INTRODUCTION TO LIQUID CRYSTALS

- In Crystalline Solid state: Positional and orientational orders are present.
- In Liquid state: there are no positional and orientational order.
- In Liquid crystal: positional order may be lost, but some of orientational order remains.
- Therefore, Liquid Crystal is phase is also referred as *mesophase*.

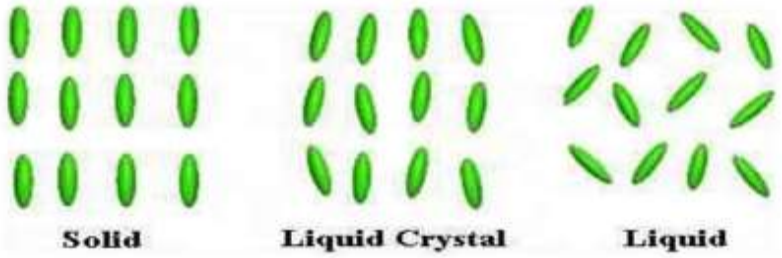


Figure 1: Arrangement of molecules in solid, Liquid Crystal and Liquid

- Liquid Crystals are soft condensed matters discovered by Scientist Reinitzer.
- He found two melting points for Cholesteryl benzoate.One at 145.5 ^{0}C and another at 178.5 ^{0}C.

Criteria for a molecule being liquid crystalline

a) The molecule must be elongated in shape-length should be significantly greater than its width
b) Molecule must have some rigidity in its central region
c) The ends of the molecule are somewhat flexible

Director

An imaginary vector in the preferred direction of liquid crystal molecules is called director

Assuming that the direction of preferred orientation in a liquid crystal (LC) is ↑, this direction can be represented by an arrow, called the director of the LC.

Order Parameter:

It is used to measure the amount of orientational order present in the liquid crystal material. The order parameter (S) is defined is defined as below:

$$S = \left\langle \frac{3\cos^2(\theta) - 1}{2} \right\rangle$$

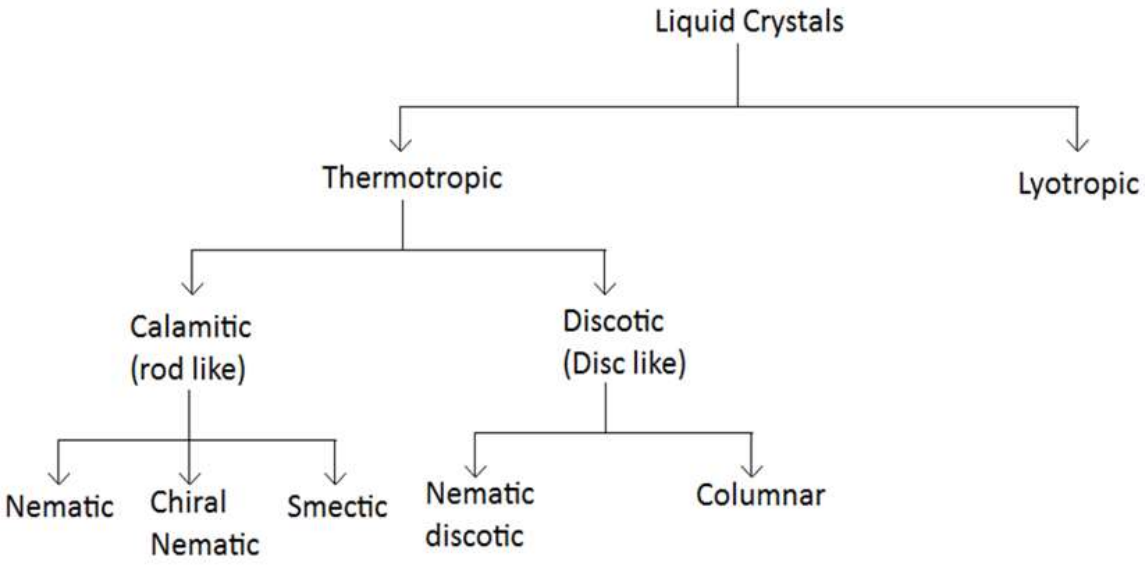
Where θ is average angle of molecules with director.

It describes the orientational order of liquid crystalline material, allowing for the individual orientational deviation of the molecules from the director, which represents the average over the collection.

