Biopolymers

- **Biopolymers** are polymers produced by living organisms, in other words they are polymeric biomolecules

- Since they are polymers, biopolymers contain monomeric units that are covalently bonded to form larger structures.

- There are three main class of biopolymers according to their monomeric units used and the structure of biopolymers formed - Protein and polypeptide, polynucleotides, and polysaccharides.

- In biological system, proteins have many roles including use as protective or supportive molecules in animals, as catalyst substrates, as oxygen transporting molecules and as regulators of chemical reactions in cells.

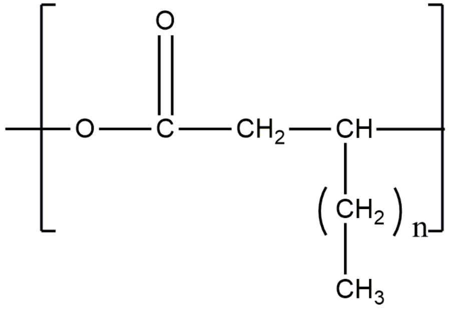
- Polynucleotide control such important functions as information storage and transfer, cell replication and protein synthesis in living systems.

- The role of polysaccharides is primarilyas skeletal reinforcement in plants and energy storage in both plants and animals.

Proteins
Polynucleotides
Polysaccharides
Cellulose
starch

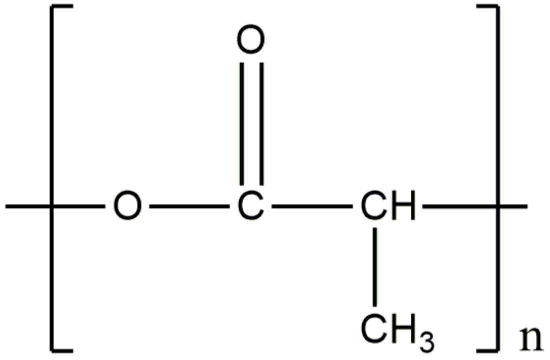
Biodegradable Polymers

Virtually no plastic is totally biodegradable.
In fact most polymers, including polyamides, polyfluorocarbons, polyethylene, polypropylene and poly carbonate are highly resistant to microbial attack.
Among synthetic polymers, polyurethanes are susceptible to biological degradation.
In general naturally occurring polymers are more biodegradable than synthetic polymers.
Polymers containing an aliphatic ester functionality may be biodegradable.
Biodegradation of these polymers proceeds by attack of ester groups by enzymes produced by ground micro organisms, combined with hydrolytic attack. Products of the degradation can be quickly metabolized by microorganisms.
One commercially important group of biodegradable polymer is the naturally occurring polyesters, the poly(beta hydroxyalkanoates) whose general structure is



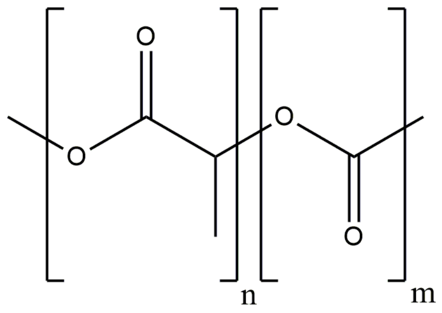
Due to their biodegradability polyhydroxy alkanoates have commercial importance as biomaterials as well as disposable plastic packaging materials. An example is polyhydroxybutyrate (PHB, (n=0). PHB is brittle polymer that is 100% isotactic and highly crystalline(65% to 85%)

Another important biodegradable polyster is PLA (Poly lactic acid)

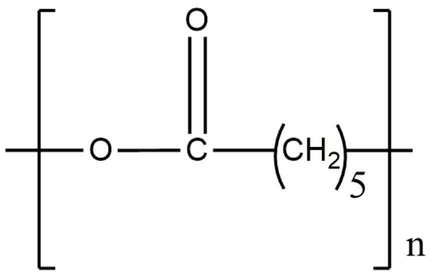


PLA can be polymerized from lactic acid produced from corn or rice dextrose. The lactic acid is converted into lactide- a ring compound that is opened and polymerised to make PLA.
It is used for making fibres and packaging.
PLA has good processability, high tensile strength, high odour barrier, important for food packaging and resistant to grease,fats and oils.
An advantage of PLA is that it degrades to lactic acid that can be metabolized in the body.
Therefore it find important use in biomedical applications.

