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# A Study On Synthesis And Application Of Liquid Crystals In The Field Of The Technology And Pharmaceutical Industry

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## Abstract

Liquid crystals have garnered significant attention in the pharmaceutical field due to their unique properties that bridge the characteristics of both liquid and solid states. The application of liquid crystal materials in pharmaceutical fields has opened up new avenues for drug delivery systems, emulsions, and other biomedical applications. The unique physicochemical properties of liquid crystals - including their ability to provide controlled release, enhance permeation, and maintain stability - make them an attractive platform for developing sustained drug delivery systems. Among the unique benefits, LC-based systems can offer to pharmaceuticals, are thermal stability, high solubilization levels, enhanced bioavailability, oxidation resistance, and controlled release characteristics. The characteristics and applications of liquid crystal materials are distinct. Pharmaceuticals and cosmetics have used LCs-based delivery systems, including creams, ointments, gels, liposomes, colloidal dispersions, and transdermal patches. Applications for liquid crystals are numerous in the domains of science, engineering, and technology. The search results demonstrate and highlight the research methods and application of the effectiveness of liquid crystals in achieving prolonged and consistent release of various pharmaceutical agents. This article's goal is to objectively demonstrate the value of pharmaceutical liquid crystals and their role in the ongoing advancement of targeted drug delivery technologies and provide thorough information about pharmaceutical liquid crystal technology, covering the most recent and innovative developments in the field.

**Keywords:** Liquid Crystal, Pharmaceutical, Drug delivery, LC Technology, Biologically active

# 1. Introduction

Liquid crystals (LCs) are a unique state of matter that exhibits properties between those of conventional liquids and those of solid crystals. They are characterized based on the tendency of their molecules to align in a common direction, known as the director, while still maintaining some degree of mobility and fluidity. Their unique molecular structure and orientational order make them essential components in modern technology and natural systems.[1,2,3] The discovery that cholesteryl benzoate had two distinct melting points by Austrian botanist Friedrich Reinitzer in 1888 marked the beginning of the study of liquid crystals. During his experiments, Reinitzer raised the temperature of a solid sample and saw the crystal change from a clear liquid to a muddy liquid. He increased the temperature even further, and the material changed back into a transparent, clear liquid. Because of his early research, Reinitzer has been credited with finding a new phase of matter, the liquid crystal phase.[4,5,6] With anisotropy of properties and no three-dimensional crystal structure, a liquid crystal is a thermodynamically stable phase that usually occurs in the temperature range between the solid and isotropic liquid phases. Anisotropic intermolecular interactions give the molecules, or mesogens, in a liquid crystalline material some orientational or positional order, but less organization than in a crystalline solid, showing that liquid crystal behaves like a liquid when it flows, however, these compounds are usually more viscous due to their positional structure.[7,8] Liquid crystals are thought to be responsive to a wide range of stimuli, such as temperature and magnetic and electric fields. This sensitivity combined with the tendency of liquid crystals to self-assemble makes them so fascinating.

Liquid crystals are used for detecting tumors and infections by painting them on the body to observe temperature changes. They can also be used to make cheap thermometers. Most liquid crystals show polymorphism and have mesophases or sub-phases. Liquid crystals can be categorized in many different ways.[5,9] For instance, the molecules that comprise the mesophases (mesogens) can be low molecular weight, polymeric, amphiphilic, discotic, calamitic (rod-like), or contain metals. Liquid crystals have either lyotropic or Thermotropic behaviour.[10,11] Lyotropic liquid crystals depend on solvents, and the concentration of the solvent affects their behaviour and aggregation. Looking at the multifunctional properties of the liquid crystals, our research aim is to synthesize, characterize, and apply these synthesized LCs in the technology and pharma industry.[12,13]

