

Research article



Journal of Atoms and Molecules

An International Online Journal

ISSN – 2277 – 1247

INFLUENCE OF LIGHT ON LIQUID CRYSTAL MIXTURES

Rita A. Gharde*, Sangeeta Y. Thakare¹

Department of Physics, University of Mumbai, Mumbai, India.

Received on: 18-09-2014

Revised on: 10-10-2014

Accepted on: 19-10-2014

ABSTRACT:

The importance of liquid crystal is growing constantly as they are widely used in display technology and other devices. Liquid crystals are characterized by high molecular orientation order in their mesomorphic states. It has been observed that the mixture of liquid crystals shares the molecular orientation of liquid crystal compound which in turn affects their physical properties. In this paper the optical properties of two liquid crystals namely Cholesteryl Nonanoate and 4n Decyloxybiphenyl 4 carboxylic acid (D2014) and their mixtures with different concentration have been studied. We have analyzed the relative concentration of liquid crystals in the mixtures and their Spatial distribution by Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet–Visible (UV) spectroscopy and Raman spectroscopy.

KEY WORDS: Liquid Crystals (LC), Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet Visible (UV) Spectroscopy, Raman spectroscopy etc.

INTRODUCTION:

Liquid crystalline state is —the fascinating, intriguing, mysterious, delicate fourth state of matter. Liquid crystal phases share some of the properties of both isotropic liquids and crystalline solids. Molecules in a liquid phase have no set ordering, the positions and orientations of these molecules are random with respect to each other, whereas in a crystalline phase the positions and orientations of the molecules are set [3]. Liquid crystal phases always possess orientational ordering and they usually have little to no positional ordering. This partial ordering arises from the anisotropy of the liquid crystal molecules, either in their shape or in their solubility properties. Cholesteric liquid crystals have attracted much interest over the years due to their exciting optical

* Corresponding author

Rita A. Gharde,
Email: gharde.rita@gmail.com

properties [4]. Liquid crystal mixtures help in realignment of the liquid crystal molecules which can have a large effect on the electrooptical properties of liquid crystal [5] Physical properties of individual mesogens may or may not undergo modifications in their mixtures. Sometimes, the modifications become characteristic thereby the study of mixtures is important. Earlier studies have suggested the formation mesomorphism of mixture of compounds increase or decrease the mixed mesomorphic ranges and thermal stabilities. These mixtures show the physical properties which are different from their constituents.[4],[5].

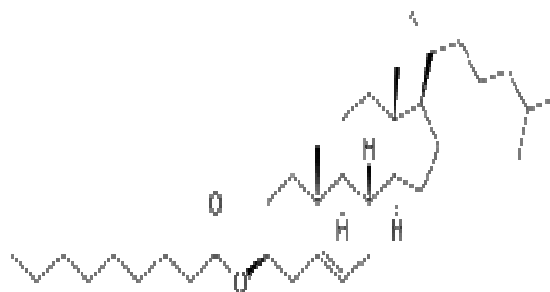
MATERIALS AND METHODS:

CholesterylNonanoate and 4n Decyloxybiphenyl 4 carboxylic acid were procured from Sigma-Aldrich Company and E. Merck Company respectively, in powder form with 99% purity. The liquid crystal mixture were prepared by dissolving appropriate amount of each material in acetone at room temperature and sonicated for one hour.

CholesterylNonanoate

Molecular formula -C₃₆H₆₂O₂

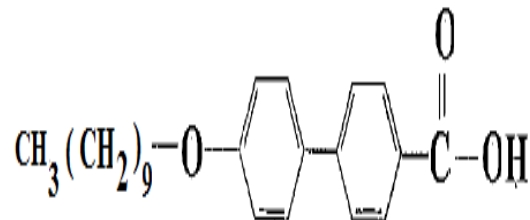
Molecular structure



4n Decyloxybiphenyl 4 carboxylic acid -

Molecular Formula -C₂₃H₃₀O₃

Molecular structure



The liquid crystals and their mixture were characterized by various techniques such as UV-VIS absorption spectroscopy and FT-IR spectroscopy and Raman Spectroscopy.

