Applied Chemistry

CORROSIOM

INTRODUCTION

- Definition: Corrosion is the degeneration of materials by reaction with environment. Examples: Rusting of automobiles, buildings and bridges, Fogging of silverware, Patina formation on copper.

CAUSES OF CORROSION

WHY DO METALS CORRODE?

- Any spontaneous reaction in the universe is associated with a lowering in the free energy of the system. i.e. a negative free energy change
- All metals except the noble metals have free energies greater than their compounds. So they tend to become their compounds through the process of corrosion

Cont.

ELECTROCHEMICAL NATURE

- All metallic corrosion are electrochemical reactions i.e. metal is converted to its compound with a transfer of electrons
- The overall reaction may be split into oxidation (anodic) and reduction (cathodic) partial reactions
- Next slide shows the electrochemical reactions in the corrosion of Zn in hydrochloric acid

Electrochemical corrosion

ELECTROCHEMICAL REACTIONS IN CORROSION

DISSOLUTION OF ZN METAL IN HYDROCHLORIC ACID,

$Zn + 2HCl = ZnCl_2 + H_2$ ------ -(1)

Written in ionic form as,

$Zn + 2H^+ + 2Cl^- = Zn^{2+} + 2Cl^- + H_2$ ----------(2)

The net reaction being,

$Zn + 2H^+ = Zn^{2+} + H_2$ ---------- (3)

Equation (3) is the summation of two partial reactions,

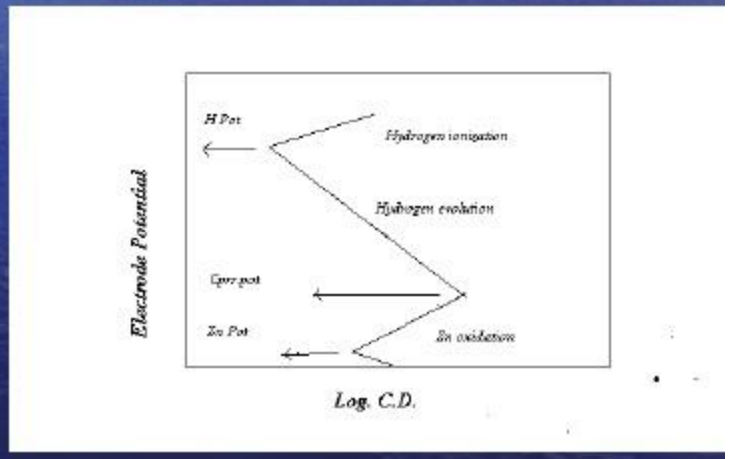
$Zn \rightarrow Zn^{2+} + 2e$ ----------(4) **and**

$2H^+ + 2e \rightarrow H_2$ ----------(5)

Equation (4) is the *oxidation / anodic* reaction and
Equation (5) is the *reduction / cathodic* reaction

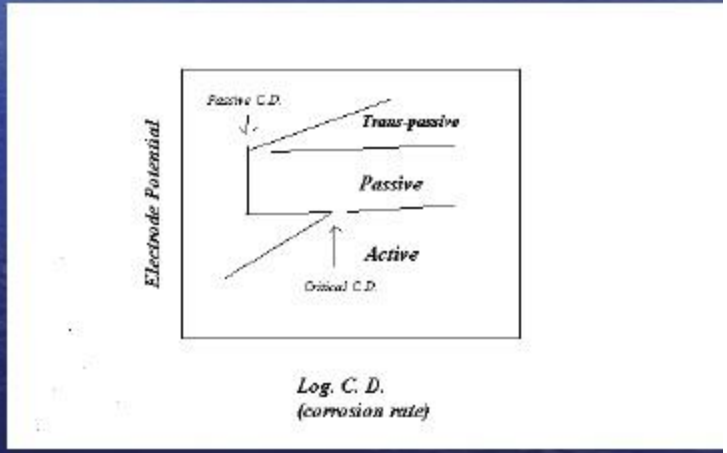
ELECTROCHEMICAL THEORY

- The anodic & cathodic reactions occur simultaneously at different parts of the metal.
- The electrode potentials of the two reactions converge to the corrosion potential by polarization



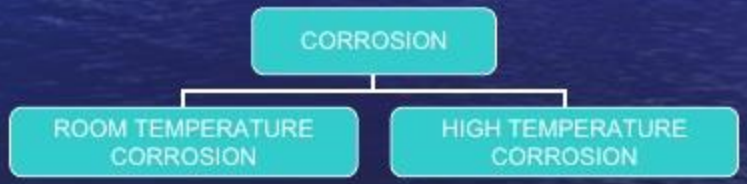
PASSIVATION

- Many metals like Cr, Ti, Al, Ni and Fe exhibit a reduction in their corrosion rate above certain critical potential. Formation of a protective, thin oxide film.
- Passivation is the reason for the excellent corrosion resistance of Al and S.S.



