

Optical Parameters through Image Analysis on azomethine 16ClAB Liquid Crystal

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ABSTRACT: In this paper, optical behavior of Azomethine liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $nClAB$ $n = 16$), comprising terminal chloro substituent is investigated using microscopic texture analysis on MATLAB platform. This involves the computation of temperature dependent optical parameters from the microscopic textures of samples. Such parameters are Optical Transmittance, Optical density, Birefringence and its dispersion. Optical behavior of the sample is explained based on the parameter curves as a function of three monochromatic wavelengths and temperature. Obtained results show that azomethine liquid crystals with high electronegative as terminal chloro substituent exhibit the good thermo optical behavior.

KEYWORDS: Azomethine liquid crystals, Electronegativity, Microscopic textures, MATLAB, Transmittance.

I.INTRODUCTION

Strong demand of new liquid crystals with targeted properties and future applications lead to the synthesis of wide range of mesogens in particular thermotropic liquid crystals [8]. Structure property relationship is essential knowledge for synthesizing new mesogens. Mesomorphic materials with two aromatic rings having different terminal substituents are often studied exclusively owing to their application in the fields of photonics and opto electronics. This kind of materials has the most suitable molecules which exhibits the mesomorphic properties useful in optical device applications [1-5]. The presence of different polarity of terminal substituents either suppresses or promotes the mesomorphic properties of the materials in terms of melting points and phase stabilities. The placement of a polar group in a terminal position of molecule modifies its thermal and optical properties effectively and enable them as promising candidate towards variety of applications involving photonic devices, nonlinear optics, optical data storage and information systems, optical switches, liquid crystal display etc [5-9]. Therefore in this paper, optical behavior synthesized Schiff base liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $nClAB$ $n = 16$), comprising terminal chloro substituent [10] is investigated. In this Schiff base liquid crystals, azomethine and ethers are useful linking units for generating mesomorphism in two or three aromatic ring compounds. By enhancing the rigidity of core system by azo compounds through metal complex formation improves the mesogenic properties. The presence of terminal substituent of electro negative halogen atom chlorine either promote or suppress the mesomorphic properties depending on the structural property relationship [11,12].

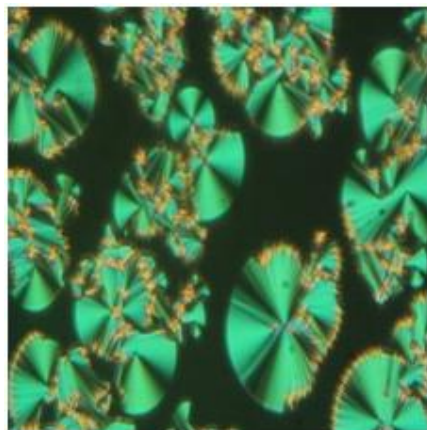
There are several experimental and theoretical models have reported the temperature dependence of optical behavior of thermotropic liquid crystals [13-15]. All these methods require different experimental setups to observe the optical properties of the liquid crystals. Due to continued advances in data acquisition systems, image analysis has significant impact on diverse fields such as science, engineering, medicine, industry, etc. In microscopy, image analysis technique has been developed to aid the interpretation of microscopic images and to extract as much information as possible from image objects [16]. In case of liquid crystals, the analysis of liquid crystal textures obtained from the Polarizing microscope can be used to study the properties of liquid crystals. Here, image analysis technique in conjunction with POM to study thermo optical behavior Schiff base liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $nClAB$ $n = 16$) comprising terminal chloro substituent is investigated towards the optical device applications. Optical behavior includes the parameters like Optical transmittance, Optical density, Birefringence and its dispersion.