Ultraviolet Visible (UV) Spectroscopy

UV spectroscopy is an accurate and powerful procedure to analyze a substance. Molecules and atoms have electronic transition in UV – visible range. A UV-Vis spectrophotometer measures the amount of light absorbed at each wavelength of the UV and visible regions of the electromagnetic spectrum. Electron makes transition from lower to higher energy levels after absorbing ultraviolet or visible light. Because the spectrum of an atom or molecule depends on its electron density level, it is useful for identifying unknown substances.

Fourier Transform Infrared Spectroscopy (FTIR)

Infrared spectroscopy is a technique based on the vibrations of the atoms of a molecule. An infrared spectrum is commonly obtained by passing infrared radiation through a sample and determining what fraction of the incident radiation is absorbed at a particular energy. The energy at which any peak in an absorption spectrum appears corresponds to the frequency of a vibration of a part of a sample molecule. For a vibration to give rise to the absorption of infrared radiation, it must cause a change in the dipole moment of the

molecule FTIR is used to identify types of chemical bonds in a molecule by producing an infrared absorption spectrum that is like a molecular fingerprint.

Raman Spectroscopy

Raman spectroscopy is a very useful tool in the investigation of vibrational dynamics of liquid crystalline compounds. The measurement and analysis of line widths and peak position give information about the structure and dynamics of the system undergoing phase transitions. The intensity provides important information about the fluctuation of some physical quantities undergoing changes during phase transition.

RESULTS AND DISCUSSION:

Ultraviolet Visible (UV) Spectroscopy

When light passes through the sample, energy from the light is used to promote an electron from a bonding or non-bonding orbital into one of the empty anti-bonding orbitals.

