MESOPHASES of LIQUID CRYSTALS

1、Mesophases formed on heating such compounds are classified into three types: nematic, smectic, and cholesteric.

2、There are more than ten recognized smectic modifications and these denoted are SA, SB, SC --- SL.

3、A description of the structural features of these phases may be found in standard books and reviews

Nematic

1、The nematic phase is the least organized and the most common type of liquid crystalline phase.

2、This phase is characterized when molecules are ordered in one dimension and the average direction of the long axes of the molecules are parallel

3、 The nematic phase possesses long range orientation order but no positional order

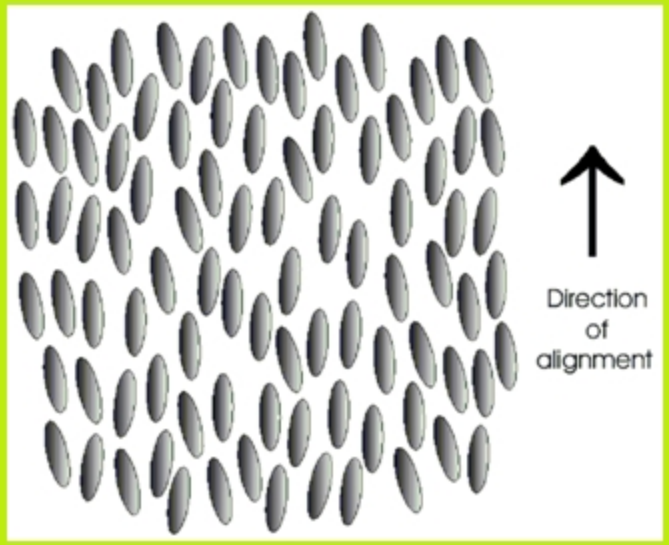


Figure 19 Schematic representation of molecular arrangements in nematic.

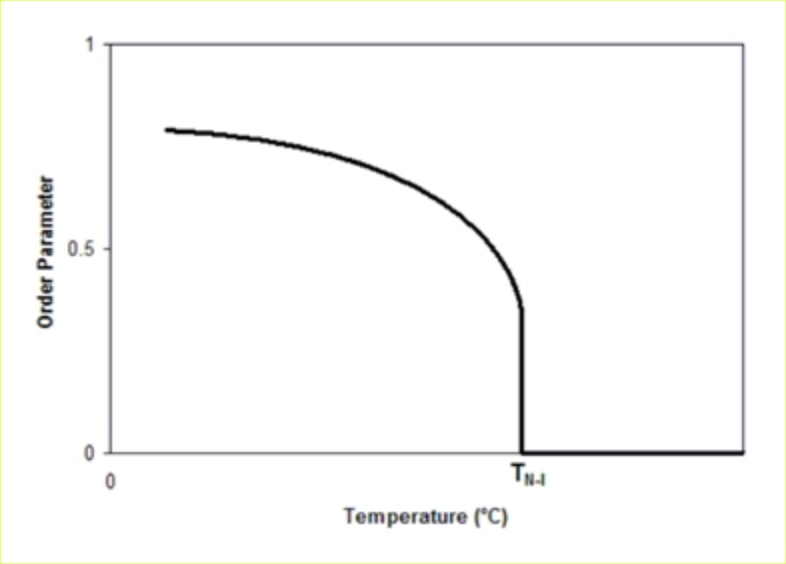


Figure 20 Order vs. temperature for a typical liquid crystal. TN-I is the temperature of transition between the liquid crystal and liquid

Cholesterics

1、The cholesteric liquid crystalline phase is often referred to as “twisted nematic” or “chiral nematic” phase.

2、The cholesteric phase is characterised by layers of nematic oriented molecules where each layer is twisted with respect to the ones above and below it 。

3、 A schematic representation of the structure of the cholesteric phase is illustrated in Figure 21.

4、Cholesteric phase possesses only orientation order, but neither long-range order nor positional order of the molecules.