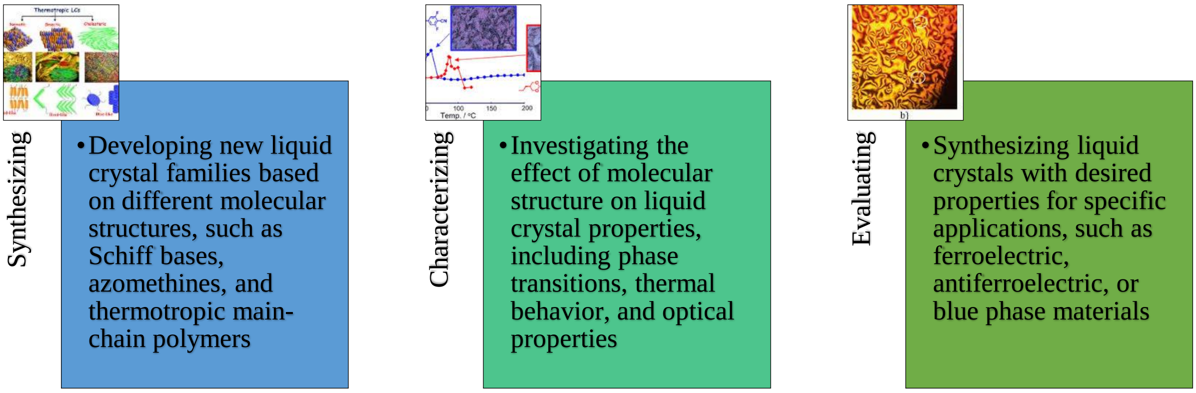


Fig-1 Objective of synthesizing, characterising and Evaluating Liquids Crystals

By pursuing these objectives, researchers also aim to expand the fundamental understanding of liquid crystal science and develop new materials and technologies that harness the unique properties of these fascinating substances.

## 2. Material and Methods:

The synthesis of biologically active liquid crystal compounds involves several innovative approaches and methodologies, focusing on the development of new materials with unique properties that employs various methods, each tailored to create specific types of liquid crystalline compounds. The most common methods are listed in Fig-2.[14,7] These methods facilitate the creation of novel liquid crystalline compounds and align with the growing emphasis on sustainability in chemical synthesis. Each method contributes uniquely to the diversity of biologically active liquid crystals, paving the way for their application in fields such as pharmaceuticals, materials science, and nanotechnology.[15,16]

## 3. Characterization and Applications

The characterization of these compounds typically involves thermal and optical studies to determine their mesomorphic behavior and stability. The findings suggest that these biologically active liquid crystal compounds could lead to advancements in areas such as:[17,18,19]

- **Chemical and Biological Sensing**: The unique properties of these liquid crystals make them suitable for sensing applications, providing a platform for detecting various chemical and biological entities.
- **Pharmaceuticals**: Liquid crystals derived from natural sterols have implications in drug delivery systems and other pharmaceutical applications due to their biocompatibility.
- **Advanced Materials**: The development of metal-free liquid crystals opens avenues for creating stable and environmentally friendly materials for various industrial uses.

