Variation of Temperature range of Blue Phase, Pitch and Textures of Ferroelectric Chiral Smectic Liquid Crystal doped with non-mesomorphic Chiral Compound with Temperature.

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ABSTRACT **-** The present investigation is to study the variation of d-spacing and pitch of mixture of liquid crystalline samples as a function of temperature and the study also covered the possibility of enlarging temperature range of Blue Phase of liquid crystal compound 4-(2-methylbytyl) phenyl 4-(4-octylphenyl) benzoate(CE8) by doping with non-mesomorphic chiral compound.The compound CE8 is a ferroelectric liquid crystal composed of rod-like molecules shows a chiral smectic phase with stable Blue phase range, only for temperature of 1.9^0C around 136.5^0C to 138.9^0C. The non-mesomorphic chiral compound used in the present study is 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile,which is isotropic at 70^0C.Doping of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile to CE8 enlarged the tempertature range of blue phase of CE8 to about 3.1^0C in the mixture of 85% of CE8 and 15% of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile. Pitch and d-spacing pure CE8 decreased considerably when it is doped with 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile. Also the study included texture analysis of pure CE8 and mixture of CE8(85%) and non-mesomorphic chiral compound(15%) with temperature. Mixture of these compounds exhibits Blue phase, SmA and SmC sequentially, when specimen is cooled from its isotropic phase. These phases have been characterised by using microscopic technique.

Key words **–**Optical texture, Blue phase, Doping, Phase transition, pitch,d-spacing.

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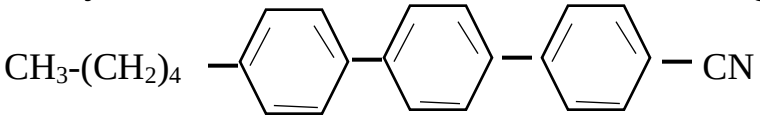
I. INTRODUCTION

Many of materials showing liquid crystalline behaviour belong to two general classes: Thermotrophics and Lyotropics. Transition into mesophases obtained by purely thermal process is called "Thermotrophics" where as in which mesophases are obtained by the influence of a solvent on solid is called "Lyotropics". Thermotropic liquid crystals generally exhibits three types of Phases, namely, Nematic, Cholesteric and Smectic phase. Blue phases are liquid crystalline phase that appear in a narrow temperature between isotropic and cholesteric phases. In cholesteric liquid crystals with high twist, three district Blue phases can appear BP I, BP II and BP III with increasing temperature. Three Blue phases differs in Quantum of order and structures in chiral molecules form. However, Blue phase can exist only in a small temperature range of 0.5^0C to 2^0C between isotropic and Chiral nematic phases. The compound CE8 is a ferroelectric and thermotropic liquid crystal exhibits Blue phase temperature range of 1.9^0C around 137^0C to 138.9^0C. In the Cholesteric phase there is a spontaneously formed macroscopic helical structure with the director rotating along optic axis leading to helical structure, hence the name twisted nematic or chiral nematic (N*) is given to this phase. The distance over which the director rotates by a full turn is called the pitch, which will be altered with variation in temperature and with addition of dopants.Measurement of pitch in cholesteric phase to asses the stability of the blue phase as blue phases found to exists in chiral nematics system with short pitches.The non-mesomorphic chiral compound used in the present study is 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile which has melting point of 53.5^0C with a resistivity of 3×10^{-6} Ωm. It's molecular structure is given by



In the present investigation textural changes of mixture of CE8 and the non-mesomorphic chiral compoundas as function of temperature is observed and recorded. Also the study aimed at the possibility of enlarging the temperature range of blue phase of liquid crystal compound CE8 by doping it with the non-mesomorphic chiral compound. The study included the measurement of variation of d-spacing and pitch of pure CE8 and mixture of CE8(85%) and non-mesomorphic chiral compound(15%) with temperature.

