Unit 6
Paint, Varnishes, Insulators, Polymer, Adhesives and Lubricants

Course Outcome : Use relevant engineering materials in industry.

Unit Outcomes :

6a. Identify the ingredients of the given paints.
6b. Differentiate salient properties of the given paint and varnish.
6c. Describe the properties of insulating materials for the given applications.
6d. Differentiate the given types of structural polymers.
6e. Describe the polymerization process of the given polymer.
6f. Explain the properties and uses of the given polymer elastomer and adhesives.
6g. Describe the application of relevant adhesives required for the given material.
6h. Explain the properties of given type of lubricants.

Rationale: Polymer, Plastic, Resins are materials which have changed a world in 19 th century. Polymers are widely used in electronic, automobile sector, chemical industries, domestic applications.

Paint and Varnish protect the substrates like metaks, woods, plastic, ceramic ware, wall from environmental attack. They also provide asthetic and pleasent look.

Lubricant is a substance which reduces friction, heat and wear and tear when introduced between two moving surfaces. Using the correct lubricant helps to maximize the life of machinery there by saving money, time and manpower. Thus making operations more efficient and more reliable.

The knowledge of insulator is essential to keep us safe from the attack of heat, electricity and large sound. The insulators are the substances which prevent the transfer of heat, sound and electricity.

6.1. Paints

Significance: Paints and varnishes are widely used as materials for covering surfaces for decorative and protective purposes. The knowledge of paint and varnish helps the technologist to select proper painting material for the engineering applications. Increasing urbanisation in the developing as well as developed economics is positively affecting the paint and varnish market.

Paint is a mechanical dispersion mixture of one or more pigments in a vehicle.

A pigment is solid colouring material suspended in a liquid medium (vehicles, thinner) that on drying forms protective or decorative film on various surfaces. Paint dries up by oxidation, polymerization or evaporation of its components and gives a thin film which has considerable hiding power. Paint is used as a final finishing to any surface and also as a coating to protect and decorate the surfaces. Paint film is opaque so it is very useful to completely cover and hide the surface. Paint is available in different forms: oil based, cement based and water based.

6.1.1 Purposes of Applying Paint:

Paints are generally used for covering the metallic and non-metallic surfaces and also for the construction work. The main purposes of applying paint are as follows:

1) Paint protects the iron from corrosion and rusting.
2) Paint protects the iron from wear and tear.
3) Paint protects the wooden surfaces from insects and fungi.
4) Paint protects the wooden surfaces from moisture.
5) Paint reflects the heat and light.
6) Paint provides beautiful appearance to the surface on which it is applied.
7) Paint provides smoothness to the surfaces.
8) To give aesthetic look.

6.1.2 Characteristics of Good Paint

The characteristics of good paint are as following:

1) It should be easily applicable on the surface with a brush, roller or spraying devices.
2) It should possess a high spreading or covering power.
3) It should cover the body uniformly and homogeneously on which it is applied.
4) It should be resistant to wear and tear of the atmosphere.
5) It should maintain its colour, smoothness and finish for a long time.
6) The film produced should be washable.
7) The film should be glossy and attractive.
8) It should protect the surface against chemical and environmental effect for a long time.
9) It should be elastic.
10) It should possess good adhesion capacity on the surface.
11) It should be cheap and ready to use.
12) The film should not crack or shrink on drying.
13) When paint is applied on a metal, it should resist corrosion.

6.1.3 Ingredients of Paint / Constituents of Paint

1) Pigment
2) Vehicle or film forming materials
3) Thinners
4) Driers
5) Pigment extenders or fillers
6) Plasticizers
7) Ant skinning agents

1) Pigment:

It is a essential constituent of paint. Pigment is a solid substance added during manufacturing of paint, which gives color and opacity to the paint.

Examples:

White - White lead, Zinc oxide, Titanium oxide

Coloured pigments:

Red – Red lead, Ferric oxide, Chrome red, Venetian red

Green – Chromium oxide
Blue – Prussian blue
Black – Carbon black
Brown – Umber brown

Functions of pigment:

1) Pigment provides opacity to the paint film.
2) It provide desired colour to the paint.
3) It gives protection to the paint film by reflecting harmful ultraviolet radiations.
4) It provides durability and strength to the paint film.
5) It improves impermeability of the film to the moisture.
6) Pigment imparts aesthetic appeal to the film.

2) Vehicle or film forming materials:

It is a film forming constituent of paint. Vehicles are a carrier for non-volatile components of paint.

Examples:

The commonly used vehicles for oil paints are - linseed oil, soyabean oil, dehydrated castor oil, fish oil etc. Water is the main vehicle for water based paint.

Functions of vehicle:

1) It provides toughness and durability to the paint film.
2) It provides good adhesion to the film.
3) It provides water proofness to the film.
4) It helps to form the film by evaporation or by oxidation and polymerization of the unsaturated constituents of the drying oil.

3) Thinner

Thinner is a colorless solvent that are added in the paint. A thinner is used to thin oil based paints so that the paint is easy to apply on the surface. The thinner evaporates while drying the paint and get dry pigmented film.

Examples:

Turpentine, mineral spirit, benzene, dipentene, naptha, toluene, xylol, kerosene, methylated napthalene etc.

Functions of Thinner:

1) It reduces the fluidity of paint.
2) It makes the paint smoother.
3) It helps to penetrate the paint into porous structures.
4) It helps to dry the paint film by evaporation.
5) It suspends the pigment.

4) Driers

Driers are oxygen carrier catalyst.

Examples :

Resinates, linoleates, tungstates and napthnates of Co, Mn, Pb and Zn.

Functions of Driers:

1) It increases the rate of drying of paint film by oxidation, polymerization and condensation.
2) It improves the drying quality of the oil film.

5) Pigment extenders or fillers:

Fillers are the inert solid material added to the paint. They do not effect on the colour of the paint but they do alter some properties.

Examples:

Quartz, Sand (SiO_2), Talc, Baryte ($BaSO_4$), Kaoline, clay, Limestone ($CaCO_3$) etc.