FORMS OF CORROSION

- Corrosion may be classified in different ways
- Wet / Aqueous corrosion & Dry Corrosion
- Room Temperature/ High Temperature Corrosion

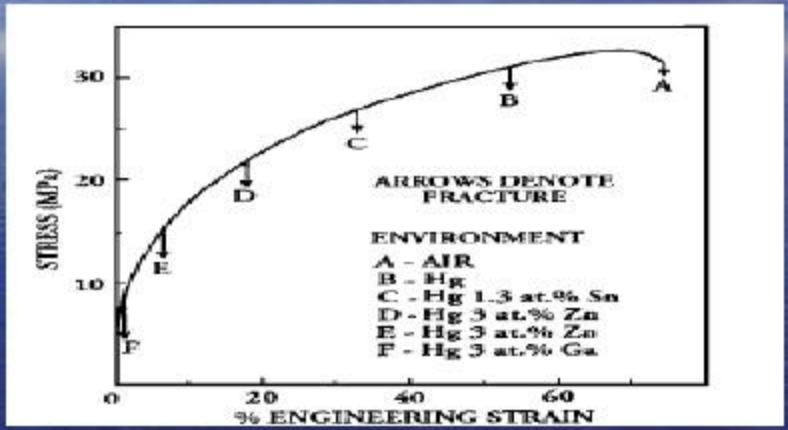


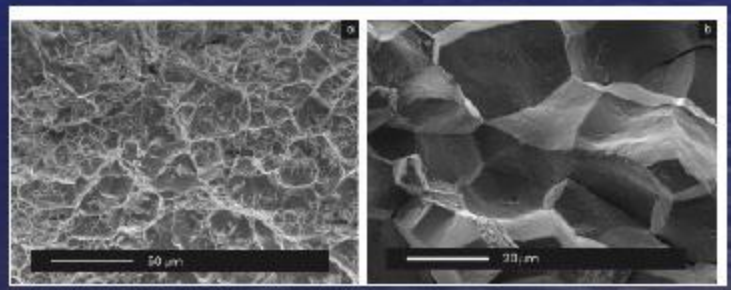
WET & DRY CORROSION

- **Wet / aqueous corrosion** is the major form of corrosion which occurs at or near room temperature and in the presence of water
- **Dry / gaseous corrosion** is significant mainly at high temperatures

LIQUID METAL EMBRITTLEMENT

- Certain metals like Al and stainless steels undergo brittle failure when stressed in contact with liquid metals like Hg, Zn, Sn, Pb Cd etc.
- Molten metal atoms penetrate the grain boundaries and fracture the metal
- Fig. Shows brittle IG fracture in Al alloy by Pb





CATHODIC & ANODIC PROTECTION

- Cathodic protection: Make the structure more cathodic by
  - **Use of sacrificial anodes**
  - **Impressed currents**

  Used extensively to protect marine structures, underground pipelines, water heaters and reinforcement bars in concrete
- Anodic protection: Make passivating metal structures more anodic by impressed potential. e.g. 316 s.s. pipe in sulfuric acid plants

COATINGS

- Most popular method of corrosion protection
- Coatings are of various types:
  - Metallic
  - Inorganic like glass, porcelain and concrete
  - Organic, paints, varnishes and lacquers
- Many methods of coating:
  - Electrodeposition
  - Flame spraying
  - Cladding
  - Hot dipping
  - Diffusion
  - Vapour deposition
  - Ion implantation
  - Laser glazing

LUBRICANT

DEFINITION OF LUBRICANTS

- Due to mutual rubbing of one part of a machine with other, resistance is offered which is known as friction.

- Any substance introduced between two sliding parts in order to reduce the friction between them is known as Lubricants.

FUNCTIONS OF LUBRICANT

- Reduces the friction forces
- Reduces cost of maintenance
- Reduces heating energy produced due to friction
- Enhances the efficiency of machine.

MECHANISM OF LUBRICATION
THREE TYPE OF MECHANISM

- 1. Fluid-film or thick-film lubrication (Hydrodynamic lubrication)
- 2. Boundary lubrication (Thin film lubrication)
- 3. Extreme pressure lubrication

1. FLUID FILM OR THICK-FILM LUBRICATION (HYDRODYNAMIC LUBRICATION)

- The condition in which surfaces are completely separated by a continuous film of lubricating fluid is commonly referred to as Hydrodynamic or Full Fluid Film Lubrication. Since thick film of lubricant is used, hence it is also known as thick film lubrication.
- This type of lubrication works only when load is not high.

EG

2. BOUNDARY LUBRICATION (THIN FILM LUBRICATION)

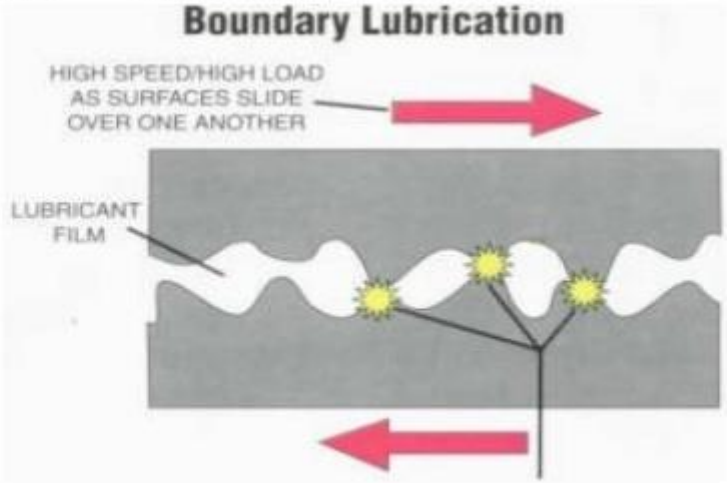
This lubrication comes into play when thick film lubrication fails.

