International Journal of Research in Medical and Basic Sciences
Volume 9 Issue 03, March 2023 ISSN: 2455-2569 Impact Factor: 7.028
Journal Homepage: http://mbsresearch.com, Email: mbsresearchp@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal

Basic Typology of Liquid Crystalline Polymers and its Applications

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Abstract

The liquid crystalline behaviour of polymeric materials has piqued researchers' curiosity in recent decades. Liquid Crystalline (LC)Polymers have gotten a lot of press because of their prospective applications. This article provides a basic overview of liquid crystalline materials, including their definition and classification. This work aims to explorethe unique self-assembly structure and orientation of Liquid crystalline Polymers (LCPs) along with their relevance in industry. The article would be beneficial for chemists or researchers studying LCP for the detailed understanding.

Keywords: *Liquid Crystalline Polymers, Polymeric Materials, Typology*

1. Introduction

Liquid crystal (LC) polymers are a unique type of material that exists at the interface between a solid and a liquid. These orientationally ordered liquids are considered to be the fourth state of matter [1]. Despite the fact that liquid crystallinity has been found in 1888 as well as a phrase "liquid crystals" (LC) has been primary utilised in 1980[2], liquid crystallinity has been recognised rigorously in the last two decades. Liquid crystalsseem to be anisotropic compounds those flows qualities are substantially influenced by their structure and molecule orientation. Molecules are positionally and orientationally organised in three dimensions in the crystalline solid state, but these orders are completely annihilated in the isotropic liquid state [3, 4].

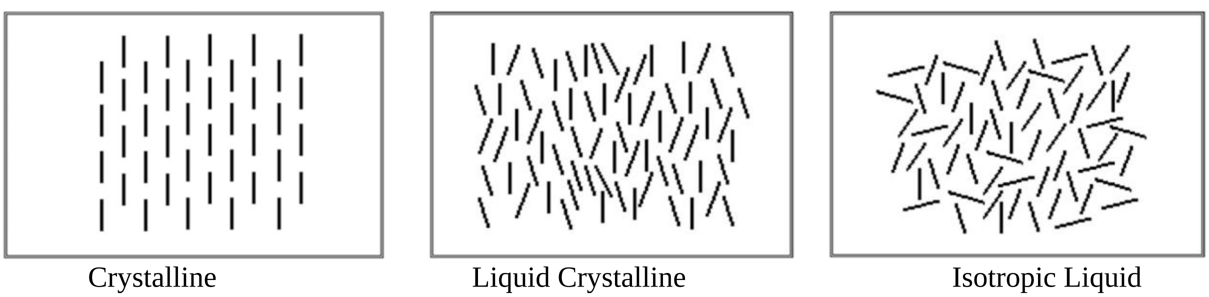

Fig. 1: Organization of LC Polymers

LCPolymers have the ability to self-assemble into a variety of LC phases, including nematic, smectic, columnar, and cholesteric. The architectural and chemical structures of the polymer backbone, mesogenic unit, flexible spacer, surrounding alkyl tail, and other components can impact the self-assembling structures of LCPolymers.

LCPolymers have the fluidity of regular liquid crystals but have the order of a solid crystal structure. Since this rigorous synthetic polymer mesophases self-align in the direction of flow, liquid crystalline behaviour throughout melting, the viscosity decreases, making LCPolymers easier to process than isotropic polymers. LC Polymers have been extensively studied due to their immediate application in technology. However, related elements of LCPolymers are still in their early stages of development and are a source of ongoing study interest. The invention and marketing of DuPont's "KEVLAR" poly (p-phenylene terephthalamide) (PPTA) fibre, which can be made as rigid and strong as steel, stimulated scientific and technological interest in LCPolymers in the 1970s [5, 6].

2. Methodology

The work is related to the discussion of application of LCP and information is based on the secondary data.

3. Types of Liquid crystals

The thermotropic and lyotropic forms of liquid crystals are the most common. **Thermotropic** LCs exhibit a variety of Temperature dependence of liquid crystalline forms. They're made throughwarming to a point where crystal lattice isn't any longer holds together. LCs with thermotropic properties are extremely stable and have extremely wide mesomorphic ranges, perhaps hundreds of degrees.A liquid crystalline thermotropic materials have been further classified into two subgroups: thermodynamically stable-unstable monotropic and enantiotropic. [7, 8]. Enantiotropic LCs' mesophase can be observed by either raising or lowering the temperature of a solid crystalline phase, but monotropic LCs' mesophase can only be noticed by reducing the liquid phase's temperature. Occasionally, molecules that are mesomorphic in a solvent that is not mesomorphic form crystalline liquid phases. [2, 3, 9, 10], resulting in a state that exhibits liquid crystalline properties but is not a true solution. A transition to the isotropic liquid phase occurs when a number of solvent molecules that are not mesogenic is increased above the certain accumulation. Therefore, as consequence, **lyotropic** LCs are those that form when the solvent concentration is adjusted.

