Effects of Concentration of Multiwall Carbon Nanotube on Cholesteric Liquid Crystal

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Abstract

It has been observed that Carbon Nano Tube influence the existing properties of liquid crystal (LC) and with liquid crystal doped with CNT can enhance the properties of LC which can be used for displays applications. It has been observed that mixing of CNTs into LC hosts can modify the physical properties of LCs along with CNT alignment in LC matrix. If CNTs can be well dispersed in LC matrix, they will align with their long axes along the LC director to minimize distortions of the LC director field and thus the free energy. In this paper, we doped Cholesteryl Nonanoate by a small amount of multiwall carbon nanotube i.e. in the concentration of 0.05%wt and 0.1% wt. The prepared samples were characterized using various techniques to study its structural, properties. i.e XRD and Raman Spectroscopy .The refractive index analysis at wide range of wavelengths is done by Abbeys refractometer.

Key words - liquid crystal, multiwall carbon nanotube, XRD, Raman Spectroscopy etc.

1.Introduction

Liquid crystalline materials have been useful for display devices i.e watches, calculators, automobile dashboards, televisions, multi media projectors etc. as well as in electro tunable lasers, optical fibers and lenses .A carbon nanotube (CNT) is a type of very attractive material for many unique properties because of its nanometer size tubular structure.

Liquid Crystals have the long range orientational order rendering them to be anisotropic phases. Dispersion of CNTs in LCs can provide us a cheap, simple, versatile and effective means of controlling nanotube orientation on macroscopic scale. the easy and speed of changing the director field by means of electric or magnetic fields can lead to switches based on reorientation of CNTs. Liquid crystals (LCs) turn out to be excellent hosts for carbon nanotubes (CNTs). Having molecular structure similar to CNTs, LCs perfectly incorporate CNTs into own structure.

Particularly, the liquid crystalline orientational order can be imposed on CNTs so that aligned ensembles of these particles can be attained [1]. The alignment axis of CNTs can be easily driven by the LC reorientation in the external field (Dierking et al., 2008); CNTs follow reorientation of LC director demonstrating guest-host effect known for molecular solutions and dispersions of anisotropic nanoparticles in LC hosts (Blinov & Chigrinov, 1996). Finally, LC can be removed and thus pure aligned CNTs can be obtained (Lynch & Patrick, 2002). This altogether means that LC gives unique opportunity

for controllable alignment of CNTs. Great attention has been attracted by the anisotropic soft matter systems including particles of different size, shape and aspect ratio. Among the most interesting are multi-walled carbon nanotubes dispersed in liquid crystalline (LC) media [2-3]. At low NT concentrations, each NT aligns several molecular layers of nematic molecules on a short-range scale [4, 5].

This work is focused on the incorporation of multiwalled carbon nanotubes in cholesteric liquid crystal. We observed the changes of the properties of the cholesteric host, as well as the influence of the helical structure on the dispersion quality and stability of mixture.

2.Experimental Details

Materials and Methods

Liquid crystal, Cholesteryl nonanoate is procured from E. Merck and multiwall carbon nanotube (MWCNT) from Sigma Aldrich having diameter 110.170 nm and length 5.9 micrometer were used as basic materials. Small amount of MWCNT (0.05% ./wt.) and (1% wt) were mixed into Cholesteryl nonanoate at room temperature. To reduce aggregation, a small amount of CNTs was dispersed in acetone and sonicated for one hour. Liquid crystal was added to acetone + CNT mixture and the mixture was soinicated for two hours.

The prepared samples then analyzed by XRD technique,Raman spectroscopy and Abbey's Refractometer.

3.Result and Discussion

Order Parameter (S)

In a cholesteric phase with long-range orientational order parameter ,long axes of nanotubes deviate from the preferred direction by a certain angle θ. The scatter of θ values is determined by the orientational order parameter

$$S = (3\cos 2\theta - 1) / 2$$

And from the "aspect ratio" of the nanotubes i.e.

$$\sin \theta = d / l\sqrt{c}$$

Where d is diameter, l is length and c is concentration of MWCNT.

The estimated order parameters of the nanotubes for different concentrations at room temperatures are shown below.