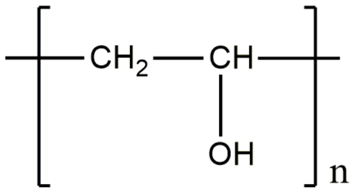
Another important biodegradable co popymer is poly(lactide-co-glycolide) PLGA



PLGA can be obtained from the coplymerisation of lactide and glycolide
At composition from about 25% to 75% GA, PLGA is amorphous and suitable for use in drug delivery systems.
Other two important biodegradable synthetic polymers are polycaprolactone(PCL)-Polyester. Polyvinyl alcohol and cellulose and cellulose derivatives.



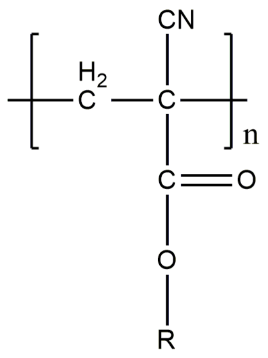
PCL



polyvinyl alcohol

Polymers used in medical field

- ✓ Defective heart valves can be replaced by synthetic valves made of silicone rubber.
- ✓ The advantages of silicone rubber are its inertness, elasticity and low capacity to cause blood clotting.
- ✓ Balloon like expansion of arterial wall (Aneurism) can be replaced by reinforcement of the artery with a tube of woven polyester or poly tetrafluoroethylene fabric.
- ✓ Teflon is relatively non interactive with blood.
- ✓ Silicon rubber and polyurethanes are used for making artificial heart pumps.
- ✓ Synthetic polymer can be used to glue tissues together .the use of adhesive would be much more rapid and effective than the sewing of a wound with suture. Poly alpha cyano acrylates are used for this purpose.



R can be methyl, butyl, hexyl. octyl ...

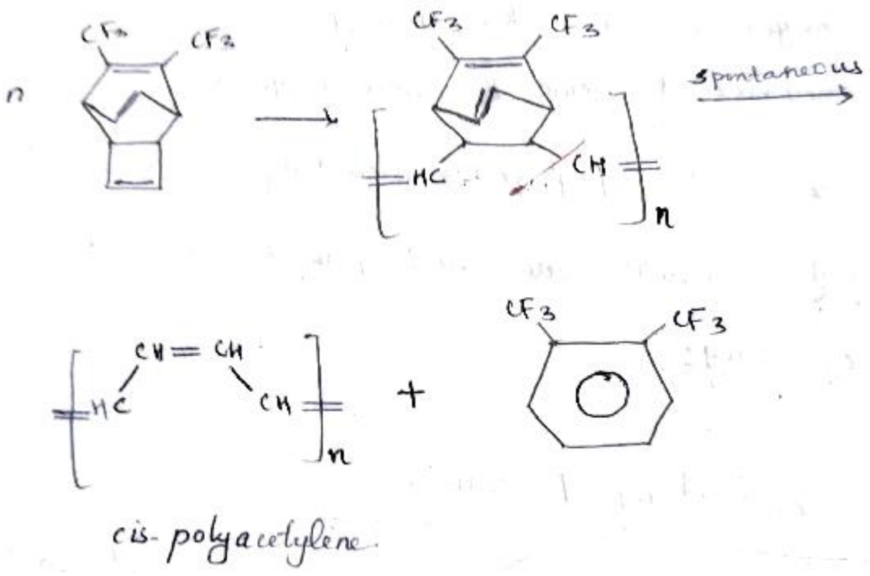
In addition to their use as skin sdhesives, they have been used as adhesives in corneal and retinal surgery

- ✓ Synthetic polyaminoacid films are used as synthetic skin to cover large burns.