II EXPERIMENTAL

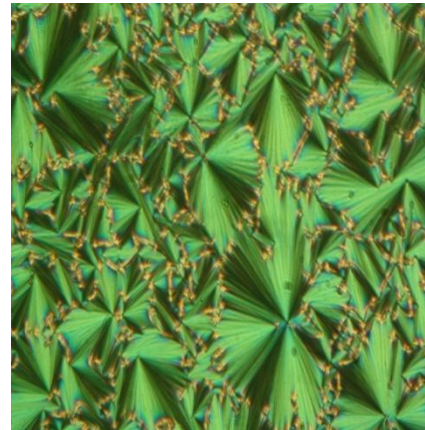
Synthesized azomethine liquid crystals: Schiff base liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $nClAB$ $n = 16$) comprising terminal chloro substituent [10] is used. The ITO coated liquid crystal cell of $5\mu m$ thickness is obtained from Instec Inc., USA, is used to prepare liquid crystal sample for investigation. The experiment involves Meopta Polarizing optical microscope in the attached arthroscopic mode with hot stage defined by Gray[17] and camera attachment for viewing, recording the textures as a function of temperature. The camera's color image has a resolution of 2592×3888 pixels that reflects the true color pixel tone of 24bits ranging from 0 to 255 in R, G and B colors under crossed and parallel polarizer's. The digital camera of canon made model (EOS Digital REBEL XS/ EOS1000D) of 10.10 mega pixel image sensor is used to record the texture pictures. To investigate sample thermo-optical behavior, sample textures from isotropic to solid phase are recorded as a function of temperature in three monochromatic image planes (red, green, and blue). Textures on three monochromatic planes of the image reveal the greatest differences in intensity [10-12,16]. The program was written in MATLAB (implemented with 2 GB RAM computation on P5 1.6GHz) for computational analysis of textures [18,19]. The parameters: Optical transmittance, Optical density, Birefringence and its dispersion which gives information about the optical behavior of the samples are given in [20-23].

III. RESULTS AND DISCUSSION

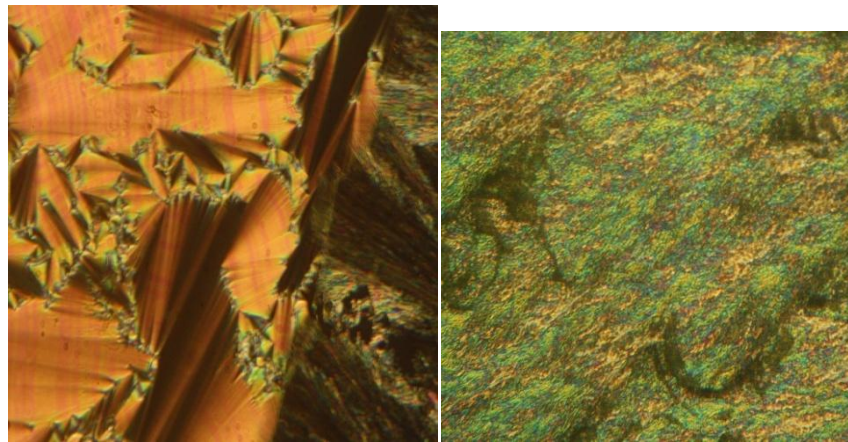
Schiffs base liquid crystal 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $n = 16$) comprising terminal chloro substituent is considered for the investigation of thermo optical behavior towards the device applications. Here, the compound $nClAB$, exhibit the Smectic A and Smectic B on cooling. On cooling, 16ClAB exhibits three transitions between isotropic liquid and crystalline solid [10]. The first transition from isotropic liquid to Smectic A at temperatures $103.5^{\circ}C$, second transition from smectic A to Smectic B at temperature $78.5^{\circ}C$ and third transition from Smectic B to crystal phase at temperatures $70.5^{\circ}C$. The mesophase range for the compound 16ClAB is $32.4^{\circ}C$. In this study, compound with higher alkyl chain length was considered. This is due to the fact, the drop in molecular polarity of liquid crystals and increase in alkyl chain length influences the level of association, leading often to the formation of a smectic phase layer structure. Therefore smectic phase is observed for the compound and textures of the sample are shown in Fig 1.