Function of fillers or extenders:

1) It increases the durability of the paint.
2) It reduces the cracking of paint film after drying.
3) They increase the random arrangement of pigment particles.
4) They act as a carrier substance for pigments.
5) They are used to fill the voids or pores in the paint.
6) It reduces the cost of paint.
7) It gives good adhesion, hardness and toughness to the paint film.
8) It provides a water resistance to the paint.

6) Plasticizers:

Plasticizers are the substance which imparts elasticity to the paint film after addition and prevents the cracking of film after drying.

Examples :

Tricresyl phosphate, triphenyl phosphate, tributyl phosphate, diamyl phthalate, dibutyl tartarate.

7) Antiskinning agent

The antiskinning agent like polyhydroxy phenols sometimes added to the paint. Their function is to prevent gelling and skinning of the paint film.

Table 6.1

Constituent of Paint	Function
1. Pigment	1.Impart Color, opacity, aesthetic look 2. Protect paint film by reflecting ultra violet light.
2. Drying oil or medium	1. Film forming constituent. 2. Impart water proofness and durability.

3. Thinner	1. Reduce the viscosity of the paint. 2. Dissolve film forming constituent and suspend the pigment.
4. Driers	1.Acts as the oxygen carrier catalyst and 2.Improve the drying quality of the paint.
5. Extenders	1. Increases the durability of the paint 2. Acts as a pigment carrier.
6. Plasticizers.	1. Prevent cracking. 2. Impart elasticity.
7. Antiskinning agent	1.prevent gelling and skinning of the paint film

6.2 Varnish

Introduction

Varnish is a solution of a natural or synthetic resins in drying oil or in volatile solvent or in drying oil and volatile solvent (thinner) both. When it is applied on a surface, it gives a transparent, hard, protective film. The film dries up by evaporation, oxidation and polymerization of its constituents leaving behind glossy, lustrous and durable film.

6.2 Types of Varnish

There are two main types of varnishes

1) Oil varnish or oleoresinous varnish

It is a mixture of natural or synthetic resin and thinner (volatile solvent). Oil varnish dries up by evaporation of volatile solvent followed by oxidation and polymerization of the drying oil.

The presence of oil reduces the brittleness of the film.

For example**: Copal varnish**

Copal varnish is prepared by mixing copal in linseed oil (drying oil) and turpentine (thinner)

2) Spirit varnish

It is a mixture of resin in a volatile solvent (thinner). Spirit varnish dries up by evaporation of the volatile solvent and the film produced is brittle and has a tendency to crack and peel off. To avoid the brittleness of film small amount of plasticizer is added in a spirit varnish. Such a varnishes are usually used for polishing wooden surfaces.

For example**:** A solution of resin shellac in alcohol.

6.2.1 Difference between Paints and Varnishes

Table 6.2

Sr. No.	Paints	Varnishes
1)	Paint is a mixture of pigment in vehicle.	Varnish is a mixture of resin in drying oil or thinner or in both.

2)	Paint contains pigments.	Varnish do not contains pigment.
3)	Paint produces opaque film.	Varnish produces transparent film.
4)	Painted surface reflects heat and light.	Varnished surface do not reflects heat and light.
5)	Paint has different colours.	Varnish has little or no colour.

6.3 Thermal Insulator

Significance:

Insulators play a vital role in the three phases of power sector of generation, transmission and distribution. Insulators used for high-voltage power transmission lines are made from glass, porcelain or composite polymer materials. Industrial insulators are used to create air gape for ensuring as effective insulation between two or more conductors. Insulators form an integral part of transmission and distribution and helping resisting stresses as well such against heat, cold and contamination.

Insulator: Thermal insulators are defined as "The material or combination of materials that retard the transfer of heat". Heat may be transmitted between materials by the process of convection, conduction or radiation. Heat always flows from warmer to cooler surfaces until temperature of both surfaces becomes equal. Thermal insulators retard this flow of heat.

6.3 Characteristics of Thermal Insulators:

An ideal insulating material should have following characteristics.

1) It should have extremely low thermal conductivity.
2) It should be chemically inert.
3) It should be able to withstand vibrations, abrasion and bending.
4) It should be stable at different working temperatures.
5) It should be fire-proof.
6) It should be capable to withstand the loads.
7) It should be odourless.
8) It should have low density.
9) It should be water-proof.

6.3.1 Classification of Thermal Insulators:

Thermal insulators are classified into two types.

1) Organic thermal insulators

These are based on hydrocarbon polymers, which can be expanded to obtain high void structure. These are suitable up to 150 ºC temperature.

For example**:** Thermocole (Expanded polystyrene) Polyurethane Foam (PUF), wool, cotton, paper, charcoal powder, saw dust, coke powder, rubber.

2) Inorganic thermal insulators

These are based on Siliceous / Aluminous / Calcium materials in fibrous, granular or powder form. These are suitable above 150 ºC.

For example**:** Mineral wool, calcium silicate, glass wool, porous silica, refractory insulating bricks, asbestos paper, asbestos fibre etc.

6.3.2 Glass wool:

Glass wool is an insulating material prepared from the fibers of glass. The glass fibers are prepared from the molten glass, flows into a cylindrical container having small holes. The container rotates rapidly and the horizontal stream of glass flows out the holes. The molten glass streams are converted into fibers by a downward blast of air. The fibers fall onto a conveyor belt and are arranged using a binder into a texture similar to wool.

Glass wool is produced in rolls or in slabs with different thermal and mechanical properties.

Properties of glass wool:

1) It has extremely low thermal conductivity.
2) It is chemically inert.
3) It is non-corrosive.
4) It is highly resistance to moisture.
5) It has good tensile strength.
6) It is fire-proof.
7) It has low density.

Applications of glass wool:

1) It is used in ovens, refrigerators.
2) It is used to insulate the flat surfaces such as cavity wall insulation, ceiling tiles, curtain walls, as well as ducting.
3) It is used to insulate piping and for sound proofing.
4) It is used for electrical insulation.
5) It is used in air filters as a dust filtering material.

