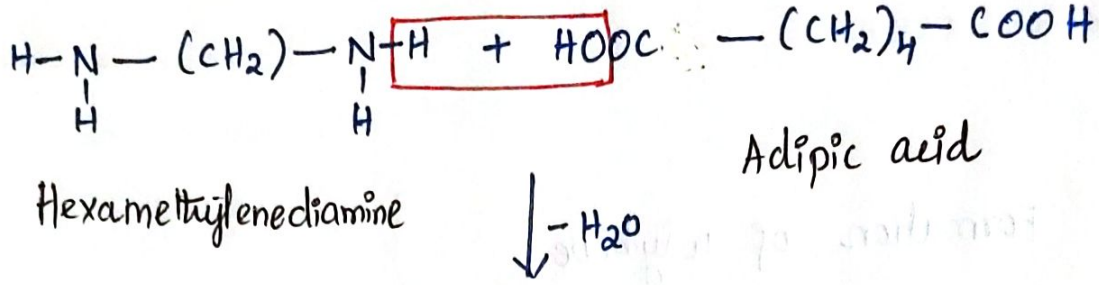
Eg. 2 Formation of PVC



Condensation polymerization

condensation polymerization is a reaction in which the monomers combine together with the elimination of simple molecules such as water, HCl, CH_3OH etc. The polymer, obtained by this type of polymerization is known as condensation polymer.

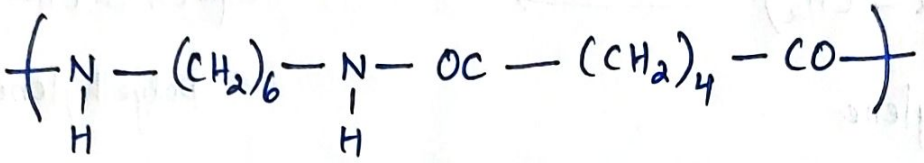
Eg. 1 Formation of Nylon 6:6



Hexamethylenediamine

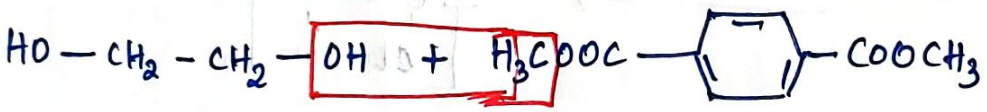
Adipic acid

$-H_2O$



Polyhexamethylene diadipamide (or) Nylon 6:6

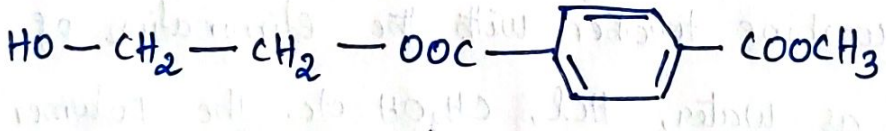
Eg. 2 Formation of Terylene

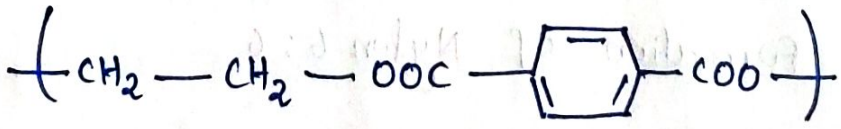


Ethylene glycol

Dimethylterephthalate

$-CH_3OH$

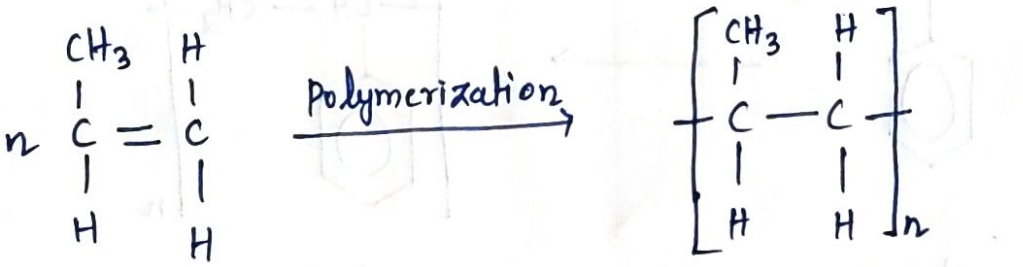




Terylene

Polypropylene

Polypropylene is obtained by polymerizing propylene in the presence of Ziegler-Natta catalyst. ($AlR_3 - AlCl_3$)



Propylene

Polypropylene (PP)

Properties

1) Polypropylene is isotactic and highly crystalline polymer (m.p 160-170°C)
2) It possesses better hardness, strength, stiffness than polyethylene.
3) It is more resistant than PE.

