UNIT-IV

Non-Metallic and Advanced Materials :-

polymers :- The large organic molecules in which same structural unit are repeated several times, which are covalently bonded to form long chains is called polymers.

- The word "polymer" is derived from Greek words, 'poly' which means many and 'mer' which means units.
- A polymer is a long-chain molecule that is composed of a large no. of ~~identifying~~ repeating units of identical structure.

characteristics of polymers :-

1. Molecular structure :- polymers have a large molecular structured composed of repeating units is called monomers. The arrangement and bonding of these monomers determine the properties of the polymer.

2. Diversity :- polymers exhibit a wide range of properties. They can be flexible, rigid, elastic or fibrous, depending on the composition and molecular structure.

3. Lightweight :- Many polymers have a low density, making them lightweight materials.

4. Durability :- polymers can be highly durable and resistant to wear and chemicals, depending on their composition and structure.

5. High-molecular weight :- polymers have a high molecular weight, typically ranging from thousands to millions of grams/mole.

5) Versatility :- polymers can be tailored to meet specific requ by adjusting their composition, molecular weight and processing methods.

6) Insulating properties :- polymers often possess good electrical and thermal insulation properties, making them suitable for applications in electrical wiring, insulation and electronic devices.

7) cost effective :- polymers are generally less expensive th many alternative materials like metals and ceramics.

8) Environmental impact :- Some polymers can be recyclable and environmentally friendly, and reducing waste.

Application of polymers :-

i) packaging :- polymers like polyethylene, polypropylene and polystyrene are used extensively in packing materials due to their lightweight, durability and barrier properties against moisture and gases.

ii) Textiles :- Synthetic polymers such as polymers and nylon are used in clothing, carpets and other textiles due to their strength, elasticity and resistance.

iii) Construction :- polymers are used in construction for pipes, insulation materials, adhesives and coating due to their durability, water resistance etc.

iv) Automotive :- polymers are used in automotive applications for manufacturing parts.

vi) Electronics :- polymers are used in making insulation materials and circuits etc.

vii) polymers are used in medical devices and equipments.

viii) polymers are used in making furniture, toys, appliances, containers, tray, bottle, disposable glasses and plates.

viii) polypropene are used in a industry such as - textiles packaging, stationery, plastics, aircraft, construction, rope etc.

ix) PP is used in making sports equipments : such as bicycles, golf clubs, athletic shoes, and other sports materials.

x) PVC is used in T.V, radio, phone cabnets etc.

xi) PP is used for making food containers and cups etc.

Types of polymers :-

polymers are classified into different types :-

Basis of classification	Types of polymer.
(a) origion	- Natural, Semi synthetic, synthetic
(b) Thermal behavior	- Thermoplastic and Thermosetting
(c) Mode of formation	- Addition and condensation.
(d) Line structure	- linear, Branced, cross linked.
(e) physical properties	- Rubbers, plastic, fibers.
(f) Chain	- Hetro polymer, Homopolymer.

Date
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i) Addition polymers :- The polymerisation in which the monomers unit having (C=C) double bond add directly without removal any smaller molecules forming a large molecule is called Addition polymerisation and the polymers obtained in this way is called addition polymers.

e.g- polyethene, polypropene, PVC, PAN (orlon) etc.

→ it is also known as chain-growth polymerisation.

ii) Condensation polymer :- The organic reaction in which a no. of small molecules are associates together forming a large molecule with removal of some smaller molecules such as H_2O, CH_2-OH, C_2H_5-OH etc this is called condensation polymerisation and the polymers obtained in this way is called condensation polymers.

e.g :- Terylene, Nylon-6, Nylon-6,6

→ it is also known as step-growth polymerisation.

iii) linear polymer :- This polymers having simple straight-chain structure where the monomer units are connected end-to-end in single chains.

e.g :- PVC and polyethene etc.

iv) Branched polymers :- In this polymers additional polymeric chain or side chains are attached to the main polymer chain forming a complex structure.
e.g :- starch, glycogens.

v) Cross-linked chain :- chains are interconnected through covalent bond, forming a Network.
e.g :- vulcanised rubber etc.

vi) Natural polymers :- The polymers which are obtained or occurs naturally is called natural polymers. A natural polymers has its origin in plants and animals.
e.g :- starch, cellulose, proteins.

vii) Synthetic polymers :- The man-made polymers or the polymers which are synthesized in the laboratory through chemical process is called synthetic polymers.
e.g :- polyethylene, pvc, Bakelite, Nylon and synthetic rubbers etc.

viii) Co-polymer | Heteropolymer :- Heteropolymer is a type of polymer that is made | formed of two or more different types of monomers.