3.1. LCPsstructural arrangements

LCPs can also be thermotropic and lyotropic since they are liquid crystals and can be characterised as an important-string, side-string, combination important-string/sidechain, or cross-linked based on the mesogenic groups position.

3.1.1. The **important-chain LCP** is generated while mesogenic groups have been integrated into a polymer's backbone [11, 12]. The liquid crystalline phases are created by polymer chains folding in a similar fashion to how polymers crystallise. A schematic representation of the LCP with molecular-chain is depicts in Figure 2.

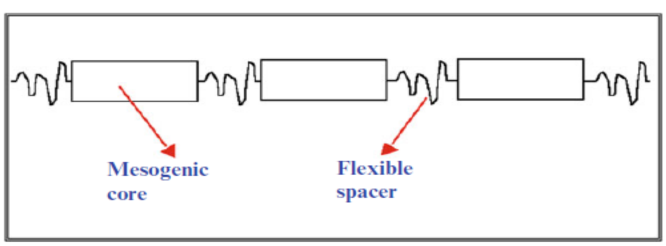

Fig. 2: Main chain LCP

3.1.2. The **comb-like or side-chain** LCPs are generated while mesogenic groups have been covalently bonded to a polymer mainchain as a side chains[13]. Figure 3 shows a schematic representation of this.

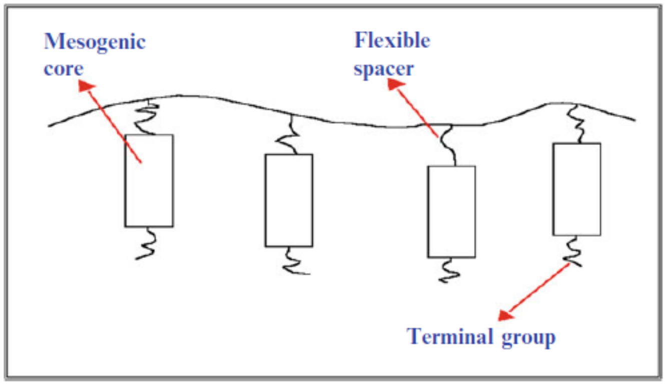

Fig. 3:LCPs with side chain

SCLCPs (**polymers that are liquid crystalline with side chain**) strike out not just because of their qualities as materials in a variety of modern electro-optical technologies, but also because they pose a difficult challenge to our understanding of molecular self-assembly. The fundamental reason for this is that SCLCPs were able to combine the unique features of low-molar mass liquid crystals and polymers, making film formation easier during material processing.

Designing compounds in an appropriate order to construct the mesophase while maintain adequate chain adaptability to achieve a temperature at which crystals melt or (Tm) are obtained inside the typical operating temperature range is a critical objective inside the SCLCPs synthesis. The ease with which these polymers form film during material processing is one of their distinctive structural characteristics. As a result, SCLCPs may be used to solve issues a certain liquid crystal with a poor molecular mass have been incapable of solving, as well as implementations may emerge that require a mixture of such features is essential.

4. Conventional Applications of LCPs

LCPs have a special combination capability in terms of mechanical, orientation, optical, electrical and magnetic properties, as well as high toughness, easy flowability, superior thermal and chemical resistance, a small die swell, dimensional stability and high modulus.

As a result, materials derived from LCP may be used to solve problems that traditional materials. These applications chemical processing, electronic/electrical components, telecommunications and transportation (with aerospace and automotive), as well as components and polymeric fibres with a high stiffness, holography, thermography, as well as, more previously, electro-optical and optical display devices, diagnostic tools based on medical science and optical computing.

Furthermore, when new features and varieties of LCPs are discovered and studied, these materials will undoubtedly become more important in commercial as well as scientific applications, because the material science's most promising fields. In the following table, most of the applications of LCPs are specified in accord to their properties.

Table 1: Applications of LCPs [14]

Potential area of application	Important properties of LCPs	Examples of application
Electrical/elec-tronics/ optoelectro-nics/ sensors	• Good thermal conductivity • High dielectric strength • Low dielectric constant • Resistance to solvents and cor-rosive chemicals • Good electric insulation • Low thermal coefficient of expansion • High dimensional stability • Low ionic content	Connectors, switches, relays bob-bins, laser beam deflectors, potenti-ometers, electronic packaging, optical amplifiers, sensors, biosensors
Information technology	• Excellent electrical • Optical and non-linear properties • Possibility to orient the mole-cules locally by action of electric or magnetic fields and more recently by action of light	Data storage devices, liquid crystal displays, electro-optical devices, non-linear optics, flat-panel dis-plays, optically-addressed spatial light modulators
Fiber optics	• Inherent flame retardance • Good moisture resistance • Excellent mechanical properties	Couplers, connectors, strength members
Medical	• Non-toxicity • Compatibility with sterilization techniques • Low permeability and toughness	Cancer diagnosis, localizing the placenta prior Caesarean, thin films with high strength, optical filters and membranes, pharmacological tests, temperature indicators, diagnostic aids
Aircraft automotive	• Low coefficient of thermal expansion allowing mating with or replacement of metal parts • Excellent mechanical, chemical and electrical properties • Excellent heat resistance • Toughness • Low viscosity during processing • Easy filling of molds having complicated geometries • Low thermal shrinkage • Resistance to automotive fluids, solvents and other chemicals	Electronic and electric related com-ponents, fuel system components, automobile parts
Chemical	• Excellent chemical and heat resistance • Toughness • Low flammability • High strength • High elastic modules • The ability to incorporate high levels of fillers	Pump housings, pump shafts, tower packing, valves, chemical analysis equipment, optical filters
Domestic equipment	• Temperature resistance • Chemical resistance • Microwave transparency • Toughness • Resistance to staining and abuse	Microwave equipment, cookware, compact disc components, films
Other	Any of the above properties	High strength fibers for helmets and bulletproof vests, sport and leisure equipment, etc.

