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Hussain A. Badran, and Harith A. Hasan

Synthesis and Study Dielectric Properties of a new Schiff-base liquid crystal

Hussain A. Badran[1,a)] ,Harith A.Hasan[2, b)]

[1]*Department of Physics,College of Education for Pure science, University of Basrah, Basrah,Iraq*
[2]*Department of Material Science, Polymer Research Centre, University of Basrah, Basrah, Iraq*

[a)] Corresponding author: badran_ hussein@yahoo.com
[b)]harth.alqata100@yahoo.com

Abstract. Anew central linkage group aromatic Schiff base liquid crystal has been synthesized by using condensation of an Alkyl chloride (CnH2n+1(Cl)n=4,5,6,7).This crystal was characterized by Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC) and polarizing optical microscopy (POM). Schiff base liquid crystal sample exhibiting the sematic phase. The temperature variation of the dielectric anisotropy ($\Delta\varepsilon$) of the sample has been measured. The dielectric anisotropy was found to be ($\Delta\varepsilon$ =0.38). This research studies the effects of concentration of Schiff base liquid crystal on the behavior of optical limiting and threshold power.

Keyword. DSC; Schiff base; liquid crystal; Optical limiting; laser.

INTRODUCTION

The materials of liquid crystalline are very interest subject in different scientific areas including material science, life sciences, and their applications in numerous fields, such as thermo-conducting materials, electro-optics, the fields of optics and fast switching [1,2].The relevance of liquid crystals largely depends not only on their expanded application in display apparatus/devices but also on a variety of scientific applications [3]. However, the use of liquid crystals in different devices is dependent upon some properties which may include the following: optical transmittance, dielectric anisotropy, dielectric constant, birefringent behavior, elastic constants, etc. Smectic liquid crystals show both orientational order and some translational order [4]. The molecules are gathered into layers, applying positional order in one way. Inside of the layers, the ordering can be designated by the smectic order factor [5]. Several sorts of molecules packing in layers; each sort matches with altered varieties of smectic phases. The smectic phases are coded with letters A, B, C, etc. SmA and SmC phases are classified as the most vitalsmectic phases. A characteristic feature of smectic liquid crystals is not only the exhibition of a phase transition behavior but also their dielectric properties and results from optical studies. These studies are useful in explaining the molecular dynamics and structure as well as the interaction between different molecular types which may depict likely phases as can be seen in molecular samples [6]. In this work, the LC properties of E-2- chloroethyl 4(4-hydroxybenzylidene) aminobenzoate have been investigated. The anticipation of this study was that the side pendants would offer channels for carrier transport and the rigid backbone would performance as a mechanical strength manufacturer. Their synthesis, liquid crystalline properties, thermal analysis and dielectric anisotropy of the Schiff base liquid crystal will be described. Also, employed is the use of a standard and reliable tool-“Optical polarizing microscopy (OPM)” used in the determination of phase transitions in the liquid crystal.

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EXPERIMENTAL METHODS.

Materials preparation.

Alkyl chloride (CnH_{2n+1} (Cl) where n= 4,5,6,7) , 4- hydroxyl benzaldehyde and all solvent and reagents were bought and applied without any additional purification. The preparation of the liquid crystal sample was by two-step methods. First step was by alkylation of 4-Hydroxy benzaldehyde with $C1_2$ H_{25} Br and 4- Amino benzoic acid with Cl C_2H_4OH. Second step was by condensing equimolar amounts of 2-chloroethyl 4-aminobenzoate with 4-(dodecyloxy) benzaldehyde in boiling ethanol as well as rising the temperature gradually at limit 150°C. The product was filtered and then separated using diethyl ether and distilled water. Phase transition temperatures were calculated using differential scanning calorimeter (type star, s-w -1000), dielectric constant, dielectric anisotropy and dielectric loss were measured using an optical response. The synthetic route to misogynic Schiff's base E-2- chloroethyl 4(4-hydroxybenzylidene) aminobenzoate molecules are illustrated in Fig.1.