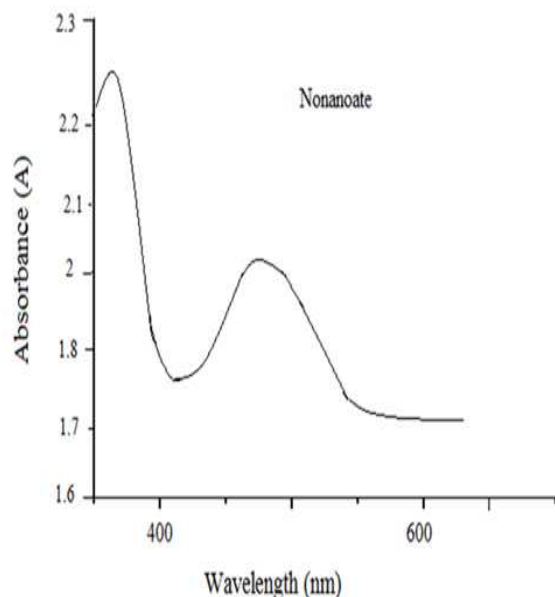


Fig. 1 UV-Vis spectra of Cholesteryl Nonanoate

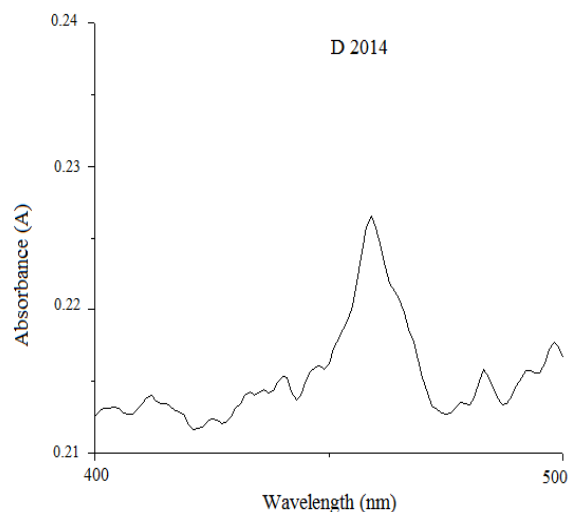


Fig. 2 UV-Vis spectra of D2014

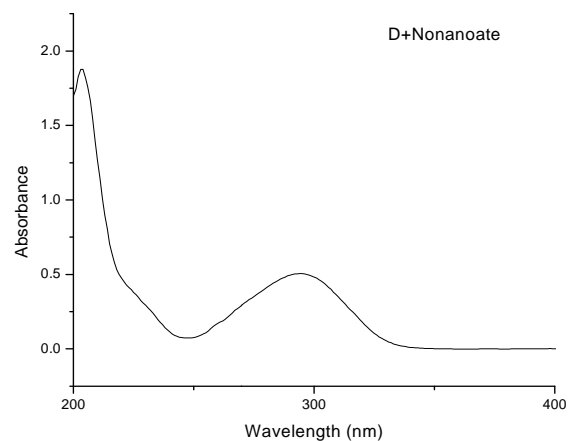


Fig. 3 UV-Vis spectra of Mixture

Table :The wavelength range and the maximum wavelength of absorption of the samples

Sample	CholesterylNonanoate	D2014	Mixture
λ range (nm)	340nm-560nm	440nm-485nm	210nm-330nm
λ_{max} (nm)	340 nm	460nm	210nm

All compounds exhibit two absorption bands. They show that all the radiations for Cholesterylnonanoate and D2014 are in visible range. This is due to the presence of the oxygen atom and the third conjugated phenyl ring. Highly delocalized systems in a molecule are often responsible for absorbing light in the visible region. The long π -electron conjugation shifts the absorption tail of the samples towards longer wavelengths. This band is shifted to longer wavelengths when the carbonyl group is conjugated with a double bond.

The absorption peaks are broad this is because the energy levels of the ground state and the excited state of a molecule are subdivided into

rotational and vibrational sublevels and the transition can occur to and from the different vibrational levels. The maximum wavelength in the mixture is 210nm which is shorter than the liquid crystals attributes to $n - \pi^*$ transition.

Fourier Transform Infra-red Spectroscopy (FTIR)

The FTIR spectra of Liquid crystals and their mixture is shown in the figures4-6 in a wave number ranging from 4000 to 400 cm^{-1} . The samples show spectra in which many peaks spread over the wide range of frequency. Each peak is associated with a particular vibration. The complexity of the spectra reflects large number of fundamental vibrations.

