INTRODUCTION

1.1 THE INTERMEDIATE STATE BETWEEN SOLID AND LIQUID

The state of crystalline solids comprise of long-ranged ordered molecules while isotropic liquids are of disordered molecules. Liquid crystals are matter in a state exist between the crystalline solid and isotropic liquid state (Chandrasekhar, 1977; Collings and Hird, 1997 and Demus et al., 2011). As the intermediate phases, they are more order than liquid but less order than crystal. The some extend of order among the molecules make them exhibits several physical properties of crystals but having fluidity comparable to liquids. For this reason, they are called liquid crystals, and can be properly named as mesomorphic phases.

The two most commonly encountered liquid crystals are thermotropic liquid crystals, in which the phase transitions are realised by varying temperature, and lyotropic liquid crystals, in which the phase transitions are obtained by the action of solvents. In addition, certain systems that possess the ability to form both thermotropic as well as lyotropic mesomorphism are called as amphotropic. The thermotropic liquid crystals have become more commonly known owing to their employment in photo-optic technology such as liquid crystal displays (LCDs) and photonic devices. The lyotropic liquid crystals on the other hand, are responsible for many chemical and biological processes. Since this thesis deals with only thermotropic liquid crystals, discussion about other type of liquid crystals are not included here.
The common characteristic between thermotropic and lyotropic liquid crystals is the shape anisotropy of their structural units make up of elongated molecules, with a rigid central region and flexible ends. Such anisotropic molecules, called mesogens, are the primary factor for the formation of liquid crystalline phases. The interactions between these anisotropic mesogens lead to orientational order in the system. Molecules in orientational order tend to orient their long molecular axes in specific direction on a long-range basis. The preferred direction is known as director, denoted by the unit vector $n$. The amount of orientational order in a liquid crystalline material can be determined by calculating its order parameter. In an isotropic liquid, the order parameter is equal to zero, whereas in crystalline solid, it is one. On the other hand, the order parameter of liquid crystals ranged between 0.3 and 0.9. So, having the small degree of order produces anisotropic nature in liquid crystal systems.

Due to the anisotropic nature, the properties of the liquid crystals depend on direction they are measured. That is to say, the optical, electrical, magnetic and other properties of the material vary when measure in different direction, either parallel or perpendicular to their length. The same holds true for liquid crystal materials in crystalline solid state. In contrast, liquid crystal molecules in liquid state are energetic and found to be in constant random motion. This causes them to lose the anisotropic nature, and thus become isotropic. This means their properties are uniform in all direction although the molecules are anisotropic. Hence, with this difference it is possible to distinguish between the liquid crystalline state and the liquid state.

The anisotropy of reflective index is one of the optical properties of liquid crystal characteristic that give birefringence colour and texture to the materials. Light passes through liquid crystal materials are broken into two components, travel with different velocities. Thus, a beautiful birefringence colours and textures can be observed under a polarising optical microscope. The difference in colour and texture can provide a lot of information about the macroscopic structure, useful for identification of liquid crystal phases. Manipulating the unique optical properties of liquid crystals by external fields enable them to be used in many applications.
Apart from orientational order, liquid crystals also show positional order. Positional order refers to the extent an average molecule or group of molecules shows a periodic order with translational symmetry as crystalline state shows. However, not all liquid crystal phases possess positional order. If they exhibit positional order, the molecules are constrained to occupy specific sites in the three dimensional lattice and form layers structure. An example of liquid crystal phase exhibiting the positional order is given in the following section.

1.2 PHASE TRANSITION IN THERMOTROPIC LIQUID CRYSTAL

Basically, there are different types of thermotropic liquid crystals exist, classified based on the anisotropic shape of mesogens. The traditionally know thermotropic liquid crystals are rod-shape molecules. Such liquid crystals are called calamitic liquid crystals. However, it has been found that bent-core molecules whose shape resemble a banana shape, results in a new class of liquid crystals, called banana liquid crystals (Niori et al., 1996; Pelzl et al., 1999; Jákli et al., 2002; Elamain, Hegde and Komitov, 2013). Each of these classes exhibit different intermediate phases with the changes in amount of order under the influence of temperature.

As the temperature increases, liquid crystals in crystalline solid state undergo transition to isotropic liquid state. During the process of transition, the thermal motion in the molecular lattice increase until reach a point where orientational and positional order are completely destroyed. Thus, result in the transition from the bright birefringence crystalline state to dark isotropic state. It is between this order and disorder states that liquid crystalline phases can be found (figure 1.1). Liquid crystalline phases are stable within specific temperature range before they become the disordered liquid. The intermediate phases present in thermotropic liquid crystals can include nematic and smectic-A phases, depending on the amount of orientational and/or positional order as the temperature increases. These intermediate phases are collectively known as mesophases.