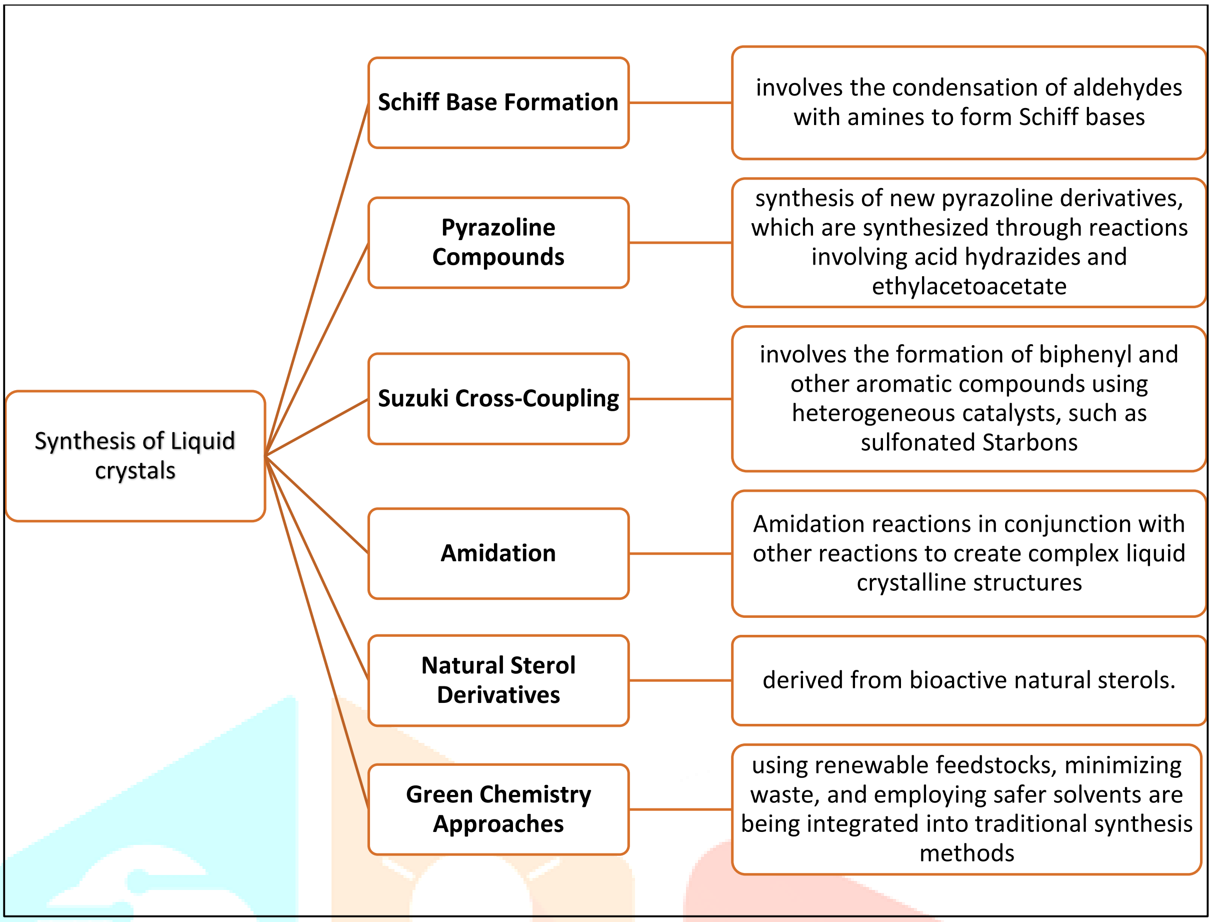


*Fig-2 Different methods of synthesis of Liquid Crystals*

The researchers are developing liquid crystal-based devices for displays, such as liquid crystal displays (LCDs) that utilize their light modulating properties. In addition, there have been many Explorations on the use of liquid crystals in sensors and detectors, taking advantage of their sensitivity to temperature, electric fields, and other stimuli. Investigating the potential of liquid crystals in photonic and optoelectronic applications, such as tunable lenses, optical data storage, and nonlinear optics. Also by studying the incorporation of nanostructures into liquid crystals to create novel composite materials with enhanced properties and potential applications.