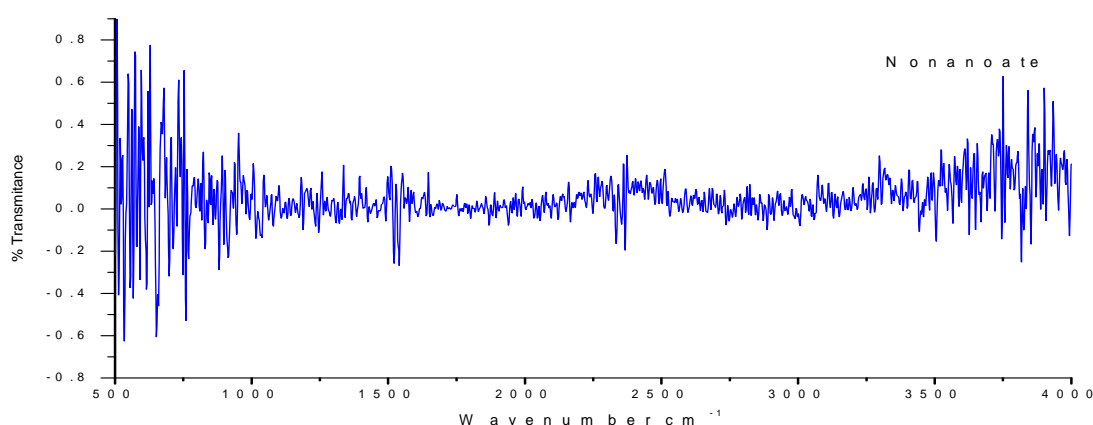


Fig. 4 FTIR of Cholesteryl Nonanoate

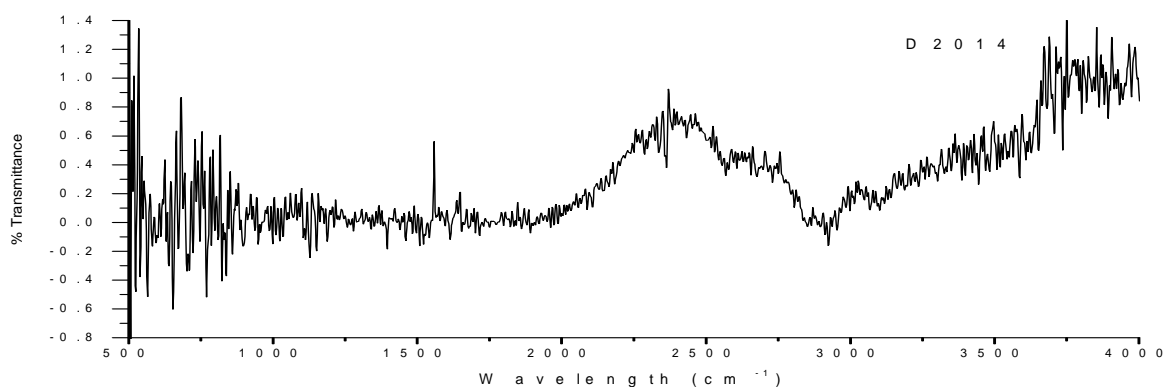


Fig. 5 FTIR of D2014

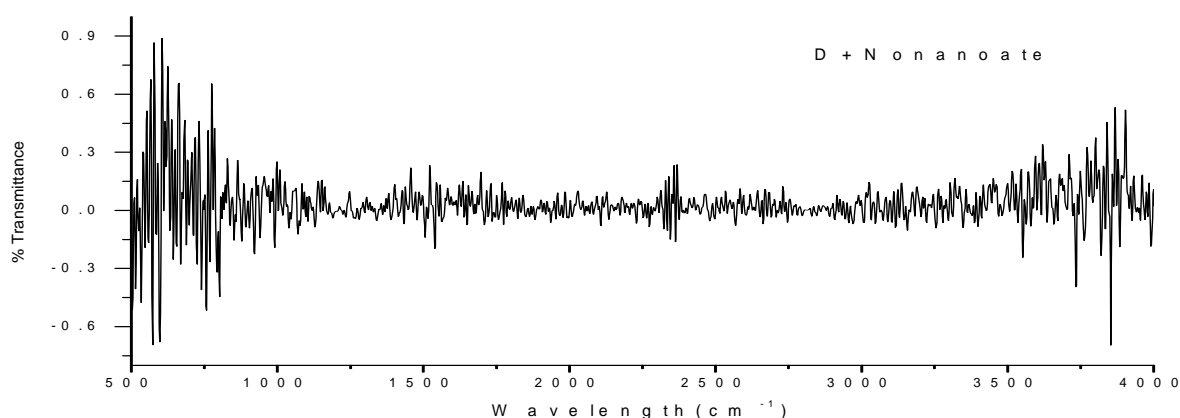


Fig. 6 FTIR of Mixture

The peak around 2100 cm^{-1} is due to C=C bond and in $3600\text{ to }3200\text{ cm}^{-1}$, is due to stretching of O-H bond, while peaks between $2500\text{ to }3000\text{ cm}^{-1}$ are due to carboxylic acids. Absorption peak between $3200\text{--}3600\text{ cm}^{-1}$ and around 2500 cm^{-1} , these are due to stretching of O-H bond. Strong absorption in the region $600\text{ to }1000\text{ cm}^{-1}$ indicates presence of aromatic compound. The absorption of radiations in the region $3500\text{ cm}^{-1}\text{--}4000\text{ cm}^{-1}$ observed in cholesteryl nonanoate remained same in the liquid crystal mixture. The wavelengths of the mixture are common as the compounds but the intensities are different. This is due to the change in the

dipole moment as the sample molecules absorb radiation of specific wavelengths. The intensity of absorption peaks is related to the change of dipole moment. Peak intensity is observed to decrease relative to the other bands in the spectrum so the less value of the intensity of absorption indicates the stability in the structure.

Raman Spectroscopy Analysis

In Raman spectroscopy, a laser photon is scattered by a sample molecules and loses or gains energy during the process. The amount of energy lost is seen as a change in wavelength of the photon.

