

**Thermosetting plastics:**

- Thermosetting polymers become permanent hard when heat is applied and do not soften upon subsequent heating.
- Thermosetting polymers have a similar structure as the thermo plastics before heating, but cross linking occurs during heating. This result in a three dimensional giant molecule.
- Thermo setting polymers cannot be remoulded or reshaped.
- Thermo setting polymers are very harder, stronger and more brittle than thermo plastics.
- Dielectric strength is high.
- Thermo sets possess lower ductility and poor impact properties.
- Recycling is not possible.
- Fabrication is expensive.

**E.g. Phenol formaldehyde, Urea formaldehyde, Nylon, etc.,**

*(What are elastomers?)*

**Elastomers:**

- They have large characteristic ability to undergo large elastic deformations without rupture.
- They are soft, and they have a low elastic modulus.

**4.3 COMMODITY POLYMERS: (What are commodity polymers?)**

- They are mostly widely used polymers.
- They are light weight polymers with low strength and stiffness and not suitable for high temperature uses.
- These polymers are inexpensive and can be readily formed into a variety of shapes ranging from plastic bags to bath tubs.

**4.4 ENGINEERING POLYMERS: (What are Engineering polymers?)**

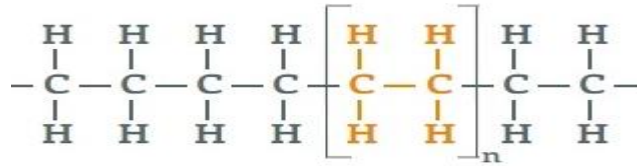
- The polymers that are designed to give improved strength, greater environmental resistance, better performance at elevated temperature are called engineering polymers.
- These materials are produced relatively in small quantities and are more expensive.

## 4.5 PROPERTIES AND APPLICATION OF POLYMERS:

(Explain the characteristics & applications of PE, PP, PS.)

### 1. Polyethylene(PE)

- Polyethylene (PE) is a thermoplastic material.
- Trade name is Fortiflex.
- The monomer is ethylene.
- It is a commodity plastic.
- It is available in different crystalline structures, as HDPE, LDPE, and LLDPE.
- It is produced by addition or radical polymerization.
- It is used in making of plastic containers, bottles, bags, plastic toys, etc.



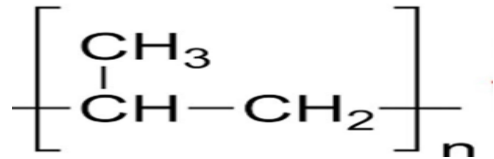
Molecular Structure of Polyethylene

### Characteristics & applications of the types of polymers:

	LDPE	LLDPE	HDPE
<b>Polymer Full Name</b>	Low Density Polyethylene	Linear Low Density Polyethylene	High Density Polyethylene
<b>Characteristics</b>	Flexible and good transparency Good moisture barrier properties High impact strength at low temperature Excellent resistance to acids, bases and vegetable oils	As compared to LDPE, it has: higher tensile strength higher impact and puncture resistance	Excellent Chemical Resistance High tensile strength Excellent moisture barrier properties Hard to semi-flexible
<b>General Applications</b>	Shrink wrap, films, squeezable bottles garbage bags, extrusion moldings, and laminates	High performance bags, cushioning films, tire separator films, industrial liners, elastic films, ice bags, bags for supplemental packaging and garbage bags	injection moldings or flat yarns, hollow plastic products and pipes

## 2. PP (Polypropylene)

- Polypropylene (PP), also known as polypropene.
- Trade name is Fortilene.
- The monomer is propylene.
- It is a thermoplastic polymer.
- It is produced via chain-growth polymerization.



**Structure of PP**

### Characteristics of PP

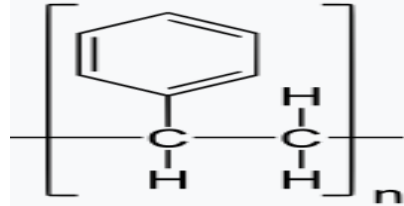
- Semi-rigid.
- Translucent.
- Good chemical resistance.
- Tough.
- Good fatigue resistance.
- Good heat resistance.
- Higher strength and stiffness.
- Low cost.
- Light weight.
- Poor resistance to ultra violet sun lights.
- Good surface hardness.
- Brittle at low temperatures.

