A Review on Physical, Chemical and Optical Properties of Liquid Crystal

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ABSTRACT

The foundation of the upcoming generation of cutting-edge gadgets and digitally augmented technologies is expected to be smart soft materials. Because of their responsiveness and adaptability, liquid crystals (LCs) are promising smart soft materials. In the 20th century, LCs were crucial to changing the information display sector. However, several beyond-display uses for LCs have been proven at the turn of the twentieth century, neatly using their controlled stimuli-responsive and adaptable properties. New LC materials have been developed and engineered for such applications. The review comes close with a summary and viewpoints on the potential and problems facing LCs as smart soft materials. This review is expected to inspire a wide range of concepts for the application of nature's delicate phase of matter in the generation and beyond of smart and augmented devices.

Keywords: Liquid Crystal, Optical Properties, Physical and Chemical Parameters.

INTRODUCTION

Structure and Classification of LCs

The materials known as LCs are those that simultaneously exhibit certain physical characteristics common to liquids and others common to crystals (De Gennes, 1993). Mesomorphic materials, or materials exhibiting mesomorphic states, are a more accurate term for them. These states of aggregation arise between the liquid and solid phases (Demus, 2011). In the mesomorphic form, they typically resemble liquids from a macroscopic perspective, but in contrast to typical liquids, they exhibit a significant anisotropy in the physical characteristics, making them more like to crystals in this regard. "Anisotropic fluids" is another term that is applicable (Demus, 2001).

By altering the thermodynamic parameter for a particular material, the mesomorphic state (perhaps more than one) is manifest. LC materials are often classified as thermotropic or lyotropic under constant pressure and volume (Foelen, 2023). While others achieve these states by adjusting the concentration ratio of components, the first exhibit a mesomorphic behaviour when the temperature is varied (Gao, 2022). Because moststudies on nonlinear optical characteristics have been conducted onne matic states, we shall solely discuss thermotropics in the sections that follow.

Mesomorphism is seen in compounds where the orientational order of LC molecules is produced by the chemical composition. Only when each molecule is lengthened in a single, distinct direction can orientation be understood. For this reason, the typical molecules of thermotropic LCs are represented by stiff rods with lengths of 20 to 40A and widths of 4 to 5A (Jakli, 2006). These chemicals fall into a wide variety of categories, and more are continually being created. However, a general standard for the chemical makeup of an organic substance showing mesomorphic states may be provided (Kelker, 1980).

Through chemistry and the study of LCs, physics is extended to the biosciences (Demus, 1984). Both fundamental and applied research have seen remarkable linkages and changes as a result of borderline status (Fratini, 2016). When P.G. de Gennes received the 1991 Nobel Prize in Physics for his contribution to our knowledge of the LCline state, the public was made aware of the rapidly developing field of study and application (Brown, 1973). Additionally, LC phases and their technological application are necessary for displays in a variety of commonly used devices and equipment (Dunmur, 2001). Membrane development, stability, molecular-molecular interactions, and recognition are areas of biochemistry, bioorganic, and organic chemistry that are seeing a lot of attention and research. Detergents, lipids, and steroids are associated with LC phenomena (Lu, 2022).

The liquid crystal block diagram as shown in Figure 1.

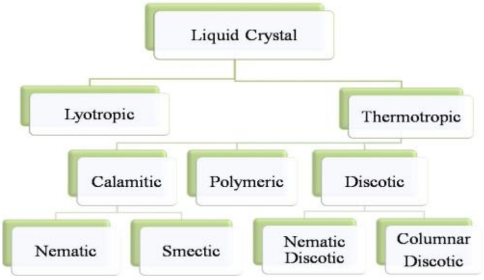

Figure 1. Block diagram of LC molecules

Compared to previous LC data collections, the range of substances described in these tables is much wider (Bahadur, 1990). Despite of a significant family of LC chemicals, LC polyols (Chandrasekhar, 1980) were not previously included. Because the method used to demonstrate mesogenic characteristics frequently varies, several substances that have not yet been demonstrated to be LC are also included (Liang, 2022). Monotropic phases are sometimes overlooked, although for dopants extrapolation data may be just as significant as temperature measurements (Jeridi, 2022).

Recently, LC polymeric materials have shown to be useful in "high tech" fields such as home appliances and space exploration (Liu, 2023).