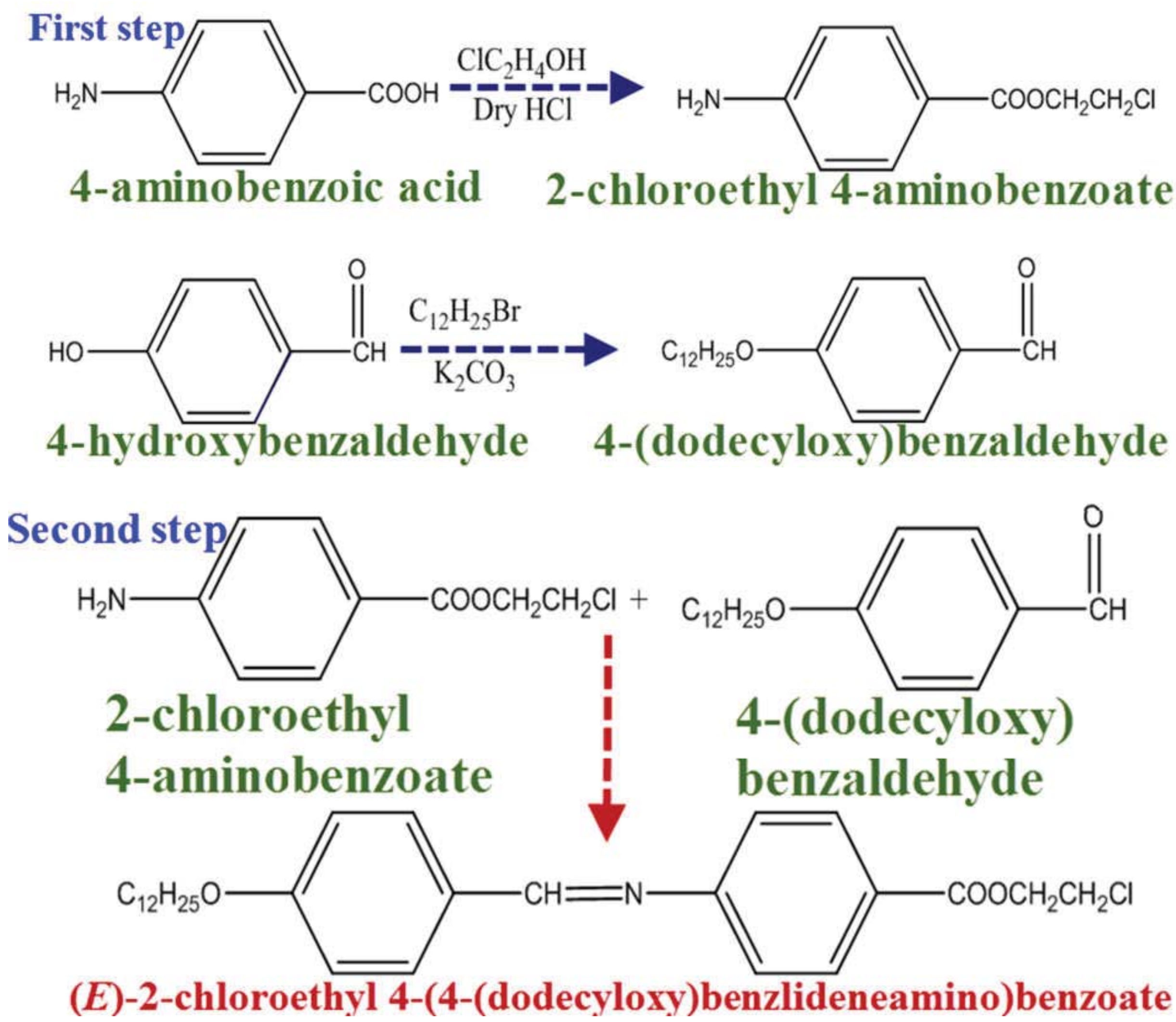

FIGURE 1. The reaction conditions of the prepared compound.