Table.1 Values of order parameter

Concentration	sin□	sin2□	Order parameter (S)
0.1%	0.54	0.2916	0.5626
0.05%	0.81	0.6591	0.0113

In the isotropic phase, the effective order parameter S, is equal to zero. S substantially decreases with decrease in concentration.

XRD Analysis

Following Figures shows the X-ray diffraction patterns of Cholesteryl nonanoate and with different concentrations of carbon nanotube.

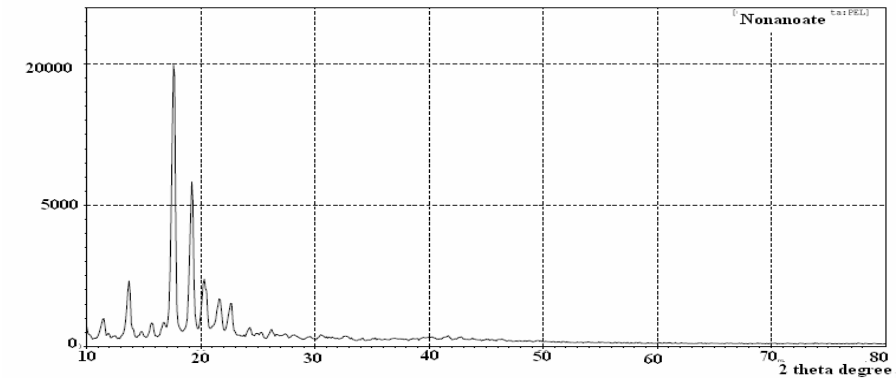

Fig1. XRD of Cholesteryl nonanoate

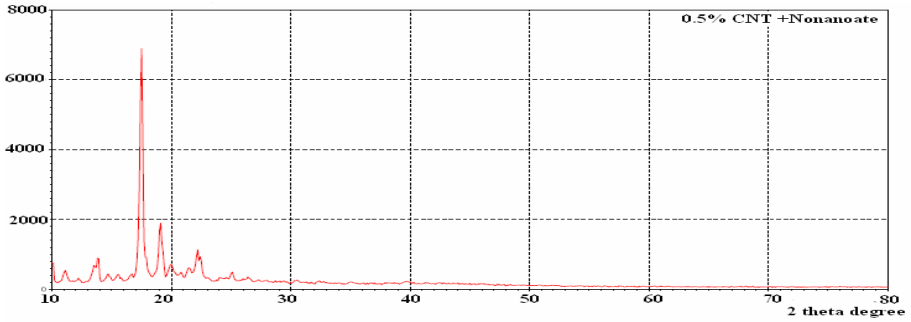

Fig2. Cholesteryl nonanoate+ 0.5%wt CNT

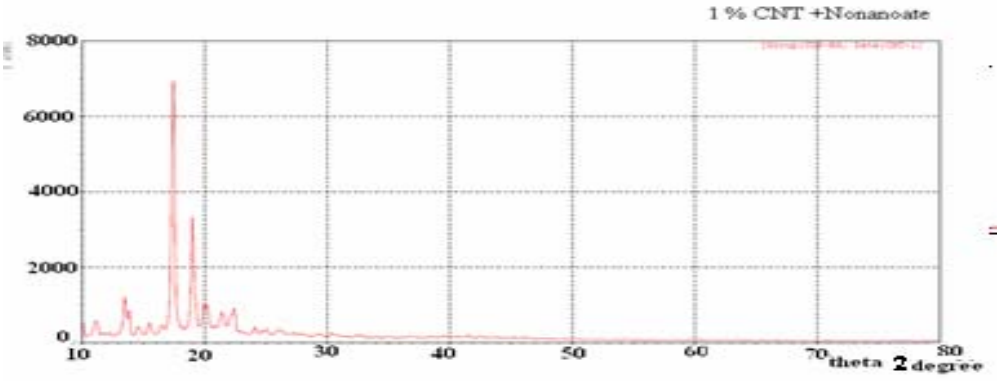

Fig 3. Cholesteryl nonanoate+ 1%wt CNT

The intensities of peaks for Cholesteryl nonanoate are high, which indicate higher crystallinity But the intensities of peaks have been reduced in doped Liquid crystal. The decrease in width of major peaks and intensities in doping Liquid crystals confirms the presence of MWCNT.

