# E-Content

## Topic: Liquid crystals (Part 1)

## Chapter: Liquid State

## Physical Chemistry

## B. Sc. Chemistry (H) 1st Year

By

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# Introduction

- Some organic compounds often have two melting points. On heating such a crystal, it melts into turbid liquid at a definite temperature; and on heating further, the turbid liquid becomes clear at another temperature. The turbid liquid is called **'liquid crystal'.** These changes get reversed on cooling at the same temperature.

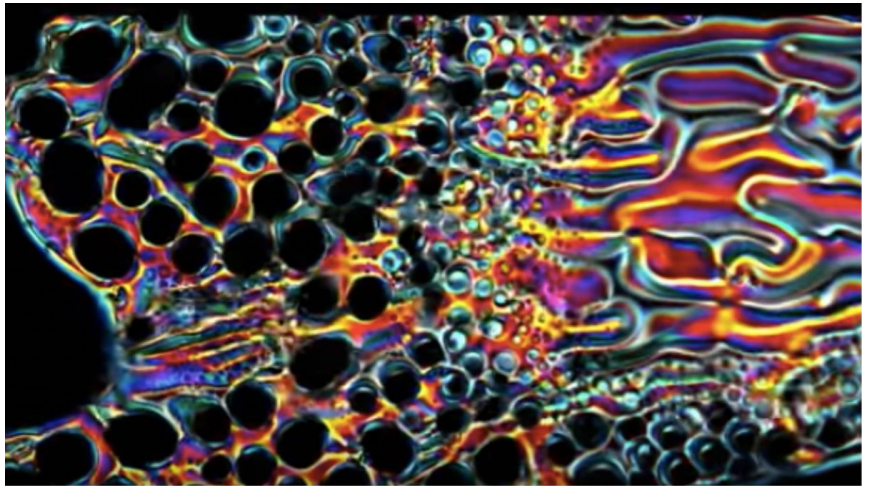


**Fig.** Microscopic image of a liquid crystal

- The turbid liquid show anisotropy i.e. they have different physical properties from different directions.

- Gases and true liquids are **isotropic.** i.e same physical properties in different directions. But a crystalline solid (or a single crystal) shows anisotropic behavior.

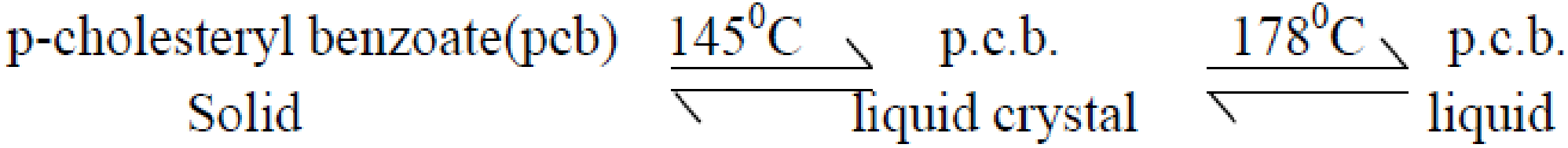
- As anisotropic properties are associated with crystalline state, therefore, the turbid liquids are known as liquid crystals

- Liquid crystalline state is also called mesomorphic state i.e. the intermediate form.

- Substances which show the above behaviour are usually some long chain organic molecules either terminating in groups such as-OR, -COOR or having groups like –C=N-,-N=NO-,-C=C- in the middle.

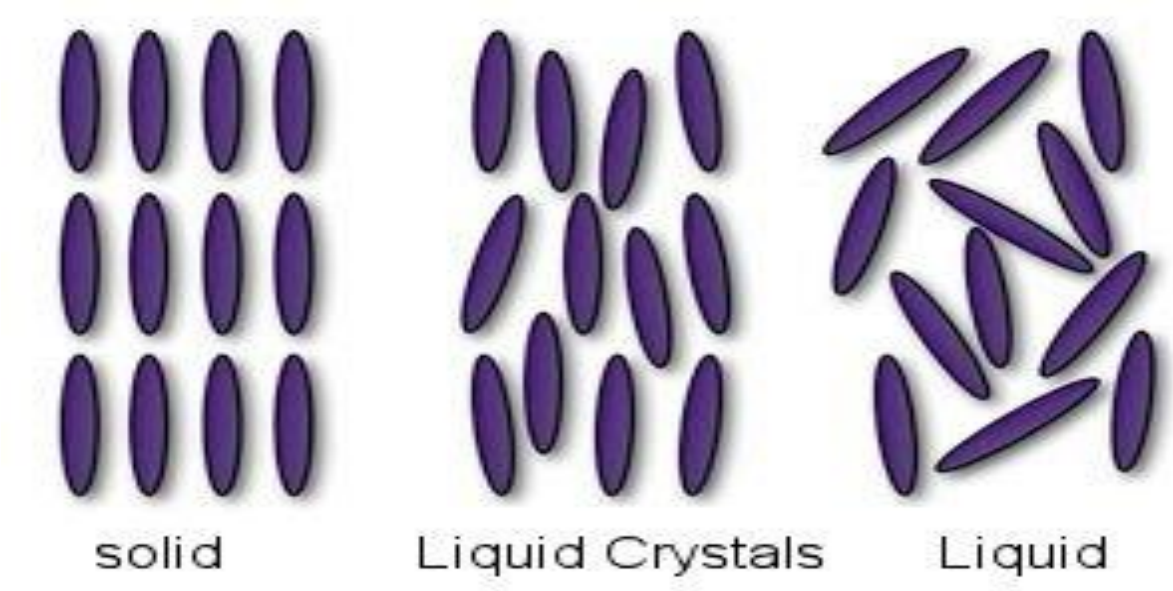
- The first solid showing this peculiar property was discovered in 1888 was cholesteryl benzoate $C_6H_5COOC2_7H_{45}$.

