

Polymer: A polymer is a long chain molecule formed by joining together of thousands of small molecules by chemical bonds. A polymer is called a macromolecule because of its large size.

Polymerization: The chemical process leading to the formation of polymer from its monomer is called polymerization.

Monomers: The small molecules which combine to form large molecules or polymer are known as monomers.

For eg: $n(\text{CH}_2=\text{CH}_2) \longrightarrow \text{---}(\text{CH}_2\text{---CH}_2)\text{---}$
ethene (monomer) polyethene or polyethylene (polymer)

n is the degree of polymerization.

Degree of polymerization (DP): It is the number of repeat units or monomer units in a polymer. DP in cellulose is 250 and in vinyl polymers are 400.

It is the long chain that gives the polymer its unique properties.

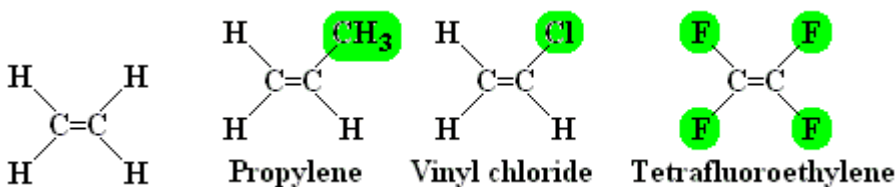
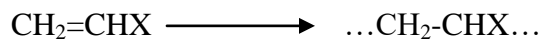
Ethane, $\text{CH}_3\text{-CH}_3$, is a gas molecule at room temperature. Because of their small size, ethane molecules are very mobile and can run almost anywhere they want without interacting with other molecules.

Now, if we double the chain length or the total number of carbons to four, we get butane, $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-CH}_3$. It is a liquid fuel. In liquids, atoms or molecules can no longer act as independent units. Because of their larger size, butane molecules are less mobile than ethane molecules. Their lowered mobility allows them to run into or interact with one another more frequently.

When the chain length increases 6 fold, as in paraffin, $\text{CH}_3(\text{CH}_2\text{CH}_2)_{10}\text{CH}_3$, we get a waxy substance. In this case, the solid-like property of paraffin is a reflection of the entanglement of its long molecules when they move. If we keep increasing the number of repeating carbon units to, say, 2000, i.e., $\text{CH}_3(\text{CH}_2\text{CH}_2)_{2000}\text{CH}_3$, we have a polyethylene polymer, which is a very strong, brittle solid. The polymer molecules have become so long and so entangled that their movement becomes almost completely restricted.

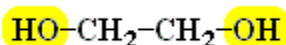
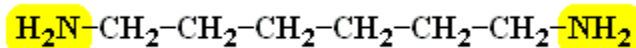
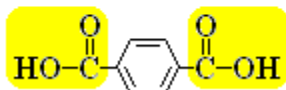
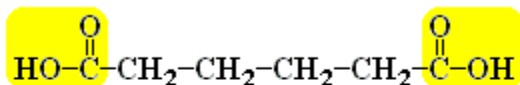
Functionality: It is the number of bonding or reactive sites in a monomer. Reactive sites can be double bond, a triple bond, -NH_2 , -OH , -COOH , -SH etc. For a molecule to behave as a monomer, minimum two functional groups must be present. Hence molecules like acetic acid, benzoic acid, ethyl alcohol, aniline, methyl isocyanate etc cannot act as monomer since they are mono-functional.

Vinyl monomer is bifunctional because the double bond in it is considered as a site for two free valencies. When the double bond is broken, two single bonds become available for combination.



The double bond is the vital feature that allows these monomers to form the long polymer chains. The highlighted areas show the side groups on these monomer molecules. These groups give the polymer chain some of its properties.

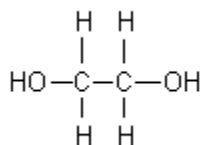
In the following examples, the functional groups are highlighted in yellow. Each molecule has two functional groups.



It is the presence of two functional groups that allow such molecules to behave as monomer giving them ability to form chains and polymerize.

Classify the following on the basis of their functionality:

- a. Ethylene glycol: Its chemical formula is:

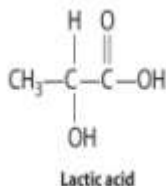


Functional groups present are 2 hydroxyl groups. Hence it is bifunctional.

- b. Vinyl chloride. Its chemical formula is $\text{CH}_2=\text{CHCl}$

Number of double bonds is one. Hence it is bifunctional.

- c. Lactic acid: Chemical formula is



Functional groups present are 1 hydroxyl group and 1 carboxylic acid group. Hence it is bifunctional.

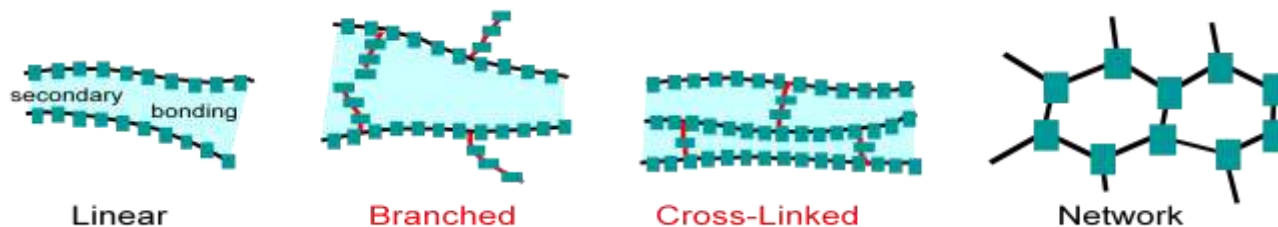
Significance of functionality:

1. When the functionality of monomer is two, linear or straight chain polymer molecule is formed. Example of bifunctional monomer is vinyl monomers, adipic acid, ethylene glycol, amino acid, hexamethylene diamine etc.
2. When the functionality of monomer is three, a three dimensional network polymer is formed. Example is phenol, melamine etc.
3. When a trifunctional monomer is mixed with a bifunctional monomer, a branched chain polymer is formed.
4. When a bifunctional monomer is mixed with a trifunctional monomer, a three dimensional network polymer is formed.