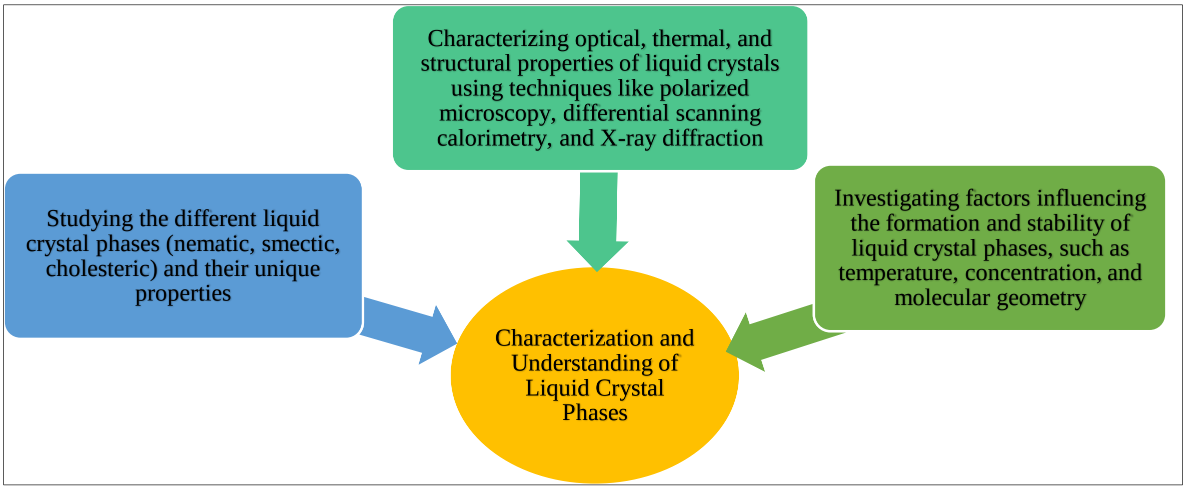


Fig-3 Characterization and Understanding of Liquid crystal Phases

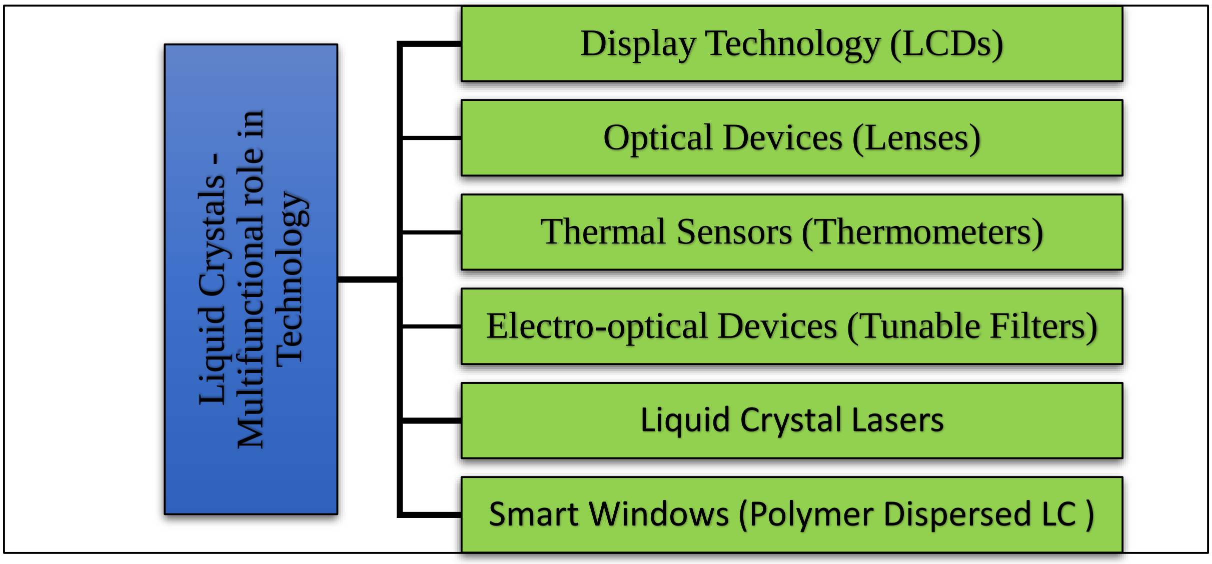


*Fig-4 Multifunctional role of Liquid Crystal in field of Technology*

Characterization Techniques: There are various methods for characterizing ionic liquids, including spectroscopic techniques (Ultraviolet Visible Spectroscopy, Differential Scanning Calorimetry, Polarized Optical Microscopic studies). These methods can be used to analyze the composition of ionic liquids, monitor their components and properties, and gain valuable insights into their structure and behavior.[19,20,21]

By utilizing these analysis methods and techniques, researchers can gain valuable insights into the properties, structure, and behaviour of liquid crystals, enabling advancements in various fields such as materials science, nanotechnology, pharmaceuticals, cosmetics and environmental research.[14,8,22,23]

## 4. CONCLUSION

In conclusion, the diverse applications of liquid crystal materials in different fields offer innovative solutions for technology, drug delivery, emulsions, crystallinity characterization, and micro/Nano droplet organization. The unique properties of liquid crystals, such as biocompatibility, responsiveness, and structural diversity, exhibiting optical properties such as iridescence and light transmission, make them promising materials for future renewable applications and valuable tools for advancing pharmaceutical research and development. These functions highlight the versatility of liquid crystals in modern technology, making them essential components in various electronic, optical, and sensing applications.

### Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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