Finding out about chemicals that have been unsuccessfully examined might occasionally be useful, as it can help save unnecessary experiment repeats or provide strategies for future research (An, 2016). Up to now, a significant number of mesogenic chemicals have not been investigated with regard to their thermotropic LC line features. These consist of substances such as steroids, glycolipids, lipids, and surfactants (Ruixue, 2023). If mesogenic qualities were anticipated and particular melting anomalies (sintering, softening) were known, such derivatives would be added (Kelker, 1989). The classification of LC molecules as shown in Figure 2.

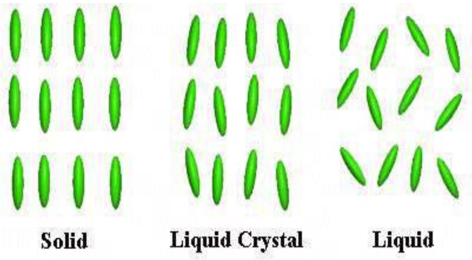

Figure 2. Classification of LC molecules

Data are provided for the Following

Crystallised liquid (compounds with proven thermotropic LC properties) Mesogenic structures not LCs,

a. Dyes chiral dopants.
b. Unstudied substances (cleaning parameter 0)
c. Mesogenic substances investigated that lacked LC characteristics
d. LC fundamental structures

These are compiled for each Compound

a. The temperatures at which solids become solids.
b. The transitional heats
c. Thetemperatures at which LCs transition.

Data on LC mixes, statistic copolymers, and lyotropic LCs are not provided (Froyen, 2023). The study of LCs crosses several academic disciplines. Thus, a chemical arrangement that was primarily determined by physical properties could scarcely satisfy a chemist (Bobrovsky, 2023). Then, he would discover smectic phenyl benzoates close to smectic alkyl glycosides, but he was unable to determine where to insert a unique LC line molecule from this information (Blach, 2021). However, a completely chemical structure would be difficult for the physicist to accept. Columnar discotic and smectic inositols would be found in a single table, and if he needed to look for certain qualities, the entire document would need to be read from the beginning to the end (Reinitzer, 1888). Due to the progressive dominance of chemical and physical principles, the layout was chosen. The chemical categorisation of substances into monomeric and polymeric groups comes first (Collings, 1997).

Following physical principles, the most significant class of monomeric chemicals is divided into calamitic and discotic LCs. These groups are further split into amphiphilic and monophilic LCs according to chemical-physical characteristics (Lehmann, 1918). The biggest class of monophilic calamites is once more split into simple calamites, acids, and steroids based on chemical characteristics. These kinds of compounds are then assigned to the various systems according to formal chemical considerations such as the quantity and order of the fragments (Saed, 2020):

Principles of order for Mesogenic Systems

1. Rings present
2. The number of bridge groupings
3. Ring precedence fourth, importance of linking groupings, importance of side groupings

Order of the Rings

1. Benzene
2. Substituted benzenes
3. Halogen-substituted benzenes,
4. deuterated benzenes,
5. Alkyl-substituted benzenes are examples of isomers.

Aromatic Rings with Six Members

Monocyclic Aromatic rings

1. Complex Ring Systems
2. Cyclohexane
3. Alicyclic rings
4. Metal Complexes

Rank Order of Side Groups

1. Compounds Devoid of Terminal Alkyl Chains
2. Compounds containing a single terminal alkyl chain
3. Compounds that have two terminal alkyl chains

The overview of the system provides the simplest method for performing a compound search. In this case, the only representations of the mesogenic groups that are presented are their structural pages [32]. They are organic molecules called LCs. When benzene rings are present, they are considered aromatic and are called benzene derivatives [33]. Figure (2), which shows an aromatic LC molecule and has a side chain R, two (2) or more (2+) aromatic rings A and A capable of connecting by linkage groups Y and X, and at the other end capable of connecting to a terminal group R The aryloxyl, alkyl carbonate, alkoxy carbonyl, nitro and cyano groups are examples of alkoxy (CnH2n + 1), alkyl (CnH2n+1) side chain and terminal groups. The X and Y of the linkage groups are (−CH=CH−) stilbene, (−COO) ester, (−C≡C−) tolane, (−C≡C−C≡C−) diacetylene, (−N=N−) azoxy, (−CH=N−) Schiff base, (−C≡C−) (Friedel, 1931, Brown, 1971, Davidson, 2020, Jia, 2022).