### Applications

1. making of,
  - plastic furniture
  - low friction applications, such as gears in machinery and vehicles.
2. packaging for,
  - cleaning products
  - bleaches and
  - first-aid products
3. medical applications include,
  - syringes
  - medical vials
  - Petri dishes
  - pill containers
  - specimen bottles

### 3. Polystyrene (PS)

- The trade name is Styron.
- Polystyrene is a synthetic aromatic hydrocarbon.
- the monomer is styrene.



Structure of PS

#### Characteristics of PS:

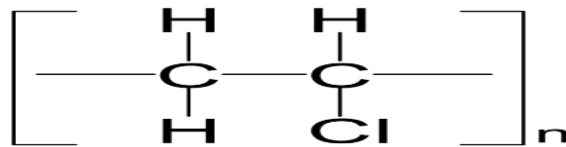
- Excellent mouldability.
- Good electrical, heat and strain resistance.
- Poor chemical resistance.
- Poor corrosion resistance.
- Good dimension stability.
- Hard and brittle.

#### Applications:

- Used for low-cost transparent mouldings such as CD cases, ball point pens, disposable food containers, lighting panels, toys, battery cases,
- rigid foams used for thermal insulation, automobile parts, radio/TV components.

### 4. Polyvinyl chloride (PVC):

- The trade name is Saron,
- It is a thermoplastic plastic.
- The monomer is vinyl chloride.



Structure of PVC

#### Characteristics of PVC:

- Strong and brittle.
- Low cost.
- Good flame, electrical, chemical, oil and weather resistance.

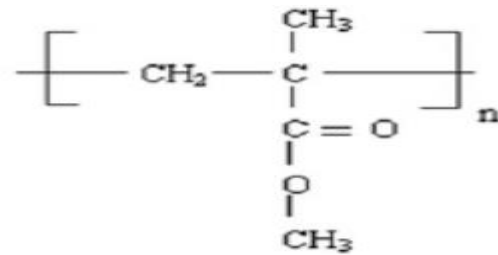
#### Applications:

- Pipes, valves, floor tiles, fittings, toys, wire insulations, safety glass etc.

*(Describe the properties & applications of PMMA & PET)*

### 5. PMMA: (Polymethyl-methacrylate)

- Trade Name is Perplex.
- Polymethyl-methacrylate (PMMA) is a transparent thermoplastic.
- It is used in sheet form as a lightweight or shatter-resistant alternative to glass, Lucite, Flexi glass, Acrylite.



**Poly (methyl metacrylate)**

#### Properties:

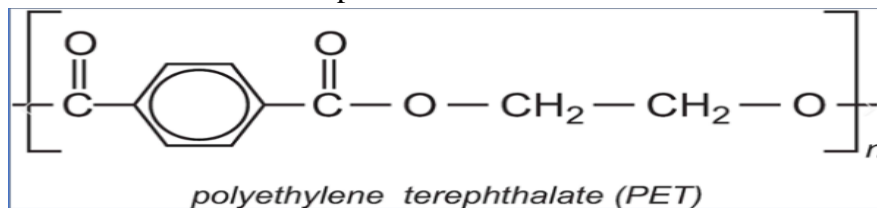
- Good strength and rigid.
- High hardness.
- Tend to absorb heat.
- It can be readily coloured.
- Used for decorative purposes.
- Good chemical resistance.

#### Applications:

- Used as lenses in cameras, flash-lights, safe glasses, guards, pumps, pipes, covers, weather proof coatings.

### 6. PET (Polyethylene Terephthalate):

- Trade name: Polyester, Dacron.
- most common thermoplastic resin.



#### Properties

- Good strength.
- High stiffness thermoplastics.
- Good fatigue strength.
- Good mechanical and electrical properties.
- Good resistance to humidity, acids, greases, oils and solvents.

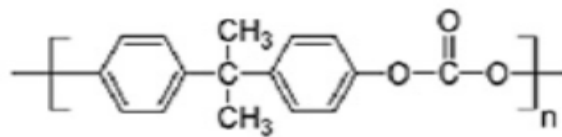
- They are produced as fibers, as transparent films and as moulding materials.

#### Applications:

- Fibers for clothing, films for photography, recording tapes, containers, bottles, auto parts, gears etc.,

#### 7. PC (Poly Carbonates):

- Trade names: Lexan, Merlon.
- Polycarbonate is a transparent thermoplastic.
- Polycarbonate is the leading plastic material for various high functioning temperatures and safety features.