Classification of Polymers

1. Based on Structure/Shape of polymer

Polymers can be linear, branched, cross linked or networked.



- Linear polymers have monomeric units joined end to end in single chains. There may be extensive van der Waals and hydrogen bonding between the chains. Examples: polyethylene, PVC, nylon.
- In branched polymers, side-branch chains are connected to main chains. HDPE – high density polyethylene is primarily a linear polymer with minor branching, while LDPE – low density polyethylene contains numerous short chain branches. Greater chain linearity and chain length tend to increase the melting point and improve the physical and mechanical properties of the polymer due to greater crystallinity.
- In cross-linked polymers, adjacent linear chains are joined to one another at various positions by covalent bonding of atoms. Examples are the rubber elastic materials.
- Small molecules that form 3 or more active covalent bonds create structures called network polymers. Examples are the epoxies and polyurethanes.

2. Based on number of monomers:

Polymers can be homopolymers when only one type of monomer is present (eg: polyethylene, polypropylene, polyvinyl chloride).

Polymers can be co-polymer when two or more types of monomeric units are present (eg: styrene, acrylonitrile etc)

Homopolymers – only one monomer (repeating unit): - A – A – A – A – A – A – A -

Copolymer – more than one monomer

Statistical Copolymers Also called random copolymers. Here the monomeric units are distributed randomly, and sometimes unevenly, in the polymer chain: ~ABBAABAABBBABAABA~.

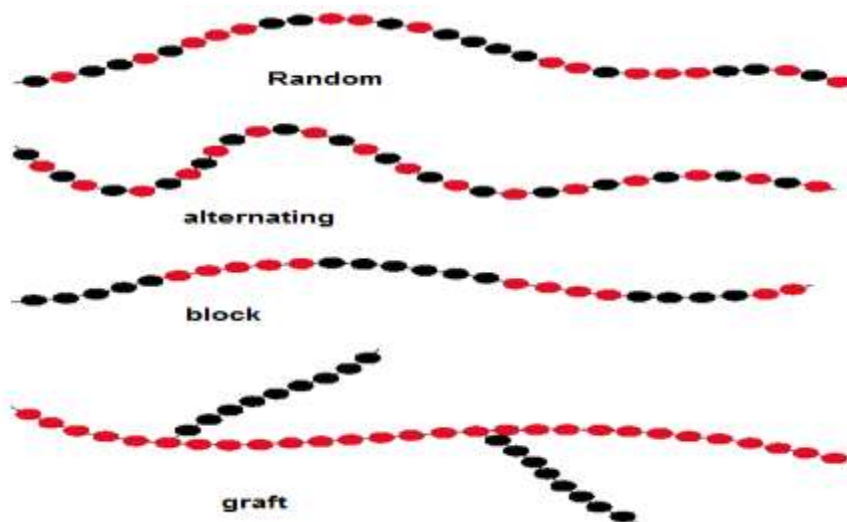
Alternating Copolymers Here the monomeric units are distributed in a regular alternating fashion, with nearly equimolar amounts of each in the chain: ~ABABABABABABABAB~.

Block Copolymers

Instead of a mixed distribution of monomeric units, a long sequence or block of one monomer is joined to a block of the second monomer: ~AAAAA-BBBBBBB~AAAAAA~BBB~.

Graft Copolymers

As the name suggests, side chains of a given monomer are attached to the main chain of the second monomer: ~AAAAAAA(BBBBBBB~)AAAAAAA(BBBB~)AAA~.



Red Dot: A; Black Dot: B

3. Based on Origin:

Synthetic organic polymers

Biopolymers (proteins, polypeptides, polynucleotide, polysaccharides, natural rubber)

Semi-synthetic polymers (chemically modified synthetic polymers)

Inorganic polymers (siloxanes, silanes, phosphazenes)

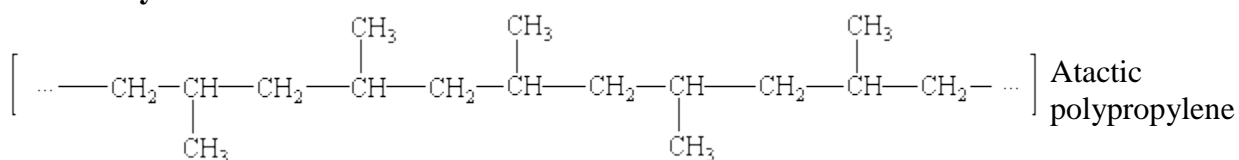
4. Based on Tacticity:

