Module lll

ENGINEERING MATERIALS AND NANOCHEMISTRY

ALLOYS

An alloy is a mixture of two or more elements, one is essentially a metal.

Purpose of making alloy

- To increase the hardness of metal
- To lower the melting point
- To improve castability
- To improve the colour
- To increase corrosion resistance
- To improve chemical inertness
- To increase tensile strength

alloy	composition	uses
Brass	Cu = 60-90% Zn = 40-10%	Used for making utensils, wires, parts of machinery etc.
Bronze	Cu = 80-95% Sn = 20-5%	Used for making statues, utensils, coins etc.
Solder	Pb = 50% Sn = 50%	Used for soldering

GLASS

Chemically glass is a mixture of silicates and hence have no definite chemical formula.Glass is amorphous, hard, trasparent and super cooled liquid.

Properties of Glass

- It is amorphous.
- It can be molded into desired shape.
- It is a good electrical insulator.
- It is not affected by air, water, or acids.
- It has no definite melting point.

Types of Glasses

1. Soda Glass or Soft glass

It is a mixture of sodium and calcium silicate. Raw materials used for making soda glass are sand, limestone and sodium carbonate.

Uses: Making window glass, bottles, bulbs, jars and dishes.

2. Borosilicate Glass or Pyrex Glass

It is a mixture of sodium aluminium borosilicate.

Properties: Resistant to high temperature and chemicals. Low coefficient of expansion

Uses: Used to make laboratory wares, kitchen wares, television tubes, pipelines for corrosive liquids.

3. Safety Glass

Obtained by fixing vinyl plastic with adhesive between two glass sheets. It does not break under ordinary impact. If it breaks the pieces do not shatter.

Uses:Used for making wind shields of aero planes, automobiles and train.

4. Insulating Glass

It is prepared by two or more glass sheets separated by 6 to 13mm gap filled with air by sealing the edges.

Uses:Used for separating rooms to maintain cool during summer and warm during winter.

Refractories

The heat resistant materials used for making linings for high temperature, furnaces tanks and other processing units.

Eg; alumina, Magnesia, silica.

Properties of refractories

1. Refractoriness: Ability to withstand high temperature without softening

2. Less Porosity: (The ratio of pore volume to bulk volume) Less porosity

3. Minimum tendency for Thermal Spalling:(Fracturing, peeling or cracking on rapid cooling)

4. Strength: Should possess good high mechanical strength at operating temperatures

5. Chemical inertness

6. Least thermal expansion

7. Low electrical conductivity

Classification of refractories

Based on chemical nature refractories are classified into three.

Acid refractories

They are

not attacked by acid slags, but easily attacked by bases.

Eg*: alumina (Al_2O_3), silica (SiO_2)*

Basic refractories

These are not attacked by basic or neutral substances but easily attacked by acid substances.

Eg: *lime (CaO), Magnesia (MgO), magnesite, dolomite*

Neutral Refractories

They consists of feebly acidic or basic materials. They are not attacked by feebly acidic or basic materials.

Eg. Chromite, graphite.

Classification based on physical form

Shaped refractories

These materials have fixed shape and are commonly known as refractory bricks.

Unshaped Refractories

These refractories does not have definite shape. Shape is given only after application. Categories of these refractories: plastic refractories, mortars, castables etc.

POLYMERS

Polymers are high molecular weight molecules formed by joining many repeating units using covalent bonds.

The repeating structural units are called **monomers.**

The process of converting monomers to polymer is called **polymerization.**

CLASSIFICATION OF POLYMERS

1. **Based on nature of monomers**
    1) ***Homopolymers:*** These polymers are derived from same type of monomers.
    Eg: Polystyrene, polyethene, polyvinylchloride(PVC)

2) ***Copolymers:*** These polymers are derived from more than one type of monomers.
   Eg: Nylon-66 (Adipic acid and hexamethylenediammine), Buna-S Butadiene and styrene), Bakelite(phenol and formaldehyde)

Based on mode of polymerisation

1. **Addition polymers/ Chain growth polymers**
   These polymers are formed by the repeated addition of monomers having double or triple bonds. These polymers are also called *chain growth polymers.*
   Eg: polyethene, polypropene, polystyrene.
2. **Condensation Polymers/ Step Growth polymers**
   These polymers are formed by the condensation of monomers. In this polymerization elimination of small molecules such as water, alcohol, HCl, etc take place.
   Eg: Nylon-66, Bakelite, Terylene

(i) ***Thermoplastics:*** It becomes soft on heating. It can be remoulded by applying heat or pressure. Heating and cooling can be repeated without any change in chemical and mechanical properties.

Eg: Polyethene, polypropene,polystyrene

(ii) ***Thermosetting plastics:*** The low molecular weight polymers which cannot be remoulded by the application of heat or pressure are called thermosetting plastics. On heating these polymers becomes hard due to extensive crosslinking.
Eg: Bakelite, urea- formaldehyde.