(a)



(b)

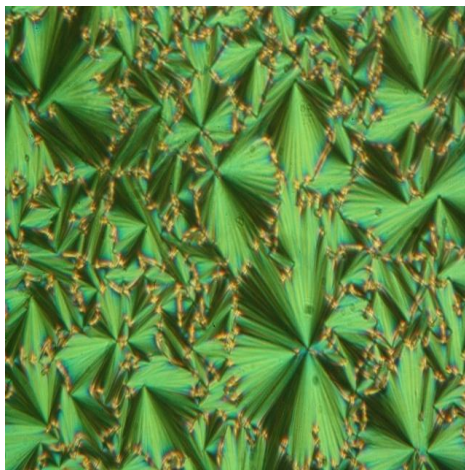


(c)

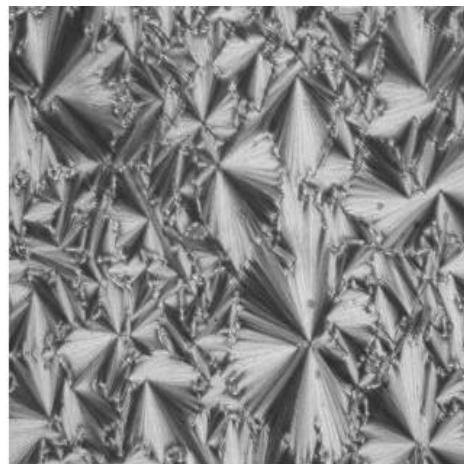
(d)

Fig.1. optical textures of Liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $n = 16$), (a) I - Smectic A phase, (b) Smectic A phase ; (c) Smectic B – Crystal phase, (d) Crystal phase.

The nature of the terminal substituents or end groups in the molecule of the mesogen has profound influence on the optical properties also. Here, optical behaviors of the compounds are studied with respect to temperature. As a function of temperature, phase change occurs due to disturbance in directions of the molecules. In solid phase liquid crystal molecule directors remain undisturbed and no phase change occurs. While passing the phase, orientation of molecular directions results phase transitions. In this region, the optical behaviors of the compounds are vary from the initial phase This can be investigated using different techniques. By using the standard optical microscopic technique, these transitions can observe as beautiful textures.



(a)



(b)