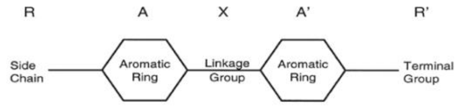

Figure 3. Molecular structure of a typical LC

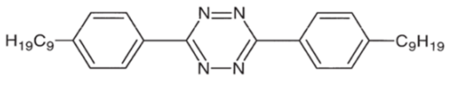

Figure 4. Molecular structure of a heterocyclic LC

The number of reported LCs has drastically grown in recent years. Therefore, only computer-aided methods are practical for the registration and evaluation of all chemicals (Tschierske, 2001; Tschierske, 1996). On the other hand, it is now difficult to classify substances before based on only synthetic features. On the other hand, it is challenging to show a categorisation of compounds in tables that onlyconsiders the atom connection (Lu, 2022). Consequently, a unique fragment-orientated data bank system based mostly on the academic jargon often used by LC researchers was necessary for the recording of LCs. The molecular structure of general liquid crystal as shown in Figure 3. The organic liquid crystal as shown in Figure 4.

All compounds must be presented and categorised with clarity on a level higher than the comtectivities of atoms (Ge, 2019). The mesogenic group is organised into rings, bridges, and pieces (Bruce, 1986). Links and terminal groups are divisions of the side groupings. There are also certain particular components, such as steroids, discs for monophilic discotics, and polymer backbones for side group polymers (Jingjing, 2022). Each LC component is broken down into an ordered series of pieces. Single bonds hold fragments together. A number of identical fragments can bond to one side of some pieces. Forked compounds, discotics, and twins all employ these kinds (Kim, 2013).

LC Thermotropic Phases

The condition of LCs

A state of order between a liquid and a crystal is represented by LCs. In three dimensions, crystals exhibit a long-range order of orientation and position. On the contrary, pure liquids (water) do not exhibit any long-range organisation (Svenson, 1994). Mesophases are between crystals and liquids because imprecise long-range ordering are seen in them. LCs and plastic crystals examples may be discriminated in mesophases. Positional order is lost while orientational order is preserved in LCs, however; ordered liquids are anisotropic in nature. The positional order is preserved, but the orientational order is broken in plastic crystals (Blinov, 1996). The phase transition in liquid crystal as shown in Figure 5.

Mesophases may arise for a variety of reasons, including the shape of the molecule, which may lead to advantageous packing. Alternativel, the amphiphilic property that causes microseparation of several molecular components may be responsible. Furthermore, an interpretation of the behaviour of the LC line was termed anisotropy of van der Waals interaction (Guin, 2020, Zhang, 2021). Mesogenic compounds often take the following forms: the smectic and nematic phases of calamitic LCs, which are composed of rod-shaped molecules. Molecules that resemble discs and create discotic LCs. Crystals made of spherical molecules known as plastics [46].

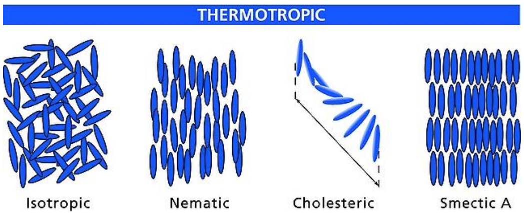

Figure 5 Phase transition in liquid crystal state

Nematic Phases

Nematic is the most common and basic phase of the LC line. The long axes or molecular axes are orientated in one direction, but the molecular centres of LC are statistically situated within the medium in this case. The cholesteric phase is a unique category of nematic phases (Sun, 2015). Here, the director's n-degree orientation only applies to a virtual layer rather than the entire medium. In the case of blue phases LC, such a helical structure develops not just in one dimension, but also in all three. As a result, very intricate structures with chiral cubic symmetry are produced. The discoid-nematic phase is a nematic phase that can arise from molecules that are neither rodlike nor disclike (Anthal, 2012).

Nematic LCs

Nematic LCs has a long-range orientational difference from regular liquids (Bruce, 2004). The alignment must be taken to be nonpolar if ferroelectric effects cannot be seen (Berardi, 2008). As in a regular liquid, the distribution of the centres of gravity is. The long axis, or molecular axis, of the LC molecules is allowed to spin freely. LCs is uniaxial with regard to all physical attributes as a result of this structure (Gupta, 2021). The molecular or long axis of the LC structure represents the length L, and the axis of symmetry are the same. The anisotropy of the LC molecular polarizability is thought to be the cause of the LC line phase, according to Maier and Saupe's molecular statistical hypothesis (Tschierske, 2010). More in-depth discussions of the connection between molecular structure and mesomorphic behaviour may be found in Grey and Winsor (Mistri, 2020, Pang, 2019).

