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# An Introduction to Liquid Crystals and It's Types Nematic, Smetic and Cholestric Crystals

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***Abstract*** **- Liquid crystals (LCs) are considered as the "fourth state of matter," which can display properties between crystals and isotropic liquids. LCs can be classified into lyotropic liquid crystals (LLCs) and thermotropic liquid crystals (TLCs), among which LLCs are a kind of self-assemblies formed by amphiphile molecules in a given solvent within certain concentration ranges. The structures and properties of LLCs can be tuned by the incorporation of various kinds of additives, which represents an interesting and novel route for realizing functional composites. Liquid crystalline materials typically involve organic compounds and show a state of order intermediate between the familiar crystalline lattices and those of isotropic liquids. Today, the word "mesophase" is a more appropriate and meaningful description of this intermediate state between crystal and liquid. Any organic liquid comprised of nonspherical (either rod-like or discotic) molecules is, in theory, capable of forming a mesophase, and about 0.5% of all pure organic compounds show liquid crystalline behaviour. Liquid crystals may be divided into two broad categories: thermotropic and lyotropic. Thermotropies have temperature-dependent phase behaviour, while lyotropic exhibit concentration-dependent phase behaviour. The former is typically a one-component system, while the latter requires a solvent (e.g., water) plus the liquid crystalline solute. In this monograph, emphasis will be given to thermotropic systems. However, the results obtained from nuclear magnetic resonance (NMR) spectra are quite similar in both types of liquid crystals.**

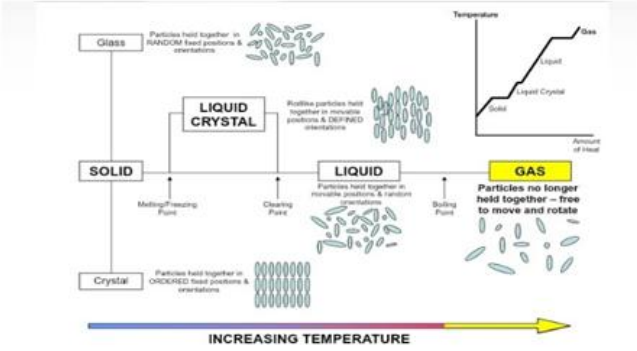
***Keywords:*** Liquid Crystals, Nematic, Smetic, Cholestric Crystals.

## I. INTRODUCTION

In 1888, Reinitzer [1.1] performed experiments with molten cholesteryl benzoate under a polarizing microscope and discovered two melting points. The substance melted from a solid at 145.5°C into a cloudy but completely fluid phase, and only at a much higher temperature (178.5°C) did it become completely clear. Lehmann [1.2] found that the turbid liquid was birefringent, and hence optically anisotropic. He coined the term liquid crystal for this new state of order.

There are different types of material in nature. These types of matter are also called state of matter. The nature of material depends upon types of attraction present between the molecules and mobility of atom and molecules. Main state of matter is three types:

1. Solid state
2. Liquid state
3. Gaseous state




In solid state, attraction between atoms and molecules is high. Molecules are close to each other inter molecular forces between the atoms or molecules are high. So molecules of solids have fix orientation in space which keeps the molecule fix shape. So these properties solids have high melting and boiling point. In liquid state of matter, attractive forces between the molecules are weak as compared to the solid but strong as compare to gases. The molecules of liquids have more empty spaces as compare to the solid, attractive is weak the molecules move around with each other but molecules remain close to each other so fluid do not have fix shape and adapted the shape of container that hold it. While in the cause of gases attractive forces among the molecules is weak. The molecules are faraway from each other. The molecule has high large empty spaces so the atoms or molecules of atoms are compressible. The gas molecules have high empty spaces molecules of gases moves randomly so the molecules of gases will expand and fill the container.

Three states of matters have several intermediate states; gel is an example of intermediate state. It is like a solid and like a liquid. The liquid crystal is also another example of intermediate state which have both solid and liquid phase.

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Liquid crystal has solid like properties but flow like liquid. The liquid crystals are first observe in cholesteryl benzoate. It is first liquid crystal.