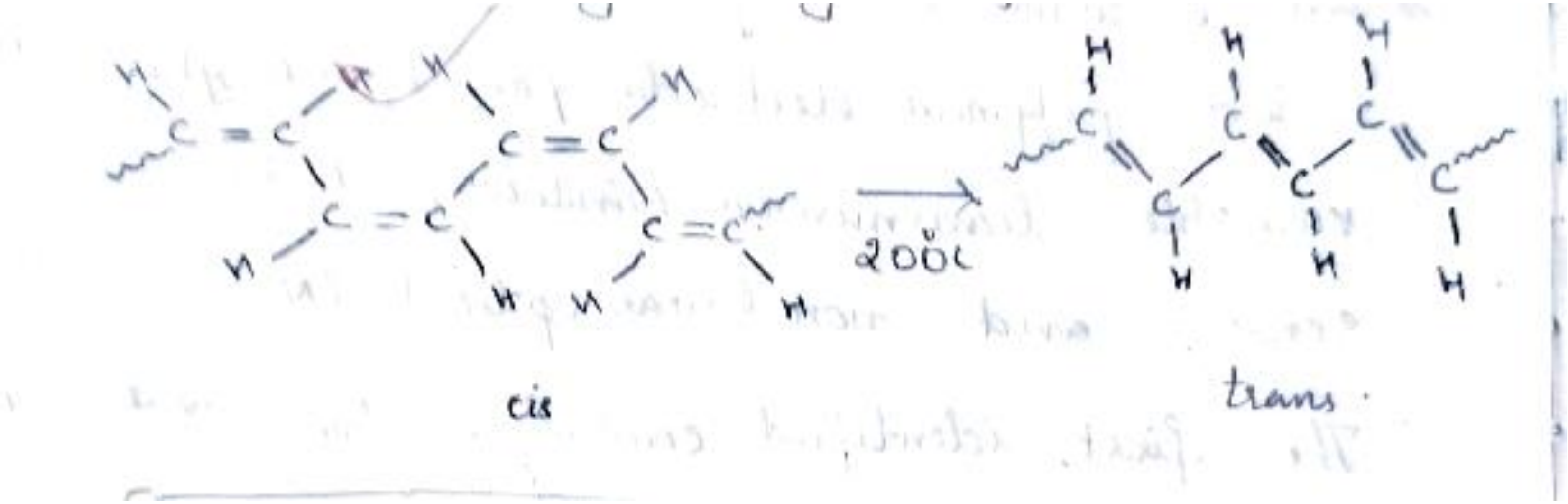
- ✓ Bone fractures are repaired with polyurethanes, epoxy resins and vinyl resins.
- ✓ Silicone rubber rods are used for the replacement of finger and wrist joints and vinyl polymers and nylon have been used for replacement of wrist bones or elbow joints.
- ✓ Cellophane and silicone rubber have been used in knee joints to prevent fusion of the bones.
- ✓ PMMA is used for making teeth
- ✓ Polydimethyl siloxane which has excellent transparency is used for making contact lenses.
- ✓ Cellophane (regenerated cellulose) is used for semipermeable dialysis membranes in synthetic kidney machines.
- ✓ A number of polymers including poly glycolic acid and polyanhydrides are used for the controlled release of drugs.

Conducting polymers

- A number of polymers are electrically conductive or can be made to be conductive by doping with an electron donor or acceptor. Applications of such polymers include polymeric electrodes for light weight batteries variable transmission windows, electrochromic displays sensors and non linear optical (NLO)materials.
- The first identified conductive polymer was polyacetylene(PAC)
- Other polymers in this class include poly-P-Phenylene(PPP), Polypyrrole (PPy)etc.
- Poly acetylene with molecular weight upto one million can be prepared through a complicated process called Durham process as illustrated below.