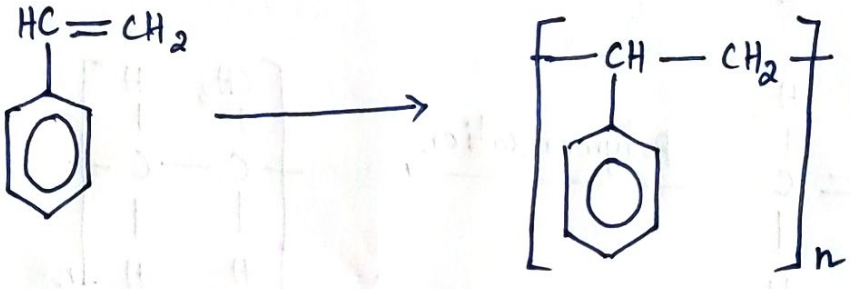
Uses

1) In producing moulded parts and fibres.
2) Its fibres are used in making ropes, indoor and outdoor carpets, furniture, upholstery, blankets, hand bags, apparels etc.
3) It is also used for making water-pipes, washing machines parts, sterilizable hospital equipments.

Polystyrene

Preparation.

Polystyrene is prepared by polymerization of styrene (dissolved in ethyl benzene) in presence of benzyl peroxide catalyst.



Styrene

Polystyrene

Properties

(i) Polystyrene is a transparent, light, good light-stable excellent moisture-resistant.

(ii) It can be nitrated by fuming nitric acid and sulphonated by Conc. H_2SO_4.

(iii) At about 100°C, it yields water emulsion.

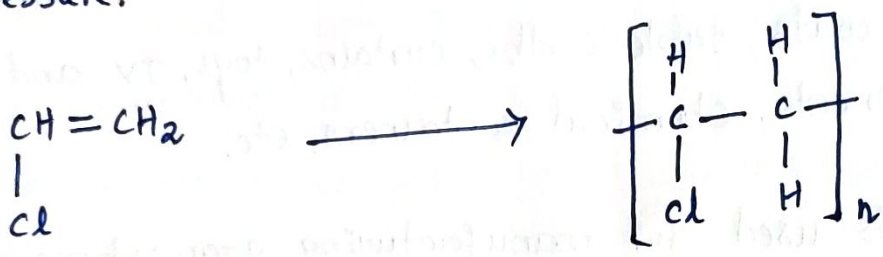
(iv) It is highly electric insulating, highly resistant to acids and good chemical resistant.

Uses

1. It is used in moulding of articles like toys, combs, buttons and buckles.
2. It is used in moulding radio and television parts.

Polyvinyl chloride

Polyvinyl chloride (PVC) is obtained by heating a water emulsion of vinyl chloride in the presence of a small amount of benzyl peroxide (or) hydrogen peroxide in an autoclave under pressure.



Vinyl chloride

Polyvinyl chloride

Properties

(i) PVC is a colourless, odourless, non-inflammable powder.

(ii) It is chemically inert.

(iii) It is resistant to light, inorganic acids and alkalis.

(iv) It is soluble in hot chlorinated hydrocarbons, such as ethyl chloride.

(v) It has high softening point (148°C)

(vi) It is more rigid and stiffer than polythene.

(vii) It is brittle, but by adding plasticizers it can be made flexible.

Uses

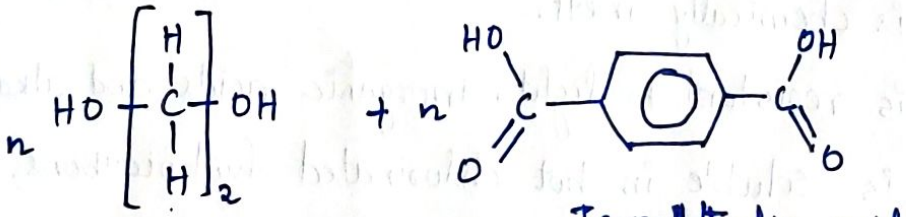
(i) Rigid PVC or unplasticized PVC has properties such as chemical resistance and high rigidity. It is used for making sheets, tank-linings, light fittings, helmets refrigerator components, tyres, pipes etc.

(ii) Plasticized PVC or flexible PVC is used for making rain coats, table cloths, curtains, toys, TV and radio components, chemical containers, etc.

(iii) PVC is used for manufacturing gramophone records.