The high intense peak was observed at 17.5941^0 c in Cholesteryl nonanoate and for Cholesteryl nonanoate+ 0.5% CNT and Cholesteryl nonanoate+ 1% CNT the high intense peak occurred at 17.4656^0c and 17.4267^0c respectively. The Millar Indices for Cholesteryl nonanoate are given in the following table. Lattice constant a = 1.90 A^0

Table.2 XRD data

2θ	d	h,k,l values
11.3979	7.75718	(100)
13.6601	6.47721	(010)
16.7000	5.30438	(110)
17.5941	5.03678	(111)
21.5797	4.11469	(200)
22.5654	3.93713	(020)

Raman Spectroscopy Analysis

The Raman spectrum of pure liquid crystal and doped liquid crystals were observed at low temperature. The excitation source used was the 514.5 nm line from an Ar+ laser. In Raman spectra of MWCNT ,two peaks, namely G(graphite) (at ~1580 cm^{-1}), and D(disorder)-band (at~1360 cm^{-1})are seen. The *D*-band in graphite involves scattering from a defect which breaks the basic symmetry of the graphene sheet. It is observed in the lattice vibration of all carbon materials with sp2 bonds .The carbons containing porous, impurities or other symmetry-breaking defects. On the other hand, the second-order G′-band does not require an elastic defect-related scattering process, and is observable for defect-free sp2 carbons[6]. These bands show a dependence on the chirality and diameter of nanotubes [7] and on laser excitation energy [8].The tangential G- which derived from the graphite-like in-plane mode, is split into G1 (1577 cm^{-1}) and G2 (1610 cm^{-1}). This result are also reported in the other papers .

Their second-order harmonic (the G' band), explicitly appears at ~1580 cm^{-1}, ~1360 cm^{-1} and ~2700 cm^{-1}, respectively. In addition, Its other features like G2 or D' near 1610 cm^{-1} and G+D band (~2930 cm^{-1}) are also observed.

For Cholesteryl nonanoate 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. The bands at 1570 and 1751cm^{-1} that are attributed to C=O stretching motions of ester carbonyls and C=C stretching motions of the aromatic rings. With doping concentration of MWCNT to liquid crystals some changes are observed. The peak at 1751cm^{-1} is disappeared in doped liquid crystals a decrease in the intensity of the compound peak at 2863 cm^{-1} to 2942 cm^{-1} was observed. It suggested presence of CNT in liquid crystal.