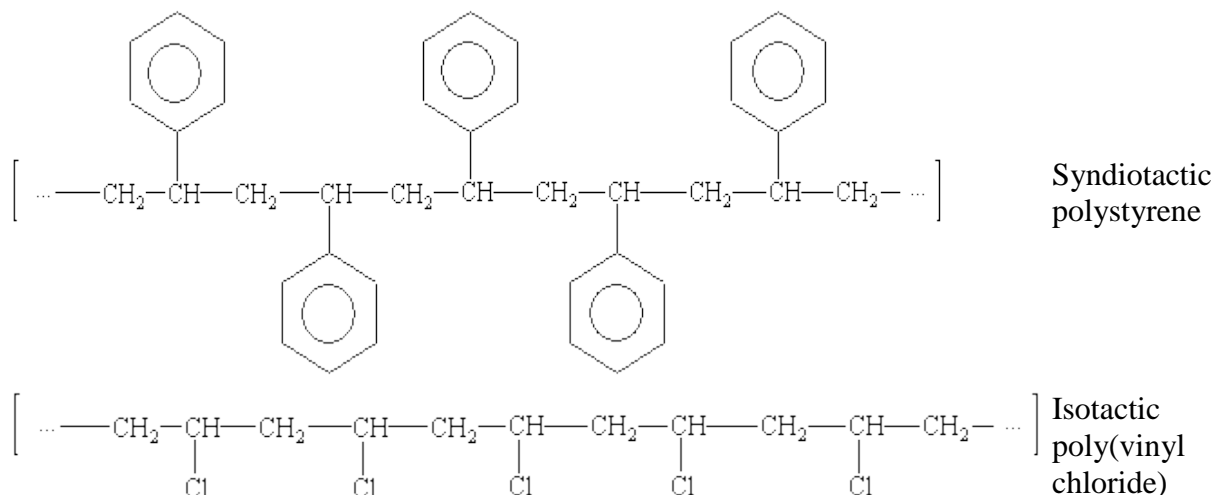
Polymers with regular substituents on the polymer chain possess a property known as **tacticity**. Tacticity results from the different ways in which the substituents can be arranged on the polymer backbone.

When the substituents are arranged in an irregular, random fashion, the polymer is **atactic** (literally, no arrangement).

When the substituents are all on the same side of the chain, the polymer is **isotactic** (literally, the same arrangement).

If the substituents alternate regularly from one side of the chain to the other, the polymer is **syndiotactic**.





5. Based on its behavior to heat

Polymers may be classified according to the mechanical response at elevated temperatures: Thermoplasts and Thermosets.

Difference b/w thermoplast and thermoset polymer

	Thermoplastic polymer	Thermoset polymer
1.	They are low molecular weight and are soluble in suitable solvent	They are high molecular weight and are insoluble in any solvent.
	Linear and branched polymer are thermoplastics	They have three dimensional, cross-linked structures.
2	Adjacent polymer chains are held together by either Van-der-Waals forces or by dipole-dipole forces or by H-bonds	Adjacent polymer chains are held together by strong covalent bonds or cross-links.
3	They are formed by either addition or by condensation polymerization reactions.	They are formed by condensation polymerization reactions.
4.	They soften on heating and stiffen on cooling	They do not soften on heating
5.	They can be remoulded, reshaped and reused	They cannot be reused.
6.	They can be recycled	They cannot be recycled
7.	They are tough	They are brittle
8.	There is no change of chemical composition during remoulding	There is change of chemical composition during remoulding
9	Thermoplastics are very soft and ductile	Thermoset polymers are harder, stronger, more brittle and have better dimensional stability.
10.	Example: PE, PP, PVC, PMMA, PS, PTFE, Nylon, Polyester	Example: vulcanized rubber, Epoxy, phenolic resins, XLPE etc.

Addition and Condensation Polymerization:

Addition Polymerization: Addition polymers are formed when an unsaturated organic compound (presence of double/triple bond) react to form long chain polymer molecule and when no small molecules are eliminated during the reaction.

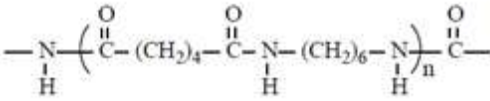
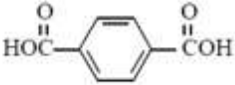
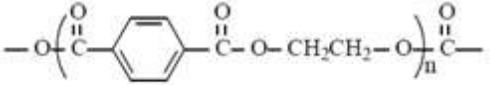
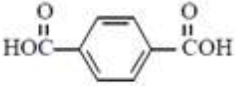

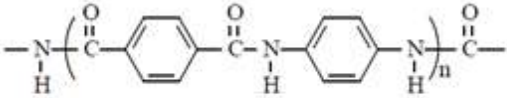
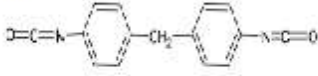
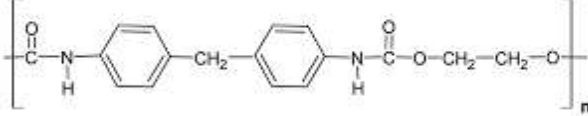
Some Common Addition Polymers

Name(s)	Formula	Monomer	Properties	Uses
Polyethylene low density (LDPE)	$-(CH_2-CH_2)_n-$	ethylene $CH_2=CH_2$	soft, waxy solid	film wrap, plastic bags
Polyethylene high density (HDPE)	$-(CH_2-CH_2)_n-$	ethylene $CH_2=CH_2$	rigid, translucent solid	electrical insulation bottles, toys
Poly(vinyl chloride) (PVC)	$-(CH_2-CHCl)_n-$	vinyl chloride $CH_2=CHCl$	strong rigid solid	pipes, siding, flooring
Polystyrene (PS)	$-[CH_2-CH(C_6H_5)]_n-$	styrene $CH_2=CHC_6H_5$	hard, rigid, clear solid soluble in organic solvents	toys, cabinets packaging (foamed)
Polyacrylonitrile (PAN, Orlon, Acrilan)	$-(CH_2-CHCN)_n-$	acrylonitrile $CH_2=CHCN$	high-melting solid soluble in organic solvents	rugs, blankets clothing
Polytetrafluoroethylene (PTFE, Teflon)	$-(CF_2-CF_2)_n-$	tetrafluoroethylene $CF_2=CF_2$	resistant, smooth solid	non-stick surfaces electrical insulation
Poly(methyl methacrylate) (PMMA, Lucite, Plexiglas)	$-[CH_2-C(CH_3)(CO_2CH_3)]_n-$	methyl methacrylate $CH_2=C(CH_3)CO_2CH_3$	hard, transparent solid	lighting covers, signs skylights
Poly(vinyl acetate) (PVAc)	$-(CH_2-CHOCOCH_3)_n-$	vinyl acetate $CH_2=CHOCOCH_3$	soft, sticky solid	latex paints, adhesives

Condensation Polymerization: The process of formation of polymer via condensation of two different bi-or poly functional monomers having functional groups which have affinity to each other. Condensation polymers form when:

- bifunctional monomers combine to form a long chain polymer molecule.
- small molecules like water is eliminated during the reaction.