II. MATERIAL AND METHODS

In the present investigation, the mixtures of different concentrations of liquid crystal compound 4-(2-methylbytyl)phenyl 4-(4-octylphenyl)benzoate i.e., CE8 and the non-mesomorphic chiral compound i.e., 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile were prepared. The mixtures of different concentrations of samples were kept in desiccators for a long time. The samples were subjected to several cycles of heating, stirring and centrifuging to ensure homogeneity. The optical textures of these mixtures at different temperature are observed and recorded with the help of a Gippon-polarising microscope in conjunction with a hot stage. The samples are sandwitched between the slide and coverslip, then sealed well for microscopic observations. The temperature-concentration phase diagram for mixture of CE8 and non-mesomorphic chiral compoundwith different weight percentage is drawn to observe possibility of widening of temperature range of blue phase of CE8. Cano wedge cell method for measurement of pitch of liquid crystal cell is used. The sample is prepared in the form of thin wedge between two rubbed glass plates inclined at a small angle θ and the twist axis is approximately normal to the plates. When the sample is observed under the polarizing microscope, regular striations are seen running across the film. The distance between neighbouring visible sharp lines under polarizing microscope were

carefully measure and its is equal to half of the pitch. The pitch is, therefore, calculated using the equation **P=2d tan(θ)**

III. OPTICAL TEXTURE STUDIES

Molecular Orientations of Optical textures shown by the sample were observed and recorded using Gippon polarising microscope in conjunction with hot stage. The specimen, in each case, is taken in the form of thin film and sand witched between the slide and covering slip. When the specimen of 85% of CE8 and 15% of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile is cooled from isotropic phase, specimen passes through cholesteric, Blue phase, SmA and SmC sequentially. This has been recorded. However, the similar sequential phase changes have been noted for all concentrations of 10% to 90% of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrilein with CE8 .When sample is cooled from its isotropic phase, cholesteric phase appears.Then texture slowly transform to SmA phase in which molecule are arranged in layers and the texture is shown in fig1(a). On further cooling the specimen, the unstable SmA phase changes to SmC phase as shown in fig1(b. The specimen enters to the crystalline phase on further cooling.

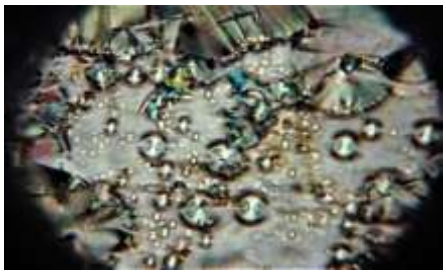


Fig-1(a) *Fig-1(b)*

Figure1.Microphotographs obtained in between the crossed polar

1(a) Texture of Sm A phase(250 X), 1(b)Texture of SmC phase(250 X),

IV. MEASUREMENT OF PITCH AND d-SPACING

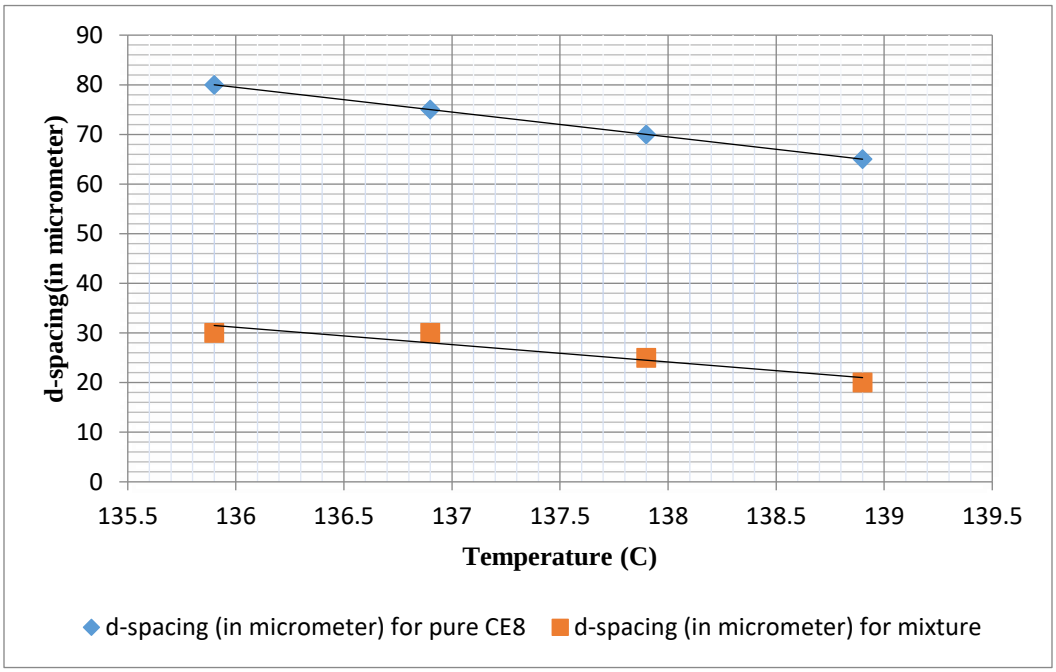
Table 3(a) and 3(b) shows variation pitch and d-spacing with temperature.