This can happen when

- Load is very high
- Viscosity of oil is very low
- Speed is very slow

- A type of lubrication in which the lubricant film is very small between the two surfaces in contact.
- Lubricant gets adsorbed over metal surfaces by physical or chemical forces.
- Metal layer avoid the metal – metal forces.
- e.g. rollers, tractors require such type of lubrication

- Many time, Lubricant film is too thin to provide total surface separation. Contact between surface asperities (or microscopic peaks and valleys) occurs which causes wear and tear.



3. EXTREME PRESSURE LUBRICATION

- When the moving surfaces are working under a very high pressure and high temperature, the ordinary liquid lubricants either vaporizes or decomposes.
- In such cases 'Extreme pressure lubrication' is done.
- special additives are used along with the liquid lubricants eg chlorinated esters, sulphurized oils, tricresyl phosphate etc are examples of additives.
- these additives forms metallic chlorides, sulphides and phosphides which form a durable film.

CLASSIFICATION OF LUBRICANTS

Mainly 3 classes

- 1. Solid lubricants
- 2. Semi-solid lubricants
- 3. Liquid lubricants

SOLID LUBRICANTS

- Lubricants which exist in solid form called solid lubricants.
- e.g. graphite, molybdenum disulphide, wax, chalk, talk etc.
- Graphite is most commonly used lubricant bz
  - it is non flammable,
  - resist oxidation even at higher temperature.

CONDITIONS FOR USING SOLID LUBRICANTS

It is used in machines when

- semisolid or liquid lubricants are not suitable.
- machine is heavy.
- semisolid (grease) or liquid lubricants are contaminated due to presence of dust particles.

Q: WHY GRAPHITE IS USED AS SOLID LUBRICANTS?

Ans. Due to following reasons

- It is soapy in touch.
- it is non flammable
- it is not oxidized in air
- it can be used in powdered form or in suspension form.
- when graphite is dispersed in oil, it is called 'oildag' and when graphite is dispersed in water, it is called 'aquadag'
- it has a unique structure. Each C atom is sp^2 hybridized and covalently attached to 3 neighboring carbons.

Q: Why molybdnum disulphide is used as solid lubrocant?

Ans: (i) It has sandwich structure. The layer of molybdnum atoms lie between two layers of sulphur atoms. Layers are held together by weak vander Waal forces that's why it is soft and smooth in nature.

- (ii) It is stable up to 400 °C temp.
- (iii) it has low coefficient of friction.
- (iv) It is used in powdered or on additives.

2. SEMI-SOLID LUBRICANTS

- Lubricants which are neither solid or liquid are called semi-solid lubricants.
- E.g. grease, Vaseline, waxes, creams etc.

Conditions for using solid lubricants

it is used when

- Machine works under high load or at low speed.
- lubricating oil is not suitable for machines.
- sealing of oil is problematic.

3. LIQUID LUBRICANTS

- Lubricants which exist in liquid form and reduce friction or wear between the metallic surfaces by providing a continuous film in between them are called liquid lubricants e.g. animal oil, vegetable oil, mineral oil (petroleum oil).

Conditions for using liquid lubricants

it is used when

- solid or semisolid lubricants are not suitable.
- machine are operated under low load.
- machine produces low heat.

CLASSIFICATION OF LIQUID LUBRICANTS

- Animal
- Vegetable
- Mineral
- Synthetic
- blended oil
- emulsions

ANIMAL LUBRICANTS

- Lubricants with animal origin:
  - Whale oil
  - Seal oil
  - Lard oil
  - Neat's foot oil
  - Porpoise oil
- These are highly stable at normal temperatures
- Animal lubricants may not be used for internal combustion because they produce fatty acids

Limitations of animal oil

- Undergo oxidation easily

VEGETABLE LUBRICANTS

- Examples of vegetable lubricants are:
  - Castor oil
  - Olive oil
  - Cottonseed oil
- Animal and vegetable oils have a lower coefficient of friction than most mineral oils.

MINERAL LUBRICANTS

- These are obtained from fractional distillation of petroleum.
- They have poor oiliness but they are widely used as lubricants bz they are cheap and available in large amount.
- These lubricants are used to a large extent in the lubrication of aircraft internal combustion engines.
- Eg petroleum oil

SYNTHETIC LUBRICANTS

- Because of the high operating temperatures of gas-turbine engines, it became necessary to develop lubricants which would retain their characteristics at temperatures that cause petroleum lubricants to evaporate and break down
- Synthetic lubricants do not break down easily and do not produce coke or other deposits eg

BLENDED OIL

- Mixture of two or more oil or any additive added in oil, resultant mixture is called blended oil.
- Blended oil has better quality as compared to their components.
- Some additives are
- *Oiliness carrier*: cater oil, coconut oil etc.
- *antioxidant*: amino compounds
- *Anti foaming agent:* glycol and glycerol.

EMULSIONS

- Mixture of oil and water is called emulsion.
- It is prepared by vigorous mixing in presence of emulsifier (stabilizer) eg sodium salt of sulphuric acid.
- Emulsions are important lubricants which are used in boring and milling. Two types:
- Oil in water (cutting emulsion): Oil in dispersed phase and water as dispersion medium. Oil act as lubricant and water as coolant. It is used in boring, drilling machines.
- Water in oil (cooling emulsion): Water is dispersed phase and oil as dispersion medium. It is used in steam cylinders to keep wall cool with less oil consumption.