Some Common Condensation Polymers and Their Monomers

Monomers Names and Formulas	Polymer Name and formula	Typical Uses
1,6-diaminohexane $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$ hexandioic acid (adipic acid) $\text{ClC}(\text{O})(\text{CH}_2)_4\text{C}(\text{O})\text{Cl}$	Nylon 66, a polyamide 	Women hose, rope, fabric carpeting
Terephthalic acid  Ethylene glycol $\text{HOCH}_2\text{CH}_2\text{OH}$	Dacron or Mylar (polyesters) 	Clothing, films, tapes
Terephthalic acid  1,4-diaminobenzene 	Kevlar, a polyamide 	Bullet proof vests
diisocyanatobenzene  Ethylene glycol $\text{HOCH}_2\text{CH}_2\text{OH}$	Polyurethane  Polyurethane	foams

Difference between addition and condensation polymerization

S.No	Addition Polymerization	Condensation Polymerization
1.	Requires the presence of double bond in the monomer	Requires the presence of minimum two functional groups in a single monomer which are of close proximity to each other
2.	No by product is formed	A byproduct like H ₂ O, HCl etc is formed
3.	Polymer formed is homopolymer	Polymer formed is heteropolymer
4.	Polymer is thermoplastic	Polymer formed is thermosetting
5.	Example: a. Ethylene polymerizing to polyethylene b. Vinyl chloride polymerizing to PVC c. styrene polymerizing to polystyrene	Example: a. Hexamethylene diamine and adipic acid polymerizing to nylon 66 b. Caprolactum polymerizing to Nylon 6 c. Terephthalic acid and ethylene glycol polymerizing to polyethylene terephthalate

The Mechanism of Addition Polymerization

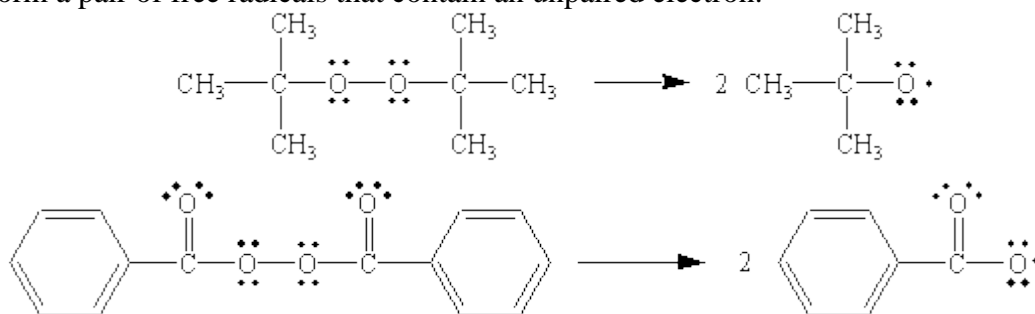
Depending on the initiator used to start the polymerization process, the mechanism can be classified as:

1. Free Radical Addition Polymerization
2. Anionic or Carbanion Addition Polymerization
3. Cationic or Carbanion Addition Polymerization

1. Free Radical Polymerization mechanism: The simplest way to catalyze the polymerization reaction that leads to an addition polymer is to add a source of a **free radical** to the monomer. The term *free radical* is used to describe a family of very reactive, short-lived components of a reaction that contain one or more unpaired electrons. In the presence of a free radical, addition polymers form by a chain-reaction mechanism that contains chain-initiation, chain-propagation, and chain- termination steps.

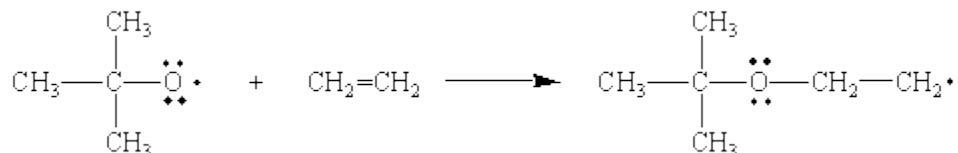
Chain Initiation

A source of free radicals is needed to initiate the chain reaction. These free radicals are usually produced by decomposing a peroxide such as di-*tert*-butyl peroxide or benzoyl peroxide, shown below. In the presence of either heat or light, these peroxides decompose to form a pair of free radicals that contain an unpaired electron.

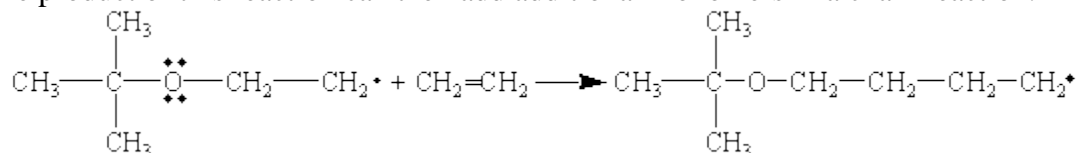


Chain Propagation

The free radical produced in the chain-initiation step adds to an alkene to form a new free radical.