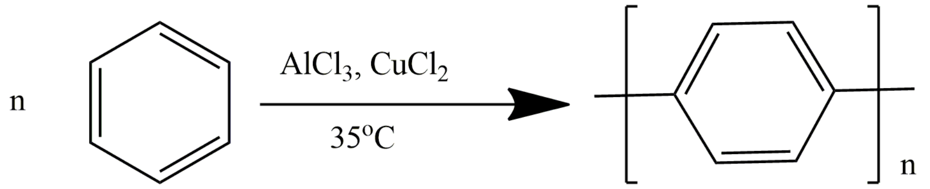


The Cis isomer can be transformed to the more stable trans isomer by heating as follows



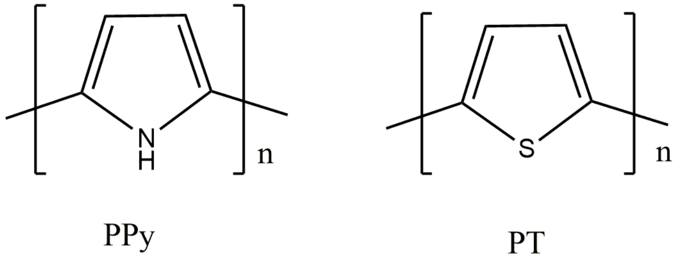
The trans isomer has the higher conductivity (4.4x10-5Scm-1) than the cis isomer (1.7x10-9Scm-1) . Conductivity is greatly increased by doping addition of AsF5 increases conductivity to 400Scm-1. PAC has good thermal stability however it is easily oxidised. It found applications in solar cells and batteries.

Poly(paraphenylene) (PPP) can be prepared by Friedel craft polymerisation of benzene.



PPP can be converted from an electrical insulators to a highly conductive charge transfer complex by doping with strong electron donors or acceptors.

Polypyrrole (PPy) and polythiophene (PT)are similar in structure and properties.



PPy is obtained by the electropolymerisation of pyrrole as a highly colored, dense conducting film. Unlike polyacetylene, polypyrrol can be synthesised in the doped form and very stable in air. But their conductivities are lower than that of polyacetylene.

High temperature and fire resistant polymer

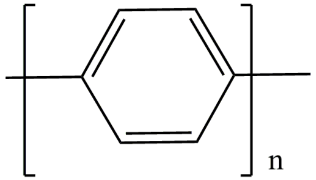
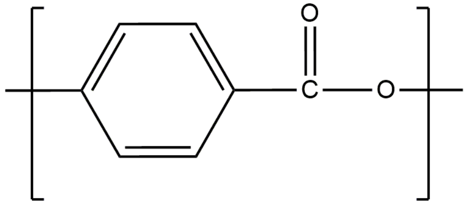
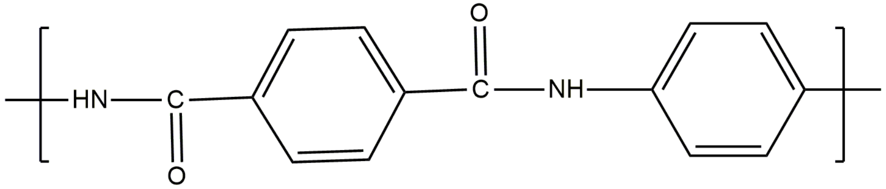
- Generally polymeric materials are not stable at high temperature and decompose. However some polymers can withstand hightemperature and these thermally stable polymers are useful in aeronautic and aerospace industries. Some requirements of thermally stable polymers are

a) It should have high melting point and degree of crystallinity.

a) It should have structural features that do not allow degradation by low energy process.

a) It should posses high bond dissociation energy.

Examples of high temperature polymers and their decomposition temperature are given below

Polymer	Structure	Decomposition temperature(Td)
Poly (p-phenylene)		660^{oC}
Aromatic polyester		480^{oC}
Polybenzamide		500^{oC}

Thermal stability after results from aromatic rings in the chain which impart rigidity, high bond energy and low degree of reactivity.

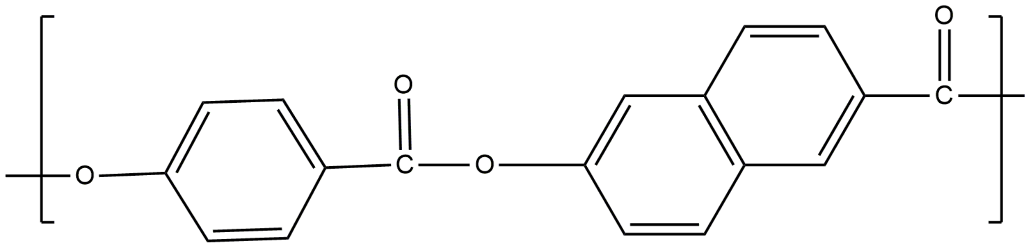
Liquid Crystalline Polymers

The molecules in a crystalline material have a restricted mobility which maintains a degree of order compared to a true liquid. This results to anisotropy.

