→ Anti-static coatings
→ In communication devices.
→ Biomedical devices (artificial veins).

10/08/2022

ENGINEERING MATERIALS

* Which has diversified applications in different fields.

→ Composite Materials → Liquid crystals.

* Combination of either of the 2 of metals, ceramics and polymers forms a composite materials.

* The properties obtained in composite materials are completely different from the initial materials.

* Because of composite materials: processability and time for production decreases.
- Moulding is more
- Low cost
- High performance materials.
- Least effected by environment
- Offers high resistance to chemicals
- light weight materials.
- almost inert.

* ~~except reactive~~

aspect ratio: length to diameter ratio.

If the aspect ratio is different: properties differ from one material to another.

* Phases → Matrix phase (design)
  → Dispersed phase (filler).

* Fibres used as reinforcement for composite materials:

1) Carbon Fibre → light
2) Glass Fibre → heavy, high cost
3) Aramid → very light

Used widely in Aerospace industry.

* Composite materials are new class of materials which are produced by mixing (or) more different materials (polymers, metals & alloys, ceramics).

- These are multiphase materials having different properties compared to the constituted material (materials used in them).
- The produced composite material properties are completely new & different compared to initial
- These contains 2 phases → Matrix
  → Dispersed.

* Classification based on matrix phase:

- Polymer Matrix Composite (Polymer)
- Ceramic Matrix Composite (ceramic)
- Metal Matrix Composite (Metal)

} Matrix phases

* Classification based on dispersed phase:

This can be of polymer, metal, ceramics, but dimensions can be different.

- Whisker – Spring like structure
- Flake – irregular shape
- Particle – particles
- Fiber – thread like structure

* Layered Composites: eg: Plywood (cellulose + lignin)

16/08/2022

- Basic arrangement → matrix → skeleton
- Fillings in the matrix → dispersed
- to increase the strength of the materials: reinforcements are added.

* classification based on structural arrangement:

- Single layered
- Multi layered

* Manufacturing Methods:

- Open Method : Handlayup method.
- closed Method:

→ Used ~~at~~ low temperatures only due to which they are eco-friendly in nature

Volatile Material + Catalyst + Heating + Solvent + Binder = Resins

*closed Method:

- RTM : Resin transfer moulding method.
- Pull trusion Method
- Filament Winding Method

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* LIQUID CRYSTALS:

- Having both solid & liquid like properties also anisotropic in nature; such materials are called liquid crystals.
  - definition
  - classification
  - Chemical composition
  - Molecular bonding
  - Applications

Solid —Δ→ mesophase → Turbid Liquid —Δ→ Clear liquid solution.

Turbid Liquid ⇓ Thermodynamically stable.

~~* liquid crystals~~

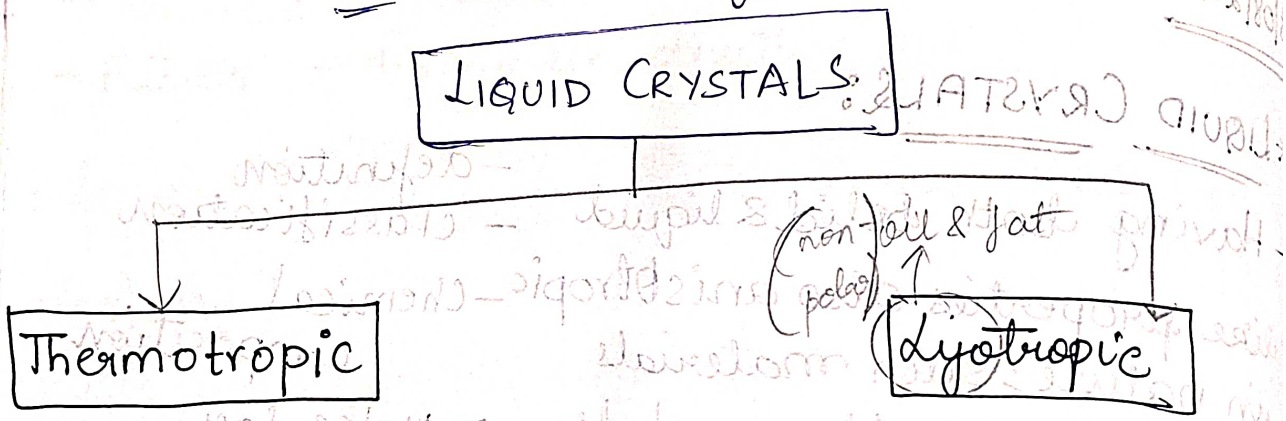
* Materials having solid like properties (molecular ordering & orientation) and liquid-like properties (flow like properties) and a stable meso-phase existing between solid and liquid and exhibits anisotrophy