LUBRICATING OIL PROPERTIES

- Flash Point and fire point
- Viscosity
- Viscosity index
- Cloud Point and Pour Point
- Aniline point
- Saponification value
- Iodine value

FLASH AND FIRE POINT

Flash Point: The flash point of an oil lubricant is the temperature at which lubricant gives off sufficient vapor that ignite for a moment, when a flame is brought near it.

Fire point: The flash point of an oil lubricant is the temperature at which lubricant gives off sufficient vapor that ignite (burn) for at least five seconds, when a flame is brought near it.

VISCOSITY

- Viscosity of a lubricating oil is defined as the internal friction offered by the layers of fluid of its flow.
- Viscosity is a measure of flow ability of a liquid at a definite temperature.
- It determines the performance of oil under operating conditions.
- Higher the viscosity of fluid lesser will be its flow.

- Coefficient of viscosity is called absolute viscosity is defined as tangential force per unit area required to maintain a unit velocity gradient between two parallel layers a unit apart. It is denoted by η (eta).

Mathematically, $\eta = \frac{F}{A.\,dv/dx}$

Where F = force

A= Area

dv/dx=velocity gradient.

Units: In C.G.S. system poise = dyne $cm^{-2}s$

In SI system $Nm^{-2}s$.

The absolute viscosity of lubricant is determined by measuring the time of flow of the oil through a capillary of definite dimensions at uniform temperature.

The viscosity is can be measured by a Redwood viscometer.

CLOUD POINT AND POUR POINT

- The cloud point is the temperature at which the oil becomes cloudy in appearance is alled cloud point.
- A temp. at which oil do not flow or solidify called pour point.

VISCOSITY INDEX

- The rate at which viscosity of oil changes with temperature is called viscosity index.
- It is used to characterize lubricating oil.
- The viscosity of liquids decreases as temperature increases.
- if the viscosity of oil is much affected with the rise in temperature, it is called low viscosity index and vice versa.
- A good lubricant should have high viscosity index i.e. no much change in viscosity of oil with increase in temperature.
- Some lubricant has high viscosity index
- *e.g.* Silicone, Polyglycol ethers, Diesters, triesters etc.

IODINE VALUE OR IODINE NUMBER

- The **iodine value** (or "iodine adsorption value" or "iodine number" or "iodine index") is the mass of iodine in grams that is consumed by 100 grams of a oil.
- In a typical procedure, the fatty acid is treated with an excess of the Hanuš or Wijs solutions, which are, respectively, solutions of iodine monobromide (IBr) and iodine monochloride (ICl) in glacial acetic acid. Unreacted iodine monobromide (or monochloride) is then allowed to react with potassium iodide, converting it to iodine, whose concentration can be determined by titration with sodium thiosulfate.

ANILINE POINT

- It is minimum temp at which equilibrium exist between aniline and oil sample.

DETERMINATION

- Firstly aniline and oil are mixed with help if stirrer in a tube.
- Now mixture is allowed to cool in a cold bath.
- Temp at which cloudiness is observed is reported as Aniline point.

- Saponification or Koettsdoerfer number:

Saponification is process of alkaline hydrolysis of oils (vegetable or animal) and fats giving soap.

Saponification number is defined as number of milligrams of KOH required to saponify 1 mg of a fatty oil.

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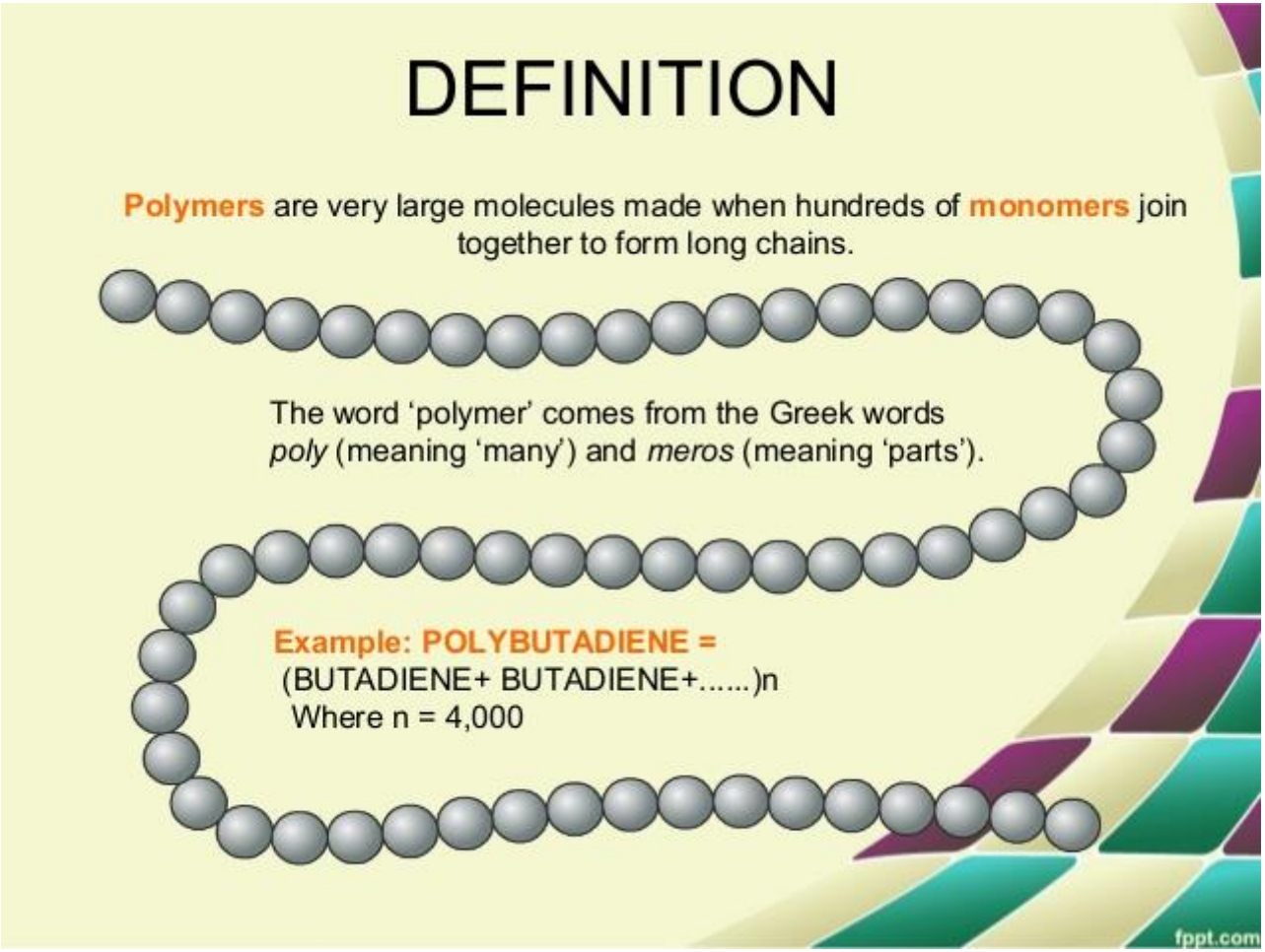
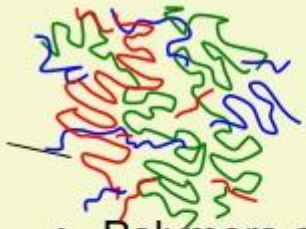
POLYMER AND PLASTIC





