

## CHARACTERIZATION TECHNIQUES FOR LIQUID CRYSTAL MATERIALS AND ITS APPLICATION IN OPTOELECTRONICS DEVICES

Vishal Sharma<sup>1</sup>, Dr. Anil Kumar<sup>2</sup>

Department of Physics

<sup>1,2</sup>OPJS University, Churu, Rajasthan (India)

### *Abstract*

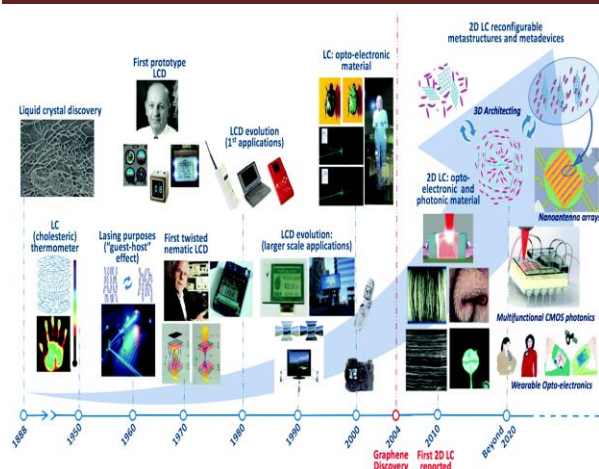
This research employs characterization techniques for liquid crystal materials and its application in optoelectronics devices. Two-dimensional (2D) nanocomposite materials with dynamically tunable liquid crystalline properties have as of late developed as a highly-encouraging class of novel, useful materials, opening new courses inside a wide assortment of potential applications from the deposition of highly uniform layers and heterostructures, to novel display technologies. Here, we will present the fundamental ideas that support this ongoing mechanical progress; give an outline of the engineered courses towards such 2D nanocomposite materials; and survey late advances in the application and appropriateness of these materials inside the fields of optoelectronics and photonics. Since the approach of graphene in 2004, there has been a blast in the examination of an extensive variety of molecularly thin (two-dimensional) materials.

### 1. OVERVIEW

The liquid crystal phase is a phase of issue that exists for an assortment of particles and materials, contingent upon their geometric and substance properties, with qualities middle to those of an ordinary crystalline strong and a liquid[1]. Liquid crystals (LCs) have discovered use in an assortment of applications as the years progressed. The liquid crystal phase was at first portrayed by Austrian botanist Friedrich Reinitzer in 1888 when taking a gander at the properties of cholesterol subsidiaries, albeit some credit likewise goes to Julius Planer, who announced comparable perceptions 27 years prior[2].

This new and unmistakable condition of issue was then recognized as the "liquid crystal phase" by Otto Lehmann in 1890 and

in 1904 the principal monetarily accessible LCs were created by Merck-AG. Over the accompanying 18 years, researchers built up the presence of three particular liquid crystalline phases (nematic, smectic and cholesteric) at the same time, without any applications of note inevitable, the investigation of LCs was stopped. For the following 30 years, established researchers disregarded LC materials, considering them as an intriguing curiosity[3]. Be that as it may, following a renaissance in liquid crystal science in the 1950s, the beforehand logical interest has turned into a pervasive piece of the advanced technology scene.



**Figure 1** Timeline of the History of Liquid Crystal Phase Applications, From Their Discovery to the Present Day

During the 1950s, the innovation of the primary cholesteric LC temperature pointers, and additionally advances in scientific metrology, tumor diagnostics, and non-ruinous material testing techniques drove another period in liquid crystal science. By 1962, liquid crystals were at that point discovering applications in best in class laser devices, in spite of the relative youth of laser science. Be that as it may, the most critical mechanical advancement came in 1965 with the improvement of the primary LC displays (LCDs). Like this, wound nematic LCDs (1969– 1971) propelled the field further[4].