Ex: para-azoxy cinnamate

→ Isotrophy: Properties of materials remains same in all the directions Ex: pure solids & liquids

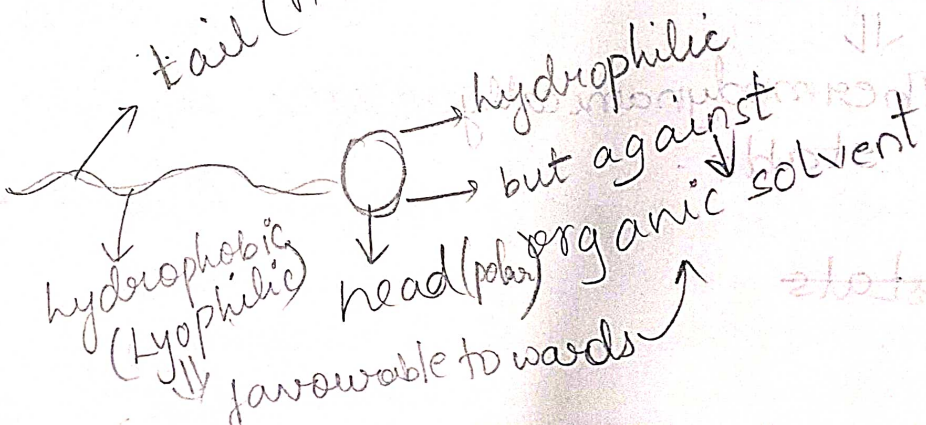
→ Anisotrophy: Properties differ in different directions

Ex: liquid crystals.



- Diagnosis purposes
- change in temperature
- Rigid compared to lyotropic.

- Proteins, lipids
- solute-solvent interactions.



Like dissolves like

* Thermotropic:

- Liquid crystalline state can be obtained by changing the temperature.

  Ex: para-azoxy

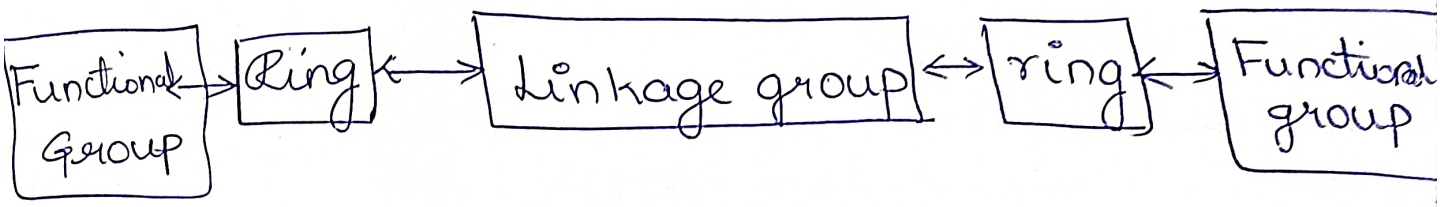
* Lyotropic:

- Liquid crystalline state can be obtained by the solute-solvent interactions.

