Electro-Optical Studies on Nanopowder Doped Liquid Crystal

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Abstract

Very dilute suspensions of $BaTio_3$ nanoparticles in liquid crystals seem to have remarkable effect on the liquid crystal properties. We work on the cholestric liquid crystal doped with $BaTio_3$ (~100 nm) nanopowder. Ferroelectric nanoparticles in liquid crystal host posses enhance anisotropy and are sensitive to an electric field. Frequency dependence of dielectric constant are studied for pure and doped liquid crystal. Dielectric studies of liquid crystal are important as they provide information about molecular structure, internal interaction and molecular dynamics in the present work. It is found that at lower frequency dielectric is varies and becomes constant at higher frequency.

We also observe variation in refractive index at different wavelength by multiple wavelength refractometers. Measurement of the particle size also showed noticeable change in the doped sample. The knowledge gain from this studies, have many applications as electro-optic materials in the thin film and display devices vertical and horizontal alignment of liquid crystal molecules has different optical and dielectric properties.

Keyword: Cholestric liquid crystal, Dielectric Constant, Particle size, Multiple Wavelength Refractometer.

Introduction

Liquid Crystals (LC) are soft condensed matter and now commonplace in display devices, light modulator, temperature sensor and optical communication networks. They have different phases like Nematic, Smectic and Cholesteric. Cholesteric Liquid Crystals (CLC) have attracted due to their various applications in electro – optics. Suspensions of various micro – or nano – particles to CLC have recently been the subject of new interest because they combine the fluidity and anisotropy of CLC with specific properties of particles [1-4]. For example, dispersed ferromagnetic particles greatly enhance the electric properties of liquid crystals. Large colloidal particles form defects in liquid crystal matrices, producing large director deformations. Ensembles of these particles and defects can form complex structures. It is found that doping of a cholestric liquid crystal (CLC) with a small amount of ferroelectric nanoparticles strongly affects the dielectric properties of the system.

The ferroelectric nano – particle dispersed CLC have attracted attention due to their convenient preparation technique and enhanced dielectric properties. The ferroelectric nano – particles are so small that macroscopically homogenous structures are obtained i.e. the suspension appear similar to the pure LC with no readily apparent evidence of dissolved particles.

For enhancing the opto-electrical properties, a proper selection of nano – powder for CLC depend upon various factors such as type, size, shape, preparation method, surfactant concentration and amount of doping material. Our research is inspired by previous publications that describe the behaviour of CLC doped with nano – particles [5-10]. The ferroelectric colloids can increase the liquid crystal phase transition temperature, influencing their order parameter and thereby birefringence. The advantage of ferroelectric particles over other material is that they significantly maintain the intrinsic properties of the material from which they are made and do not significantly perturb the director field.

In the present paper, we are discussing the results which shows that the phenomenon due to opto-electric properties of LC suspension containing ferro – colloidal nano – particles. There is change in dielectric constant, particle size, and refractive index at different temperature due to strong interaction between CLC and ferroelectric nano – powder.

Materials and Preparation

In this work, we used ferroelectric nano – powder of Barium Titanate ($BaTiO_3$) of size less than 100nm. This material is used extensively in electronics and microelectronics owing to its excellent ferroelectric, piezoelectric and dielectric properties. The $BaTiO_3$ particles are slightly anisotropic and their size is less than100nm. We have chosen heptane as carrier liquid and oleic acid as a dispersing agent (both from Sigma Aldrich.) $BaTiO_3$ were mixed with oleic acid and heptane in appropriate proportion by weight and then mixed with Pelargonate by ultrasonication method [11]. The molecules of dispersing agent attach their polar group to the $BaTiO_3$ surface, while the motion of their non – polar tails builds up the repulsive force between the particles. The ultrasonicator ensures homogeneous distribution of nano-powder in CLC. The mixtures were kept in vacuum for 8 hours for evaporation of heptane completely. The sample contains the small concentration (~1%) of $BaTiO_3$ nano – particles.

Experimental Techniques

The characterizations were done by impedance analyzer, Particle size, Multiple Wavelength Refractometer. The dielectric study of liquid crystals not only provide useful information about the molecular structure, inter molecular forces and molecular dynamics but also provides useful clues related to the display performance such as threshold and operating voltage, switching times, operating and isotropic frequencies. The optical and dielectric properties of LCs are determined by rigid core of molecules. The core generally content two or more benzene rings which have high density of delocalized electrons. The core is therefore highly polarizable and the dominant part of the molecule in terms of optical and dielectric properties.