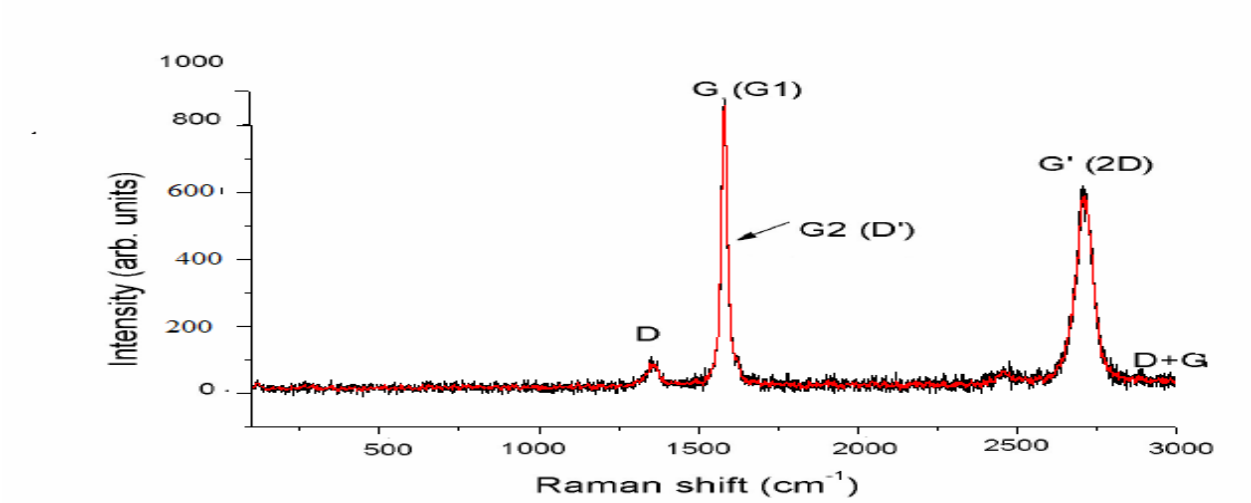

Fig 4. Raman Spectrum of MWCNT

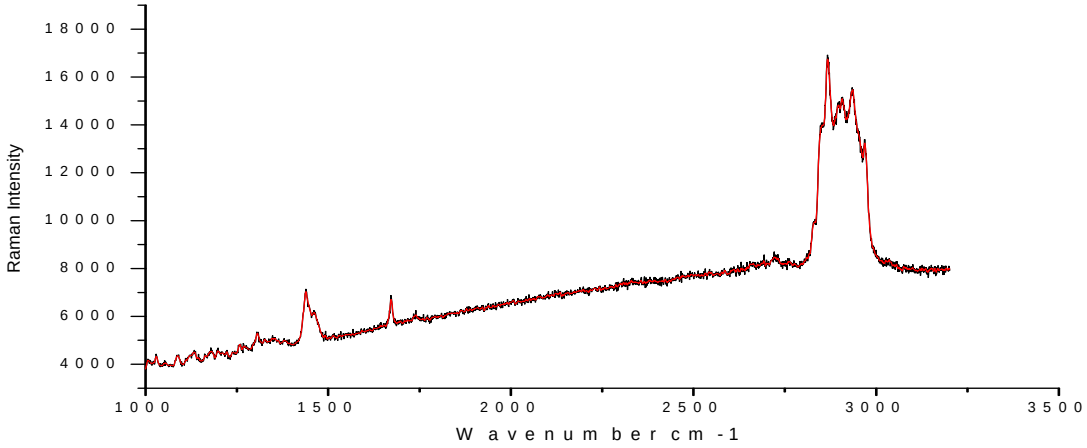

Fig5. Raman Spectrum of Cholesteryl nonanoate

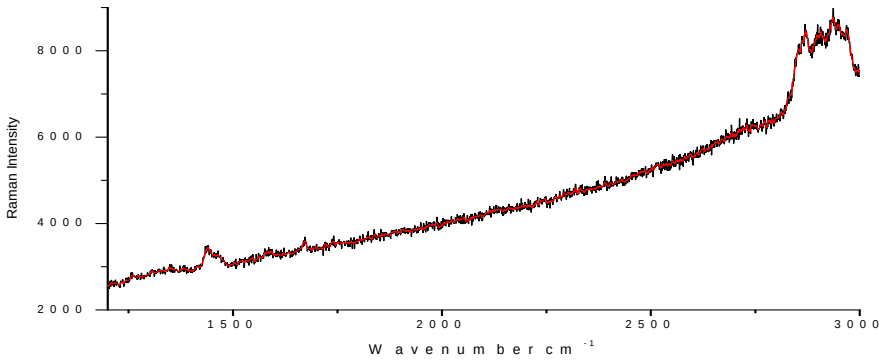

Fig6. Raman Spectrum of Cholesteryl nonanoate+0.5 %wt CNT

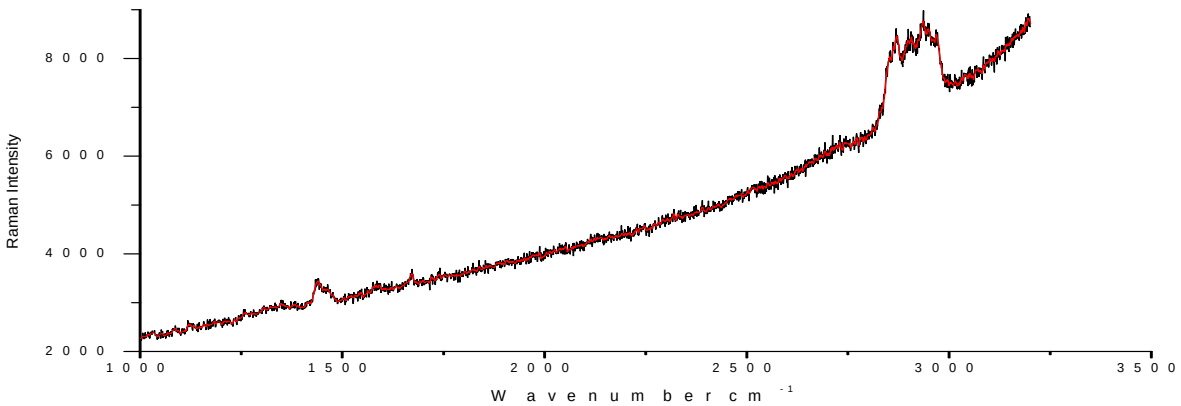

Fig7. Raman Spectrum of Cholesteryl nonanoate+1%wt CNT

Refractive Index Measurement

Refractive indices of the samples are measured using Abbe's refractometer at multiple wavelengths as shown in following figures .The accuracy of this refractometer is up to fourth decimal. The refractive index decreases as the temperature increases. It can be related to density fluctuation. Near phase transition temperatures it decreases rapidly as density decrease with increasing temperature. The refractive index of pure liquid crystal is 1.56 at 404nm but for the same wavelength the RI of 0.5% wt and 1 % wt of CNT are 1.56 and 1.51 respectively .It indicates that refractive index doesn't change with the 0.5% wt concentration . But with increase in concentration it decreases considerably.