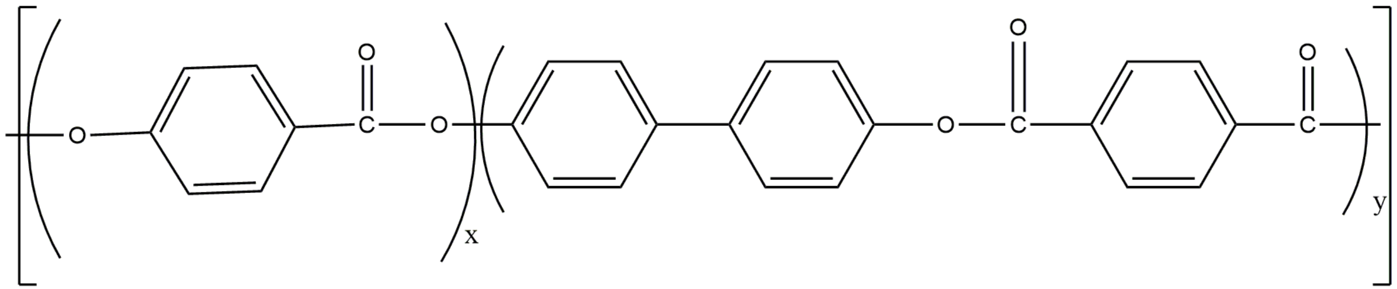
polymeric materials possessing liquid crystalline (LC) behaviour are called liquid crystalline polymers.

The best known example of liquid crystal polymer is that of an aromatic polyamide, Kevlar

Other examples are liquid crystal polyesters with highly aromatic structures such as Vectra.



and Xydar



It is made from the polycondensation of P-hydroxy benzoic acid (HBA) , P,P’-biphenol and terephthalic acid
The high cost of liquid crystalline polyester has limited these resins to specially applications as electronic components (eg: computer memory modules), light wave coductors a variety of aerospace applications and filaments

Polymers used as Adhesive and coatings

- ✓ Adhesives, any substance often natural or synthetic polymers that are capable of holding materials together in a functional manner by surface attachment that resists separation.
- ✓ The adhesives often work on the principle that they form either primary covalent bond or interact with the surface through physical forces.
- ✓ There are several types of adhesives.
- ✓ Solvent based adhesives are dissolved in solvent and the solvent is then allowed to evaporate in the presence of surface to be glued.
- ✓ Latex adhesives give a flow and good surface contact on evapouration of water from a water based latex.
- ✓ Important and highly effective adhesives are reactive adhesives which are low molecular weight liquid polymers and solidify due to the cross linking.
- ✓ Cyano acrylates, phenolic resins, silicones, epoxy polymers and unsaturated polyesters are some exapmle of reactive adhesives

Coatings

The fundamental purpose for coating is for protection. A coating is normally a mixture of various components. In latex emulsion type paint the major components are poly methyl methacrylate, TiO_2 as the white pigment and water.