→ Heteropolymers are produced by copolymerization.

e.g :- ~~PVC~~, DNA, Nylon-6,6, Dacron etc.

→ More than one type of monomer is used for the production of heteropolymers.

viii) **Homopolymer:-** Homopolymer is a type of polymer that is made from identical or same types of monomers.

→ A single type of monomers is used for the production of homopolymers.

→ Homopolymer are produced by homopolymerisation.

eg:- PVC, polystrene.

on the basis of thermal behavior :-

i) Thermoplastic polymer
ii) Thermosetting polymer.

Thermoplastic polymer	Thermosetting polymer
i) The polymers which becomes soft on heating and its turns into hard on cooling are called thermoplastic polymers.	i) The polymers which become hard on heating and it again turns into hard on cooling called thermosetting polymer.
ii) Most of the addition polymer and few condensation polymer are thermoplastic in nature.	ii) Most of the condensation polymers and few addition polymers are thermosetting in nature.
iii) There is no cross linking among the polymeric chain.	iii) There is a large cross linking among the polymeric chain.
iv) eg- PVC, polyethene, polystyrene.	iv) e.g- Bakelite, ureaformaldehyde

vi. Thermoplastics are formed by addition polymerisation.
vii) Thermoplastics are usually soft, weak and less brittle. ~~and~~
viii) These are soluble/dissolve in organic solvents.
viiii) Melting point lower than the degradation temperature.
ix) flexible, elastic and highly chemical resistant.

v) These are formed by condensation polymerisation.
vi) Thermosetting plastics are usually harder, strong and more brittle etc.
viii) These are not soluble in organic solvents.
viiii) Melting-point more than the degradation temperature.
ix) Inelastic, brittle, rigid, Heat and chemical resistant.

properties of thermoplastic and thermosetting polymers :-

Thermoplastic	Thermosetting
i) it ~~has~~ linear molecular structure and weak ~~bond~~ molecular bonds	i) it has cross-linked network and strong bond.
ii) Melting point is lower than the degradation temperature	ii) Melting point is more than the degradation temperature.
iii) it is highly resistant to chemicals	iii) Highly resistant to heat and chemicals.
~~iv) it is recycla~~	
iv) it is recyclable	iv) it is non-recyclable.
v) it is durable, flexible and elastic	v) it is strong, rigid and brittle.
vi) it can be dissolved in organic solvents.	vi) it cannot be dissolved in organic solvents.
vii) Thermoplastic have low melting point and low tensile strength.	vii) Thermosetting have high melting point and high tensile strength.
viii) Thermoplastic is lower in molecular weight.	viii) Thermosetting plastic is high in molecular weight.

ix) it is reversible in nature ix) it is irreversible in nature.
x) cracks can be repaired easily x) Difficult to repairing cracks

uses of thermoplastic polymers:-
i) packaging like containers, bottles, films and wraps.
ii) Textile like clothing and industrial fabrics.
iii) Consumer products like appliance, toys and household items.
iv) Automotive parts, components.
v) Medical devices such as - Disposable instruments, Syringes and tubing.
vi) Electrical insulation, connectors and components.
vii) Construction such as - pipes, fittings and roofing materials.

uses of thermosetting polymers:-
i) electrical components :- Insulators, connectors and circuit boards.
ii) Adhesives and coating like bonding materials and protective layer
iii) Reinforced materials for aerospace, automotive and sports equipments.
iv) In building materials: such as - plywood and laminates.
v) In industrial equipment such as - Gears, bearing and mechanical parts.
vi) In medical devices such as - Dental material, bone cements

Ceramics - types - properties and application

- **Ceramics**:- ceramics are those products which a from inorganic materials and have non-met properties.
- ceramics can also defined as pure material which containing the compound of both metallic and non-m elements/substance.
- They are known for their thermal stability, corro resistance, wear-resistance, hard and brittle.
- The word ceramics is derived from the Greek keramos which means 'potter's clay'.

Ceramics are two types based on gen

i) traditional ceramics ii) Modern ceramics

i) The traditional ceramics materials are stone, brick Concrete, clay, glass, Refractory enamel, abrasives ~~majority of these are composed of~~ silicates.

ii) New ceramic materials/Modern ceramics includes oxi Carbides, Borides, Nitrides, silicates etc. and other si Compound.