- It fuses sharply at $145^0$C to form turbid liquid and on further heating changes into clear liquid at $178^0$C. If we cool, the above changes are reversed i.e., the clear liquid when cooled first changes into turbid state at $178^0$C and then into the solid state at $145^0$C.
- Other examples of compound that exist in liquid crystals form are, p-azoxyanisole and p-azoxyphenetone.
- In 1991 P.G. De Genees, a French physicist got the Nobel Prize in Physics for contribution to liquid crystals and polymers.



## Structure

In a liquid the molecules have random arrangement and they are able to move fast each other. In a solid crystal the molecules have an ordered arrangement and are in fixed positions. In a liquid crystal, however, molecules are arranged parallel to each other and can flow like a liquid. Thus liquid crystals  have the fluidity of a liquid and optical properties of solid crystals.



## Classification:

- Depending upon the structural pattern of molecules, liquid crystals are mainly classified into three types:

    **i. Smetic liquid crystals**

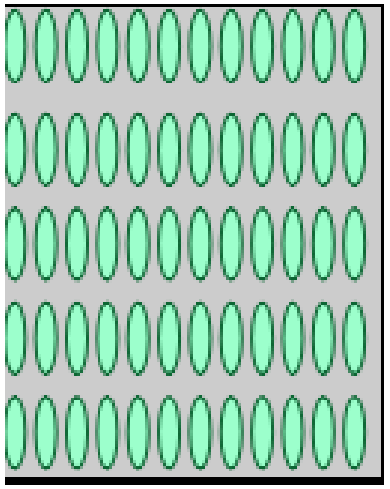
    **ii. Nematic liquid crystals**

    **iii. Cholesteric liquid crystals**

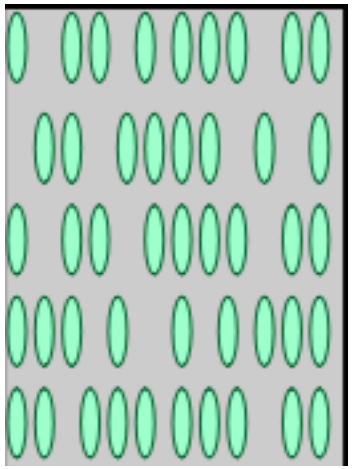
### *Smectic (soap like) liquid crystals:*

- They have molecules arranged in parallel layers or planes. These planes are at equal distances. These layers can slide past each other.
- The molecules in all the planes point to the same direction. That is, the molecules have same orientation.

- The only difference between a solid crystal and a smectic liquid crystal is that in the former, the particles are arranged at regular intervals within a plane; whereas in the latter it is not so.
- Smectic liquid crystals are slippery, like thick residue found at the bottom of soap dishes.
- They Show non-Newtonian flow.



Solid crystal



Smectic liquid crystal

## *Nematic liquid crystals:*

- These have all the molecules with the same orientation. Unlike in smectic type, the molecules are not arranged in planes in nematic liquid crystals.
- Application of an electric field causes a change in the orientation of the molecules in a nematic liquid crystal.
- A change in molecular orientation, causes a change in optical properties. It is this anisotropic character that makes a nematic liquid crystal useful in LCD (liquid crystal display) watches and calculators.
- Show Newtonian flow and flow more readily than smectic.