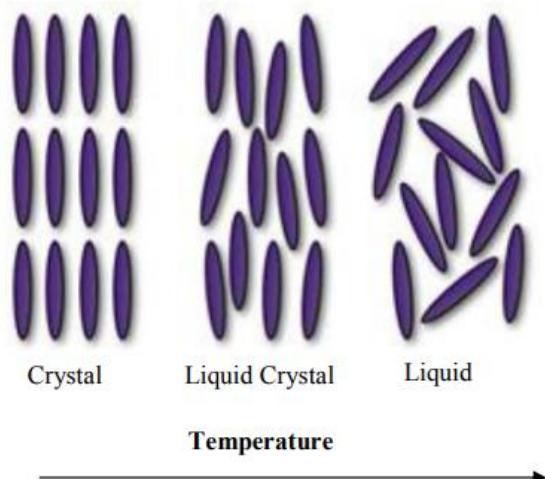
Huge leaps forward in the advancement of liquid crystal technologies happened in the 1980– 1990s and kept on having a significant effect on everyday life: the scaling down of display technologies encouraged the improvement of compact PCs, cell phones and innumerable other innovations[5]. Since, the beginning of the new thousand years, LCs and as of late

found 2D material LCs have come into the request as optoelectronic and photonic materials. The likelihood of the presence of a liquid crystal phase stems basically from the geometric structure of the particles in the material, and also the practical groups exhibit in the atom.

In lyotropic liquid crystals, mesogens are scattered in a host dissolvable (regular water however other natural solvents can be utilized relying upon the atom). Lyotropic liquid crystals show a liquid crystal phase inside a specific scope of temperatures yet also require a centralization of the dynamic mesogens that falls inside a specific range. In the lyotropic phase, the ease of the material is prompted by the dissolvable particles as opposed to being characteristic for the mesogens themselves. The mesogens contain immiscible solvophilic and solvophobic parts isolated at contradicting 'finishes' or aspects of the particle, making them amphiphilic.

## 2. LIQUID CRYSTALS

Liquid crystals (LC) are partially ordered anisotropic fluid that exists between crystalline solid and isotropic liquid as shown in Figure 2 (Larson & Ronald 1999). If the temperature increases the molecules flow like a liquid but also have some degree of ordering in its molecular arrangement.



**Figure 2 Schematic illustrations of the crystalline solid, liquid crystal and isotropic liquid**

LC materials are bounteous in nature as proteins, cell films and viruses. They are utilized as a part of the assembling of numerous electronic devices to be specific level LC display (LCD), plasma TV screens, guides, cell phones, individual advanced aides, organic lighting, solar cells devices, and so on. Because of this, there is an expanding interest for LC materials for different applications. The simple process capacity and great reasonableness make these organic materials extremely appealing towards numerous application perspectives. In addition to that the hydrogen bonded liquid crystals (HBLC) have earned research enthusiasm towards the different application aspects in the most recent two decades.

### 3. TYPES OF THERMOTROPIC LIQUID CRYSTALS

Based on the positional and orientation orders of molecules, it is classified into two types

1. Orthogonal phase
2. Tilted phase.

These phases are further again sub-divided into many types. Mainly it is classified into

1. Nematic (N) phase
2. Cholesteric phase and
3. Smectic (Sm) phase.
4. This type of separation.

Further, thermotropic LC are classified according to their molecular shape and is alienated into

1. Calamitic LC
2. Discotic LC (DLC)
3. Polymeric LC
4. Banana shape of rod like, disc like and bend core molecules.

#### Nematic phase

N phase is the most vital phase in the LC. The name N landed from Greek word nema which implies string like structure. This term impels from string like topological structure which is seen in the Ns, and is formally called as disclinations. Ns are additionally called hedgehog topological imperfections.

#### Cholesteric Phase

Cholesteric phase has smoothness like the N phase given long-range translational request. For a neighborhood scale, cholesteric phase and N phase are fundamentally the same. By the by on a bigger scale, the cholesteric chief n follows helix structure because cholesteric mesogens are shaped by the optically dynamic material.

#### **4. SYNTHESIS AND CHARACTERIZATION TECHNIQUES**

These days blend of high-quality materials with wanted properties is most extreme imperative in the consolidated test issue physical science research. A few physical, chemical and natural combination methods have been produced to upgrade the performance of nanomaterials displaying enhanced properties with the intent to have a little control over the particle measure appropriation and morphology. The required nanostructure can be blended in an assortment of shapes and sizes relying on their necessities, for example, single crystals, composite, undefined solids, thin films, thick films, polycrystalline powder, and so forth.

#### **6. CHARACTERIZATION AND TEXTURE OBSERVATIONS OF CALAMITIC LIQUID CRYSTALLINE COMPOUNDS**

Liquid crystalline conduct has been watched for the most part in two kinds of molecules: linear or bar like molecules that frame calamitic phases and circle like molecules that shape discotic phases. The structure of liquid crystalline phases is described by the game plan of the molecules, the compliance of the molecules, and the intermolecular collaborations. The transition between the different liquid crystal mesophases from crystalline to smectic to nematic happens at characterized temperatures which can be distinguished utilizing differential filtering calorimetry, while the nature and surface of the mesophase is typically investigated utilizing enraptured optical microscopy.