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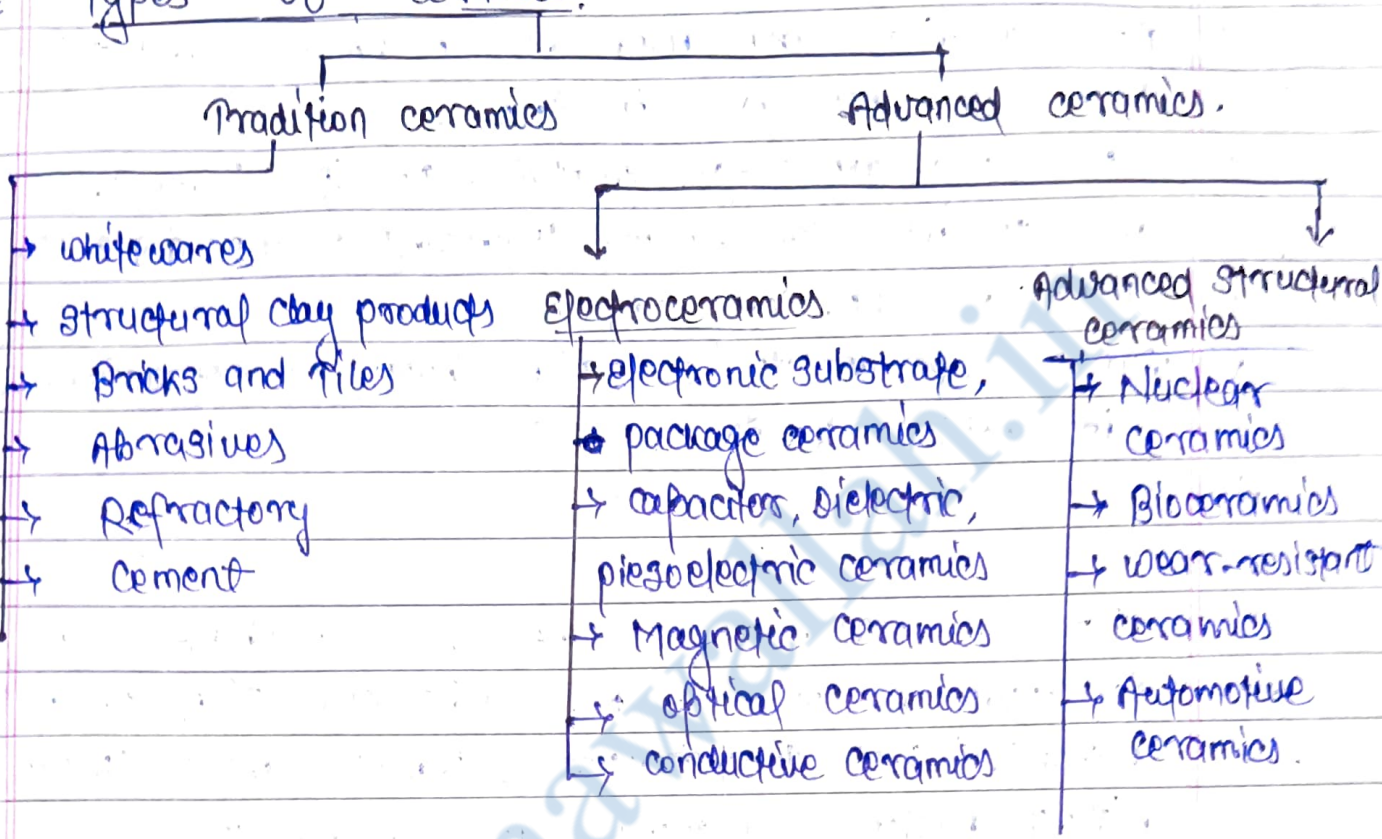
properties of ceramics materials :-

i) They are hard, brittle and durable.
ii) They have high melting points.
iii) Good corrosive resistance
iv) These are excel excellent refractory materials.
v) Low thermal conductivity
vi) Low electrical conductivity.
vii) Good chemical and thermal stability.
viii) High wear resistance with low density.
ix) High compressive strength.
x) Low density

Applications of ceramic materials :-

i) used for metallurgical polishing, cutting tool and engine components.
ii) Used in sand stone and glass papers, energy paper and grinding wheels.
iii) used in furnaces and chemical processing system.
iv) used for coating of cutting tools and engine components.
v) used as thermal barriers.
vi) used in fuel cells, glassware, dinner ware etc.
vii) used in ceramic fibres, ceramic rotors, valves, sensors, piston rings, safety glass wind shields in automobiles.
viii) used for flooring and as a decorative materials.
ix) used in glass fibres and optical fibres
x) used in insulators, capacitors and IC packages.
xi) used in bricks, lab equipments, cements, etc.
xii) used in communication equipments like TV and radio components, microphones.