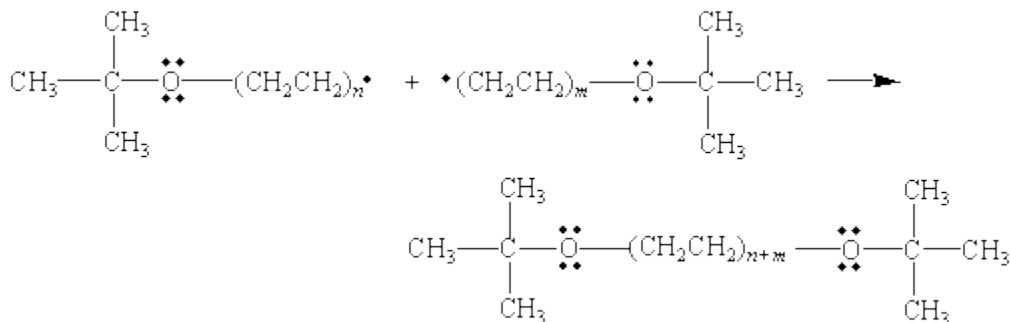


The product of this reaction can then add additional monomers in a chain reaction.



Chain Termination

Whenever pairs of radicals combine to form a covalent bond, the chain reactions carried by these radicals are terminated.

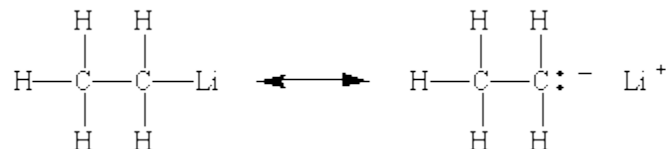


2. Anionic Polymerization

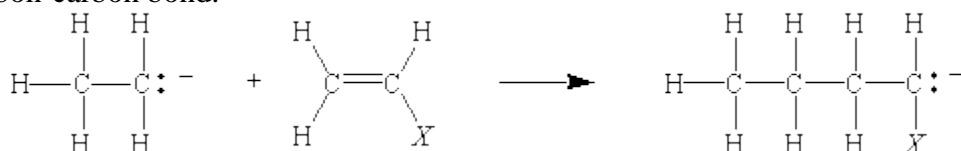
Addition polymers can also be made by chain reactions that proceed through intermediates that carry either a negative or positive charge.

When the chain reaction is initiated and carried by negatively charged intermediates, the reaction is known as **anionic polymerization**. Like free-radical polymerizations, these chain reactions take place via chain-initiation, chain-propagation, and chain-termination steps.

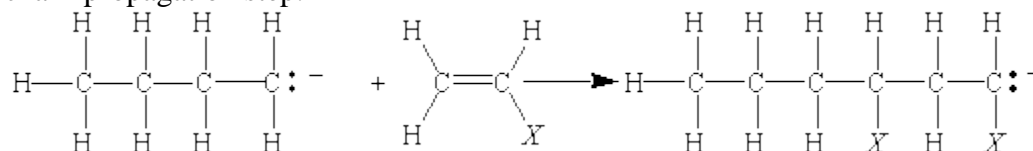
The reaction is initiated by a Grignard reagent or alkyllithium reagent, which can be thought of a source of a negatively charged CH_3^- or CH_3CH_2^- ion. Species that have been used to initiate anionic polymerization include alkali metals, alkali amides, alkyl lithium and various electron sources.



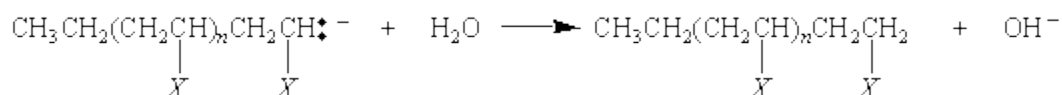
The CH_3^- or CH_3CH_2^- ion from one of these metal alkyls can attack an alkene to form a carbon-carbon bond.



The product of this chain-initiation reaction is a new carbanion that can attack another alkene in a chain-propagation step.

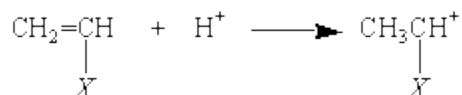


The chain reaction is terminated when the carbanion reacts with traces of water in the solvent in which the reaction is run.

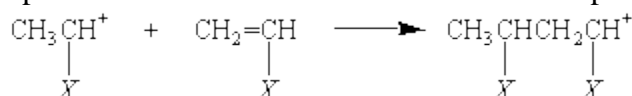


3. Cationic Polymerization

The intermediate that carries the chain reaction during polymerization can also be a positive ion, or cation. In this case, the **cationic polymerization** reaction is initiated by adding a strong acid to an alkene to form a carbocation.



The ion produced in this reaction adds monomers to produce a growing polymer chain.



The chain reaction is terminated when the carbonium ion reacts with water that contaminates the solvent in which the polymerization is run.

Monomers bearing cation stabilizing groups, such as alkyl, phenyl or vinyl can be polymerized by cationic processes. These are normally initiated at low temperature in methylene chloride solution. Strong acids, such as HClO_4 , or Lewis acids containing traces of water (as shown above) serve as initiating reagents.