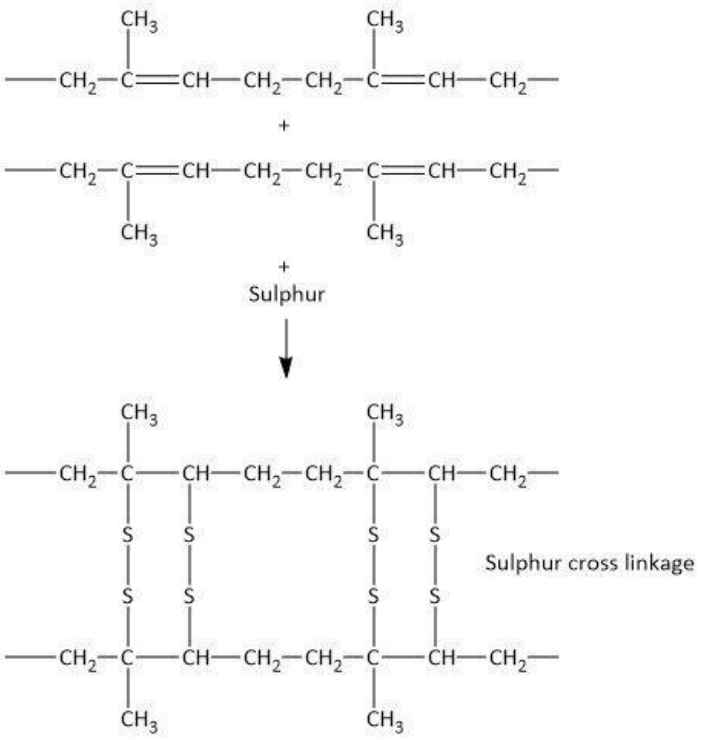
polymeric coatings are coatings or paint made of with polymers that provide superior protection from corrosion. Examples of polymeric coatings include

- ✓ Natural and synthetic rubber
- ✓ Urethane
- ✓ polyvinyl chloride
- ✓ Acrylic, epoxy, silicone
- ✓ phenolic resins
- ✓ nitrocellulose

Polymer coatings can be applied to metals, ceramics as well as synthetic materials. They are temperature resistant upto approax.535F(280 degree C) and FDA approved and are therefore used primarily for food production(example: containers, multi-head scales, frying pans)

Vulcanisation of Rubber

Vulcanization is a chemical process in which the rubber is heated with sulphur, accelerator and activator at 140–160°C. The process involves the formation of cross-links between long rubber molecules so as to achieve improved elasticity, resilience, tensile strength, viscosity, hardness and weather resistance.



- Vulcanization, chemical process by which the physical properties of natural or synthetic rubber are improved; finished rubber has higher tensile strength and resistance to swelling and abrasion, and is elastic over a greater range of temperatures.

- Vulcanization gives rubber its characteristic elastic quality. This process is carried out by mixing the latex with sulphur (other vulcanizing agents such as selenium and tellurium are occasionally used but sulphur is the most common) and heating it in one of two ways.

- Natural rubber is soft and sticky. Vulcanized rubber is hard and non-sticky. Similarly natural rubber has low tensile strength. vulcanized rubber has high tensile strength.

Environmental hazards of plastics and recycling

- ✓ Plastic pollution involves the accumulation of plastic products in the environments that adversily affects wildlife, wildlife habitat, or humans.

- ✓ Plastics that act as pollutants are categorized into micro, meso or microdebis based on size.

- ✓ The important cause of plastic pollution is correlated with plastics being inexpensive and durable which results to high levels of plastics used by humans. However, it is slow to degrade. plastic pollution can unfavorably affect lands, waterways and oceans.

- ✓ Living organisms, particularly marine animals can also be affected through direct ingestion of plastic waste or through exposure to chemicals within plastics that cause interruption in biological functions.

- ✓ Humans are also affected by plastic pollution, such as through the disruption of the thyroid hormone or hormone levels.
- ✓ In uk alone, more than 5 million tonnes of plastics are consumed each year. Of which an estimated more 24% makes it into recycling systems. That leaves a remaining 3.8 million tonnes of waste, destined for landfills.

- ✓ Plastic reduction efforts have occurred in some areas attempts to reduce plastic consumption and pollution and promote plastic recycling.

- ✓ Plastic recycling is the process of recovering scrap or waste plastic and reprocessing the material into useful products. Since plastic is non-biodegradable recycling it is a part of global efforts to reduce plastic in the waste stream, especially approximately eight million matrix tonnes of waste plastic that enter the earths ocean every year. This helps to reduce the high rate of plastic pollution.

- ✓ Plastic recycling includes taking any type of plastic sorting it into different polymers and then chipping it and then melting it down into pellets after their stage it can then be used to make items of any kind such as plastic chairs and tables.

- ✓ Soft plastics are also recycled such as polyethylene film and bags

- ✓ Plastic recycling is often more challenging because of low density and low value.

- ✓ Another barrier to recycling is the widespread use of dyes, fillers and other additives in plastics.