INTRODUCTION

- Polymers are complex and giant molecules usually with carbons building the backbone, different from low molecular weight compounds.
- The small individual repeating units/moleules are known as monomers(means single part).
- Imagine that a monomer can be represented by the letter **A**. Then a polymer made of that monomer would have the structure:

  -A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A-A

- This kind of polymer is known as **HOMOPOLYMER.**

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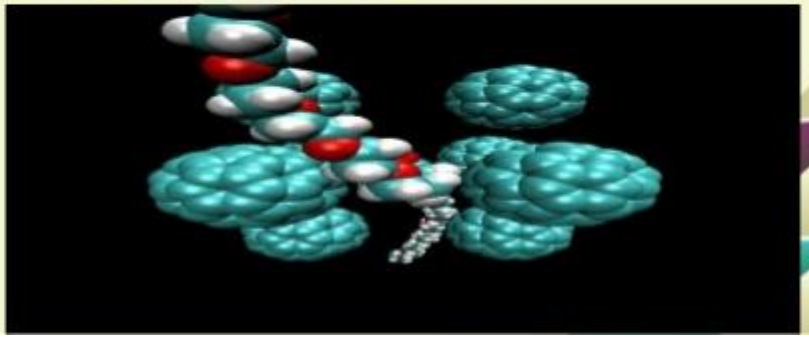
CONT…..

- In another kind of polymer, two different monomers might be involved.
- If the letters A and B represent those monomers, then the polymer could be represented as:

  -A-B-A-B-A-B-A-B-A-B-A-B-A-B-A-B-A-B-A-B-A-B-A- B-A-B-A

- A polymer with two different monomers is known as a **COPOLYMER / HOMOPOLYMER.**



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POLYMERISATION

- The process by which the monomer molecules are linked to form a big polymer molecule is called '**polymerisation**'.
- **Polymerization** is a process of bonding monomer, or "single units" together through a variety of reaction mechanisms to form longer chains named Polymer
- As important as polymers are, they exist with monomers, which are small, single molecules such as hydrocarbons and amino acids.

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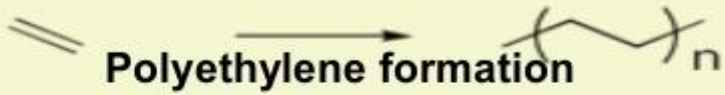
Types of polymerization

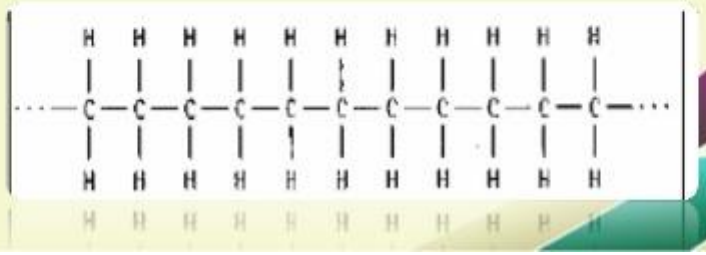
- **Addition Polymerization=**

  When monomers just add on to form the polymer, the process is called ‘addition polym erisation’. The polymer is the *only* product

  e.g. Ethylene monomers add on to form polyethylene. (5 Ethylene monomers)



Polyethylene formation



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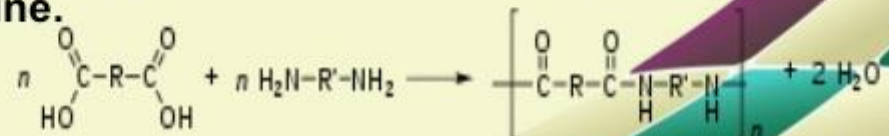
CONT….