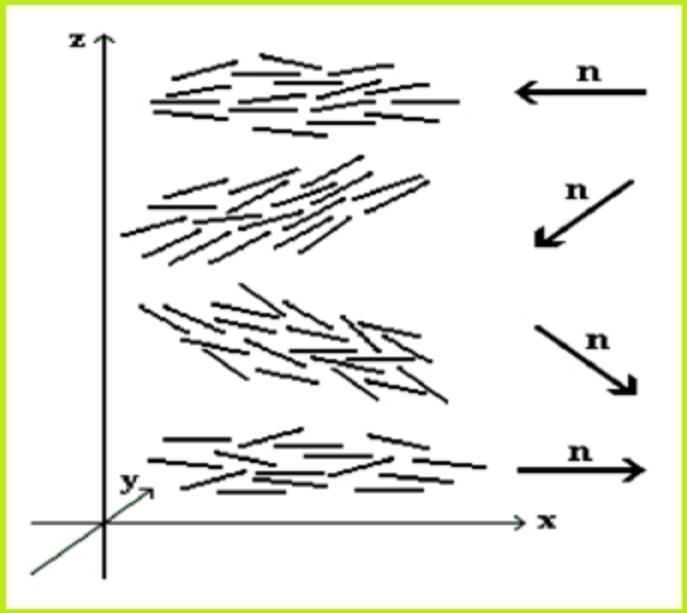


Figure 21 Schematic representation of cholesteric liquid crystalline phase

Smectic

1、The smectic liquid crystalline phase is characterised when molecules possess a degree of long range orientation order as well as long range positional order: the molecules are parallel and arranged in layers which stack on top of each other (Figure 2.22)

2、If nematic and smectic phases occur within one compound, the smectic phases will occur at lower temperatures.

3、The higher order of smectic phases causes them to be more viscous than nematic phases.

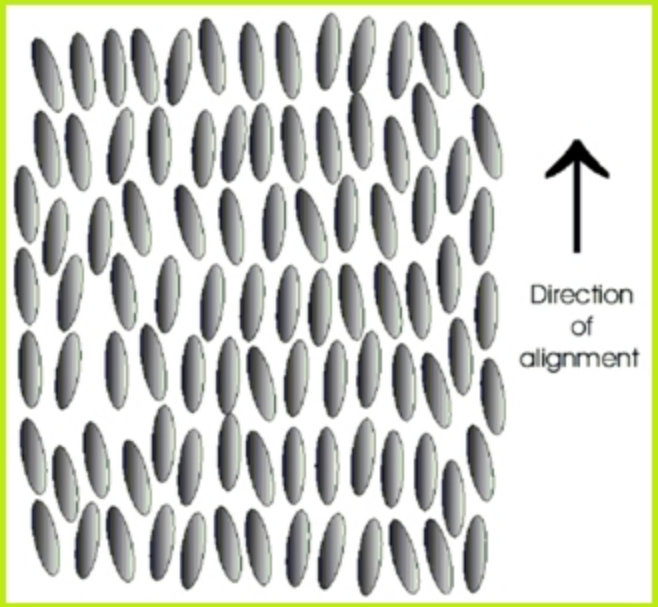


Figure 2.22 Schematic representation of smectic liquid crystalline phase

Columnar phase

1、Columnar phases are formed on heating/cooling of compounds composed of disc-shaped molecules that can pack together to form flexible cylinders or columns of different type 2、

2、The arrangement of disc-shaped molecules within an individual column can be either ordered or random

3、The research effort on this phase is still somewhat limited, but increasing steadily.

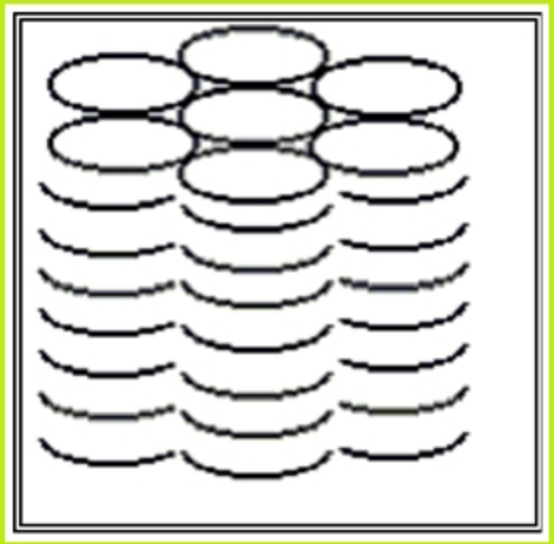


Figure 23 Schematic representation of columnar liquid crystalline phase

CHARACTERIZATION OF SCLCPS

1、Optical polarizing microscopy is a standard tool in the identification of liquid crystal phases and phase transitions but requires considerable experience, particularly in the study of new and less familiar materials.