Types of ceramics :-



Q. what is glass ? properties and uses ?

Ans→ Glass can be defined as a hard, brittle, translucent or transparent materials made by compound of silica, combined with varying properties of oxides of sodium, potassium, calcium, magnesia, iron and other minerals. The glasses are non-crystalline silicates containing other oxides such as CaO, Na_2O, K_2O and Al_2O_3.

properties :-

i) very low coefficient of thermal expansion.
ii) Relatively high mechanical strengths.
iii) High thermal conductivities
iv) can be easily fabricated.

uses of glass:-

i) glass ceramics are used as ovenware and tableware
ii) it is used as insulators.
iii) As substrates for printed circuit boards.
iv) due to its high melting temperature used in shock resistors
v) used in laboratory equipment
vi) due to high density and high index of refraction used in optical lenses.
vii)

Q. what is refractory materials? properties and applications

ans→ Refractory materials are substances that can withstand extremly high temperature, typically above 1000°C, without melting, deforming or decomposing.
some common refractory materials are silica, magnesite, dolomite, silicon carbide, Zircon and graphite.

properties:-

i) These materials do not fuse or soften at the temperature
ii) Excellent resistance against thermal ~~conductivity~~.
iii) These material do not crumble or crack.
iv) High melting point.
v) Highly resistance to corrosion
vi) These materials have low coefficient of thermal conductivity
vii) It has mechanical strength.

uses:-

i) it is used in high temperature furnaces, boilers and heat converter.
ii) it is used in glass production.
iii) Steel and Aluminium production.
iv) used in Aerospace and defense applications
v) Refractory lining for industrial equipment.

Composite Materials:-

A composite material is a structural materials that consist two or more materials are combined together to produce a new material, which possessed much superior properties than any one of the constituent material. Such a material is known as composite material.

- The common example of a natural composite materials is wood which consist of long cellulose fibre held together by amorphous lignin.
- Some of the artificial (or synthetic) composite materials are cement, concrete, glass, reinforced, plastic, plywood etc.
- The composite material is generally better than any of the individual components as regard their strength, heat resistance or stiffness.

properties of composite Materials:-

i) High strength-to-weight ratio.
ii) High strength-to-weig stiffness to weight ratio.
iii) Good wear resistant
iv) Superior magnetic properties
v) High modulus of elasticity
vi) Superior mechanical properties.
vii) High resistance to thermal expansion.
viii) Good corrosive resistivity
ix) Excellent fatigue resistance
x) Improved toughness and occupy less space.

Applications of composite Materials:-

i) used in Aerospace where light weight, stiffness and fatigue resistance are essentially required.
ii) used in gas turbines
iii) used in storage battery plates.
iv) used in high temperature engine parts.
v) used in structural walls, shells, cylinders, pipes etc
vi) used in reactors
vii) used in electrical components.
viii) used in deep sea mining equipment
ix) used in pressure vessels.
x) used in aircrafts

Laminated materials :-

The materials, which are produced by bonding two or more layers of differents materials completely to each other, are known as laminated materials or laminates. The material, constituting a laminated material, may be metallic or non-metallic depending upon the type of applications.

The common examples of laminated materials are plywood, Tufnol, Sunmica, ~~Linolium~~ Linolium etc.

- In laminated materials the top most layer provides the desired appearance and workability, while the lower layer contributes to its strength.

properties of laminated Materials :-

i) Equally stong in all directions.
ii) Good appearance and high rigidity.
iii) High modulus
iv) Excellent strength in all directions
v) High fracture toughness
vi) Good resistance to wear and tear
vii) Resistance to moisture.
viii) provides certain degree of shear rigidity.

Application of laminated materials :-

i) used for roofs, floors and walls of the building.
ii) used for furnitures
iii) used in aircraft for wings, fuselage and tailplane su
iv) used in kitchens, bathrooms.
v) used for cabinet shutters
vi) used for interiors of heavy vehicles.
vii) used in sports equipment.
viii) used in musical instrument such as. Guitar bodies, violin tops and drum shells.
ix) used in agricultural equipment such as. tractor components and irrigation system.

fibre-reinforced materials :-

The fibre-reinforced materials are those materials in which the disperse phase is in the form of the fibre.

The fibre-reinforced composites with high specific strengths and moduli have been produced by using low density fibre and matrix materials.

Matrix materials :- The metal and polymeres or ceramics are generally employed as matrix materials.