#### **5. OPTOELECTRONICS**

Liquid crystalline nanocomposites fusing 2D material particles demonstrate awesome guarantee for optoelectronic applications because of their field prompted tunability and upgraded usefulness originating from the plenty of properties displayed by the scope of exfoliative materials. For instance, scatterings of liquid crystalline graphene oxide have been appeared to experience electro-optical exchanging with low edge voltage necessities. By balancing out a suspension of diminished GO utilizing surfactants, they showed expanded time security and enhanced electro-optic properties with an initiated birefringence twice as vast at a similar field quality as that with an unreduced GO suspension.

##### **5.1 Optoelectronic Property**

The most important factor responsible for a material to show a better optoelectronic property is the large exciton binding energy and this property is possessed by Zinc oxide having binding energy of 60mev which could be attended at and above room temperature due to excitonic recombination. The process of optical absorption and emission have been influenced by bound excitons which are extrinsic transition related to dopants or defects thereby usually responsible for creating discrete electronic states in the band gap. Theoretically, neutral or charged donors and acceptors are the members by which exciton could be bound with and it merely depends on the band structure of semiconductor material.

## 5.2 Application and Prospectus

The self-assembling nature of liquid crystalline materials has prompted the utilization of graphene oxide scatterings for the arrangement of all around requested layers and piles of 2D materials. That graphite suddenly sheds into single-layer graphene in chlorosulfonic corrosive, and immediately frames liquid-crystalline phases at high concentrations. Straightforward, directing movies were delivered from the liquid crystalline scatterings. The readied scatterings were utilized to accomplish self-amassed layer-by-layer multifunctional 3D crossover structures involving SWNTs and GO with promising mechanical properties.

## 5.3 Types of Optoelectronics Devices with Applications

Optoelectronics is the communication between optics and electronics which includes the study, design and manufacture of a hardware device that converts electrical energy into light and light into energy through semiconductors. This device is made from solid crystalline materials which are lighter than metals and heavier than insulators. Optoelectronics device is basically an electronic device involving light. This device can be found in many optoelectronics applications like military services, telecommunications, automatic access control systems and medical equipment's.

This academic field covers a wide range of devices including LEDs and elements, image pick up devices, information displays, optical communication systems, optical

storages and remote sensing systems, etc. Examples of optoelectronic devices include telecommunication laser, blue laser, optical fiber, LED traffic lights, photo diodes and solar cells. Majority of the optoelectronic devices (direct conversion between electrons and photons) are LEDs, laser diodes, photo diodes and solar cells. Optoelectronics are classified into different types such as:

- Photodiode
- Solar Cells
- Light Emitting Diodes
- Optical Fiber
- Laser Diodes

### Photo Diode

A photo diode is a semiconductor light sensor that creates a voltage or current when light falls on the intersection. It comprises of a functioning P-N intersection, which is worked backward inclination. At the point when a photon with a lot of vitality strikes the semiconductor, an electron or entire combine is made. The electrons diffuse to the intersection to frame an electric field. This electric field over the exhaustion zone is equivalent to a negative voltage over the unprejudiced diode. This strategy is otherwise called the internal photoelectric effect. This device can be utilized as a part of three modes: photovoltaic as a sun powered cell, forward one-sided as a LED and turn around one-sided as a photo identifier.

### Solar Cells

A solar cell or photo-voltaic cell is an electronic device that specifically changes



over sun's energy into electricity. At the point when sunlight falls on a solar cell, it produces both a current and a voltage to deliver electric power. Sunlight, which is made out of photons, transmits from the sun.

### Light-Emitting Diodes

Light-emitting diode is a P-N semiconductor diode in which the recombination of electrons and openings yields a photon. At the point when the diode is electrically one-sided the forward way, it emanates incongruous tight spectrum light. At the point when a voltage is connected to the leads of the LED, the electrons recombine with the gaps inside the device and discharge energy as photons. This effect is called as electroluminescence.

### Optical Fiber

An optical fiber or optic fiber is a plastic and straightforward fiber made of plastic or glass. It is to some degree thicker than a human hair. It can work as a light pipe or waveguide to transmit light between the two finishes of the fiber. Optical filaments as a rule incorporate three concentric layers: a center, a cladding and a coat. The center, a light transmitting district of the fiber, is the focal segment of the fiber, which is made of silica. Cladding, the defensive layer around the center, is made of silica.