Polyester resins (or) Terylene (or) Dacron (or) Polyethylene Terephthalate (PET)

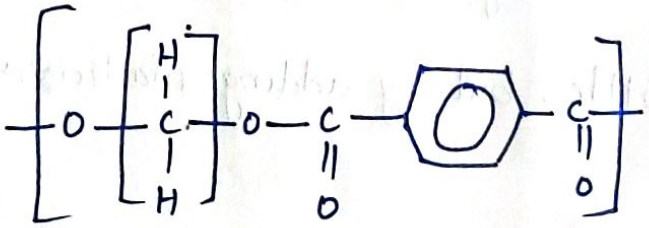
Preparation



Ethylene glycol

Terephthalic acid

condensation polymerization



Polyethylene terephthalate (PET)

Properties

1) PET is highly resistant to mineral and organic acids.
2) It is less resistant to alkalis
3) It is a good fibre forming material and it is converted into commercial fibres
4) These fibres have high stretch - resistance, high creep and wrinkle resistance.

Uses

1) PET is used for making synthetic fibres like terylene dacron etc.
2) It is used for blending with wool to provide better crease and wrinkle resistance.

Teflon (or) Polytetrafluro ethylene (PTFE)

Teflon is obtained by polymerization of water-emulsion of tetrafluoroethylene in the presence of benzoyl peroxide under pressure.

$$n(CF_2 = CF_2) \xrightarrow{Be_2O_2} -(CF_2 - CF_2)-$$

Tetra Fluro Ethylene → Teflon

Properties

(i) Teflon possesses good electrical and mechanical properties.

(ii) It is extremely tough.

(iii) It has high softening point

(iv) It resists the action of chemicals.

Uses

(i) It is used for making gaskets, packings, non-lubricating bearings and chemical carrying pumps.

(ii) It is used as an electrical insulator in motors, cables, transformers, electrical fitting, etc.

Nylon 6:6

Preparation

Nylon 6:6 is obtained by the polymerization of adipic acid with hexamethylene diamine.

$$H_2N-(CH_2)_6-NH_2 + HOOCH_2-(CH_2)_4-COOH$$

Hexamethylene diamine + Adipic acid

$$\downarrow$$

$$\left(\overset{H}{N}-(CH_2)_6-\overset{H}{N}-CO-(CH_2)_4-CO\right)_n$$

Polyhexamethylene diadipamide (or) Nylon 6:6

Properties

(i) It is translucent, whitish, horny, high melting polymer (160 to 264°C)

(ii) It possesses high temperature stability and good abrasion resistance.

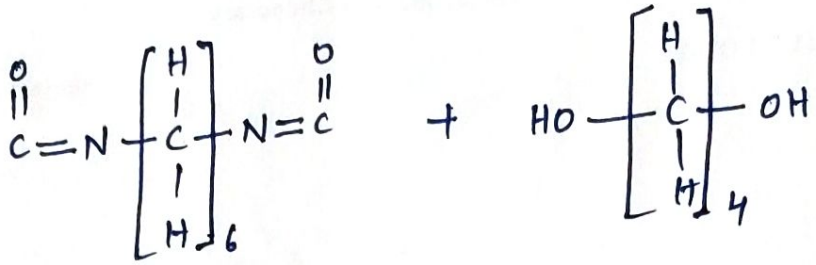
(iii) It is insoluble in common organic solvents (like methylated spirit, benzene and acetone) and soluble in phenol and formic acid.

Uses

It is majorly used in tire cords.

Polyurethanes

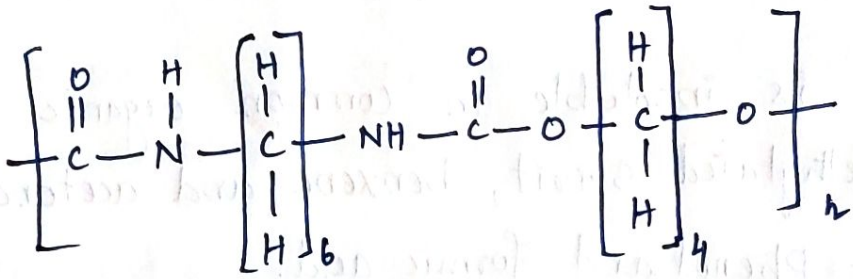
Polyurethanes are obtained, commercially by treating diisocyanate and diol. For example Perlon-U (a crystalline polymer) is obtained by the reaction of 1,4- butane diol with 1,6-hexane diisocyanate.



1,6-hexamethylene diisocyanate

1,4-butane diol

Polymerization



Polyurethane (Perlon-U)

Properties

1) Polyurethanes are less stable than polyamides (nylons) at elevated temperature.
2) They are characterized by excellent resistance to abrasion and solvents.

Uses

1) Polyurethanes are used as coatings, films, foams, adhesives and elastomers.
2) Resilient polyurethane fibres are used for foundation garments and swim-suits.
3) They are used to cast to produce gaskets and seals.