The X groups that join the two modified phenyl rings that are most significant are listed above. The literature provided there is recommended for readers interested in chemical synthesis techniques (Chaikin, 1995). Rand R's are comparatively tiny groupings or short chains. The journal structure provides examples of chemicals that show a nematic phase. The most popular substance is p-azoxyanisole (1). MBBA is a crucial room-temperature nematic LC. Combining MBBA and EBBA can increase the LC line maximum temperature (3). The azoxy compounds (4) and the phenyl benzoates are more examples of low melting materials (Francescangeli, 1997). The nematic liquid crystal as shown in Figure 6.

Figure 6. Nematic LC

Smectic Phases

Smectic phases are formed by layering rod-like molecules. There are several distinct species into which they may be categorised (Novotna, 2008). These divisions are the result of diverse molecular configurations inside the layers and varying mobility restraints. The simplest smectic phase, the A phase, may be thought of as a 2D (two-dimensional) liquid (Chen, 2019). The molecules are set up in a manner consistent with the layers. The only difference between the smectic A phase and the smectic C phase is that the molecule in the former is 90 degrees tilted within the layers. The chiral smectic C' phase is a special kind of smectic C, where the tilt angle changes from layer to layer and creates a helical shape. The closest packing may be thought of as the smectic B phase (Francescangeli, 2009).

The tightest arrangement of rod-like molecules, with each molecule having a hexagonal environment within the layers, may be described as the smectic B phase (Wang, 2019).

LCs Smectic

Friedel's categorization has to be expanded to take into consideration the several smectic LC kinds that go by the letters A, B, and C. Layered structures are present in all smectic LCs (Stojadinovic, 2002). The elongated molecules' centres of gravity are placed in equidistant planes. The molecules' long axes are perpendicular to the preferred direction L, which may be perpendicular to the planes (smectic A) or slanted at an angle (smectic C). The centres of gravity inside the planes may be arranged randomly or in a predictable way (Vaupotic, 2009). X-ray analysis has been used to learn about molecular ordering. In a polarising microscope, the textures of the different types ofsmectic may be used to differentiate them. At least seven different varieties have been seen, claim Demus et al. (Das, 2003). The smectic liquid crystal state to isotropic state as shown in Figure 7.

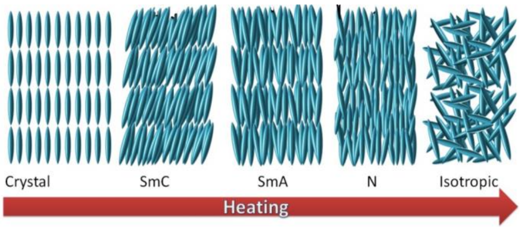

Figure 7. Smectic LC state to isotropic state

Discotic Phases

The disc-like chemicals are organised in columns during discotic phases. Once more, the orientation of the molecules inside the columns and the relationship between the columns determine the different phases in this group (Bailey, 2009). The Dhd phase is the easiest phase. It may be thought of as a liquid with only one dimension. The columns are arranged hexagonally. The discotic LC as shown in Figure 8.