## 6. ELECTRONIC AND OPTOELECTRONIC APPLICATIONS

Inorganic materials are favored for NLO applications over organic materials. The single crystals of unadulterated inorganic materials, for example, quartz, lithium

niobate ( $\text{LiNbO}_3$ ), potassium dihydrogen phosphate (KDP), potassium titanyl phosphate (KTP), and urea, show excellent NLO properties. These are the unadulterated inorganic materials utilized as a part of second harmonic generating devices, parametric oscillators, and so forth. A portion of the recognizable properties of inorganic host materials are huge mechanical quality, excellent thermal soundness, great transmittance, and high electro-optic coefficients and additionally high level of chemical inactivity.

The most recognizable single crystals of KDP display prevalent NLO properties and have been utilized as reference materials for correlation with other crystalline materials. The transmittance, hardness, and dielectric constants are enhanced by developing KDP crystals utilizing the Sankaranarayanan-Ramasamy method contrasted and the ordinary slow evaporation method. NLO materials, for example, lithium sulfate, potassium lithium niobate, and lithium triborate have exceptional focal points, for example, an expansive damage edge, high phase coordinating edge, more extensive straightforwardness range, and chemical security. Additionally, lithium sulfate monohydrate has been named a promising material for Raman laser recurrence converters. We have been growing a few inorganic materials that show high straightforwardness, great chemical steadiness, and elasticity and also second harmonic generation (SHG), recurrence transformation, optical parametric amplification (OPA), optical parametric

wavering (OPO), optical emanation and electro-optical applications.

## 7. CONCLUSION

We displayed difficulties of existing 2D material process innovations, to be specific contaminations, reproducibility, and versatility. An assortment of 2D photonic devices that demonstrate additional functionalities contrasted with best in class mass devices was exhibited. A portion of the characteristic properties of graphene, for example, the nonappearance of an electronic band hole, transporter multiplication, and high bearer portability, propose applications as broadband and high-speed photodetectors, which have been demonstrated in a few occurrences. Even though the monoatomic idea of graphene presents a limitation in the absorbance, numerous promising solutions are being sought after.

New impetuses and critical advance in investigations of ring opening polymerization (ROP) and ring opening metathesis polymerization (ROMP) take into account much better characterized polymeric structures. Vital info can be relied upon from research gave to non-covalent side chain systems. Numerous endeavors have been embraced to acquire SCLCP's layered nanomaterials by ion and hydrogen bonding driven self-get together. It offers less demanding and more effective engineered way to deal with the entire range of new

polymers. A few new main chain/side chain structures have been synthesized tossing all the more new light on the effect on the structure-properties relationships.

Since the electronic conduction in liquid crystals was found in the 1990's, ten years have passed. With continuous interests in investigating its new edge, a great reason for the second step towards device applications has been well settled, incorporating general highlights in control bearer transport properties and their hypothetical understandings in liquid crystals, which furnish us with the degree and limitation of their properties, and variation of materials having high versatility. Along these lines, we can give a correct position to the liquid crystalline materials in natural materials. Presently, we require another push to open the entryway looking another horizon of natural optoelectronic devices through, with a well-ordered way to deal with have the responses to the issues portrayed later on works, in which we need to co-work with materials researchers, physicists, scientists, and electrical designers as it happened to liquid crystal displays.

## REFERENCES

- [1].C. Zakri, C. Blanc, E. Grelet, C. Zamora-Ledezma, N. Puech, E. Anglaret and P. Poulin, Philos.

- Trans. R. Soc., A, 2013, 371,  
20120499
- [2].R. H. Chen, Liquid crystal displays:  
fundamental physics and technology,  
Wiley, 2011
- [3].H.-S. Kwok, S. Naemura and H. L.  
Ong, Progress in Liquid Crystal  
Science and Technology, World  
Scientific, 2013
- [4].D. C. Zografopoulos, R. Asquini, E.  
E. Kriezis, A. d'Alessandro and R.  
Beccherelli, Lab Chip, 2012, 12,  
3598
- [5].A. Reina, X. Jia, J. Ho, D. Nezich,  
H. Son, V. Bulovic, M. S.  
Dresselhaus and J. Kong, Nano Lett.,  
2009, 9, 30–35