Condensation polymerisation=

- The molecules do not just add on but also undergo some reaction in forming the polymer, the process is called 'condensation polymerisation'.
- Here the two molecules condense to form a polymer.The condensation takes place between two reactivefunctional groups, like the carboxyl group(of an acid) and the hydroxyl group(of an alcohol). While forming the polymer water molecules also get eliminated.
- In A. P. mol. weight of polymer is roughly equal to that of all monomers, while in C. P. the mol. weight of polymer is lesser by the weight of simple molecules eliminated during the condensation process. E.g. **Condensation polymerization diacid diamine.**



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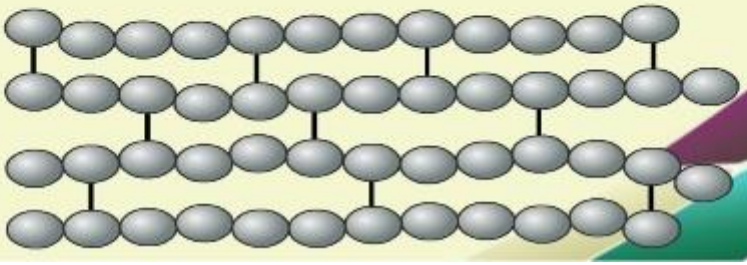
3. Thermoplastic and Thermosetting Polymer

- Some polymer are soften on heating and can be converted into any shape that they can retain on cooling.

- Such polymer that soften on heating and stiffen on cooling are termed as `**thermoplastic**' polymers.

  Ex. Polyethylene, PVC, nylon, sealing wax.

- Polymer that become an infusible and insoluble mass on heating are called '**thermosetting**' polymers. Plastics made of these polymers cannot be stretched, are rigid and have a high melting point.



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4. Plastics, Elastomers, Fibres & Liquid resins

- Polymer is shaped into hard and tough utility articles by application of heat and pressure, is known as '**plastics**'.

  E.g. polysterene, PVC, polymethyl methacrylate.

- When plastics are vulcanised into rubbery products exhibiting good strength and elongation, polymers are known as '**elastomers**'.

  E.g. silicone rubber, natural rubber, synthetic rubber, etc.

- Long filament like material whose length is atleast 100 times it's diameter, polymers are said to be '**fibres**'.

  E.g. Nylon, terylene.

- Polymers used as adhesives, potting compounds, sealants, etc., in a liquid form are described as '**liquid resins**'.

  E.g. Epoxy adhesives and polysulphides sealants.

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APPLICATIONS

- Mainly used for drug delivery.
  - As a coating material

    examples: Hydroxyl propyl methyl cellulose(HPMC),
    Methyl cellulose,
    Propylene glycol.
  - As a binders in tabletting granulation

    examples: Acacia, Gelatin, Sodium alginate.
  - As a disintegrants

    examples: starch, HPMC
  - As a thickening agent in suspension and ophthalmic preparations

    Example: methyl cellulose.
  - To form bases in ointments.
  - In hard and soft capsule gelatin is used.
  - Gelatin also used as suppository base, as an emulsifying agent and suspending agent.

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FUEL

Definition:-

- A fuel is defined as a combustible substance containing carbon as a major constituent which is able to produce a large amount of heat, that can be used for domestic and industrial purpose.

CLASSIFICATION

- Fuels can classified into 2 types.
  a) On the basis of their occurrence.
  b) On the basis of physical state of aggregation.

On the basis of occurrence, fuels are further divided into two types.

i. **Natural or primary fuels :**

Fuels which are found in nature are called natural fuels. E.g.: wood, coal, peat, petroleum and natural gas

ii. **Artificial or secondary fuels:**

fuels prepared artificially from primary fuels are called artificial or secondary fuels. E.g.: Kerosene, petrol, coal gas, coke etc.

- On the basis of state of aggregation fuels are divided into solids, liquids and gases.

Fuel

- primary/natural fuels
  - Solid — eg:coal Peat, wood
  - Liquid — eg:mineral oil (petroleum)
  - Gas — eg:natural gas
- synthetic fuels/ secondary fuels
  - Solid — eg: coke, charcoal etc.
  - Liquid — eg:petrol, kerosene, Spirit, LPG etc.
  - Gas — eg: coal gas producer gas oil gas, water gas, semi-water gas etc.

Characteristics of good fuel:-

A good fuel should satisfy following requirements:-

1) should have a high calorific value per unit weight i.e., when used as fuel unit weight of it should evolve large amount of heat.
2) Moisture content should be low to have heating value high.
3) Should not produce harmful product like co2, so2,h2s which is poisonous and pollutes air.
4) Low content of non-combustible matter in the form ash or clinker. this can enhance the cost of storage, handling and disposal of waste.
5) Size of solid fuel should be uniform for regular combustion.
6) Controllable combustion of fuel so that it can be started and stopped.
7) Economically and easily available.
8) No offensive odor

Comparison of solid liquid and gaseous fuels

Characteristic property of fuel	Solid fuel	Liquid fuel	Gaseous fuel
1) Cost	Cheap	Costlier than solid fuels	Costly
2) Storage	Easy to store	Closed container should be used for storing	Storage space required is huge and should be leak proof
3) Risk towards fire hazards	Less	More	Very high since these fuels are highly inflammable