2、DSC is a useful tool, which complements optical methods in the study of liquid crystal phase transitions. Its utilization in determining the heat supplied or extracted during a process such as a phase transition is discussed in thermal properties of polymers.

3、X-Rays provide a much more definitive means for the identification of mesophases.

Optical Microscopy

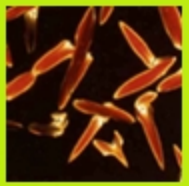
Mesophases usually show various singularities in the distribution of the molecules which are characteristic of the structural features of perfectly ordered phases. These singularities may gather, in simple experimental situations, in more or less sets forming LC textures. For a practical and relatively fast classification of LC, the microscopic observations of the textures are most useful. There are limitations, however, and a complete classification of smectic phases by textures is not always possible: similar textures may be observed with two LC states separated by a phase transition.

- The following pictures present to the textures, which are typical of nematic, cholesteric, smectic A and smectic C phases and to show how these types of mesophases can be identified and distinguished from one another. In this regard, however, it is important to note that microscopic observations are sometimes misleading owing to the difficulty with which LCPs give specific textures in the liquid crystalline state.

Nematic textures

Nematic

Cholesteric



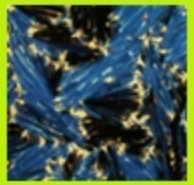
Smectic A

Smectic A

Smectic B

Smectic B

Smectic C



Smectic B

Smectic C

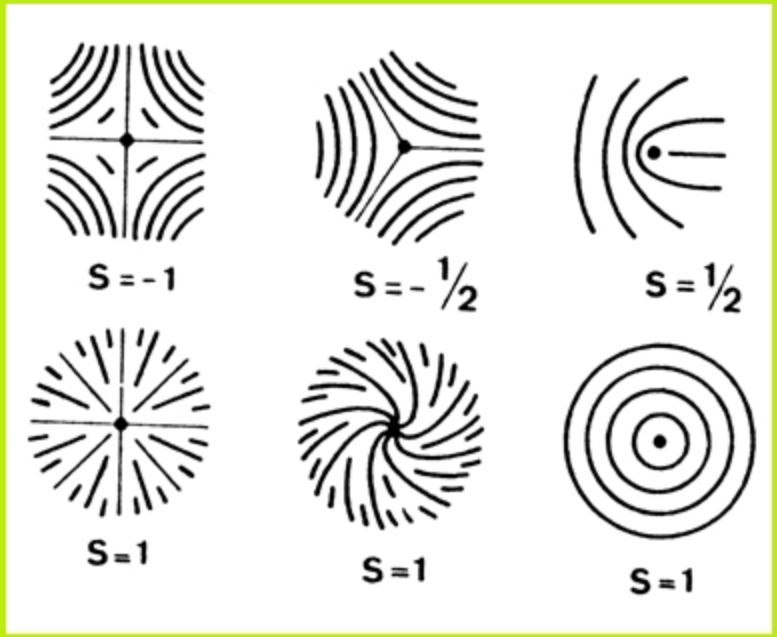
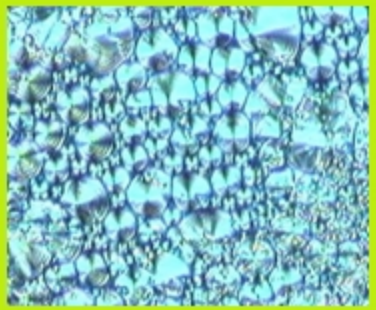
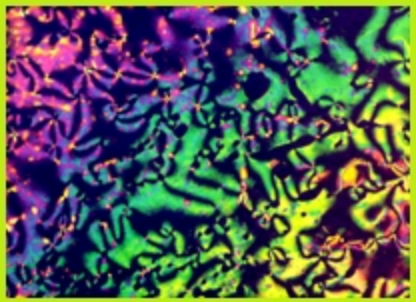


Figure 24 Schematic diagram of molecular trajectories associated with disclinations of strength ± ½ or ±1





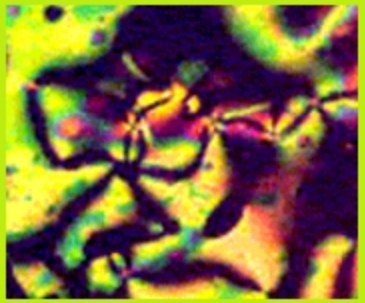


Figure 25 Nematic Schlieren texture. Schematic diagram of molecular (Han 2004)

Smectic textures

In the case of smectic polymers, observation of specific textures may be difficult. Often textures occur whose characteristics are somewhat obscure and observable only with difficulty even after extended annealing within the smectic phase.