6.3.3 Thermocole:

Thermocole is made by blowing gas into polystyrene, due to which it expands into a solid foam like material called Thermocole or EPS (Expandable Polystyrene). It is spongy, porous foam like structure contains 3-6 million discreet cells per liter giving it excellent insulating property.

Properties of Thermocole

1) It has extremely low thermal conductivity.
2) It is light in weight.
3) It is shock proof.
4) It is chemically inert.
5) It has low electrical conductivity.
6) Its density is low (15-30 kg/m).
7) It is quite strong and tough.
8) It has spongy porous and foam like structure.
9) It can be cut easily with simple tools like knife or a saw.

10) It is highly resistance to moisture.
11) It has good tensile strength (3-6 kg/cm)

Applications of Thermocole:

1) It is used in industrial refrigeration, cold storage, cooled rooms, domestic refrigerator and air conditioning.
2) It is used in building ceilings, false ceilings roofs, walls, floors, door, partitions and cemented water tanks.
3) It is used in cinema halls, factories, offices.
4) It is used for packing delicate equipment like electronic goods, glassware etc.
5) It is used for decorations.
6) It is used for sound proofing.

6.4 Polymers

Significance: Polymers are the materials of very high molecular weight that have many applications in our modern society. Polymers make up many of the materials in living organisms, including proteins, cellulose. They constitute the basis of minerals like diamond, quartz, feldspar and such man-made materials as concrete, glass, paper, plastics and rubber. According to specific requirements, polymers have been used in devices for replacing deficient parts or assisting different functions of the body because of their special physical and mechanical properties. With the development of Nano biotechnology, more sophisticated polymers have been developed.

Polymers: In Greek, poly = many, mers = parts or segments.

"Polymers are very large molecule that are made up of thousands even millions of atoms that are bonded together in a repeating pattern". The molecular links in the polymer chain are called repeated units. "The repeating units in the polymer chain called **monomers"**. In order to form polymers, monomers should either have double or triple bond or reactive functional group.

- **Polymerization:** The process in which large number of small molecules (monomers) linking together to form a large molecule (polymer) in presence of temperature, pressure and catalyst is known as polymerisation.
- **Degree of Polymerisation: "The number of repeating units present in polymer is called as degree of polymerisation."** It represents the number of repeating units in polymeric chain. For example, if polymer contains 1000 repeating units then the degree of polymerisation is 1000.

6.4 Classification of Polymers or Plastics:

6.4.1 Classification on the basis of monomers:

i) Homopolymer ii) Copolymer

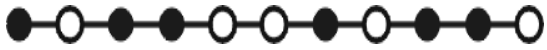
i) Homopolymer

The polymers formed from the same type of monomers are called homopolymers.

For example: Polyethylene, PVC, polystyrene etc.

ii) Copolymer

The polymers formed from the two or more different repeating monomers are called copolymers.



Example: Styrene acrylonitrile, styrene butadiene, acrylonitrile butadiene styrene, bakelite, Nylon 66 etc.

Difference between homopolymers and Copolymers:

Table 6.3

Sr.No.	Homopolymers	Copolymers
1)	These are formed by addition polymerization.	These are formed by condensation polymerization
2)	These are formed by same type of monomers.	These are formed by different repeating monomers.
3)	They have simple structure.	They have complex structure.
4)	For example: PVC, Polyethylene, Polystyrene, etc.	For example: Polyvinyl acetate, Styrene butadiene etc.

6.4.2 Classification on the basis of thermal behavior:

i) Thermoplastics ii) Thermosetting

i) Thermoplastics

These are formed by addition polymerization. Thermoplastic resin becomes soften on heating and harden on cooling without appreciable changed of properties.

For example**::** Polyethylene, polystyrene, PVC, cellulose nitrate, cellulose acetate etc.

ii) Thermosetting

Thermosetting plastics are formed by condensation polymerization and these plastics having the property of becoming permanently hard and rigid. When heated they does not become soft again.

For example**:** Bakelite, Nylon 66, Urea-formaldehyde etc.

- **Difference Between Thermoplastics and Thermosetting Plastics:**

Table 6.4

Sr. No.	Thermoplastic	Thermosetting Plastic
1)	These are formed by addition polymerization.	These are formed by condensation polymerization.
2)	They exhibit linear structure.	They exhibit cross-linked structure.
3)	They have low molecular weight.	They have high molecular weight.
4)	They are soft, weak, less brittle.	They are hard, strong, more brittle.
5)	Their intermolecular bonds are	Their intermolecular bonds are strong

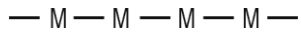
	weaker.	covalent bonds.
6)	They are soluble in organic solvents.	They are soluble in inorganic solvents.
7)	They become soften on heating, hence can be reshaped and reused.	They do not become soften on heating, hence cannot be reshaped and reused.
8)	Ex: PVC, Polyethylene etc.	Ex: Bakelite, Nylon 66

6.4.3 Classification on the basis of monomer structure:

i) Linear polymers and ii) Cross-linked polymers

i) Linear polymers

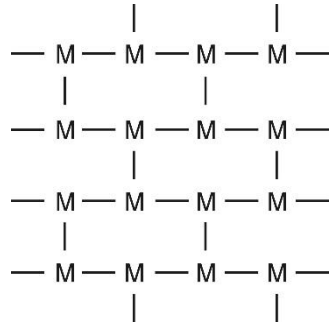
In this type of polymers monomers are joined with each other and formed long and straight chain.



For example**:** Polythene, PVC, polystyrene, Teflon etc.

ii) Cross linked polymers

In this type of polymers, monomers are joined with each other and formed a network or cross-linked structure.



For example**:** Bakelite, Nylon-66 etc.

- Difference Between Linear and Cross-linked/Branched Polymers

Table 6.5

Sr.No.	Linear Polymer	Cross-linked or Branched Polymer
1)	The monomers are joined with each other and formed linear structure.	The monomers are joined with each other and formed cross-linked structure.
2)	These are formed by same type of monomers.	These are formed by different types of monomers.
3)	Ex: PVC, Polyethylene, Polystyrene, etc.	Ex: Bakelite, nylon 66 etc.