It is state between solid and liquid crystal. It has some specific properties of a liquidity. Droplets properties as well as some crystalline properties. The liquid crystals is a material that show properties of liquid and sometime solid it is substance that like liquid and like a solid. It is slippery in nature like soap. These liquid crystals are found in soap dish. In a liquid, all type of molecules flew around anyway. Solid, the molecules have strong attractive forces among them. They are attracted with each other so they have regular pattern and they are arranged in specific shape.

The state of matter which has properties similar to crystalline solids as well as amorphous liquids is called Liquid Crystals. They can arrange regularly like crystalline solids and they can flow like liquids.

When a solid is heated, it is first converted to hazy liquid (Viscous Liquid), which on further heating converted into transparent liquid.

"The state of hazy liquid is called meso-phase or middle phase or Liquid – Crystals." Liquid crystal materials generally have several common characteristics. Among these are rod-like molecular structures, rigidness of the long axis, and strong dipoles and/or easily polarizable substituents.

The distinguishing characteristic of the liquid crystalline state is the tendency of the molecules (mesogens) to point along a common axis, called the director. This is in contrast to molecules in the liquid phase, which have no intrinsic order. In the solid state, molecules are highly ordered and have little translational freedom. The characteristic orientational order of the liquid crystal state is between the traditional solid and liquid phases and this is the origin of the term mesogenic state, used synonymously with liquid crystal state.

**History**

In 1888, the Austrian chemist Friedrich Reinitzer was performing experiments to discover correct formula and molecular weight of cholesterol. He was working on melting point. It shows variation in melting point. He observed two melting points (178.5°C and 145.5°C). When the temperature of solution reaches at 145.5°C solutions become milky when the temperature increases up to 178.5°C. The solution becomes transparent. He thought that changes between two temperature is due to some impurities but when he purify the solution be found that this changes remain still so be thought that obtaining of clear liquid is property of solution.

Otto Lehmann a German physicist. He found that change the colour was new state of matter. It is intermediate state. This new state was named "liquid crystal". It was intermediate properties of solid and liquid state of matter, distribute important properties of both.

In the 1960s, a French theoretical physicist, pierre-Gilltes de Gennes, He had worked on liquid crystal and got noble prize in physics 1991.

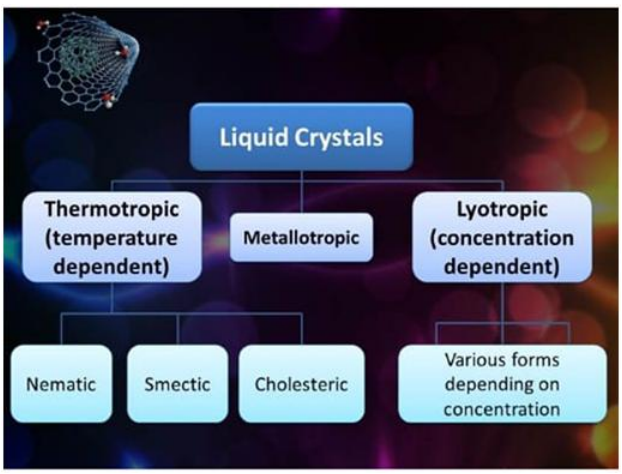
## II. CRYSTALS AND LIQUID CRYSTAL

The solid crystals and liquid crystals are different to each other due to properties. The liquid crystals are oriented with three dimension structure in the space. These three dimension structure indicate that crystals are optically active rotate the plane polarize light. Liquid crystals show twisted structure while solid crystals do not show twist structure. In liquid crystals two different phases solid and liquid phase are mix with specific proportion but in solid crystal phase do not have liquid crystals are active molecules in liquid crystals molecules of crystals are thin, long like a French fries. Even if the molecules' position share randomly. Their position can be orientation with a regular pattern then they show regular and order structure of liquid crystal.

The liquid crystal molecules do change the polarization of light. A polarizing filter works by absorbing a particular component of the electric field. The liquid crystal molecules don't absorb anything however, if they are arranged in the proper way. They can "twist" the light that is, rotate the plane in which it is polarized. If polarized light goes through the molecules, it comes out polarized in a different direction. The light is sent through that first polarizer before it enters the liquid crystal.