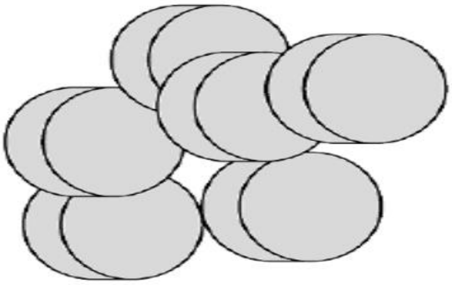

Figure 8. Discotic LC

Cholesteric LCs

Since several cholesterol esters generate this sort of LC, it is known as "cholesteric LCs". The arrangement of the molecules is parallel to a preferred direction *L* as in a nematic phase, which is how the structure may be defined as a twisted nematic structure when viewed from a certain plane (Comelles, 2021). *L* spins constantly when moving in a plane-normal direction. A helical structure is the outcome and a unit vector named l may be used to characterise its axis (Hong, 2010). The distance required to rotate *L* by 2rr while moving along *Z* is known as the structure's pitch, or *p*, and it ranges from 0.2 pm to macroscopic quantities.The nematic structure corresponds to an endless pitch (Keith, 2010). By appropriately adjusting the amount of chiralic substance added to a nematic LC, the pitch may be changed to any desired value. The helix can rotate either left-handedly (type "laevo") or right-handedly (type "dextro") (Gupta, 2019). Cholesterol chloride is an example of type dextro, although most cholesterol derivatives belong to type laevo. The kind of the cholesteric helix has no relationship to the sign of the optical activity of the free molecule. However, the presence of chiral compounds is a prerequisite for the development of the cholesteric mesophase (Francescangeli, 2010). The Cholesteric LC as shown in Figure 9.

Classifications and other technical terms

Micelles aggregate to produce lyotropic LCs. They are not molecular dispersions but rather multi component systems. They typically consist of an amphiphilic material and one or more solvents (Domenici, 2011). On the contrary, pure chemicals create thermotropic LCs. Amphotropic LCs are thermotropic LCs that also generate lyotropic LCs in the presence of appropriate solvents (Zhang, 2022). In amphiphilic LCs, including soaps and alkyl glycosides, the amphiphilic nature of the molecule is what causes the creation of the LC line behaviour. On the contrary, the molecular shape dictates the LC line characteristics of monophilic LCs (Tony, 2022). LCs with a rod-like structure will be calamitic, whereas those with a disc-like structure will be discotic.

Due to their strong resemblance to discotic LC, bowlic and pyramidal LCs are not distinguished in these tables (Takezoe, 2006). The molecular shape of phasmidic LCs is intermediate between rods and discs. Above the melting point, techniques used in this study LC phases can be found (Sun, 2022). Therefore, these stages are visible during the heating and cooling periods. Only in the super-cooled region below the melting point do monotonic LC line phases occur. Thus, only the cooling phase is used to detect these phases (Druon, 1983).

Azoxy Compounds

A precise distinction is made when it comes to azoxy compounds as to whether a pure isomer [only -N(O)=N-] or a combination of both isomers [-N(O)=N- as well as -N=N(O)-] is synthesised and described (Yuriy, 2023). Different systems will mention these two scenarios. A homologous series could be assigned to two separate systems, depending on the circumstances. For instance, the p, p'-dialkoxy azoxybenzene will fall under type A if both alkyl chains are the same length, and type B if they are different (and no separation of isomers performed) (Gong, 2020).

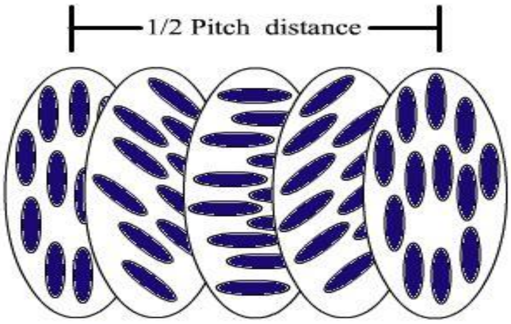

Figure 9. Cholesteric LC

Optical Properties

The study of LCs involves optics in particular because both imposed boundary constraints and external fields have a significant impact on these materials' optical characteristics (Saed, 2020). Additionally, optical qualities are widely recognised to form the basis for the numerous uses of LCs as optical devices. This fact results in distinctive optical properties, while at the same time making optical detection methods highly helpful for examining other physical aspects (Dabrowski, 2015). Numerous substances display more than one of these kinds above the melting point (Yelamagged, 2006).

Compounds or combinations with chiralic molecules form the cholesteric mesophase. The orientational sequence of the long molecular axes varies amongst the various types of mesophases (Haase, 1999). This ordering is polar in all the current known examples, and no ferro electric behaviour has been noticed (Sreenilayam, 2012).

Nematic LC Alignment

The preferred direction of a nematic LC in a macroscopic volume Lis, in general, is not uniform and varies from location to location as a result of disruptive processes such convection flow and wall effects. However, magnetic and electric forces have the ability to align even massive samples (Shafiq, 2020). This results from the unusual intermolecular interactions that cause the mesomorphic state and cause the molecules to behave cooperatively. L is parallel to the applied electric field if AX is positive. Positive or negative dielectric anisotropy, AXe', is possible. The negative and extremely tiny magnetic susceptibilities XII and Xl are found in diamagneticmaterials (Luo, 2022, Ros, 2005). In contrast to most pure nematic systems, IXll is greater than IXIII, causing AXEE to have become positive and L to be parallel to an applied magnetic field. However, compensated nematic mixes made of cholesteryl derivative and certain lyotropic LCs have also shown negative values of AX (Peng, 2015).