#### Properties:

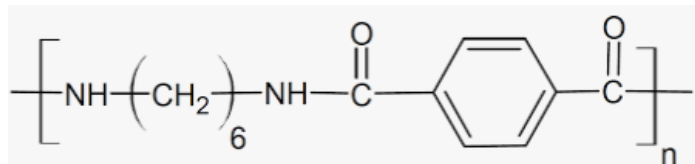
- High melting temperature.
- Low flammability.
- Good chemical resistance.
- High tensile strength.
- Good heat resistance.
- Good mould ability.
- High dimensional stability.
- Low fatigue and wear resistance.

#### Applications:

- Safety helmets, lenses, cams and gears, automotive parts like dash boards, casings, head lamp moldings, medical components and kitchen wares.

#### 8. PA (Polyamides):

- Trade name: Nylon
- It is a synthetic polymer made by the linkage of an amino group of one molecule and a carboxylic acid group of another.



**Properties:**

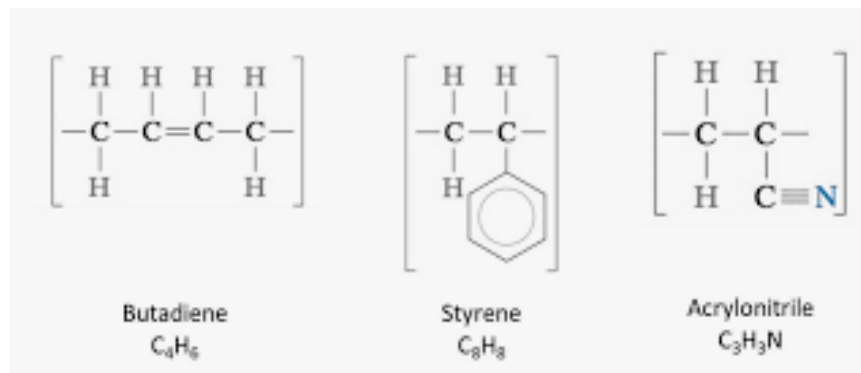
- Very strong and tough.
- High impact strength.
- Flexible.
- High softening temperature.
- Good mechanical properties.
- Low surface friction.
- Good abrasion resistance.
- High lubricity.

**Applications:**

- Rope, soles for footwear, textiles for clothing and carpets, gears, cams, bearings, automobile speedometers, wiper gears, electrical applications.

**9. ABS (Acrylonitrile butadiene styrene): (Explain the properties & applications of ABS.)**

- Trade Names: Lustron, Abson
- Acrylonitrile Butadiene Styrene is a terpolymer, composed of three different monomers.
- This amorphous blend is made up of acrylonitrile, butadiene, and styrene in varying proportions.
- acrylonitrile provides chemical and thermal stability,
- butadiene increase toughness and impact strength,
- styrene gives the plastic a nice and glossy finish.

**Properties:**

- Good strength and toughness.
- Good electric properties.
- Heat Resistant.
- Flammable and soluble in some organic solvents.

**Applications:**

- Telephone receivers, helmets, computer housings, automobile parts, Domestic cleaners and mixers, bathroom fittings etc.

**10. PAI (Polyamide Imide)**

- Trade Names: Udel
- Polyamide-imides are either thermosetting or thermoplastic, amorphous polymers that have exceptional mechanical, thermal and chemical resistant properties.
- Polyamide-imides are used extensively as wire coatings in making magnet wire.

**Properties:**

- High strength polymers.
- High temperature.
- High expensive.

**Applications:**

- Hot water system valves, electrical connectors, circuit boards, components for gas turbine and spark ignition engines.

**11. PPO (Polyphenylene Oxide):**

- Trades Names: Noryl.
- Polyphenylene Oxide is a high-temperature thermoplastic.
- It is rarely used in its pure form due to difficulties in processing.
- It is mainly used as blend with polystyrene, high impact styrene-butadiene copolymer or polyamide.

**Properties:**

- High rigidity.
- Heat deflection temperatures.
- Good strength.
- High impact strength.
- Low water absorption rate.
- Have poor processing characteristics.
- Good dimensional stability.