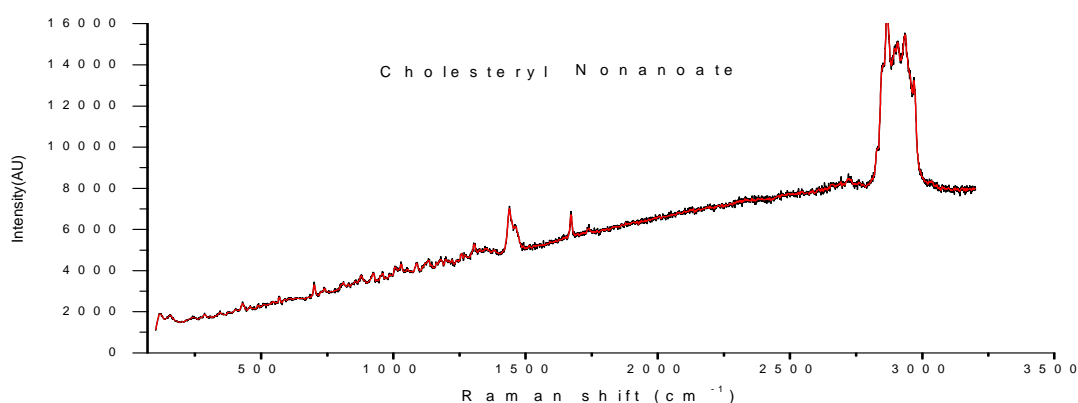


Fig.7 Raman spectra of Cholesteryl Nonanoate

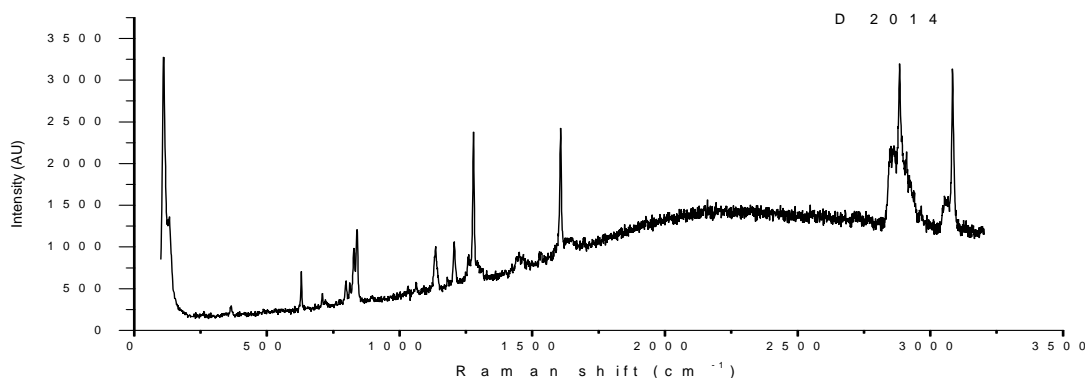


Fig.8 Raman spectra of D2014

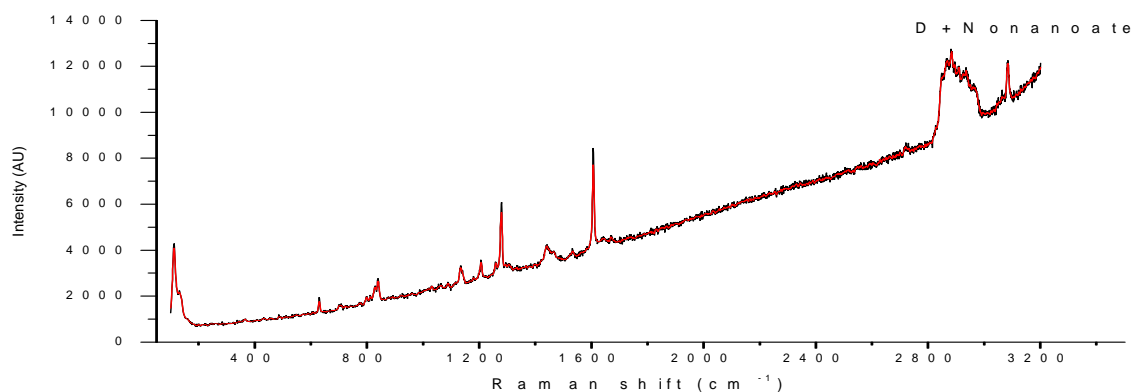


Fig.9 Raman spectra of mixture

The Raman spectrum of liquid crystals and their mixture was observed at low temperature. The excitation source used was the 514.5 nm line from an Ar+ laser. For the liquid crystals and their mixture Raman spectrum showed a doublets in the 1431 – 1570 cm^{-1} region and triplet were observed in the and 2863–2927 cm^{-1} regions. The occurrence of the triplets and doublets can be attributed to the presence of the oxygen atom. This is due to the delocalization of the charges. The bands at 1570 and 1751 cm^{-1} that are attributed to C=O stretching motions of ester carbonyls and C=C stretching motions of the aromatic rings. .. The band observed at 1165 cm^{-1} is the in-plane C H bending modes of the two aromatic rings. Similarly the bands arising at 1572 cm^{-1} , 1575 cm^{-1} , 1594 cm^{-1}

and 1598 cm^{-1} are due to the quadrant stretching modes of the aromatic rings [6], [7]. The oxygen atom adjacent to one of the aromatic rings strongly affects the band positions. The electronegativity of oxygen is higher than that of carbon for this reason; a large change in the electron cloud distribution takes place, resulting in the development of a slight negative charge at the oxygen atom with respect to the aromatic ring. The presence of the bands at 1750 cm^{-1} and 1740 cm^{-1} indicates the coexistence of two different structures, very weak bands due to aliphatic C–H stretching between 3000 cm^{-1} and 2800 cm^{-1} can be observed the C–H stretching vibration in aromatic groups, appearing at 3083 cm^{-1} is very strong.