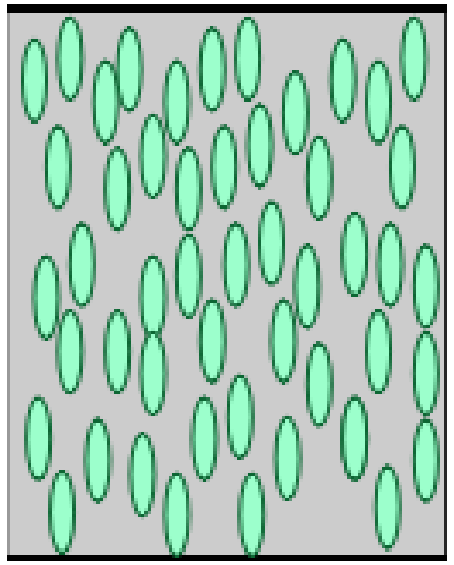
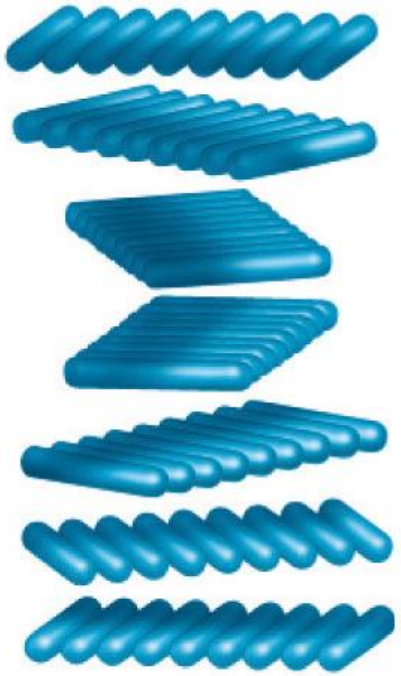


Fig: Nematic liquid crystal

## *Cholesteric liquid crystals*

- As in nematic crystals in this type liquid crystals the molecules are parallel but arranged in multiple layers.
- The molecules in successive layers are slightly rotated with respect to the layers above and below so as to form spiral structure.
- The successive twist in structure makes the cholesteric liquid crystals coloured.
- A minute change in temperature causes a change in the amount of twisting. It results in reflection of different wavelength of visible light; that is, the colour changes with temperature



- The colour of a cholesteric liquid crystal changes with the change in twist-pattern of layers in its structure.
- The anisotropic nature facilitates cholesteric liquid crystals being used in thermometers and in devices for indicating the temperature of the skin or of electrical devices.
- Temperature changes as small as 0.001 K can be detected using sensitive cholesteric liquid crystals.
- This class of liquid crystals received their name from the fact that many derivatives of cholesterol pertain to this type.

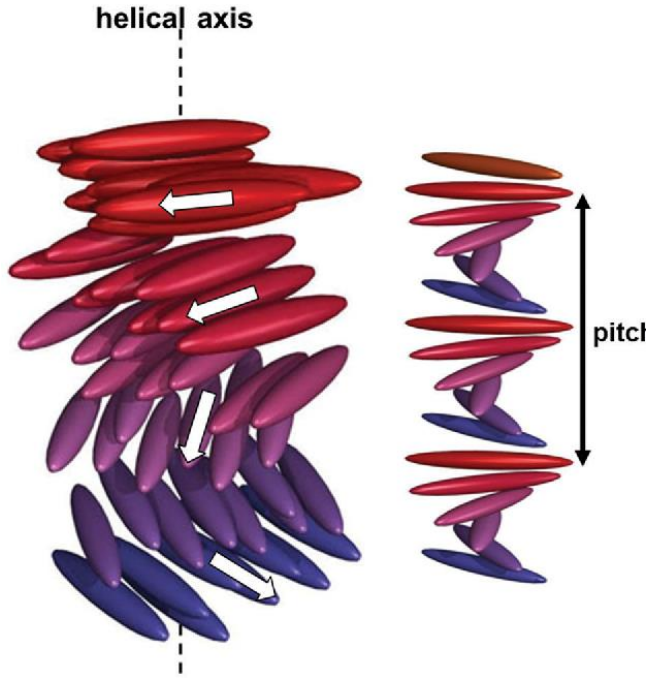
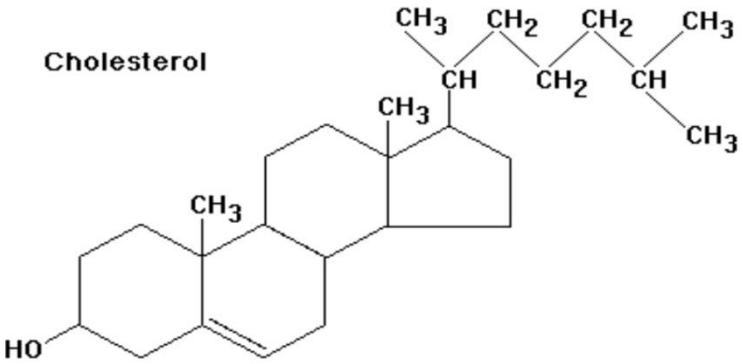



Fig. Twist in the molecular arrangement of cholesteric liquid crystal



**Note:**

*In this chapter we have given a brief introduction of liquid crystals their structure and different phases of liquid crystal. Remaining portions i.e. their properties and application etc will be discussed in the next part.*