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Importance of Phase Transitions in Liquid Crystals-A review

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Abstract:
In crystals, the molecules are arranged and tightly bound at each site. In liquids, they can randomly move in any direction. The liquid crystal is an intermediate state between the two and we can classify in terms of order. The most disordered pattern is the nematic phase. It has an directional order called director, but no positional order. The next type is the lubrication stage. During this stage, the molecules are arranged in sheets with well-defined interlayer distances beyond the directional order. The next type is a column phase. During this stage, the molecules are arranged in discs and columns where the molecules form a two-dimensional network. As seen in the phase transitions of different systems, phase transitions in liquid crystals also exhibit spontaneous symmetry breaking, strong oscillations, different susceptibility and discontinuities, arising from cooperative interactions at the micro level.
Keywords: Liquid Crystal, Nematic, Smectic, Orientational order

Introduction:

Kreisel et al [1] provided insight into the importance of phase transitions in liquid crystals. Liquid crystal materials exhibit many different phases, and therefore many forms of phase transitions. Most transformations are first-order, but there are some examples of quadratic transformations as well. In view of basic research, great interest arose in the field of LCs when the first ferroelectricity and antiferroelectricity were reported in liquid crystal materials, respectively, in 1975. [2] and 1989 [3].

Liquid crystals

LC is one of the delicate and beautiful states of matter, with the fluid properties of liquids and the anisotropic properties of crystals. There are basically two types of them. A thermotropic in which the liquid crystal mesophase is formed with changes in temperature. In liotropic, a mesophase is formed by varying the concentration of surfactant in the solvent. The structures and properties of the various thermotropic mesophases are described in the references [4-8]. The phase formation in liquid-crystalline systems is affected, not only by changes in temperature, but also by changes in pressure [5-7]. Therefore, studies of phase transition diagrams of liquid-crystalline systems are crucial for a theoretical understanding of the phase transitions [9]. The polarized light optical microscope is one of the basic and important experimental tools to study the texture of a particular phase of any newly synthesized material . By analyzing the textures, it is possible to explore the characteristic defects in the mesophases .

LCs and their properties have become an integral part of the soft condensed matter

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science, in particular, and physical sciences, in general.Liquid crystals are broadly classified into ferroelectric liquid crystals (FLCs) and antiferroelectric liquid crystals (AFLCs), chiral smectic subphases, twist grain boundary (TGB) phases, bent-core LCs, discotic liquid crystals (DLCs)[7].In this review few types of LC's are going to be discussed.

Nematic Mesogens in display devices:

A LCD may be a thin, flat panel used for electronically displaying information like text, images, and moving pictures. Its uses include monitors for computers, televisions, instrument panels, and other devices starting from aircraft cockpit displays to everyday consumer devices like video players, gaming devices, clocks, watches, calculators, and telephones. Among its major features are its lightweight construction, its portability, and its ability to be produced in much larger screen sizes than are practical for the development of CRT (CRT) displays. Its low electric power consumption enables it to be utilized in battery-powered electronic equipments. it's an electronically modulated device made from any number of pixels crammed with LCs and arrayed ahead of a light-weight source (backlight) or reflector to supply images in color or monochrome.

FLCs and AFLCs:

Ferroelectric properties in LC's could arise from rod-like molecules with low mass, having permanent electric doublet moment at a definite angle to the long axis. In most of the standard liquid-crystalline phases (nematic (N) or chiral nematic (N*), smectic A (SmA), and smectic C (SmC)) that seem in turn on lowering the temperature from the isotropic liquid phase, the symmetry is therefore high that free rotation round the molecular long axis and head–tail
equivalence forestall the incidence of ferroelectricityIn chiral smectic C (SmC*) phases, however, the symmetry is low enough to allow the existence of chirality-induced improper ferroelectricity which does not result from the dipole–dipole interaction[10-13].

In AFLC's, the molecules are tilted similar to the ferroelectric SmC * phase. However, the tilting directions of the successive smectic layers are opposite to each other, thus canceling the macroscopic polarization. The AFLC'shas been known for over 20 years and is currently being intensively researched in the field of research and development. AFLC is attractive for a variety of electro-optic applications[3]. In AFLC displays, the material is encapsulated between two glass sheets that have been processed for planar orientation. The smectic layer is placed in its own direction perpendicular to the glass plate (bookshelf shape). In the AFLC cell placed under the cross-polarizer, when the electric field E is applied parallel to the smectic layer, the material is from an antiferroelectric state of E = 0 (dark) to two symmetric ferroelectric states depending on the polarity[45,46].

Discotic liquid crystals:

DLCs have been attracting the growing interest not only because of the fundamental importance as model systems for the study of charge and energy transport, but also due to their potential applications in organic electronic devices. In a columnar mesophase, the core-core separation is usually of the order 0.35 nm, so that there is considerable overlap of π orbitals. The intercolumnar distance is usually 2–4 nm, depending on the lateral chain length. Therefore, the interactions between neighboring molecules within the same column would be much stronger than the interactions between the neighboring columns. Discotic molecules are of interest for their intriguing supramolecular architectures. Their strong π–π interactions within a column lead to high electronic mobilities, a property that is essential in the development of eco-friendly organic electronic devices [7].

Conclusions:

In summary, on the application side, note that LC has opened up a new field of displays accessible to the general public as a better option than CRTs. There is a lack of theoretical understanding of the physical properties of emerging fields. There is still a need to synthesize LC materials with adjusted properties.

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