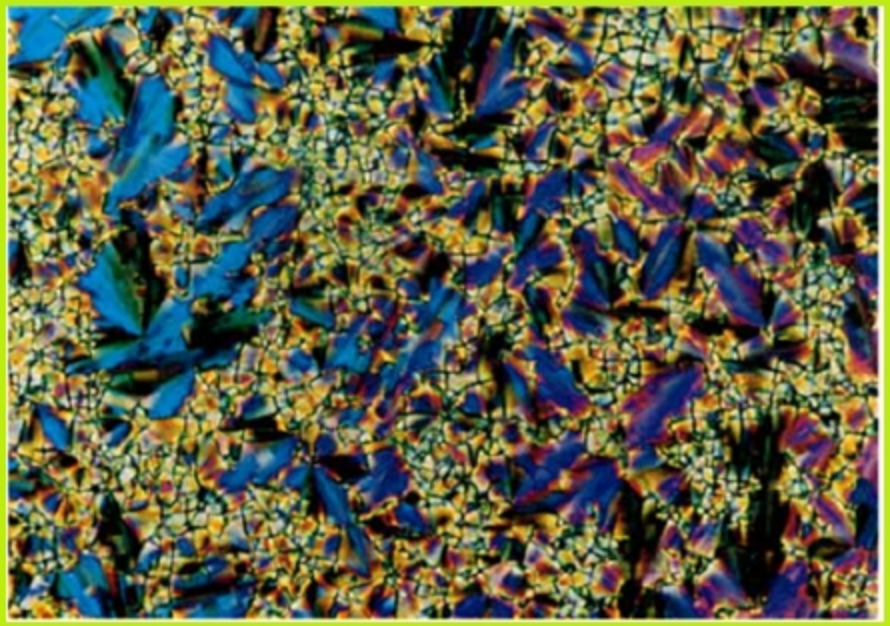


Figure 26 Typical optical polarizing micrographs of SCLCPs (focal-conic texture of the SA phase at 166 ° C)

Differential scanning calorimetry

DSC is a useful technique that complements optical methods in the study of liquid crystal phase transitions. Its utilization in determining the heat supplied or extracted during a process such as a phase transition in thermal properties of polymers

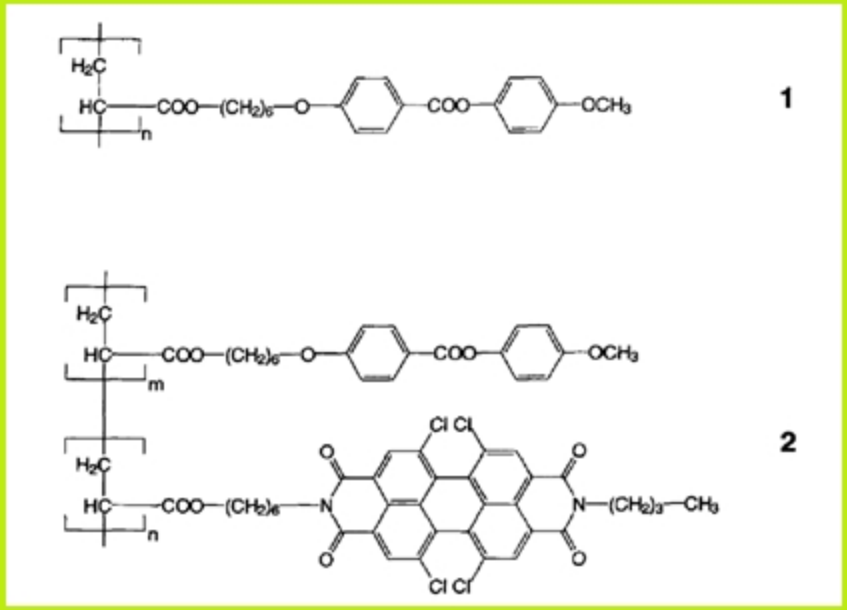


Figure 27 Chemical structure of side-chain liquid crystalline hom opolymer 1 and fluorescent dye containing copolymers