6.5 Types of Polymerization Reactions:

a) Addition polymerization **b) Condensation polymerization**

a) Addition polymerization:

The polymers formed by repeated addition of same type monomers without elimination of by products like water, ammonia, methanol are called addition polymerization.

For example**:** Polyethylene, polystyrene, PVC, Teflon etc.

b) Condensation polymerization

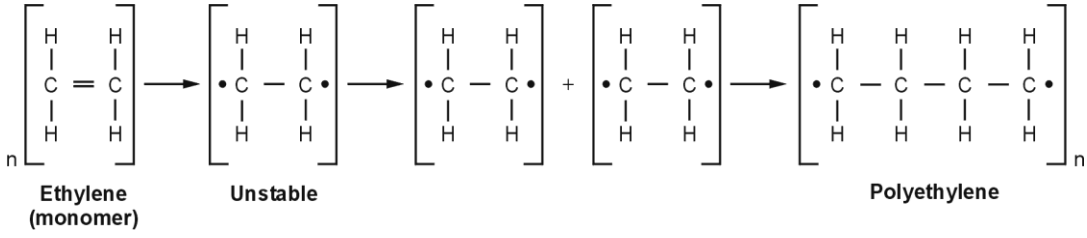
The polymers formed by condensation of different types of monomers with elimination of small molecules like water, ammonia, methanol are called condensation polymerization.

For example**:** Phenol-formaldehyde resin (Bakelite), polyester, epoxy resin, nylon 66.

6.5.1 Synthesis of Polymers:

a) Synthesis of Polyethylene

The monomer used in this formation is ethylene. One of the double bond between carbon atoms is open up leaving one electron to each carbon atom and forming unstable molecule. The unstable molecules joined with similar molecule to form polymer.



Properties

1) High Density Polyethylene (HDPE) has high tensile strength, high density, it is relatively brittle and has low impact strength. It has low moisture absorption.
2) Low Density Polyethylene (LDPE) has low density, low tensile strength, less brittle. It has low moisture permeability.

Applications

1) High density polyethylene is used in products and packaging such as water pipes, toys, detergent bottles.
2) Low density polyethylene is used for both rigid containers and plastic film applications, such as plastic bags and film wrap.
   For example: in orthopaedic products, in consumer packaging bags, bottles and liners.

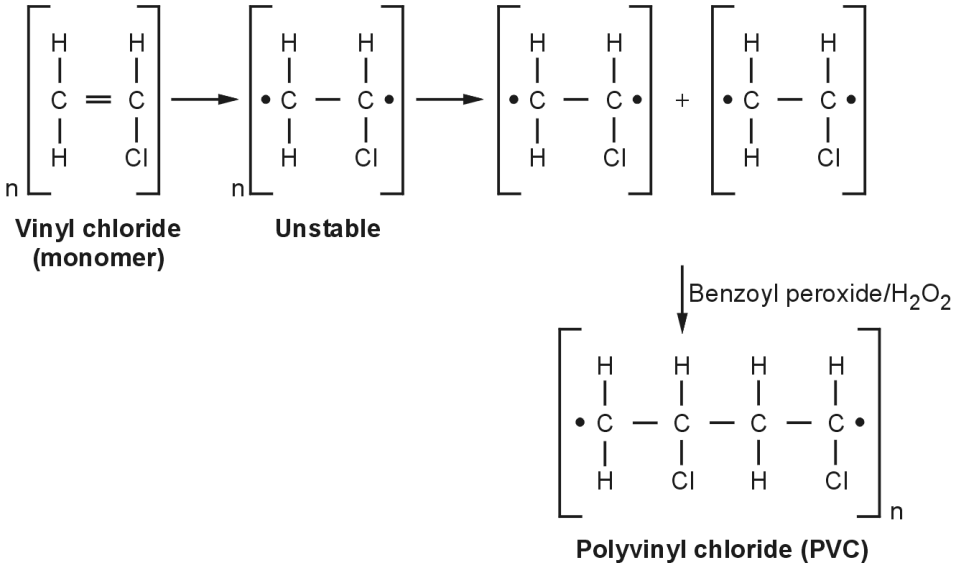
b) Synthesis of Polyvinyl Chloride (PVC)

It is prepared by heating vinyl chloride in presence of catalyst benzoyl peroxide or H_2O_2.

Properties

1) It is chemically inert.
2) It is colourless, odourless
3) It has excellent resistance to water.

4) It is non-inflammable.
5) It is resistant to light and atmospheric oxygen.
6) It has excellent resistance to aqueous solutions, but it is attacked by stronger solvents such as aromatic hydrocarbons, ketones, esters, chlorinated solvents etc.

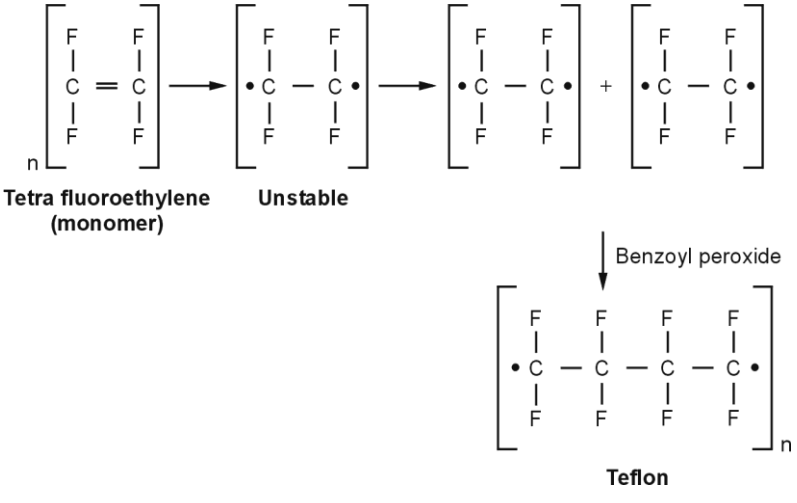


Applications

1) Plasticized PVC is used for making continuous sheets used for packing rain-coats, curtains, table cloths, electrical insulation, bottles, door and window components, film and fabric coatings, radio components, chemical container.
2) Unplasticized PVC has high rigidity and superior chemical resistance. It is used for tank linings, light fittings, safety helmets, cycle and motor cycle mudguards, refrigerator components.

c) Synthesis of Teflon (Polytetrafluoroethylene) (PTFE)

It is obtained by polymerization of tetrafluoroethylene in presence of catalyst benzoyl peroxide.