FTIR analysis.

Perkin-Elmer System 2000 FT-IR Spectrometer has been used to record IR spectra. The stretching vibration of the functional groups of synthesized compounds was shown in Fig.2, which confirmed that the method of alkylation for para hydroxyl benzaldehyde is correct. Fig.2 demonstrations the calculated Fourier Transform Infrared spectrum of the synthesized organic compound between 3600cm^{-1} and 600 cm^{-1}. The IR that, two strong peaks of aromatic double bond C=C stretching appeared at 1610-1510 cm^{-1}. Moreover, a strong peak owing to C-N stretching is originated near 1480 cm^{-1} and one more at 1680-1645 cm^{-1} is attributed to C=O stretching. Last but not least, there are a number of characterized absorption bands of substituted benzene such as C-Br and C-Cl stretching at 800 - 600 cm^{-1}, respectively. The two peaks appeared in the region of 1172–830 cm^{-1} for the (C–H) bond that is in agreement with the plane bending vibration of aromatic C–H bond. Two weak bands at 2940 and 2860 cm^{-1}denote the asymmetrical (C–H) and symmetrical stretching of aliphatic C–H bond respectively.

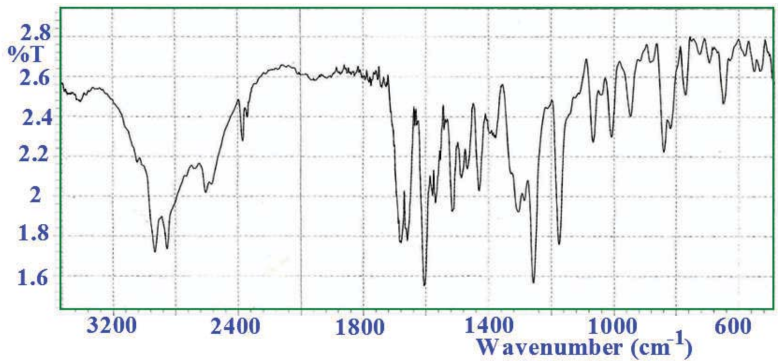

FIGURE 2. Infrared spectrum for prepared LC.

RESULTS AND DISCUSSION.

Optical Microscopic Studies.

As a primary analysis, the schiff-base revealed by the final sequence was studied by a polarizing optical microscope. The achievement of thin-film samples was by packing them in-between a glass slide and a coverslip. The prepared sample shows in Fig.3 focal-conic fan smectic texture with surface point defects at phase transition by cooling from the isotropic phase to liquid crystal phase at 72 °C.

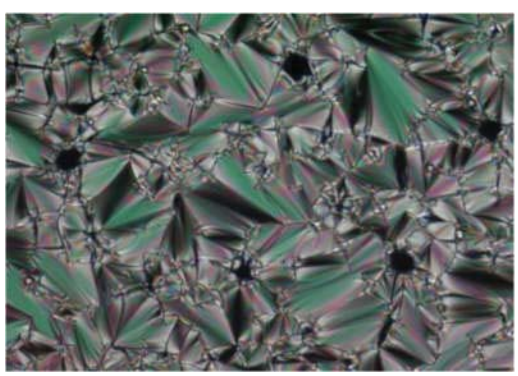

FIGURE 3. Optical textures for schiff-base liquid crystal.

Polarizing microscopy.

In existence is a diverse array of tools very useful when undergoing characterization and understanding of phase transition in Schiff liquid crystal samples. Dielectric measurements and dielectric anisotropy ($\Delta\varepsilon$) of liquid crystal compounds were examined with support of the dielectric bridge (Fluke PM6306 LCR meter) with a frequency range of between 100 Hz to 200 kHz there by providing useful information about the order parameter S. As well as the phase transition of the synthesized compounds was identified by making use of a DSC thermogram for our samples at the Polymer Research Centre at University of Basrah and the thermo grams show an efficient transition from solid to smectic phase at a phase transition temperature of about 72°C with an enthalpy(H) of 681.51 mj and Latent heat (ΔH) of 85.19 j/g, the transition from liquid crystal to isotropic phase occur at116°C with an enthalpy(H) of 45.06 mj and Latent heat (ΔH) of 5.63 j/g as well as the component decompose at 154°C as shown in the Fig.4. The thermal analyses by DSC thrmogram for liquid crystal sample provide temperature range for exhibited liquid crystalline phase equal to 44°C and melting point (T_m) for the component at 33 °C.