CONCLUSION:

We studied the characteristics of liquid crystals and their mixture. The observations of Raman vibrational spectroscopic i.e. the number of bands observed, the relative intensities of the bands, and the band widths, at the room temperature of liquid crystals and their mixture are reported here. The sharp peaks indicate crystalline nature. The Fourier Transform Infra-red Spectroscopy (FTIR) and Ultraviolet – Visible (UV) Spectroscopy techniques confirmed the stability of the mixture.

ACKNOWLEDGEMENT:

I would like to thank Dr. Anuradha Mishra, Head, Department of the Physics, University of Mumbai

REFERENCES:

- 1) J. Park and C.C. Lee, *J. Phys. E : Sci. Instr.* **7**, 641 (1974)
- 2) Lohar J M and Mashru U 1980 *Liquid crystals* (ed.) S Chandrasekhar (London: Heyden) p. 543
- 3) Lohar J M and Shah D S 1973 *Mol. Cryst., Liq. Cryst.* **28** 293
- 4) Lohar J M and Dave J S 1983 *Mol. Cryst., Liq. Cryst.* **103** 181
- 5) S-S. Seomun, T. Gouda, Y. Takanashi, K. Ishikawa, and H. Takezoe, *Liq. Cryst.* **26** (2), 151 (1999).
- 6) Dash, S. K., Singh, R. K., Alapati, P. R., and Verma, A. L., 1977, *Mol. Cryst. L iq. Cryst.*, **319**, 147;
- 7) Dash, S. K., Singh, R. K., Alapati, P. R., and Verma, A. L., 1997, *J. Phys. Condensed Matter*, **9**, 7809;
- 8) Dash, S. K., Singh, R. K., Alapati, P. R., and Verma, A. L., 1998, *L iq. Cryst.*, **25**, 459.
- 9) Rita A.Gharde and ManishaBhave2014 *International Journal of Innovative Research in Science, Engineering and Technology*, Vol. 3, Issue 5

How to cite this article:

Gharde R. A., & Thakare S. Y., "Influence of light on liquid crystal mixtures" *J. Atoms and Molecules*, 4(5), 2014: 784 – 790.