Properties

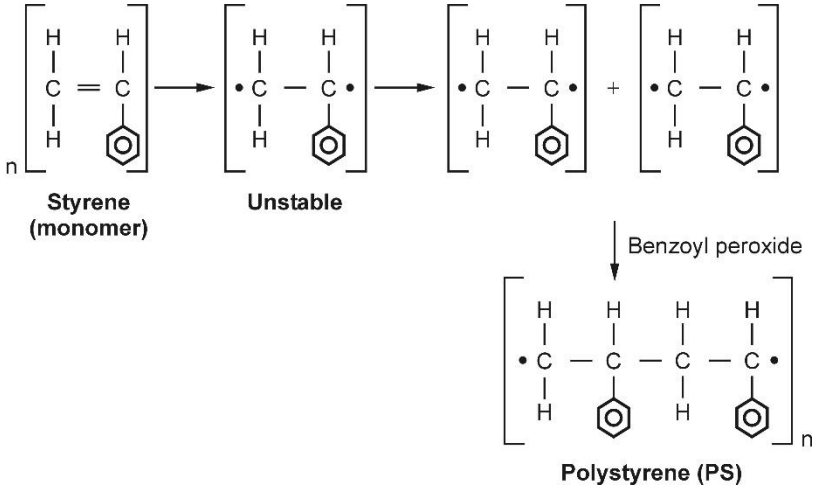
1) It has high molecular weight.
2) It has low coefficient of friction.
3) It has low chemical reactivity.
4) It is resistance to water, alcohol.
5) It is harder and stronger than the other polymers.

Applications

1) It is used in containers and pipework for reactive and corrosive chemicals.
2) It is used as an insulating material for motor, transformers, cables, wires etc.
3) It is used for making gaskets, tank linings, packings.
4) It is commonly used as a graft material in surgical interventions.

d) Synthesis of Polystyrene (PS)

It is prepared by polymerization of styrene in presence of catalyst benzoyl peroxide.



Properties

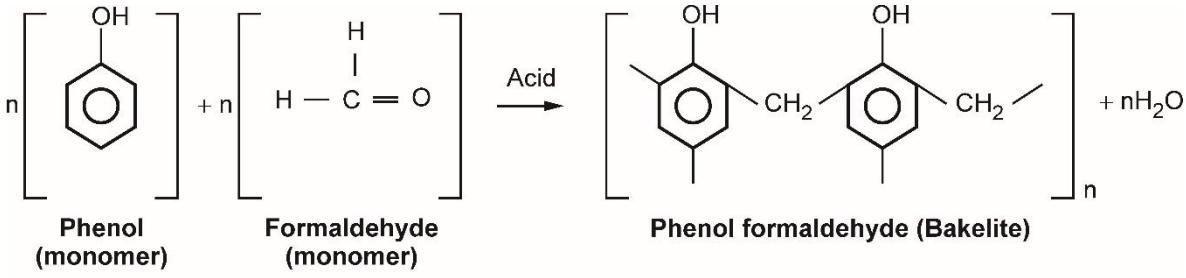
1) It is transparent, hard and brittle.
2) It has low melting point.
3) It is a very good electrical insulator.
4) It has excellent optical clarity.
5) It has good chemical resistance to diluted acids and bases.
6) It can be easily moulded.

Applications

1) It is used in food packing, optical, electronic, medical and automotive parts.
2) It is used for making the products like dining utensils, plastic cups, housewares, toys, CD cases, cosmetic containers, covers and fixtures.
3) It is used for making battery cases, refrigerator parts etc.

e) Synthesis of phenol formaldehyde (Bakelite)

It is prepared by polymerization of phenol and formaldehyde in presence of acidic or alkaline catalyst.



Properties

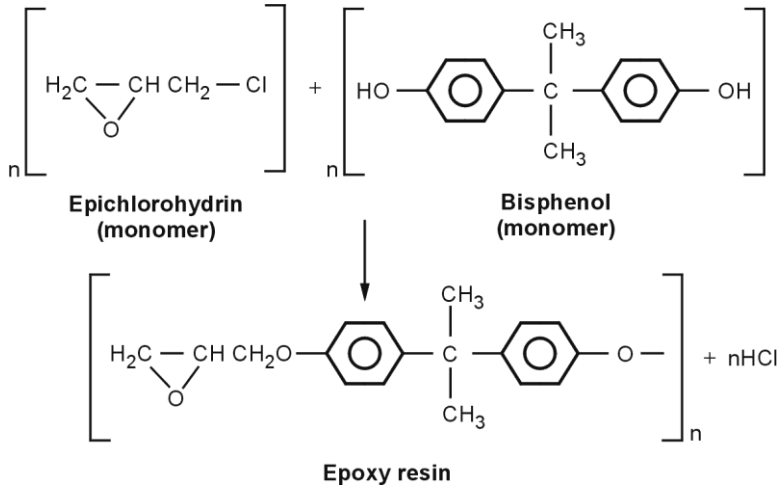
1) It is hard, rigid, non-flexible and brittle.
2) It is resistant to heat, scratches and destructive solvents.
3) It is resistant to electricity.
4) It can withstand very high temperature.

Applications

1) It is used for making, radio, telephone casings, plugs, switch boards etc.
2) It is used for making sheets, rods and tubes.
3) It is used as an adhesive.
4) For impregnating fabrics, wood and paper.
5) For making bearings, used in propeller shafts for paper industry and rolling mills.

f) Synthesis of epoxy resin

It is prepared by condensation of bis-phenol and epichlorohydrin in presence of alkaline catalyst.



Properties

1) It is highly resistant to water, acids, bases and solvents.
2) It has excellent adhesion property.