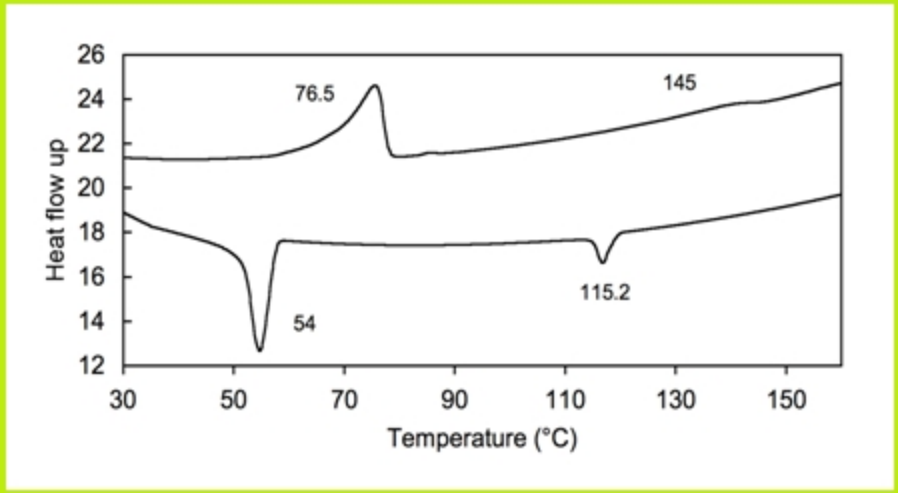


Figure 28 DSC thermograms of PECHOC2-B: second heating (up per curve) and cooling(down curve) scan (Han 2004)

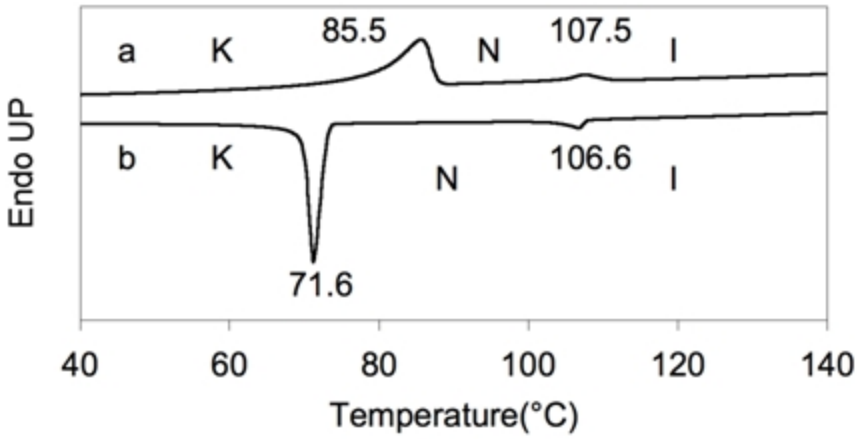


Figure 29 DSC thermogram of monomer HOC4-B at rate of 10 ° C/min, (a) heating (b) cooling (Han 2004)

X-ray diffraction patterns for oriented samples

If a material can be obtained in the form of an oriented monodomain, it is possible to extract more detailed structural information from its diffraction diagram (Hopwood *et al.* 1985b; Hardouin *et al.* 1983). For nematic, monodomains can be obtained by orientating a powder sample in a strong magnetic field. Aligned SA and SC may then be prepared by careful

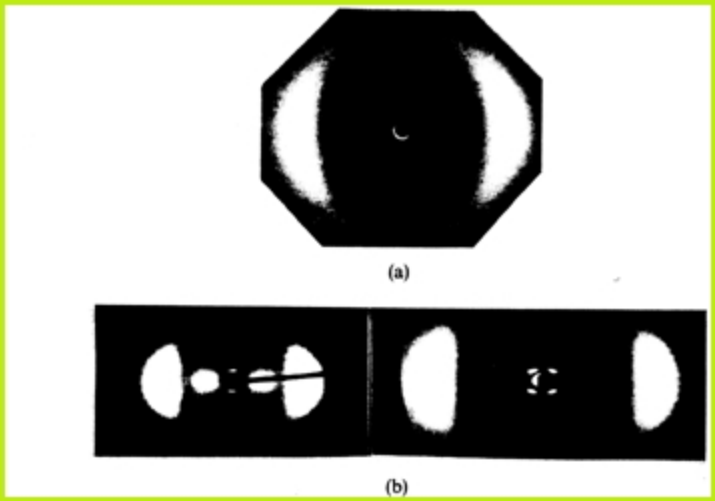


Figure 31 Typical X-ray diffraction patterns for oriented samples : (a) conventional nematic, and (b) nematic with cybotactic group s.