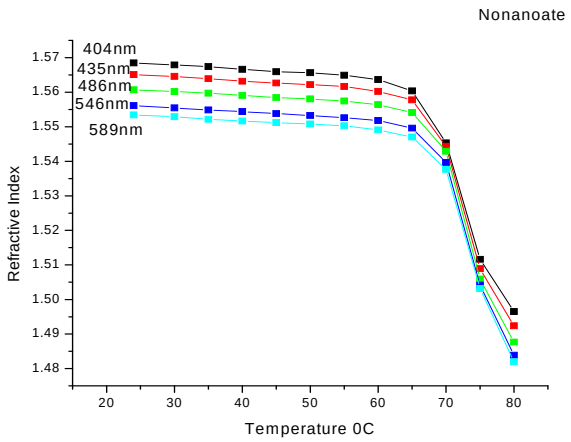

Fig.8 Temperature dependence of RI of cholesteric nonanoate

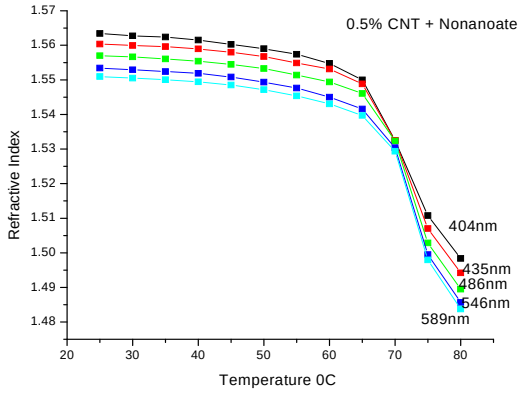

Fig.9 Temperature dependence of of RI of MW CNT

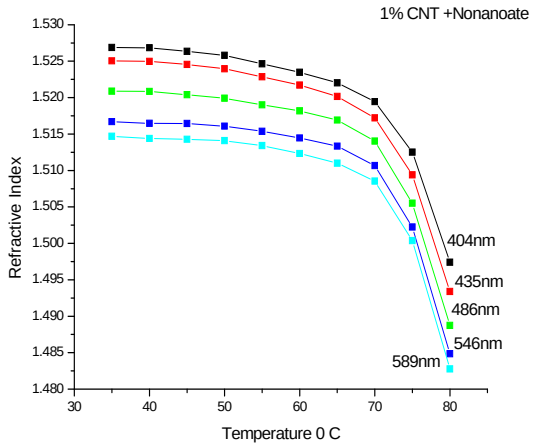

Fig.10 Temperature dependence of refractive indices Cholesteryl nonanoate+ 0.1% MWCNT

4. Conclusion

In this paper we have reported the results of study carried on pure liquid crystal and doped liquid crystal with MWCNT.It has been observed that 0.1 wt.% of –CNT mixture gives the best performance than the 0.5 wt.% of CNT mixture. Raman spectroscopy is excellent method of characterization of structural properties. Increase in concentration of MWCNT decreases the refractive index. LC mixtures could be compatible and in combination with CNT can be used in nanoelectronics displays for the design of advanced materials.

5.REFERENCS

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