3) Epoxy resin is thermosetting resin characterised by toughness, adhesion, corrosion resistance.

Applications

1) It is used for metal coatings, use in electrical and electronic components / LED, high tension electrical insulators.
2) It is used in industrial floorings, adhesives and solders.
3) Moulds made from epoxy resins used for the production of components for aircrafts and automobiles.
4) It is used for surface coatings and gas storage vessels.

Distinguish between addition polymerization and condensation polymerization

Table 6.6

Sr.No.	Addition polymerization	Condensation polymerization
1.	It is a process in which the monomers of same types undergo repeated addition to form long chain polymer without elimination of simple molecules like H_2O , HCl etc.	It is a process in which the monomers of different types joined together by condensation forming a large polymer with the elimination of simple molecules like H_2O, HCl, NH_3 etc.
2.	For addition polymerization, monomer should contain at least one C=C double bond.	For Condensation polymerization, the monomer should contain more than one functional group so as to enable intermolecular reaction.
3.	Plastics obtained by addition polymerization have of linear long chain structure.	Plastics obtained by condensation polymerization have of three dimensional network structures.
4.	Plastics obtained by addition polymerization are joined by weak covalent bond.	Plastics obtained by condensation polymerization are joined by strong covalent bonds.
5.	Plastics obtained by addition polymerization are soluble in organic solvents.	Plastics obtained by condensation polymerization are insoluble in organic solvents.
6.	For example**:** Formation of polyethylene (Polythene) from ethylene.	For example**:** Formation of Bakelite from phenol and formaldehyde.

6.6 Adhesive

Significance:

Adhesives are the social substances capable to joined permanently two surfaces, by an adhesive process. This process involves two dissimilar bodies being held in intimate contact such that mechanical force or work can be transferred across the interface. Adhesives are growing more important in industrial products, in the construction industry, in sports and leisure articles, and in

many other segments. Almost 14 million tonnes of adhesives are consumed worldwide. According to the latest study adhesive revenues will rise worldwide by 3.6% per year until 2024.
Definition: "Any substance applied to one or both surfaces of two separate items that binds them together and resist their separation is called adhesives."

6.6.1 Characteristics of Adhesives

1) It has ability to bind different materials together.
2) It is highly resistance to temperature.
3) It is highly resistance to chemicals.
4) It is resistance to moisture.
5) It possesses good adhesion property.
6) It has high resistance to stress or load.
7) It is highly resistance towards insects, fungi.

6.6.2 Classification of Adhesives

a) Classification of adhesives by structure

i) Thermosetting synthetic adhesives

These are formed by condensation polymerization and consist of a three dimensional network structure. They possess good adhesion property.

Examples

- **Phenol formaldehyde resin:** Used for making water proof plywoods, laminates, in aircraft and ship building industry.
- **Urea formaldehyde resin:** Used for wooden surfaces, plywoods, laminates, in aircraft and ship industry.
- **Polyesters:** For making laminated glass and cloth.
- **Epoxy resin:** For bonding glass, metallic and ceramic articles, in air-craft industry.
- **Silicon resins:** For bonding metals, ceramics, plastics, rubber etc.

ii) Thermoplastic synthetic adhesives

Thermoplastics are formed by addition polymerization and consist of a linear structure. It becomes soft when heated and hardens when cooled.

Examples

- **Cellulose derivatives:** Used in cloth and footwear industry.
- **Acrylics:** Used in bonding cloths, paper, glass, leather etc.
- **Polyvinyl (like PVC, Polyvinyl acetate):** Used for bonding non-porous surfaces, in the sealing operation in food industry.

b) Classification of adhesives by origin

i) Natural adhesives

Natural adhesives are extracted from the natural sources such as plants and animals.

Examples

- **Shellac resin:** Used in making belts, conveyers, etc.
- **Asphalt:** Used in bonding paper, cloth and for metal bonding.
- **Animal glues:** Used in manufacturing furniture, radio cabinets, card boxes etc.
- **Vegetable based glues or protein glues:** Used for common adhesive jobs like paper crafts, posters to the walls of buildings, scrapbooking etc.
- **Starch adhesives:** Used for manufacturing envelops, stamps, note-books, binding books etc.

ii) Synthetic adhesives

Synthetic adhesives are designed and manufactured by man. These adhesives are not found in nature. These are the most widely used adhesives in the various sectors because their mechanical, physical and chemical properties are far superior to natural adhesives.

Examples

- Polyvinyl acetate and synthetic resin are used for woodwork glue.
- Epoxy resin - used for joining metals and plastics.
- Contact adhesive - is used for joining polystyrene and fabrics and for fixing plastic laminates to a wooden base.
- Acrylic polymer adhesive - used in fabricating acrylic plastics, their emulsion used in fabric leather coating.

6.7 Lubricant:

Significance:

The primary function of the industrial lubricant is to avoid metal contact amongst the tools or finished components. Industrial lubricants exhibit good corrosion protection properties and help to extend the life of equipment. Lubricants are widely utilised in energy, textile, chemical, construction and infrastructure sectors for engine oil, hydraulic oil, bearings and wire rope applications across the industrial sector. The global market growth is attributed to the rising demand for industrial lubricant in developed and developing economy.

Lubricant: In any type of machinery, there is a constant rubbing of surfaces of moving, sliding or rolling parts, as a result of which there develops a resistance to their movement. This resistance is called friction. The friction causes a lot of wear and tear of surfaces; a large amount of heat energy is dissipated in the form of heat which would decrease the efficiency of the machine. Moreover, the moving parts gets heated up and deform i.e. change their shape. The frictional resistance can be minimised by introduction of a suitable substance between two moving parts, which forms a thin layer in between them.

“A substance reduces the frictional resistance between moving parts called as a lubricant”.

Lubrication: The process of reducing frictional resistance between moving parts / surfaces is called lubrication.

Characteristics of Lubricants:

The good lubricant should possess following characteristics:

1. It should maintain oil film between the moving parts of machine.

2. It should withstand high pressure between the moving parts.
3. It should not attack the metal surface.
4. It should not volatilize excessively.
5. It should retain fluidity at entire operation temperature condition, even at low temperature.