## III. CLASSIFICATION OF LIQUID CRYSTALS

Liquid Crystals can be classified as follows:



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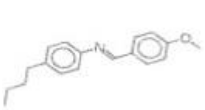
**Liquid Crystals**

1. Thermotropic liquid Crystals:

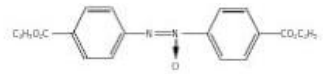
Following molecular says of thermotropic liquid crystals

1. Is 4-methoxy benzylidene-4'-n-butyl aniline (MBBA). Shif base -N-
2. Is diethyl4,4'-azoxybenoate. -S-
3. Is 4'-n-pentyl-4-cyanobiphenyl (5CB). -N-
4. Cholesteryl propionate. -Ch-

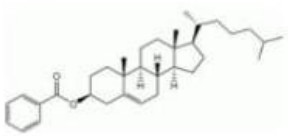
The above molecules are typical thermotropic Lcs. Common features are markedly elongated, rodlike or lathlike and rigid.



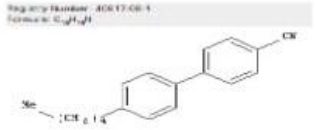
( I ) MBBA



(II)



( III ) 5CB

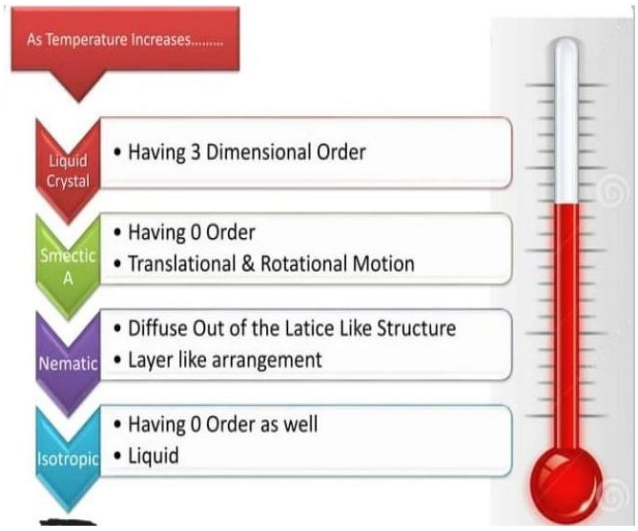


( IV )

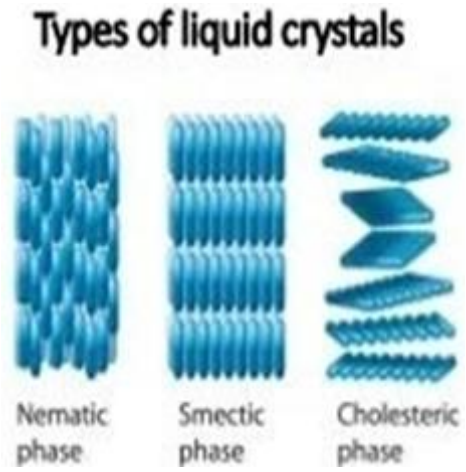
***Types of liquid crystals:***

1. Nematic Liquid Crystals
2. Smectic Liquid Crystals
3. Cholesteric Liquid Crystals

As we increase change temperature the liquid crystal in smetic, nematic and isotropic in following order as shown in figure:



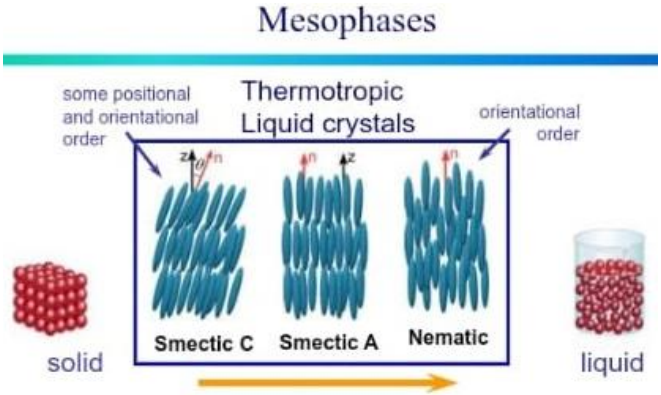

Types of liquid crystals as shown in given diagramme:




1. Lyotropic Liquid Crystals
2. Discotic & Calamatic Liquid Crystals
3. Metallotropic Liquid Crystals

**1. Thermotropic liquid Crystals:**

Those liquid crystals which are based on temperature range are called termotropic liquid crystals. These are further divided in to three parts.




**A) Nematic Liquid Crystals**

The word nematic is taken from the Greek word "**Nema**" which means thread like. So those liquid crystals which have thread like structure are called Nematic liquid Crystals.

The nematic phase is most important phase because they have lot of application for developing liquid crystals. In nematic crystal phase molecules are arranged parallel to one another. In this figure molecules are arrange in rod shape linkage of crystal molecules. It has two or more ring fixed by a central linkage group.

Long range orientation order but no positional order. Preferred direction is known as director. Phase Structure change in number way e.g.. electric or magnetic field or treatment of surface of sample container.

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**B) Smetic Liquid Crystals**

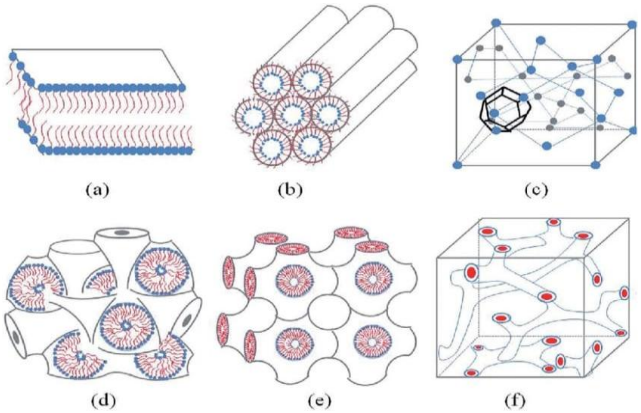
The word Smetic is taken from the "Greek" word "**Smeticus**" which means Soap like or slippery.
Those liquid crystals which has soap like structure or slippery in nature are called Smetic liquid Crystals.
# They have positional as well as orientational order.
# They are oriented in some direction.


**C) Cholesteric Liquid Crystals**

Those liquid crystals which have cholesteral like structure are called Cholesteric Liquid crystals. These are also called Chiral Nematic liquid Crystals.


**2. Lyotropic Liquid Crystal**

Those liquid crystals which are be based on concentration are called Lyotropic Liquid Crystals. For Ex: Micelles.

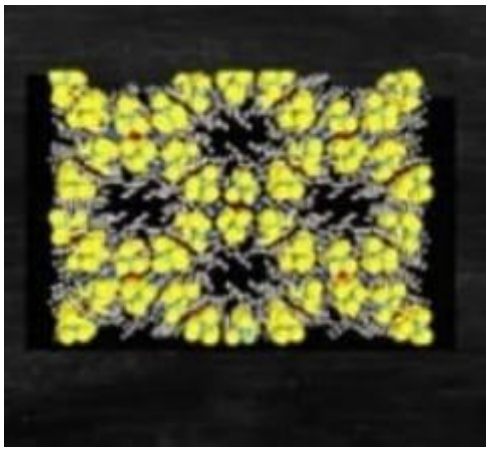



**3. Discotic & Calamatic Liquid Crystals**

Those liquid crystals which has disk like structure are called discotic liquid crystals. Those liquid crystals which has rod like structure are called calamatic Liquid Crystals.


**4. Metallotropic Liquid Crystals**

Some of the metal salts like $ZnCl_2$ behave like liquid crystals, such metal salts are called metallotropic liquid crystals.