Characteristic property of fuel	Solid fuel	Liquid fuel	Gaseous fuel
4) Combustion rate	It is a slow process	Fast process very rapid and efficient	Very rapid and efficient
5) Combustion control	Cannot be controlled	Can be controlled or stopped when necessary	Controlled by regulating the supply of air.
6) Handling cost	High since labour is required in their storage transport etc.	Low since fuels can be transported through pipes.	Low, similar to liquid fuels, these can be transported through pipes

Characteristic property of fuel	Solid fuel	Liquid fuel	Gaseous fuel
7) Ash	Ash is produced and its disposal also possess problems.	No problem of ash.	No problem of ash
8) Smoke	Produce smoke invariably	Clean, but liquids associated with high carbon and aromatic fuels produce smoke.	Smoke is not produced
9) Thermal efficiency	Least	High	highest

METALLURGY

PYROMETALLURGY

Pyrometallurgy is the branch of extractive metallurgy. It consist of the thermal treatment of minerals and metallurgical ores and concentrates to bring about physical and chemical transformations in the materials to enable recovery of valuable metal's. This treatment may produce pure metals ,intermediate compounds ,alloys ,suitable feed for further processing

EXAMPLES

Fe ,Cu ,Zn ,Cr ,tin , Mn

This metals extracted by pyrometallurgy

CALCINATION

Calcination is a process in which the ore is heated in a limited supply of air at a temperature insufficient to melt it. During calcination , organic matter , volatile impurities and moisture present in the ore are expelled and remaining mass becomes porous.

Calcination is also done to remove water from hydrated oxide ores or CO_2 from carbonate ore.

Calcination is generally done in reverberatory furnace to render the porous and easily workable in subsequent stages.

)

Examples

Limestone is heated co2 is given off then limestone is said to be calcined.

$CaCO_3 \rightarrow CaO + CO_2(g)$

Bauxite is calcined water is removed anhydrous aluminia is left behind.

Al203.2H20 ⟶ Al203+2H20

In iron calcinaton anhydrous iron is given out

2Fe203.3H20 ⟶ 2Fe203+3H20

ROASTING

Roasting is a wider term used to donate the process in which the ores either alone or with the addition of other materials are subjected to the action of heat in the presenceof air at temp well below their mp in order to bring their oxidation

During roasting volatile impurities are removed.

Roasting taken out in a reverbretory furnace or blast furnace.

SMELTING

A large number of metal oxides obtained during roasting can be reduced to metals by heating with carbon at elevated temp .This process is called smelting.

The roasted ore is mixed with a suitable quantity of carbon and heated to a high temperature above the smelting point of the metal. Carbon monoxide reduce the oxide to the free metal.

During reduction ,an additional substance called flux is added to ore . It combines with impurities to form fusible product slag.

Impurities + flux=slag

EXAMPLES

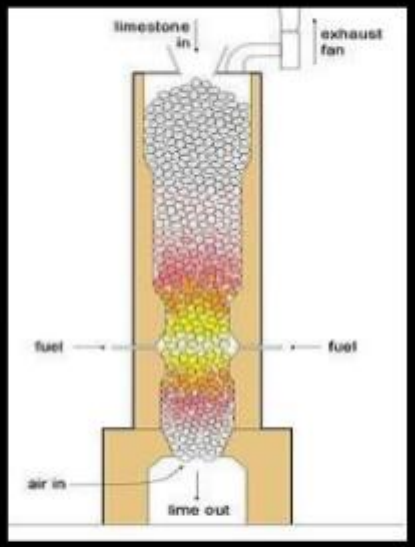
$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$

$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

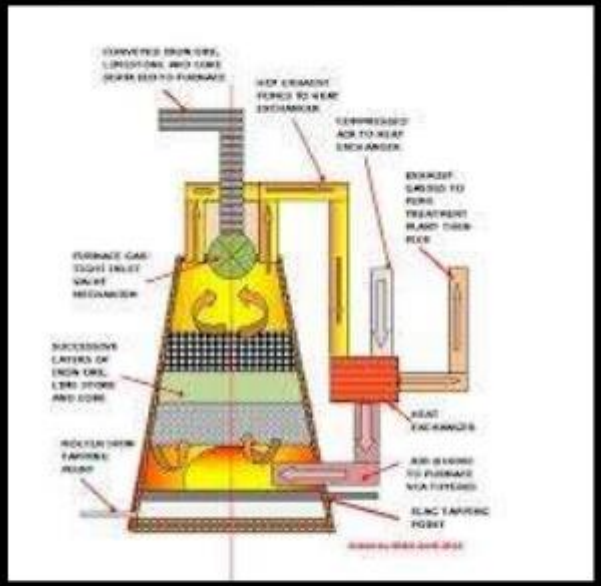
$PbO + C \rightarrow Pb + CO$

$PbO + CO \rightarrow Pb + CO_2$

Smelting is carried out in reverbretory or blast furnace in a controlled supply of air



CALCINATION



SMELTING

Why Bessemer Process has become Out-dated?

This process has got some limitation:

- Pig iron of selected composition is required to be charged.
- Phosphorus and sulphur (to some extent) can only be oxidized by basic Bessemer process.
- The steel contains high content of nitrogen, because air is blown for oxidation. This provides adverse effects and makes the steel unsuitable for most application such as deep drawing purpose.