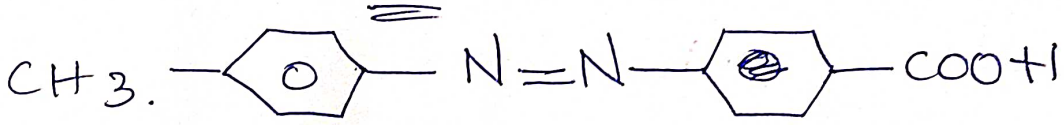
  Ex: Soap Solution

- All living beings consists of lyotrophic liquid crystals.

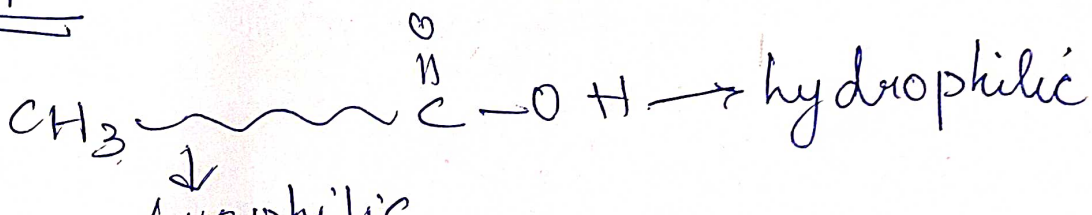
* Chemical Composition of Thermotrophic liquid crystal:



Ex:



* Lyotropic:

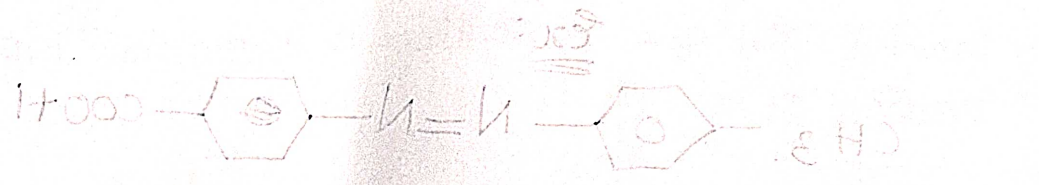


Applications of Liquid crystals:

* Temperature, Pressure sensors
* Medical Diagnosis
* Display of radio frequencies, L.C.D's
* Monitoring internal pressure of the body
* Non-Destructive Test.

→ Types of thermotropic Liquid crystals.

1) Nematic Liquid crystals.
2) Smetic liquid crystals.
3) Cholestellic (or) chiral liquid crystals



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UNIT-5

NANO MATERIALS:

Properties of a material depends on

1) Chemical composition - salt & sugar, $KMnO_4$ & $K_2Cr_2O_7$

2) Structural arrangement / Geometry - Graphi diamon

3) Size - Reduction in size : alters the properties.
- Gold, (shiny yellow to purple) - nano materials.

* Materials whose size is 10 to 100 times the size of the atom which acts abnormally when size is reduced; are called nano materials.

* Anything which is in the order of 1 to 100 Nano meter atleast by one dimensions.

* is known as nano-materials.

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

$100nm = 10^{-7}M$

10^{-9} to 10^{-7} M

* Materials whose size is bigger than nano-materials in the order of 10^{-6} M are called bulk materials.

* Why properties are diff. for nano materials?

* If surface - volume ratio changes; the properties of nano materials also changes.

Quantum dots: 3D imensionally nano size is observed.

If size of material reduces; the movement of e^- is confined to a specific level which can be called as Quantum Confinement.

$\Delta E \propto \frac{1}{L}$ Energy diff. depends on size of material.

→ Properties changing in accordance with

- Surface-volume ratio: catalytical
  optical.
  absorption

- Quantum Confinement: Electrical
  Optical
  Magnetic.

Explain why nano materials are different from their bulk material:

Bulk gold have shiny yellow colour but its smaller sized parts exhibits different colours.