Order Parameter

A single order parameter S may be used to define the effectiveness of the molecule orientation along L (Kim, 2019,Gupta, 2019): where (*S*) represents the angle between the long molecule axis and the preferred direction, and (*S*) is the time or space average (optic axis). All molecule axes are parallel when *S=1*. Near absolute zero temperature, this ideal nematic arrangement would only be feasible if the material did not freeze (Allen, 2017). *S=0* for an isotropic liquid. Depending on temperature, the order parameters of real nematic LCs range from 0.4 to 0.7. When magnetic or electric fields of standard laboratory magnitude are applied, the value of S is not significantly altered (Bryan, 1978). Other techniques make use of X-ray diffraction and nuclear magnetic resonance spectra, or ultraviolet or infrared dichroism (Dumrongrattana, 1986). Saupe and Maier provided a critical assessment of the various techniques the theory of molecular statistics

A statistical hypothesis was created by Maier and Saupe to explain the LC line state and the molecular order for the nematic phase (Levelut, 1981). This theory uses the mean field approach to characterise the intermolecular orientational forces, which is analogous to how ordering phenomena in ferromagnetics are treated. The "nematic potential" D= f (*S, V*) that each individual molecule experiences is determined by the momentary angle *(60)* among its long axis (molecular axis) and the optic axis, this same order parameter *S* as well as the molar volume *V*. Then, *S* is provided by the transition temperature and molar volumes alone may be used to compute *A*, a quantity that is unique to each molecule.

The transition temperature (*T*) and the molar volumes (*V*) immediately below and above the transition to the isotropic phase may be used to compute the amount *A*, which is specific to each molecule. The derivation is based on the hypothesis that dispersion forces drive molecule alignment as well as only the induced dipole-dipole contribution is taken into account. The mesomorphic condition is brought on by the anisotropy of the molecule polarizability, which causes the intermolecular dispersion forces to be angularly dependent (Donovan, 2019).

Theory of Elastic Continuum

The continuum hypothesis put out by Zocher and Oseen helps explain the elastic characteristics of LCs. Frank provided a clearer and more thorough explanation of this elastic hypothesis (Li, 2023). The elastic continum hypothesis is predicated on the idea that, with the exception of a few isolated lines or points, the LC has a preferred direction for its crystallographic orientation at each location, which is defined by a unit vector L and fluctuates continuously throughout space. A displaced nematic LC's elasticity energy density is given by (Jayoti, 2023).

Dielectric Properties

For instance, PAA exhibits negative anisotropy. The magnitude and angular location of the permanent electric and magnetic dipole moment, as well as the molecule polarizabilities, determine the sign of the dielectric anisotropy (Watanabe, 1996). With respect to p-azoxyanisole, a strong dipole moment exists that forms a significant angle with the molecule's long axis. As a result, E_1 is higher and the orientational polarisation is substantially bigger perpendicular to *L* than parallel to *L* (Yen, 2008).

Nematic LCs feature significant positive dielectric anisotropy in the range of 10 to 20 and are made up of molecules with the very strongly polar -C = N group in the terminal X position. By using Onsager's theory of static polarisation for nematic LCs, Maier and Meier developed these concepts more mathematically. According to the Onsager theory, the molecular polarizability as well as the permanent electrical dipole moment are two characteristics of molecules that are related to the dielectric constant. The polarizability must be considered as a tensor with all main values in the case of nematic LCs, and an angle must be included to define the location of to specify the location of the permanent dipole moment in relation to the molecule's long axis (Zhou, 2022).