Difference b/w Free radical and Ionic Polymerisation

	Free radical	Ionic Polymerisation	
		Cationic	Anionic
Monomeric units	Ethylene, butadiene, isoprene, chloroprene, acrylates, styrene, vinyl chloride	Monomers with electron releasing substituent	Monomers with electron attracting substituent
Initiator	Benzoyl peroxide, H_2O_2	Lewis acid (AlCl_3 , BF_3 , SnCl_4), Friedel craft's catalyst	Strong base like alkali metal, Grignard reagent
Intermediate	Free radical	Carbocation	Carbanion
Temperature	$\geq 50^\circ\text{C}$	0°C	
	Not sensitive to polarity of medium	Sensitive to polarity of medium	

Plastics: Preparation and uses:

1. Polyvinyl chloride (PVC):

Uses:

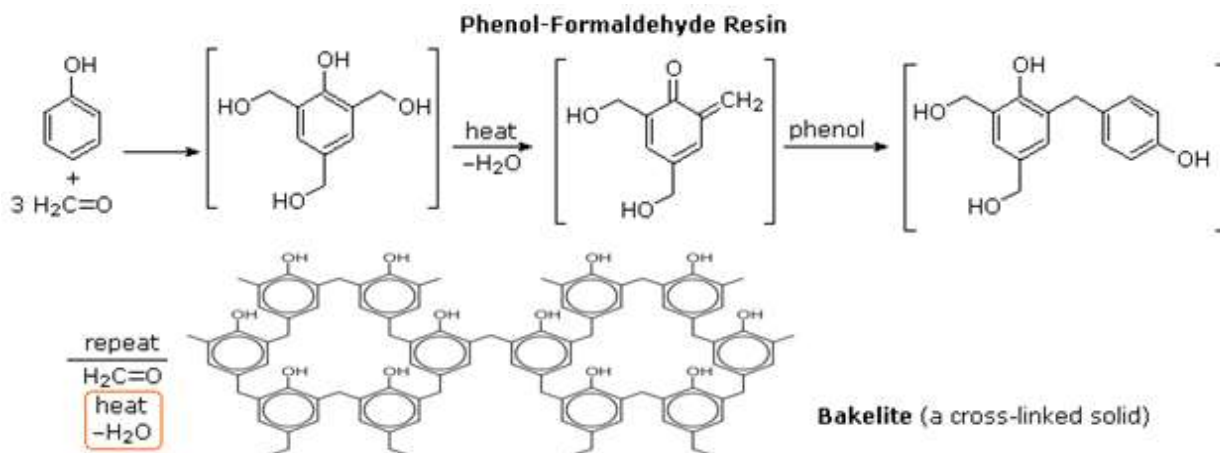
- wirings and cables
- bottles for drinks, oils, cosmetics, detergents
- building and construction (window frames), floorings, pipes for drainage
- coated fabrics
- films and sheets
- vinyl records

Preparation: This is an example of addition polymerization. PVC is made by free-radical polymerization (in the form of emulsion) in the presence of benzoyl peroxide as catalyst under pressure.



2. Bakelite (Phenol-Formaldehyde Resin)

Preparation:



Use:

- Bakelite is used for the emerging electrical and automobile industries because of its extraordinarily high resistance – not only to electricity, but to heat and chemical, such as bases and sockets for light bulbs and vacuum tubes, supports for electrical components, automobile distributor caps and other insulators.
- Bakelite is used today for wire insulation, brake pads and related automotive components, and industrial electrical-related applications. It is used in myriad applications including saxophone mouthpieces, whistles, cameras, solid-body electric guitars, telephone housings and handsets, early machine guns, pistol grips, and

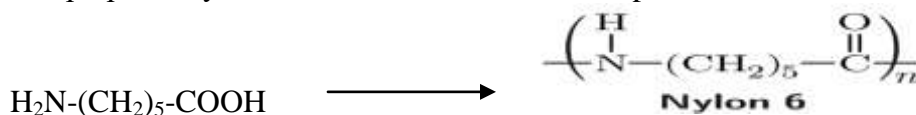
appliance casings. In the pure form it was made into such articles as pipe stems, buttons, etc.

Fibers: Preparation and uses:

3. **Thermoset-Nylon 6:** Nylon 6 is a synthetic fiber having a polyamide functional group.

Preparation:

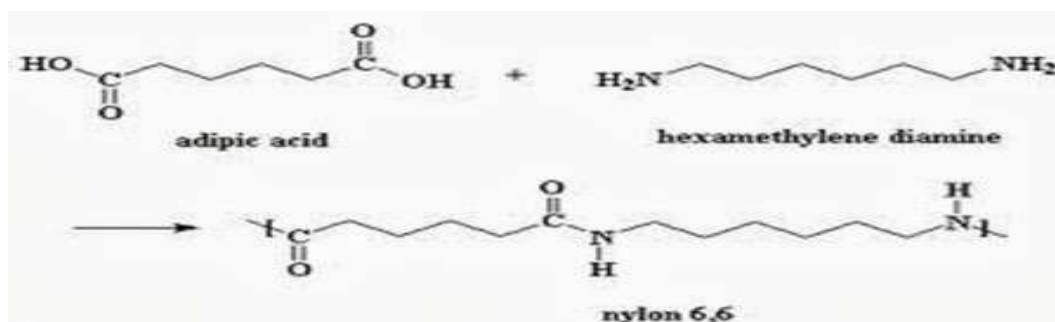
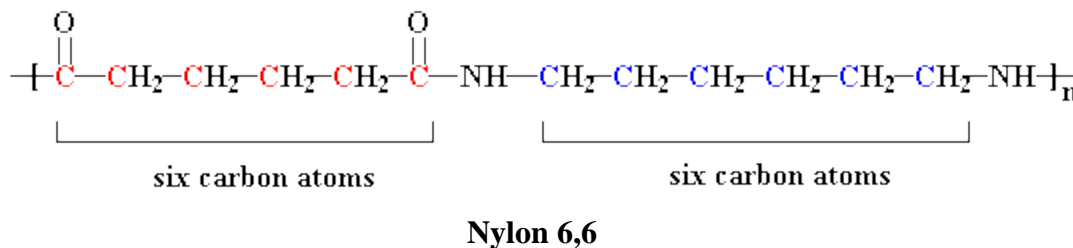
- a. It is prepared by self condensation of ϵ -amino caproic acid



- b. or by ring opening of caprolactam



4. **Thermoset-Nylon 6,6:** It is made by the condensation polymerization of hexamethylene diamine and adipic acid.