**Applications:**

- Computer housings, TV tuners, electrical connectors, Automobile components.



## 12. PPS (Polyphenylene Sulphide):

- Polyphenylenesulfide (PPS) is an organic polymer consisting of aromatic rings linked by sulfides.
- Synthetic fiber and textiles derived from this polymer resist chemical and thermal attack.
- PPS is used in filter fabric for coal boilers, papermaking felts, electrical insulation, film capacitors, specialty membranes, gaskets, and packings.

### Properties:

- High rigid and strong.
- Highly crystalline material.
- Good chemical resistant material.
- Used for electrical applications.
- High strength.

### Applications:

- Chemical processing equipment, gear type pumps, pipes, valve fittings and coupling.

## 13. PEEK (Polyether ether ketone): *(Explain the properties & applications of PEEK & PTFE.)*

- PEEK is a semi crystalline thermoplastic with excellent mechanical and chemical resistance properties that are retained to high temperatures.

### Properties:

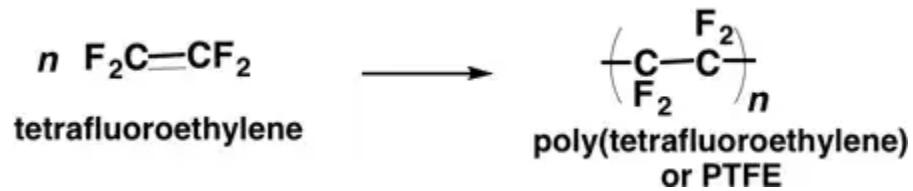
- High temperature plastics.
- High mechanical properties.
- Low flammability.
- Good fatigue and Chemical resistance.
- Avoid too many chemicals, hot water and low pressure stream.

### Applications:

- Electrical components, aircrafts and aerospace applications.

## 14. PTFE (Polytetra fluoroethylene):

- Trade Names: Poly Fluron, Teflon, Halon, Fluorothene.
- Polytetrafluoroethylene (PTFE) is a synthetic fluoropolymer of tetrafluoroethylene that has numerous applications.
- PTFE is a fluorocarbon solid, as it is a high-weight compound consisting wholly of carbon and fluorine.



**Properties:**

- Highly crystalline structure.
- Good electrical properties.
- Very low-coefficient of friction.
- Low tensile strength.
- Low creep resistance.
- High melting viscosity.

**Applications:**

- Coatings, anticorrosive seats, pipes, valves, bearings bushes, electronic parts.

**4.6 Properties & Applications of Thermosets**

*(Explain the properties & applications of Urea formaldehyde, phenol formadehyde and Nylon.)*

**1. Urea formaldehyde:**

- Urea-formaldehyde, also known as urea-methanal.
- It is a non-transparent thermosetting resin or polymer.
- It is produced from urea and formaldehyde.
- These resins are used in adhesives, finishes, particle board, medium-density fibre board (MDF), and molded objects.

**Properties:**

- Hard and rigid.
- Good strength and impact resistance.
- Good resistance to chemicals.
- Good electrical insulators.
- Variety of colours can be added.

**Applications:**

- Electrical wall plates, switches, circuit, breakers, handles, furniture, bottle caps, cups, plates etc.

## **2. PF (Phenol Formaldehyde) or Bakelite:**

- Phenol formaldehyde resins (PF) or Phenolic resins are synthetic polymers.
- They are obtained by the reaction of phenol with formaldehyde.
- They have been widely used for the production of moulded products including billiard balls, laboratory countertops, and as coatings and adhesives.

### **Properties:**

- High hardness.
- Good strength.
- Good heat and electrical properties.
- Low thermal conductivity.
- Good resistance to oils, grease etc.
- High temperature.

### **Applications:**

- Electrical plugs, sockets, switches, handles, automobile components, moulding process, grinding wheels.

## **3. Nylon:**

- Nylon is the most useful synthetic material with applications varying from daily life activities to industries.
- It is a plastic which can be drawn into fibres or moulded into daily products for making amenities.

### **Types of Nylon**

- Nylon 6
- Nylon 510
- Nylon 1,6
- Nylon 6,6 - widely used as fibres made from adipic acid and hexamethylenediamine.

### **Properties of Nylon**

- Lustrous
- Elastic
- Very strong
- Damage resistant to oil and many chemicals
- Resilient
- Does not absorb water
- Dries quickly