Pure CE8		
Temperature	**d(µm)**	**Pitch(µm)**
138.9	**65**	**0.39**
137.9	**70**	**0.42**
136.9	**75**	**0.45**
135.9	**80**	**0.48**

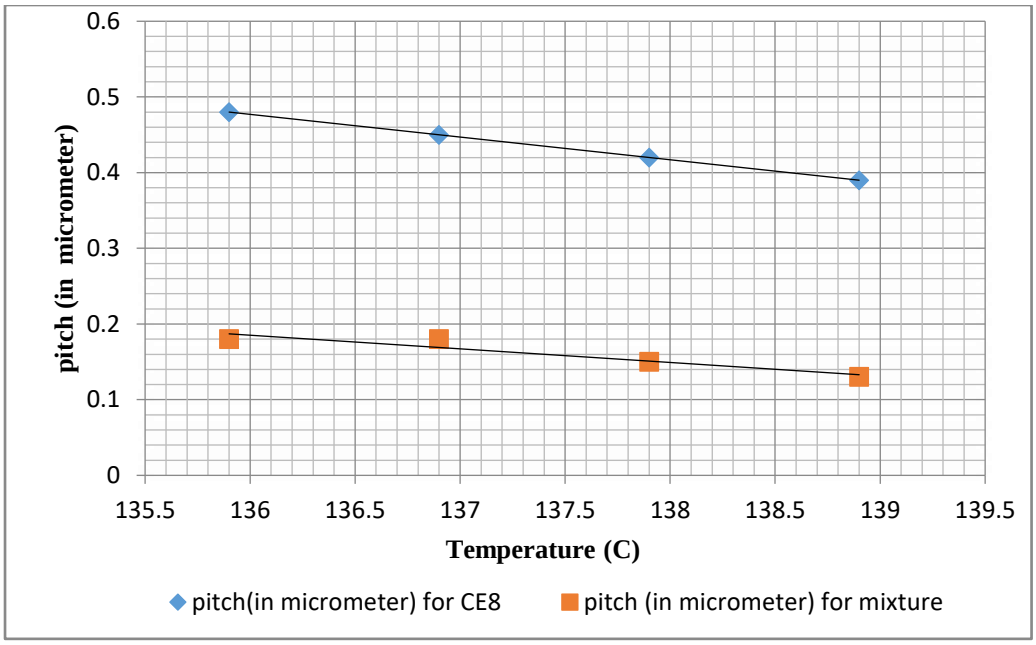
Table3(a) (Pure CE8)

CE8- non-mesomorphic chiral compound.(80%-20%)		
Temperature	**d(µm)**	**Pitch(µm)**
138.7	**20**	**0.12**
138.0	**25**	**0.15**
137.5	**30**	**0.18**
137.0	**30**	**0.18**
136.7	**30**	**0.18**

Table3(b) (80%CE8 and 20% nmcc)



Variation of d-spacing with temperature for pure CE8



From table 3(a) **,** it is clear that for pure CE8 , pitch as well as d-spacing decreases non linearly with increase in temperature. From table 3(b) , it is clear that for mixture of 80% CE8 and 20% non-mesomorphic chiral compound, both pitch and d-spacing decreases in the temperature range of 138.7^0C to 138^0C .However in the mixture both pitch and d-spacing remains same for temperature range of 137.5^0C to 136.7^0C.

V. CONCLUSION

Microscopic investigation of mixture of liquid crystal compound CE8 and non-mesomorphic chiral compound for different concentrations indicated the existence of Cholesteric, Blue phase, SmA and SmC phases sequentially when the mixture is cooled from isotropic phase.Doping of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile to CE8 enlarged the tempertature range of blue phase of CE8 to about 3.1^0C, in the mixture of 85% of CE8 and 15% of 4'-(2-Methylbutoxy)-4-biphenylcarbonitrile. In the mixture of 80% CE8 and 20%CN, both pitch and d-spacing decreases in the

temperature range of 138.7^0C to 138^0C ,however pitch and d-spacing remains same for temperature range of 137.5^0C to 136.7^0C.

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