Uses:

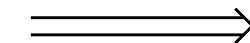
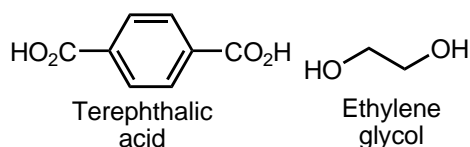
- Nylon 6 and Nylon 6,6 are used primarily as fibres in making socks, undergarments, carpets etc.
- Used in making hair combs.
- Nylon 6 is used mainly for making tyre cords.

- d. Nylon 6, 6 is used in making gears, bearings etc.
- e. Nylon 6, 6 is used for jacketing electrical ware to provide tough abrasion resistant outer cover to protect the primary electrical insulation.

2. Thermoset-Polyethylene Terephthalate (PET) (also known as Terylene or Decron)

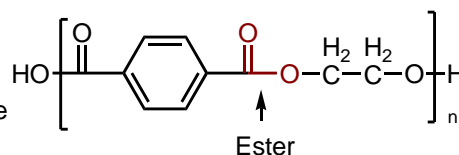
It is polyester, prepared by heating dimethyl terephthalate and ethylene glycol in basic medium.

Monomer



Poly(ethylene terephthalate)

Polymer



Uses:

- a. It is used for making magnetic recording tapes.
- b. It is used for making bottles for Cola drinks, fruit juice, sauces etc.
- c. It is used for making wide necked jars for coffee.
- d. It is used for making films of overhead projector.
- e. Glass filled PET moldings are used for housings for toasters, coffee machines, car heaters and water meter.

Conducting Polymers

Most organic polymers are insulators by nature. However, certain polymers can conduct electricity and hence known as conducting polymers.

The first polymer with significant conductivity synthesized was polyacetylene (polyethyne). Its electrical conductivity was discovered by Hideki Shirakawa, Alan Heeger, and Alan MacDiarmid who received the Nobel Prize in Chemistry in 2000. They synthesized this polymer for the first time in the year 1974 when they prepared polyacetylene as a silvery film from acetylene, using a Ziegler-Natta catalyst. Despite its metallic appearance, the first attempt did not yield a very conductive polymer. However, three years later, they discovered that oxidation with halogen vapor produces a much more conductive polyacetylene film. Its conductivity was significantly higher than any other previously known conductive polymer. This discovery started the development of many other conductive organic polymers.

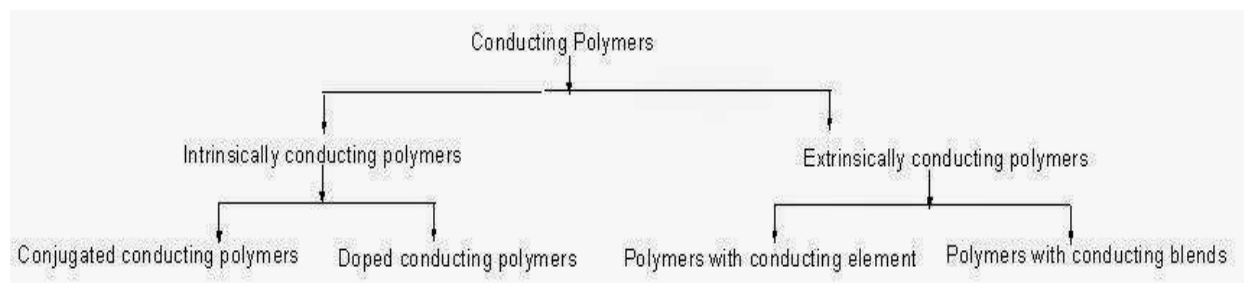
Characteristics of Conducting Polymers

Conducting polymers are organic in nature and are generally not thermoplastic i.e they cannot be thermo formable. Also, they usually do not exhibit similar mechanical properties like other commercially available polymers. Some of the advantages of conducting polymers are that they can be used in place of metals and exhibit lighter weight. Such polymers do not corrode as compared to metals.

Examples are polyaniline and polypyrrole

Classification of Conducting Polymers

Conducting polymers can be classified as:



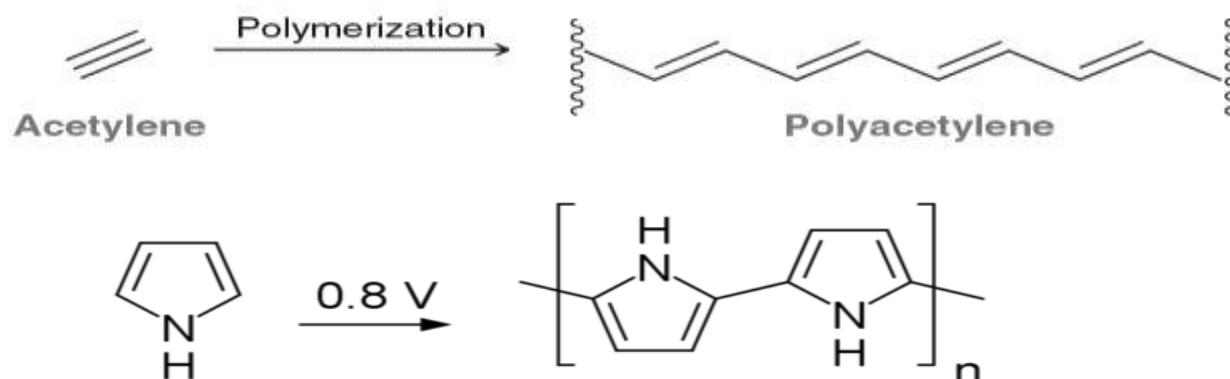
Intrinsically conducting polymers(ICP)

a. Conjugated ICP

Such polymers have extensive conjugation (alternate single and double bond) or aromatic rings (phenylene, naphthalene, anthracene, pyrrole, and thiophene) in the backbone of the polymer chain.