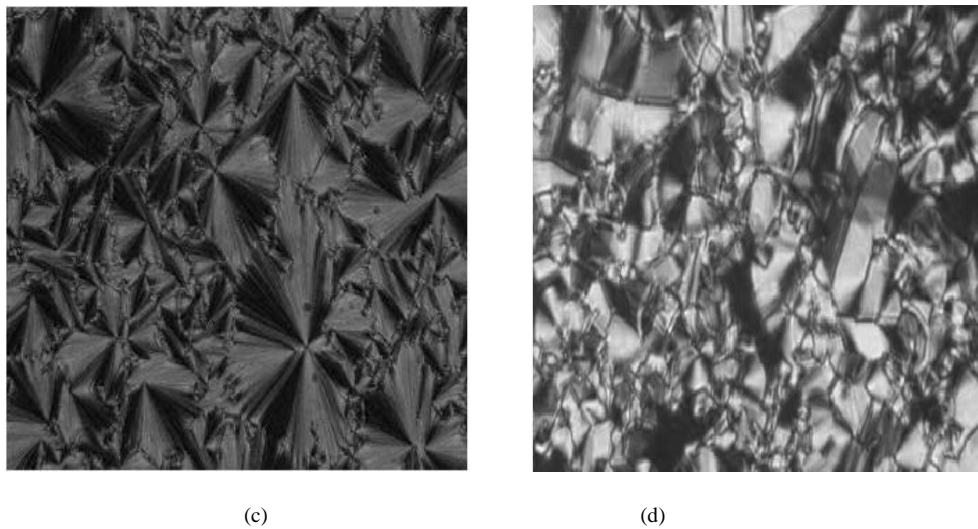
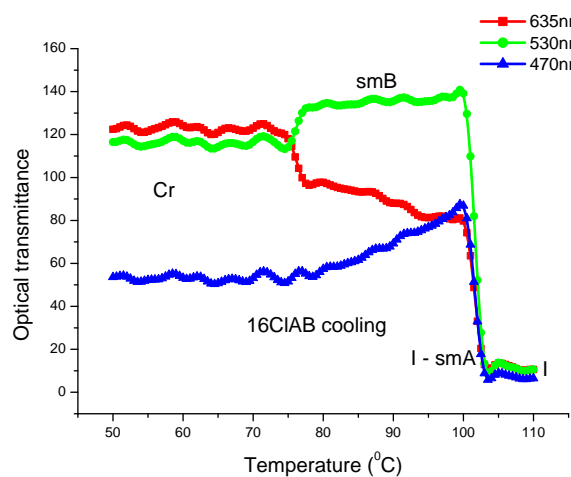
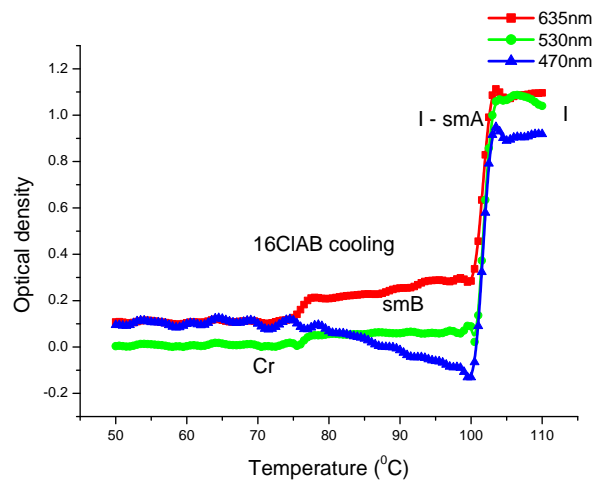


Fig.2. Optical textures (Smectic A phase) of Liquid crystal: 4-chlorobenzylidene- 4'-alkanoyloxyaniline ($C_{n-1}H_{2n-1}COO-$, $n = 16$), observed between crossed polarizers (a) for RGB colour mode; (b) for red colour image plane; (c) for green colour image plane; (d) for blue colour image plane.

For small values of temperature, there is no change in the textures and recorded textures remain same. As the temperature is increased, changes in textural features occurred reveals the phase transition. While passing a phase from initial phase (isotropic phase) to other liquid crystal phase or liquid crystal phase to solid phase, orientation of the molecules with respect to the temperature affects the transmitted intensity values of the textures in terms of textural feature changes. Analysis of these textural intensities with respect to temperature gives the information to investigate the thermo optical behavior of liquid crystals. Optical parameters are computed from the textures of samples in three monochromatic image planes using Equations given in [20-23]. As a representative case, Smectic phase of the sample in three monochromatic image planes are shown in Fig 2. The optical parameter plots drawn against the temperature and are shown in Figs 3,4.



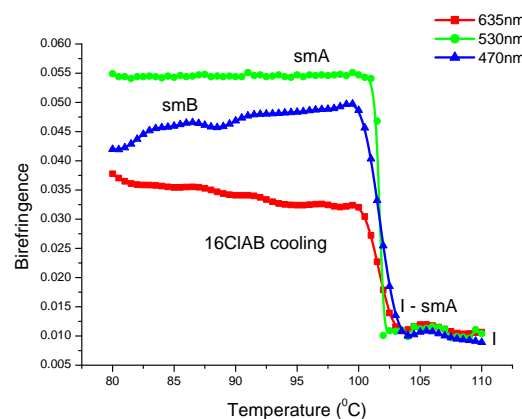
(a)