RUBBER (Polyisoprene)

Natural rubber is a polymer of isoprene. (2-methyl 1,3-butadiene). It is extracted from latex of rubber tree.

Limitations of Natural Rubber

1. It becomes soft at high temperature and hard at low temperature.
2. Low tensile strength
3. Larger water absorption capacity
4. Low resistance to abration
5. Not resistant to organic solvents
6. Easily attacked by oxidizing agents
7. It cannot be used beyond 10-50 ^{0}C

Vulcanization

It is the process of heating the rubber with sulphur and zinc oxide at 373-415K. The sulphur cross-links at reactive site and rubber becomes stiffened.

Merits of Vulcanized Rubber

1. It improves the elasticity, tensile strength, abrasion resistance and rigidity.
2. Makes rubber less sensitive to temperature changes.
3. Prevents the slippage of chains on application of stress
4. Increases to the resistance of rubber to oxidation and swelling
5. Rubber becomes good insulator

Synthetic rubbers

Buna-S (SBR)

Monomers: Styrene,1,3- butadiene

Uses: used for making auto tyres, floor tiles, foot wear, cable insulations, bubble gums

Buna-N

Monomers: 1,3-butadiene, acrylo nitrile

Uses: Making oil seals, hoses, tank lining etc.

COMMON POLYMERS – MONOMERS- USES

1.Polythene

Monomer: Ethene

Uses: Used as packaging material
Insulation for electric wires
Making toys, bottles, buckets, pipes

2. Polyvinylchloride (PVC)

Monomer: Vinyl chloride

Uses: Making rain coats, water pipes, hand bags, vinyl floorigs etc.

3. Nylon-66

Adipic acid, hexamethylenediamine

Uses: Used for making carpets, textile fibers, bristles of brushes, ibearings and gears.

4. Bakelite

Phenol, formaldehyde

Uses: used for making comb, electrical switches, handles of utensils and computer discs.

<u>Nanomaterials</u>

The materials having size within the range of 1-100 nanometer are called nanomaterials.

$1nm= 10^{-9}$ m

<u>Nanotechnology</u>

Nanotechnology deals with the study of process and manipulation of materials at the nanometer level.

<u>Classification of nanomaterials based on dimension</u>

<u>Zero dimensional (0D) nanomaterials</u>

All dimensions in nanoscale.

Eg; nanoparticle, fullerene C_{60}

<u>1D nanomaterials</u>

One dimension in macroscale and two dimensions are in macroscale.

Eg: nanofibers , nano tubes

<u>2D nanometerials</u>

Two dimensions are in macro scale and one dimension is in nanoscale.

Eg: nanosheets, nanolayers

<u>Carbon nanotubes</u>

Carbon nanotubes are formed by the rolling sheets of carbon having one-atom thickness.

Some of these tubes are closed at the ends and some are open.

<u>SWCNT-single walled carbon nanotubes :</u> it consists of only one carbon cylinder.

<u>MWCNT-Multi walled carbon nanotubes</u>

It consists of multiple concentric carbon cylinders.

Properties of carbon nanotube

1. Carbon nanotubes are very strong.
2. Its tensile strength is 100 times greater than the steel.
3. Young’s modulus is 5 times greater than the steel.
4. They conduct electricity better than the metals.
5. Its thermal conductivity is 10 times higher than silver.

   <u>Fullerenes</u>

Fullerene is an allotrope of carbon consisting of sixty or more carbon atoms connected by single or double bonds. It consists of six to seven membered fused rings of carbon atoms. The molecule may be hollow sphere or other shapes. Its composition is given by C_{2n} ($n \geq 30$).
Eg: C_{60}(Buckminster fullerene), C_{70} (rugbyballene)

Properties:
Their extra ordinary properties includes **high tensile strength, high electrical conductivity, high thermal conductivity , high ductility and relative chemical inactivity.**

Applications
Fullerene is used as
A Conductor
An absorbent of gases
A drug delivery vehicle
A lubricant

Graphenes
It is an allotrope of carbon. It consists of single layer of carbon arranged in two dimensional honey comb lattice. The 'ene' in graphene indicates the presence of double bonds. Graphene is the most reactive form of carbon.

Properties:
high tensile strength
high electrical conductivity
high thermal conductivity
harder than steel and diamond

Uses
Graphene is used in
Solar panels, flexible displays, anti corrosion coatings, and sensors

Applications of nanomaterials

Nano materials are used for
- Catalysis- due to large surface area
- Detecting and locating tumers
- Delivering toxic drugs in cancer cells
- DNA mapping of new borns
- Biocompatible joints and replacements
- Making solar panels, sensors and flexible displays