Functions of Lubricants:

1. The primary function of lubricant to keep friction, wear and heat from affecting the sliding surfaces by providing a layer of liquid between the surfaces.
2. Cutting fluids have low viscosity, because of low viscosity they can easily fill in the cracks formed on the work piece.

6.7.1 Classification of Lubricants;

According to their physical state lubricants are classified into three main classes.

1) Solid lubricants
2) Semisolid lubricants
3) Liquid lubricants

1) Solid lubricants:

Solid lubricants are used either in the form of dry powder or mixed with water or oil. Solid lubricants are used where the load is too high; the entry of dust particles is undesirable. They are especially useful at high and low temperatures, in high vacuums and in other applications where oil is not suitable. Examples: Graphite, molybdenum disulphide, hexagonal boron nitride, tungsten disulphide, soapstone, talc, mica, polytetrafluoroethylene, etc.

Applications of solid lubricants:

1. They resist being squeezed out and are useful under heavy load conditions.
2. They are useful in inaccessible parts where the supply of lubricants cannot easily be renewed.

Examples-

- **Graphite:** Graphite is widely used as a solid lubricant because of its low cost and excellent lubricating action. Graphite is used either in powdered form or as suspension in oil or water.

Applications:

1. It is used in air compressors, food industry and railway track joints.
2. They are used in brass instrument valves, open gear, ball bearings, machine shop works etc.

- **Molybdenum disulphide:** It is used up to 400 ^{o}C. It's fine powder may be sprinkled on surfaces sliding at high velocities. It is also used along with solvents and in greases.

Applications:

1. It is used in paint as a pigment.
2. It is used as a catalyst in chemical reactions.

2) Semisolid lubricants

Greases, Vaseline, waxes are the semisolid lubricants. The most widely used semisolid lubricant is grease. They contain thickening agents like soaps of sodium, calcium, lithium or aluminium mixed with mineral or synthetic liquid lubricant. The composition of greases is generally 80 %

mineral or synthetic oil, 10 % soaps and 10 % additives such as rust inhibitor, antioxidants, metal deactivator, antiwear etc.

Applications of semisolid lubricants:

1. It is used in high pressure applications and during metal cutting where liquid lubricants cannot be retained.
2. Greases are used where oil drip is undesirable because of heavy pressure.

Type of Greases:

- **Lithium based greases:** These are prepared by mixing petroleum oil and lithium soaps.
- **Sodium based greases:** These are prepared by mixing petroleum oil and sodium soaps.
- **Cup greases:** These are prepared by mixing petroleum oil and calcium soap.
- **Axle greases:** These are prepared by adding lime or any heavy metal hydroxide to resin and fatty oils.

3) Liquid lubricants:

These are mainly lubricating oils, which form a thin continuous film between the metal surfaces and reduce friction. They are used as cutting fluids in cutting, grinding, trading and drilling of the metals. Cutting fluids are used in machining operations where friction is very high because of close contact between the work piece and the tool.

Applications:

1. Liquid lubricants are used in medicines.
2. They are used in machinery as engine oils, compressor oils, gear oils and piston oils.
3. They are used as hydraulic, brake and gear box fluids.

- **Water:** It can be used as such or in combination with one of the base oil. It is commonly used in milling and lathe turning.
- **Mineral oil:** It is obtained from the crude petroleum oil.
  Example: paraffin's, naphthalene is most widely used.
- **Animal oil:** These are obtained from the animal sources.
  Example: Whale oil: Obtained by distillation of whale.
  Lard oil: Obtained from the kidney, intestines and fat of pigs.
  Tallow oil: Prepared from the fat of cattles.
  Neat foot oil: Obtained by boiling fat of neat with water.
- **Vegetable oil:** These oils are obtained from the vegetable sources.
  Example: Olive oil, Palm oil, Castor oil, Hazel nut oil, etc.
- **Blended oils:** When mineral oils are mixed with animal or vegetable oils, the mixture is called blended oils.
- **Synthetic oils:** These are chemically prepared compounds. These are very effective in severe conditions and used for applications where petroleum products are inadequate or where special characteristics such as long life, improved equipment efficiency or non-flammability is necessary.

Examples: Polyphenyl ethers, Silicate esters, Phosphate esters, Polyalkaline glycols, Chlorofluoro carbons, Fluoro silicones.

Applications:1) They are used in turbines and vacuum pumps.

2) They are used in semiconductor devices.

3) They are used in rocket motors, submarines

4) Silicate esters are used for low temperature refrigeration compressor lubrication.

Selection of lubricants:

The selection of suitable lubricant for a particular purpose is certainly made on the basis of conditions of service and its own properties. The principle considerations of service requirements are:

- Temperature of operation
- Pressure between moving parts
- Speed of moving parts
- Nature of friction surface
- Presence of moisture
- Type of lubrication system

Selection of lubricant for gears:

The gears are generally subjected to high pressure. Therefore, the lubricant used should possess following properties.

- It must possess good oiliness
- Should have anti foaming property.
- It should have high load carrying capacity.
- It should have low adsorption capacity towards dust particles.

Example- Thick mineral oils compounded with some additives such as metallic soaps and chlorine, Sulphur or phosphorous compounds.

Selection for cutting tools:

Metal cutting tools, when used for performing any machining operation such as cutting, sawing, turning, boring, drilling etc. require the use of certain oils known as cutting oils.

Therefore, the lubricant used should possess following properties.

- It should be stable at high temperature.
- It must have the capability to remove the heat from the friction and the abrasion of wear particles away from the load-carrying zone as soon as it is formed.
- It should provide lubrication.
- It should prevent the corrosion of finished product.

Example- Liquid lubricants are used for cutting tool.

Selection for steam turbine:

The problem of efficiently lubricating steam turbine is also somewhat difficult, as the lubricating oil is exposed to high temperature and oxidizing conditions. The oil film under such conditions

deteriorates very rapidly. The leakage of steam and cooling water may occur, which may form emulsion and sludges, restricting proper circulations.

Solid lubricants are used for steam turbine.