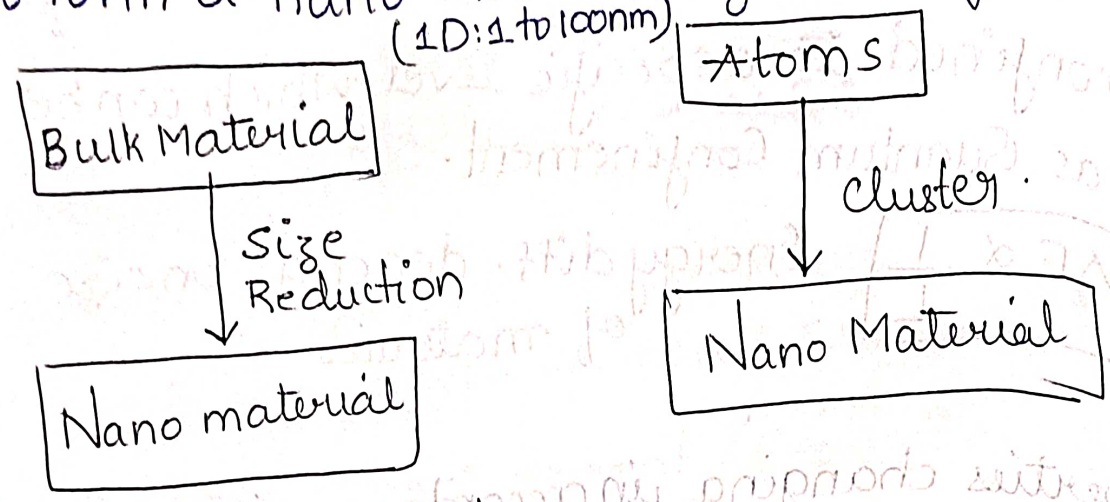
* Nano catalysts have advantages of both homogeneous & heterogeneous catalysts.

* SYNTHETIC METHODS:

*→ Top-Down method: Cutting the bulk material into small pieces i.e. finally nano material is obtained.

*→ Bottom-Up method: When we combine atoms

to form a nano material by forming clusters (1D: 1 to 100nm)



✱→ Top-Down Method:

Ex: Ball milling (mechanical alloying)
↳ operated only for hard materials like ceramics.

Thermodynamically weaker materials cannot be synthesized.

✱→ Bottom-Top Method:

Ex: Sol-Gel Method; Chemical Vapour Deposition
Pyrolysis (heating in O_2).

- Less energy is needed.

→ BALL MILLING:

In this method; tough balls are used made with tungsten carbide, titanium alloy, stainless steel balls. These balls should not undergo any changes during milling.

Based on selected material; suitable ball & rotation speed is maintained to optimise

production of nano materials

* Based on starting material, optimum conditio such as speed of ball, size of balls should be selected to get good quality of nano materials.
* This process is not suitable to convert all bulk materials into nano materials.
* This process is more suitable for ceramics, metal and alloys.
* In this method, high energy is released which is good enough to aglamarate particles to produce bulk material.
* This ~~scale~~ method is scaled up to ton scale.

→ SOL-GEL METHOD (WET METHOD):

↳ deals with chemistry of materials

* Types of Nano materials:

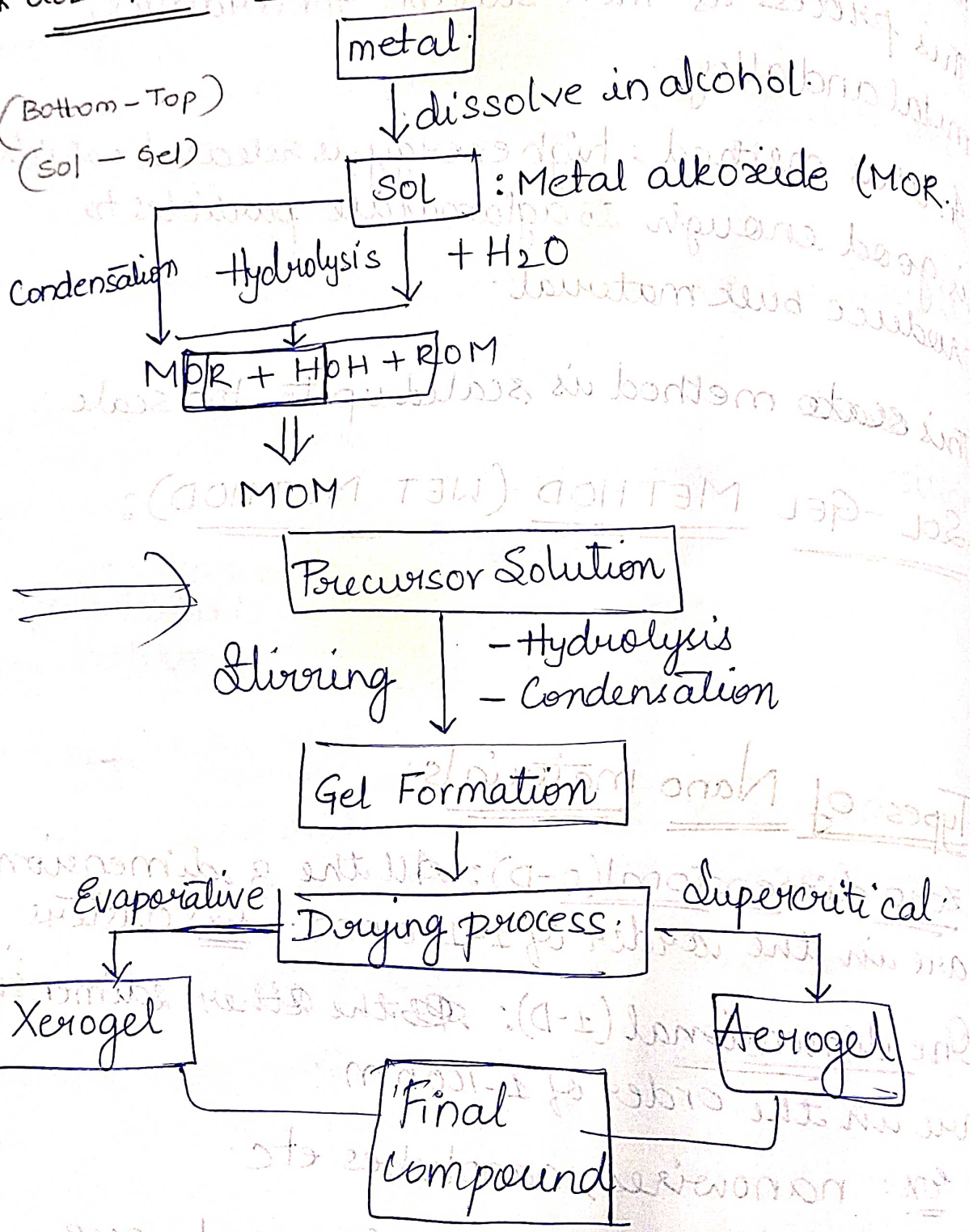
- Zero dimensional (0-D): All the 3 dimensions are in the order of 1-100 nm. Ex: clusters
- One dimensional (1-D): ~~All~~ the other 2 dimensions are in the order of 1-100 nm.
  Ex: nanowires, nanotubes etc.
- Two dimensional (2-D): ~~There~~ only one dimension is in the order of 1-100 nm

Ex: nano films, nano sheets

- 3 Dimensional (3D): None of the dimensions are in the range of 1 to 100nm.

Ex: Polycrystals

* SOL-GEL METHOD:



- controlling the pH, size can be done in this method; hence it is used over ball milling method.