Dielectric Constant: Dielectric constant at various frequencies were measured by “Wk wAYNE KERR 6500B precision impedance analyzer”

Particle size: The particle size were measured by BET Surface Area Analyser - Model SAA2000

Refractive Index (R.I):

In optics, the refractive index of a substance is a number that describes how light, or any other radiation, propagates through that medium. Refractive index of materials varies with the wavelength. In opaque media, the refractive index is a complex number, while the real part describes refraction, the imaginary part accounts for absorption. The concept of refractive index is widely used within the full electromagnetic spectrum, from x –rays to radio waves. It can also be used with wave phenomena other than light. In this case the speed of sound is used instead of that of light and a reference medium other than vacuum.

Result and Discussion

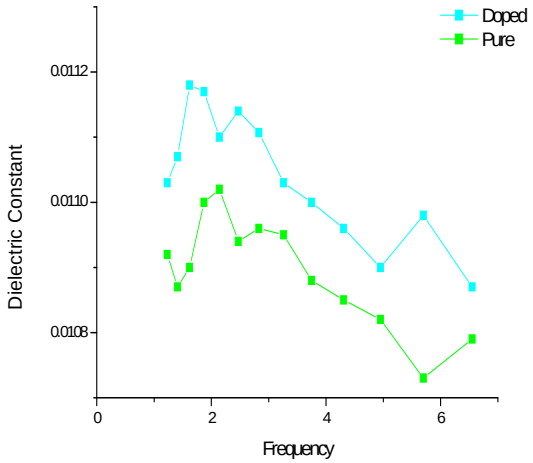
Table 1 Dielectric Constant:

Sr. No.	Frequency (10^6KHz)	Pure Dielectric Constant	Doped Dielectric Constant
1	1.07	0.01092	0.01108
2	1.23	0.01087	0.01103
3	1.41	0.01090	0.01107
4	1.62	0.01100	0.01118
5	1.87	0.01102	0.01117
6	2.14	0.01094	0.01110
7	2.47	0.01096	0.01114
8	2.83	0.01095	0.01110
9	3.26	0.01088	0.01103
10	3.75	0.01085	0.01100
11	4.31	0.01082	0.01098
12	4.95	0.01073	0.01090
13	5.70	0.01073	0.01098
14	6.55	0.01079	0.01087
15	7.53	0.01030	0.01049

Particle size: Measurement of particle size and surface area by bet nitrogen adsorption .

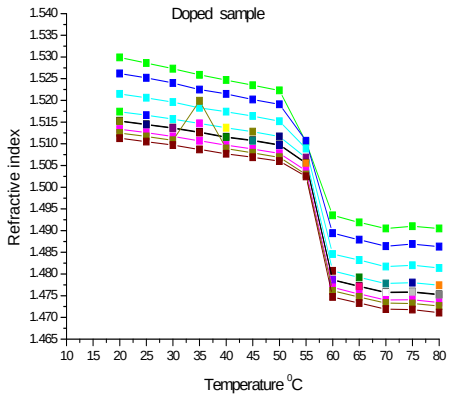
Table 2

Sr no.	Sample	Specific Surface Area(m^2\gm)	Particle Size(micron)
1	Pure	0.685	9.73
2	Doped	0.725	6.13

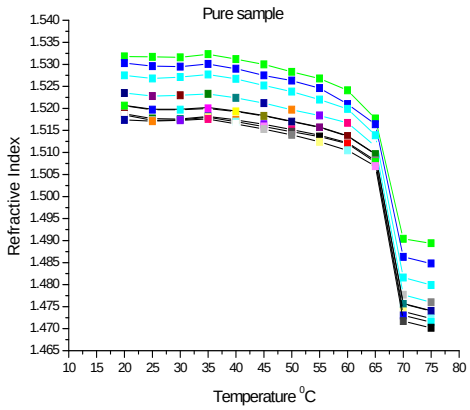


Refractive Index: The RI of pure and doped CLC were measured using Multiple Wavalength Refractrometer.The RI of pure CLC was found 1.488 whereas the RI for doped CLC were found to be 1.491.This increase in RI after doping CLC with ferroelectric nano – powder of Barium Titanate shows better optical performance of material.

Graph 2



Graph 3



Conclusions

The sensitivity of pelargonate is enhanced by doping with ferroelectric nano- particles**.** Doping increases the performances of LC mixture[12-13]. A low concentration of $BaTiO_3$ nano-particles in LC host changes the transition temperature also increases the orientation ordering of the LC. These modified characteristics of LCs are caused by the interaction of the nano-particles. In the present paper it is observed the low concentration increases dielectric constant and refractive index. These CLCs play an important role to design new materials.

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