Some important fibre reinforced materials are :-

- polymer-matrix composites
  - → Glass-fibre reinforced polymer
  - → Carbon-fibre reinforced polymer

- Metal - matrix composities
- ceramic - matrix composities
- carbon - carbon composities
- Hybrid composities.

properties of fibre-reinforced materials :-

i) High strength to ~~weg~~ weight ratio.
ii) High durability and stiffness
iii) High damping properties
iv) Good resistance to corrosion
v) High compressive strength.
vi) High elastic modulus.
vii) low thermal expansion coefficient.
viii) High wear and fire resistance.

Application of fibre-reinforced materials :-

i) used in automobile tyres.
ii) used in aircraft and millitary equipment.
iii) used for space applications and sporting equipments.
iv) used for automotive parts, storage tanks, plastic pipes etc.
v) used in marine applications.
vi) used in filament wound rocket casting and in wire wound high pressure hoses.
vii)

Advanced engineering materials - properties and applications of Biomaterials, nanomaterials and smart materials.

① Biomaterials :-

Biomaterials are natural or synthetic materials that are used in medical devices, implants or tissue engineering applications to interact with biological system.
They are designed to be compatible with the body, non-toxic and able to perform specific function such as-
i) Replacing or repairing damaged tissues.
ii) supporting tissue growth and regeneration. etc.

properties :-

i) These materials must not produce toxic substance.
ii) It should not be biodegradable.
iii) They should be reliable and durable
iv) They should have desirable strength.
v) They should have elastic modulus
vi) " " " ductility.
vii) They should be Mechanically sound.
viii) strength, stiffness and toughness to withstands physiological loads.
ix)

Applications :-

i) used for bone plates.
ii) for intraocular lenses for eye surgery.
iii) for bone cement.
iv) for dental implants for tooth fixation.
v) used for artificial ligaments and tendons.
vi) used for skin repair devices
vii) used for cancer therapy etc.

② Nanomaterials :- Nanomaterials can be defined as the materials that has at least one dimensions measuring less than 100nm.

Depending upon the no. of dimensions in the nanorange (ie. 1-100 nm or 10-100 A°), the nanomaterials can be classified as :-

i) Zero dimensional - where all three dimensions of the particle are in the nanorange.
ii) One dimensional, where two dimensions are in the nanorange and the third dimensions is much larger.
iii) Two dimensional, e.g- nanorods, nanotubes and nanowires.
iii) Two dimensional - where one dimension is in the nanorange and other two are much larger.
e.g :- nanofilms, nanosheets, and nanocoating.
iv) Three dimensional - where all three dimensional of a particular are much larger than the nanorange. also known as bulk nanoparticle.

properties:-

Mechanical properties:-

i) At a given size ~10 nm, higher the hardness and strength
ii) Increased ductility at temperatures lower than 0.47 Tm
iii) The mixed-grain size i.e: 1-3 μm decreases the strength and increas the ductility.
iv) Nanomaterials are unstable at high temperatures.

Electrical properties.

i) The microwave absorption and permittivity of the materials are very low in broad frequency range.

Magnetic properties.

i) The magnetic properties of nanoparticles is very less as compared to bulk-size.

ii) Nanomaterials have a lower melting point.

Applications:-

i) used in cell phones, laptops, power system and in electric vehicles
ii) supercapacitors can be used in solar and wind powered grids.
iii) used for fuel cells and in mobi automobile industry.
iv) used in 3D printing parts.
v) used in paints to improve their performance.
vi) used in sunscreens and cosmetics materials.
vii) used in medicines and in sensors.
viii) it can also be used in construction.

#(3) Smart materials :-

Smart materials, also called intelligent or responsive materials, are designed materials that have one or more properties that can be significantly changed in a controlled fashion by external stimuli, such as: stress, moisture, electric or magnetic fields, light, temperature, pH or chemical compounds.

OR

different smart materials are-

i) piezoelectric materials.
ii) electrostrictive materials.
iii) Magnetostrictive materials
iv) Thermoresponsive materials.
v) electrochromic materials
vi) smart gel etc.

properties :-

i) High sensitivity
ii) excellent shock absorber and damage arrester.
iii) self corrective, self controlling and self healing.

iv) They have self detective and self diagnostic.
v) Their response time is very less fast
vi) excellent ability to change their appearance and shape.
vii) They cover huge range of the scales.

Applications :-

i) used for actuator and sensors.
ii) used for electronic display units, data storage units and energy conversion devices.
iii) used in composite materials embeded with fibre-optics.
iv) Automative wheel balances, seal belt buzzers etc.
v)
vi)
vii)