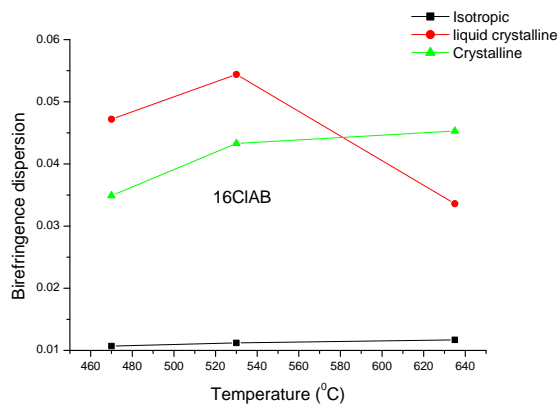
(b)

Fig. 3. (a) Optical Transmittance; (b) Optical density of 16CIAB.

Figs 3(a) and 3(b) show the variations in the values of optical transmittance and optical density [24]. These two properties give the emission and absorption of light from the liquid crystal material. Depending on wavelengths and molecular structure, the interaction between the light and atoms of molecules will take place. This can be useful to investigate the optical behavior of the samples. For different phases, this can be observed as changes in the textural features as function of temperature. On cooling, the value of optical transmittance increases near the isotropic phase to liquid crystal phase transition and show a sudden decrement or increment in the transmission values based on molecular alignments of the phases. In the azomethine liquid crystals, the terminal substituent of halogen atoms attributed to the change in the part of the chemical structure which in turn influences the optical transmittance of compounds. Fig 3(b) shows the optical density of compound 16CIAB. In Isotropic phase the molecular orientation is random and there is no transmission of light and the light is absorbed by the random orientations of the molecules. On cooling of the sample, sharp texture transformations of I - Smectic A - Smectic B - Cr give the jump like changes in the values of optical density. This is due to the fact that, the transmission of light takes place in smectic phase alignment of molecules. This can observe clearly for the compound 16CIAB and is useful for the fabrication of tunable optical filters. Absorption of the liquid crystal molecules for the compound 16CIAB is linear at all three wavelengths. Optical transmittance of the sample is inversely proportional to the optical density and clearly observed in Fig 3(a).



(a)



(b)

Fig. 4. (a) Birefringence; (b) its dispersion of 16CIAB.

Figs 4(a) and 4(b) shows the birefringence and its dispersion at three wavelengths and are plotted against the temperature. Here, computation of birefringence relies on observing an intensity change in the textures of liquid crystals. In all, a general trend is observed for isotropic and mesophases. The destruction and ordering of molecular alignment from their respective phases lead to the variations in the B values. On cooling of the sample from its isotropic phase, the value of birefringence increases abruptly in the biphasic region of I – Smectic temperature interval and there are small fluctuation in the value of birefringence at Smectic - Cr phases on further cooling. Liquid crystal coexistence regions (I - LC, LC - Cr) are commonly marked by an abrupt change in birefringence due to an immediate loss of all birefringence in a particular region of the sample. The small variations in the optical parameter curves other than transitions are due to change in the refractive index of the samples which results the continuous color changes of textures with respect to the wavelength and temperature. This can be clearly observed for two samples from Figure 3,4. The obtained results reveals that, optical behavior of the compounds towards the device applications are effected by chain length, size of the molecules and position of terminal substituents. Generally the higher electro negative atoms (chlorine) gives the high mesomorphic properties compared to the less electro negative atoms Bromine and Iodine [25]. And also the longer spacer groups of the liquid crystal compounds play a key role in determining good thermal and optical behavior which is suitable towards the optical device applications.

IV. CONCLUSION

Thermo optical behavior of azomethine liquid crystals comprising terminal chloro substituent's are investigated successfully towards the optical device applications through image analysis. Higher electro negative atoms (chlorine) give the high mesomorphic properties compared to the less electro negative atoms. The longer spacer groups of the liquid crystal compounds play a key role in determining good thermal and optical behavior which is suitable towards the optical device applications.

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