For perfect orientation: θ for all molecules = 0°, S = 1

For completely random orientation: S = 0

Classification of Liquid crystals:



NEMATIC LIQUID CRYSTALS

1. The word nematic is derived from the greek word "Nema" which means thread like molecule.
2. In these liquid crystal molecular axes are oriented parallel to one another resulting in long range orientational order and short range positional order.
3. The molecular long axis points on the average in one favored direction called director as shown in Figure 2.
4. They are anisotropic with respect to optical properties, viscosity, electrical and magnetic susceptibility, electrical and thermal conductivity.
5. Useful for display applications.

Figure 2: Nematic liquid crystal

CHOLESTERIC LIQUID CRYSTALS

1. This phase of Liquid Crystal is similar to the nematic phase, however the director in each successive layer is inclined to form angle with the direction of the axis of molecules in the preceding layer as shown in Figure 3.
2. The period of this variation ie the distance over which a complete rotation of 360° is completed is known as the pitch.
3. Cholesteric molecules are non – polar in nature, the optical properties of this phase depends on half value of pitch which is also known as period of helix.
4. Due to this, cholesteric phases have an ability of selective reflection of light of wavelength equal to the pitch length and show colors when wavelength is in visible region.

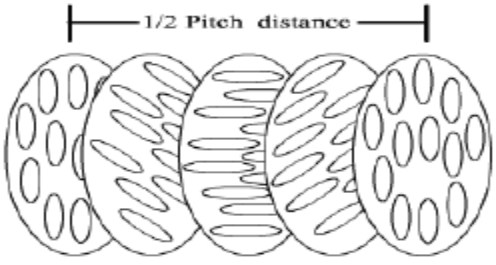


Figure 3: Cholesteric liquid crystal

SMECTIC LIQUID CRYSTALS

1. The word smectic is derived from the Greek word 'Smectos' which means soap like.
2. The molecules in this phase are arranged in layers and exhibit some correlations in their positions in addition to the orientational ordering as shown in Figure 4.
3. The long range orientational ordering is always present in all layers of the smectic liquid crystal.
4. The interlayer interactions are weaker than the lateral forces between molecules and hence the layers can easily slide over one another.

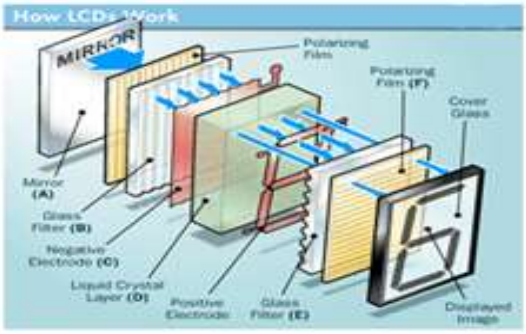
Figure 4. Smectic liquid crystal

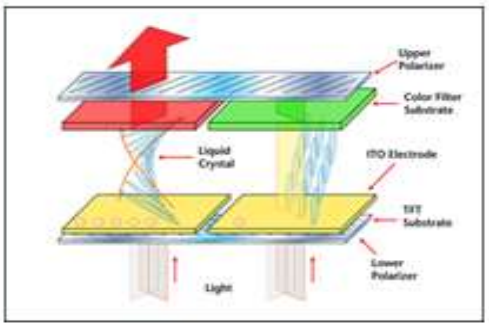
Applications of Liquid Crystals

- **LCD (Liquid crystal display)**
- **Liquid crystal thermometer**
- **Liquid crystal lenses**
- **Liquid crystal laser**
- **Optical Images**
- **Medicinal Uses**
- **Helmets and bullet proof Jackets**
- **Optical memories**

Liquid Crystal Display(LCD)

Liquid Crystal Display(LCD) screen works on the principle of blocking light rather than emitting light. LCD's requires backlight as they do not emits light by them.





ADVANTAGES OF LCD

Brightness	Produces very bright images due to high peak intensity. Very suitable for environments that are brightly lit .
Emissions	Produce considerably lower electric, magnetic and electromagnetic fields than CRTs.
Geometric Distortion	No geometric distortion at the native resolution. Minor distortion can occur for other resolutions.
Power Consumption	Energy efficient. Consume less than 1/3 the power of a comparable CRT. Consume less electricity than a CRT and produce little heat.
Physical Aspects	Take up about 40% less desk space. LCDs are thin and compact.
Screen Shape	Completely flat screen.
Sharpness	At the native resolution, the image is perfectly sharp. Adjustments are required at all other resolutions which can result in measurable degradation to the image.