5. Conclusion

While liquid crystals have been well-known besides their own contribution to the development of flat-screen innovation, it is clear that this is only a small part of how much liquid crystals depict as the balance among chaos and arrange as in substance. Liquid crystals enable the creation of new molecular structures and designs; pose open-ended questionnaire about a connection among structure chirality as well as molecular chirality, rather than amorphous condensed matter geometrical frustration; and Those who perform an important function in non-display implementations for example cosmetics composition (a massive industry) but also pharmaceutical delivery systems (a growing market), actuators, biosensors, as well as microfluidics,elements of soft robotics. Today's liquid-crystal science is a fantastic new field of matter research that was discovered more than 125 years ago.

References

1. Kumar, A., Srivastava, A. K., Sharma, D., Tiwari, S. N., & Misra, N. (2023). BO2 substituted novel alkyl biphenyl liquid crystalline series: dependence of geometrical and electronic properties on the alkyl chain length. *Theoretical Chemistry Accounts*, *142*(2), 17.
2. Ryabchun, A., &Katsonis, N. (2022). Molecular Photoswitches in Liquid Crystals. *Molecular Photoswitches: Chemistry, Properties, and Applications, 2 Volume Set*, 579-603.
3. Padilla, M. S. (2021). *New Liquid Biomaterials for Nanoemulsion-mediated Drug Delivery*. The University of Wisconsin-Madison.
4. Sponchioni, M., Palmiero, U. C., & Moscatelli, D. (2019). Thermo-responsive polymers: Applications of smart materials in drug delivery and tissue engineering. *Materials Science and Engineering: C*, *102*, 589-605.
5. Singh, J., & Gehlot, P. (Eds.). (2020). New and Future Developments in Microbial Biotechnology and Bioengineering: Recent Advances in Application of Fungi and Fungal Metabolites: Current Aspects.
6. Pavel, D. (2016). Introduction to liquid crystalline polymers. *Liquid Crystalline Polymers: Volume 1–Structure and Chemistry*, 477-499.
7. Hatakeyama, E. S., Gabriel, C. J., Wiesenauer, B. R., Lohr, J. L., Zhou, M., Noble, R. D., & Gin, D. L. (2011). Water filtration performance of a lyotropic liquid crystal polymer membrane with uniform, sub-1-nm pores. *Journal of membrane science*, *366*(1-2), 62-72.
8. Pavel, D., Yarovsky, I., & Shanks, R. (2005). Prediction of liquid crystalline properties of poly (1, 4-phenylene sebacate-oxybenzoate) by Monte Carlo simulation. *Polymer*, *46*(6), 2003-2010.
9. Donald, A. M., Windle, A. H., & Hanna, S. (2006). *Liquid crystalline polymers*. Cambridge University Press.
10. Cook, A. G., Inkster, R. T., Martinez-Felipe, A., Ribes-Greus, A., Hamley, I. W., & Imrie, C. T. (2012). Synthesis and phase behaviour of a homologous series of polymethacrylate-based side-chain liquid crystal polymers. *European polymer journal*, *48*(4), 821-829.
11. Yu L, Wei W, Xiong H (2013) Polyether based side-chain liquid crystalline polymers. Anionic polymerization and phase structures. Polymer 54(24):6572–6579.

12. Tjong, S. C. (2003). Structure, morphology, mechanical and thermal characteristics of the in situ composites based on liquid crystalline polymers and thermoplastics. *Materials Science and Engineering: R: Reports*, *41*(1-2), 1-60.
13. Petr M, Helgeson ME, Soulages J, McKinley GH, Hammond PT (2013) Rapid viscoelastic switching of an ambient temperature range photo-responsive azobenzene side chain liquid crystal polymer. Polymer 54(12):2850–2856.
14. Emoto, A., Uchida, E., & Fukuda, T. (2012). Optical and physical applications of photocontrollable materials: Azobenzene-containing and liquid crystalline polymers. *Polymers*, *4*(1), 150-186.