**Criteria for molecule being liquid crystalline:**

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

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**Methods for Characterization of LCs:**

**1. Transmission Electron Microscopy**

Due to high magnification power electron microscope, microstructure of LCs can be visualized. Aqueous sample do not survive high vacuum of electron microscope without loss of water & their microstructure changes. Therefore special techniques of sample preparation necessary which is freeze fracture.

**2. X -Ray Scattering**

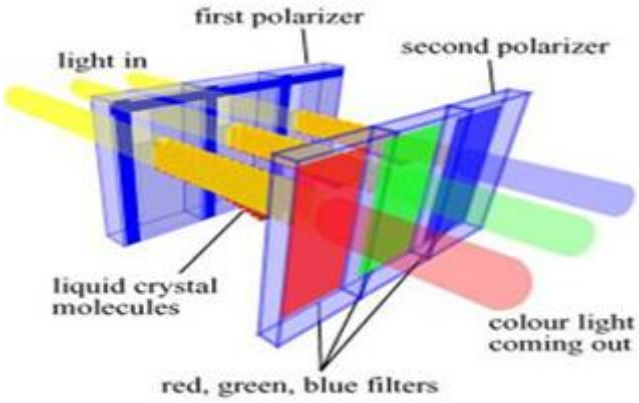
Interference pattern arises due to distance of interlayer spacing "d". Bragg's equation, d calculate: d=n (ƛ/2) sinθ where d=wavelength of x ray. n=integer & denotes under of interference. θ=angle under which interference occurs. Large'd' in region of long range order are register by small angle x ray diffraction tech. SAXD important for exact 'd' determination.

**3. Rheology**

Different LCs are rheological prop. Which increase in microstructure LCs, its consistency increase & flow become more viscous. Low flow ability of lyotropic LCs such cubic, hexagonal due to 3 & 2 dimensional order. Lamellar mesophases are one dimensional long range has high flowability due to gel character, cubic & hexagonal mesophases exhibit stress until flow occur.

## IV. APPLICATIONS OF LIQUID-CRYSTALS

1) Liquid crystalline formulation for topical use: Amphilic excipient form lyotropic LCs, surfactant use as emulsifier which form micelles after dissolved in solvent, conc. Increases form LCs.
2) Surfactant gel: Monophasic systems of lyotropic LCs are used limited to gel. High surfactant conc. form density packed &identified as cubic LCs. Gel agitated mechanically, elastic prop. Evident, because of resonance effect in audible range called as 'ringing gels'. Ringing gel used in topical NSAID formation.
3) Ointment & cream: Surfactant conc. In this lower than in gel. Ointment non a.q preparation & cream are ointment in water added. microstructure of both consist of LCs & its network or matrix formed by amphiphilic molecule.
4) Liposome dispersions for installation into lung: Liposomal formation consist of surfactant, which coats mucosa of bronchi & prevents collapse of alveolar of lung , has developed for patient suffer from infant respiratory distress syndrome.
5) Transdermal patch: Patch contain drug substance in reservoir form which drug release controlled manner. This patch disadvantage are dose dumping occur in membrane damage during handling. LCs vehicle with lamellar structure used reservoir due to high solubilization capacity.
6) Sustained release form solid, semisolis and liquid formulation: Sustained formulations it has developed reduce application frequency. LCs excipient appropriate candidate because in LCs vehicle drug diffusion is reduced by factor of 10-1000 in comparison with liquid vehicle such as a solution. Semisolid formulation: Solubilization of drug substance LCs vehicles results in semisolid formulation which is used for topical application. Solid formulation: For the sustained drug release may contain mesogenic polymer as excipient which form matrix, which usually compressed into tablet.
7) LCs in Cosmetics: LCs used for decorative purpose in cosmetic Cholesteric LCs suitable because of their iridescent colour effect and find application for nail varnishes, eye shadow and lipstick.




## V. CONCLUSION

Thanks to the scientists Reinitzer, Lehmann and their followers, we know that literally thousands of substances have a diversity of others states. Some of them have been found very usable in several technical innovations, among which liquid crystals screens and liquid crystals thermometers may be the best known. The many applications of LCs in Pharma industries made many revolutions, which become very beneficial for the society.

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