Comparison between Bessemer and Open Hearth Process:

S.No	Bessemer Process	Open Hearth Process
1.	Alone scrap iron cannot be used.	Alone scrap iron can be used.
2.	Refining and finishing requires 10 to 20 minutes.	Refining and finishing are completed within 8 to 10 Hours.
3.	Operation depends entirely on eye judgment, so that it is very difficult to produce a uniform product.	Operation is guided by laboratory analysis, so that it is comparatively possible to produce a uniform product.
4.	It produces inferior quality steel associated with blow-holes and inclusion.	Open hearth steel is of much superior quality containing lesser blow-holes and inclusion.
5.	Carbon is completely eliminated first and so requires large amount of recarburizer and the product become less homogeneous.	Carbon is partially removed and requires smaller amount of recarburizers and the product is more homogeneous.
6.	Low capital investment.	High capital investment.
7.	Because of rapidity of the process, the control of different operation is rather difficult and careful working is necessitated.	Operation is comparatively easy and finishing up to the desired analysis is feasible.

What Is Alloy?

- Alloy is a mixture of two or more elements with a certain fixed composition in which the major component is metal.

Properties of Alloys

Alloy	Composition	Properties	Uses
Bronze	• 90% copper • 10% tin	• Hard and strong • Doesn't corrode easily • Has shiny surface	• To build statues and monuments. • In the making of medals, swords and artistic materials.
Brass	• 70% copper • 30% zinc	• Harder than copper	• In the making of musical instruments and kitchenware.
Steel	• 99% iron • 1% carbon	• Hard and strong	• In the construction of building and bridges. • In the building of the body of cars and railway tracks.
Stainless steel	• 74% iron • 8% carbon • 18% chromium	• Shiny • Strong • Doesn't rust	• To make cutlery and surgical instruments.
Duralumin	• 93% aluminum • 3% copper • 3% magnesium • 1% manganese	• Light • Strong	• To make the body of aeroplanes and bullet trains.
Pewter	• 96% tin • 3% copper • 1% antimony	• Luster • Shiny • Strong	• In the making of souvenirs.

The Aim in Making Alloy

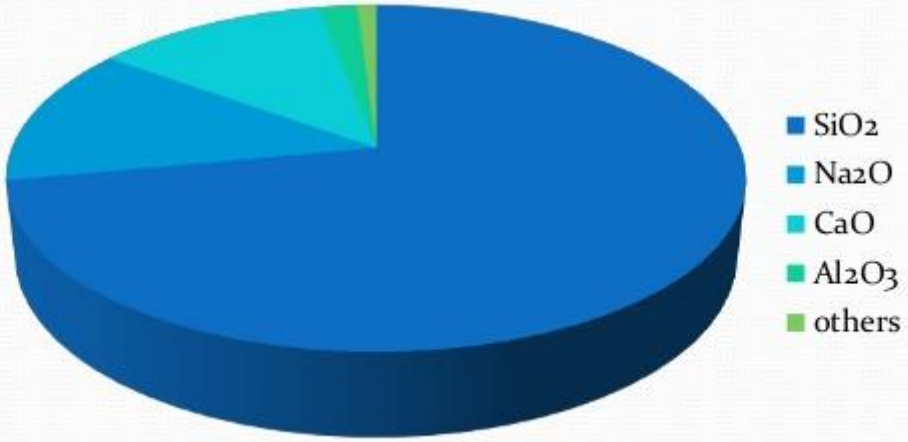
- To increase the hardness and strength of a metal
- To prevent corrosion or rusting
- To improve the appearance of the metal surface.

ENGINEERING MATERIALS

GLASS

Glass is a non-crystalline amorphous solid that is often transparent and has widespread practical, technological, and decorative usage in, for example, window panes, tableware, and optoelectronics

COMPOSITION OF GLASS



MANUFACTURE OF GLASS

Step 1	FUSION OF RAW MATERIALS •
Step 2	WORKING WITH MOLTEN MASS •
Step 3	ANNEALING •

TYPES and USES Of GLASS

_fused glass

_borosilicate glass

_soda-line glass

_lead crystal glass

FUSED GLASS

_the simplest type of glass is fused glass . it consists mainly of silica.

_fused glass is made by heating silica to a molten liquid . the liquid is then cooled rapidly to form an amorphous solid.

SODA-LIME GLASS

Soda-lime glass is the most common and earliest used glass.

It is made by heating silica with calcium oxide and sodium carbonate at around 1 500 c and cooling it quickly

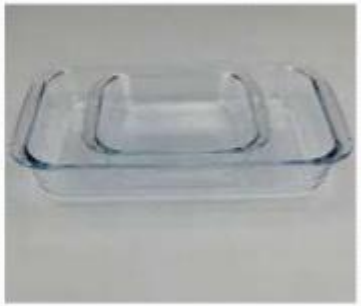
BOROSILICATE GLASS

_When boron oxide B_2O_3 is added to soda-lime glass,borosilicate glass is formed.

_it has a lower thermal expansion coefficient.

_it is about 3 times as heat-resistant as soda-lime glass.

_it is also more resistant to chemical.



LEAD CRYSTAL GLASS

_lead crystal glass is soft and easy to melt

_it is more expansive than soda-lime glass

_it is used for the finest tableware,lead crystal glassware and art objects.

_it is suitable for fine crystal becaouse it is optically transparent and contain much more lead.

RECYCLING GLASS

THANK YOU