The first term, which is always positive, is the result of the polarizability (displacement polarisation), whereas the second term, which results from the orientation polarisation of the permanent dipole moment, can either be negative or positive depending on whether the angle 13 is smaller than or greater than 55°. E_{ll} and E show a typical Debye relaxation at microwave frequencies in nematic LCs. In contrast, E exhibits no dispersion in this area whereas E_{ll} has an extra relaxation zone at considerably lower frequencies in some molecules. A relaxation time *Tl* that is longer than the typical Debye relaxation time To by a "retardation factor" can be used to describe the low-frequency relaxation process. to specify the location of the permanent dipole moment in relation to the molecule's long axis. the typical Debye rest period A "retardation factor" is defined as *g = Tl/To*, which has a magnitude range of 100–1000 and is substantially temperature-dependent. The persistent dipole component running perpendicular to the long molecule axis is responsible for this lower frequencies relaxation. E_{ll} can only be affected by this component if the molecule is rotated about a transverse axis. In order for this to occur, it is required to go over the potential barrier that, in the mesomorphic state, strives to align all molecules parallel to one another. To specify the location of the permanent dipole moment in relation to the molecule's long axis (Li, 2023).

Aspects of Cholesteric LCs' Optics

Cholesteric LCs have special optical qualities because of their helical shape. The selective light reflection, which is the source of the dazzling hues, is the most noticeable characteristic of such a consistently aligned cholesteric LC. For some reason, the cholesteric structure is commonly described as a helix (with the proper pitch and axis); this description is largely metaphorical and lacks any real physical meaning. Since it is really a cholesteric with infinite pitch, a nematic LC is not actually a separate instance. Due of the periodic structure's Bragg reflection and the spiral arrangement, cholesterol crystals' distinctive hues in reflection and extremely high optical rotatory powers are both a result. The pitch is susceptible to changes in temperature, flow, chemical make-up, and applied magnetic or electric fields.

Electric Field on Liquid Crystals

Influence of Electric Fields on the Structure

The ordering para of a LC is not appreciably altered by external fields of standard laboratory size. They do, however, have an impact on the LC's microscopic structure, which in turn has an impact on the optical characteristics. There are several electro-optic effects that may be used right away in display technology. In sandwich-shaped cells, which contain the LC material between two closely separated plates that are both internally coated with a clear conductivity layer, electric effects in LC line are often explored. The electrode surfaces get special treatment to align the LC's optic axis consistently. Electrically generated effects can be divided into three categories: Dielectric effects are (a).

These are similar to magnetically induced elastic deformation and are entirely field generated, meaning that no electric current is required for them to occur. There is no flow rate in the equilibrium condition. Several display applications depend on dielectric effects. (b) Effects that are piezoelectric. Numerous authors have studied this "piezoelectric effect" (Meyer) or "flexoelectric effect" (de Gennes), however there are currently no recognised practical uses (Bryan, 1978). Therefore, we will not discuss this type of impact any more here. Effects of electro hydrodynamics (c). These happen when the ionic conductivity is not too low and/or the negative dipole anisotropy of the materials is not too high. The generated field's frequency is not excessively high. They are interconnected to both a fluid flow as well as an electric current.

Dielectric Effects

We will talk about three significant dielectric phenomena in nematic LCs. The specimen geometry and the degree of dielectric anisotropy in each of the three examples are different. Orientation in Parallel: Freedericksz-Effect Consider a situation where the electrodes' surfaces are parallel to the LC's unobstructed optic axis. The anisotropy of the dielectric. D. € is seen as favourable. According to Saupe, the equivalent magnetic case was handled. Two competing effects must be considered while operating in an electric field: due to the positive dielectric (Dierking, 2003).

Conversely, the contact with the boundary surfaces results in elastic torques that works to return the system to its initial condition. The restorative elastic torque is greater than the electrical torque below a crucial threshold voltage Uo, preventing any deformation from happening (Coles, 2005). The home tropically aligned cell looks dark across crossed polarisers. Viscous forces are involved because the deforming and relaxation processes are linked to fluid movement. The problem is quite challenging to solve mathematically. But logical simplifications, such the small angle approximation, result in straightforward equations for rise and decay times (Xia, 2021).

CONCLUSIONS

Investigations on the special qualities of LCs and their broad applicability have been extensive. However, their effective synthesis and characterisation have started the process of assessing their usefulness for many areas. There are specific characterisation approaches that evaluate a compound's capacity to display liquid crystalline characteristics since not all related compounds may have displayed LC behaviour, making them an unsuitable option for future use.

To accommodate for various characteristics of LCs, a brief literature review has been provided in our present contribution. The Review finishes with a look ahead that discusses present problems and potential future directions for study. The following subjects are briefly reviewed; the first experimental proof that a twist deformation lowers the smectic A-nematic transition temperature, a phenomenon analogous to how a magnetic field affects the liquid crystal molecules.

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