6.7.2 Properties of Lubricants

1) Viscosity

Viscosity is a measure of fluid's resistance to flow at a given temperature.

The greater the resistance to flow, the higher is the fluid's viscosity. Low viscosity liquids are used for delicate instruments, which are working with high speed and light load like watches, clocks, sewing machines etc. High viscosity liquids are used for heavy machines, which are working with heavy load and slow speed like tractor, concrete mixture, rail track joints etc.

2) Viscosity index

It is a measure for the change of viscosity with variations in temperature.

The viscosity of liquids decreases as the temperature increases and the surfaces will come in contact with each other, thereby friction increases. The viscosity of liquids increases as the temperature decreases and the lubricant will require a large amount of energy to move on the rubbing surfaces, thereby friction increases.

A good lubricant is that whose viscosity does not change with temperature.

3) Oiliness

It is the power of an oil to maintain a continuous film at slow speed or high load while used as a lubricant.

Low viscosity liquids having high oiliness than high viscosity liquids. Lubricants possessing high oiliness form a continuous oil-film which does not collapse. Animal and vegetable oils are superior in oiliness than mineral oils. The oiliness of mineral oils can be increased by addition of neutral glycerides or fatty acids or soluble soaps.

A good lubricant should have sufficient oiliness, so that it maintains a continuous film between moving parts and reduces friction.

4) Flash point and fire point

Flash point

Definition: "The lowest temperature at which oil begins to give enough vapours which gives momentary flash of a light, when flame is applied to it is called as flash point."

Fire point

Definition: "The lowest temperature at which oil gives enough vapours which catch fire and burn continuously for 5 seconds, when flame is applied to it is called as fire point."

The flash and fire points are useful in determining a lubricants volatility and fire resistance. The lubricant having low flash and fire point will catch fire readily which causes damage to life and property of a factory.

A good lubricant should have high flash and fire point.

5) Volatility

It is the property of a lubricant to evaporate and loss its characteristics.

A highly volatile lubricant can evaporate even at lower temperature and in this case more lubricant is consumed by the machinery and lubrication process will be a costly.
A good lubricant should have low volatility.

6) Cloud point and pour point

Cloud point

Cloud point of lubricant is the temperature below which wax in the lubricant tends to form a cloudy appearance.

Pour point

Pour point of lubricant is the lowest temperature at which lubricant can flow and below which the lubricant tends to freeze or ceases to flow.

A good lubricant should have high cloud point and pour point.

In cold weather conditions, certain additives are added to it to keep its cloud point and pour point higher.

7) Acidity or neutralization number

The mass of potassium hydroxide (KOH) in milligrams that is required to neutralize acid in one gram of oil is called acidity or neutralization number.

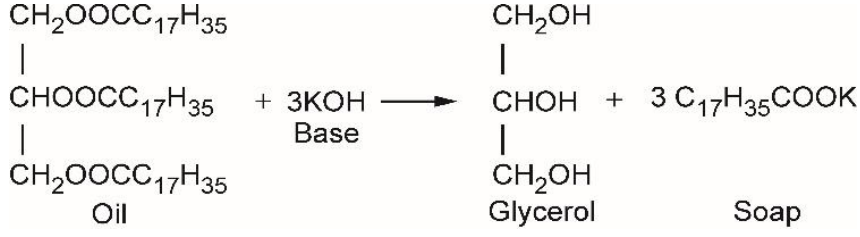
It is a measure of the amount of carboxylic acid group in a chemical compound such as fatty acid or in a mixture of compounds. A known amount of oil sample dissolved in organic solvent like ethanol. It is then titrated with a solution of potassium hydroxide (KOH) of known concentration and phenolphthalein as an indicator. An oil-fat acidity, triglycerides are converted into fatty acids and glycerol.

If the lubricant contains free acids, it causes the corrosion of metal. A good lubricant is that which does not contains free acids.

8) Saponification value

The number of milligrams of potassium hydroxide (KOH) required to saponify 1 gram of oil / fat is called saponification value.

The long chain fatty acids found in fats have a low saponification value because they have relatively less number of carboxylic functional groups per unit mass of the fat as compared to short chain fatty acids. If more number of milligrams of KOH are required to saponify N grams of oil / fat, then there are more number of moles of the fat and the chain length are relatively small.



A good lubricant should have moderate saponification value.

9) Emulsification

When oil mixed with water, the mixture is called emulsion and the process is known as emulsification. The emulsion absorbs dust particles present in the surroundings which causes abrasion of the metals in contact and hence the lubricating action of the oil is spoiled.

A good lubricant does not form any emulsion and if it formed, it should break quickly.

6.7.3 Applications of Lubricants

1) Lubricants are used to reduce friction between surfaces.
2) In machinery as engine oils, compression oil, gear oils, piston oils.
3) These are used to reduce the wear and tear of the moving parts.
4) These are used to reduce the heat generation.
5) These are used to reduce the noise and vibrations.
6) Liquid lubricants are used in medicines.
7) These are used in the soap and paint industries.
8) These are used as a rust and corrosion inhibitor.
9) It is used as a demulsifying and emulsifying agents.
10) These are used as antiwear, antioxidants and antifoaming agents.

Multiple choice questions:

1) Select the polymer from the following options which do not softened on heating.
   a) PVC b) Bakelite (Phenol formaldehyde resin)
   c) polyethylene d) All the above

2) _____ pigment gives white colour to the paint.
   a) Chromium oxide b) Zinc oxide
   c) Ferric oxide d) Brown umber

3) The function of pigment is _____ .
   a) reduces the fluidity of paint b) improve the drying quality of paint
   c) prevent gelling and skinning of the paint film d) provides opacity to the paint
4) A thermoplastic polymer is formed by the phenomenon of .
   a) addition polymerization b) condensation polymerization
   c) Crystallization d) None of above
5) Select the adhesive which is used in the sealing operation in food industry _____
   a) cellulose derivatives b) silicon resins
   c) epoxy resins d) Polyvinyl

Answers:

Question	Q. 1	Q.2	Q.3	Q.4	Q.5
Answer	b	b	d	a	a