The conductivity of conjugated polymers such as polyacetylene is due to the existence of a conducting band similar to a metal. In a conjugated polymer like polyacetylene, three of the four valence electrons form strong σ bonds through sp^2 hybridization; such electrons are strongly localized. The remaining unpaired electron of each carbon atom remains in a p_z orbital. It overlaps with a neighboring p_z orbital to form a π bond. The π electrons of these conjugated p_z orbitals overlap to form an extended p_z orbital system through which electrons can move

freely (delocalization of π electrons). The overlapping results in the formation of valence bands as well as conduction bands; both of which are separated by a significant band gap. Electrical conduction can occur only after thermal or photolytic activation of electrons to give them sufficient energy to jump the gap and reach the conduction band.



b. Doped conducting polymers

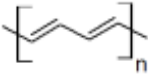
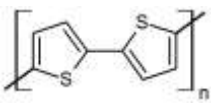
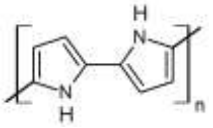
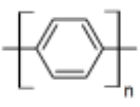
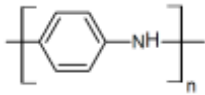
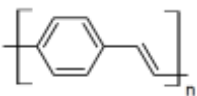
Non-doped polymers as explained above have a rather low electrical conductivity. Only when an electron is removed from the valence band by oxidation (p-doping) or is added to the conducting band by reduction (n-doping) does the polymer become highly conductive. The four main methods of doping are

- **Redox p-doping:** Some of the π -bonds are oxidized by treating the polymer with an oxidizing agent such as iodine, chlorine, arsenic pentafluoride etc.
- **Redox n-doping:** Some of the π -bonds are reduced by treating the polymer with a reducing agent such as lithium, and sodium naphthalene
- **Electrochemical p- and n-doping:** Doping is achieved by cathodic reduction (p) or by anodic oxidation (n)
- **Photo-Induced Doping:** The polymer is exposed to high energy radiation that allows electrons to jump to the conducting band. In this case, the positive and negative charges are localized over a few bonds.

Doping increases the conductivity by many orders of magnitude. Values of conductivity to as high as $10^2 - 10^4$ S/m has been reported. In the case of polyacetylene, conductivities as high as 10^5 S/m have been found which is still several magnitudes lower than the conductivity of silver and copper (10^8 S/m) but more than sufficient for electronic applications such as polymer-based transistors, light-emitting diodes and lasers.

The table below lists typical conductivities of some common conjugated polymers and their repeat units. The actual conductivity not only depends on the structure and morphology of the polymer but also on the type of dopant and its concentration.

ELECTRICAL CONDUCTIVITY OF SOME CONDUCTIVE POLYMERS

Compound	Repeating Unit	Conductivity (S cm ⁻¹)
trans-Polyacetylene		$10^3 - 10^5$
Polythiophene		10^3
Polypyrrole		$10^2 - 7.5 \cdot 10^3$
Poly(p-phenylene)		$10^2 - 10^3$
Polyaniline		$2 \cdot 10^2$
Poly(p-phenylene vinylene)		$2 \cdot 10^4$

Extrinsically conducting polymers

The conductivity of these polymers is due to the addition of external ingredients. These are of two types:

a. Conductive element filled polymer:

When carbon black, metallic fibers, metallic oxides are added, the polymer becomes conducting. Such polymers possess reasonable conductivity, are generally low in cost, light in weight, mechanically durable and strong. They can be easily processed in different forms, shapes and sizes. These polymers are used in hospital operating theatres where it is essential that static charges do not build up and help in avoiding explosion involving the use of aesthetics.

b. Blended Conducting polymers

Such polymers are obtained by blending a conventional polymer with a conducting polymer. These polymers possess better physical, chemical, electrical and mechanical properties and can be easily processed. These are used in electromagnetic shielding.

Application of Conducting Polymers

Conducting polymers have many uses. The most documented are as follows:

- In rechargeable batteries
- In analytical sensors for pH, NO_x, SO₂, NH₃ and glucose
- In electrochromic displays and optical filters (windows with adjustable frequencies)
- In electronics: Transistors, Light Emitting Diodes (LEDs), Lasers used in flat televisions, Solar cells, Displays in mobile telephones and mini-format television screens
- anti-static substances for photographic film
- Corrosion Inhibitors
- Compact Capacitors
- Anti Static Coating
- Electromagnetic shielding for computers ("Smart Windows")
- In photovoltaic devices

Biodegradable Polymers

Polymers which get decomposed by biological processes in the presence of bacteria or fungi are known as biodegradable polymers. Traditional non-biodegradable polymers cannot be degraded, hence are not environmentally friendly as they cannot be disposed off. Disposal of such polymeric materials in land can cause litter problems and when disposed off in water bodies can result in causing hazards to marine life.

Types of Biodegradable Polymers

- a. Natural Biodegradable Polymers: Natural Rubber, collagen, lignin etc
- b. Synthetic Biodegradable Polymers: Polyvinyl alcohol, polylactic acid etc.

Applications of Biodegradable Polymers

- a. Poly (β -hydroxy butyrate) or PHB is used in the manufacture of shampoo bottles
- b. β -hydroxy butyrate- β -hydroxy-valerate are suitable as matrices for controlled release of drugs due to their favorable biocompatibility and biodegradation properties. It is also used as a packaging material, in orthopaedic devices etc.
- c. Poly (lactic acid) or PLA is used widely in medical applications like sutures, drug delivery systems and wound clips. It is also used in some agricultural applications like "timed-release coatings for fertilizers and pesticides"
- d. Dextron is the 1st bioabsorbable suture made from biodegradable polyester for post operative stitches