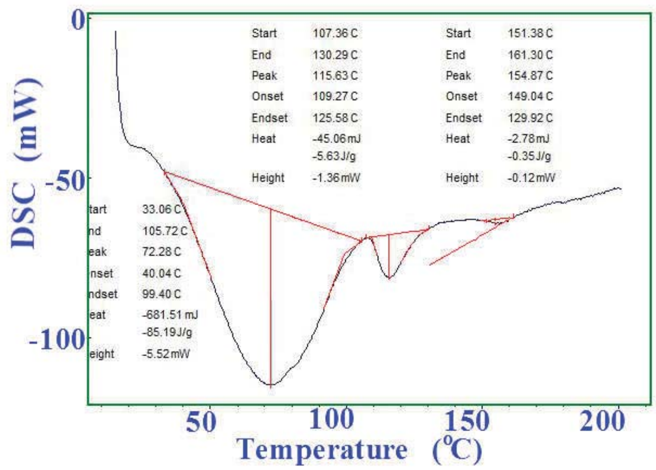

FIGURE 4. DSC thermogram for schiff-base liquid crystal.

Dielectric studiesis.

One of the most important physical properties concerning the wide applications of liquid crystals is their dielectric behavior which determines their response to the electric fields. In this research, we have measured both the parallel and perpendicular dielectric constants with the dielectric anisotropy ($\Delta\varepsilon$) as a function of frequency and temperature for our prepared samples in the homogeneous and home tropic alignments respectively as shown in Fig. 5 and 6.

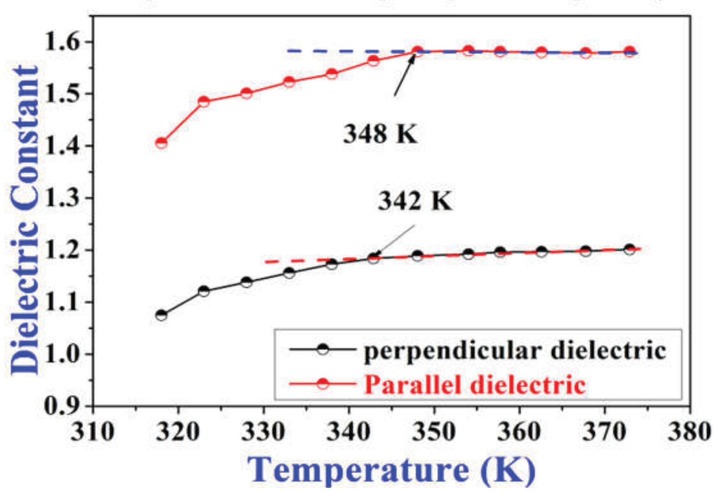

FIGURE 5. Temperature dependence of the dielectric constant.

A dielectric relaxation spectrum was gathered between 318 and 373 K, covering the smectic. The dielectric spectrum was acquired with increasing temperature stages of 5K. At each etage of temperature, the scheme was detained for steadying within 5 K. There is no discontinuity in the dielectric measurements at the quoted of 318 K. The Schiff-bas liquid crystal was also observed by polarizing optical microscopy while decreasing the temperature to 238K. In Fig.6 we show, for systems, the dielectric strength of the main process, Δε as a function of the temperature. The abrupt change occurs at 353 K. The peaks for the relaxation mechanism because of the hindered rotation about the molecular short axis are symmetrical and the temperature dependence in the bulk smectic phase of the relaxation times is Arrhenian.

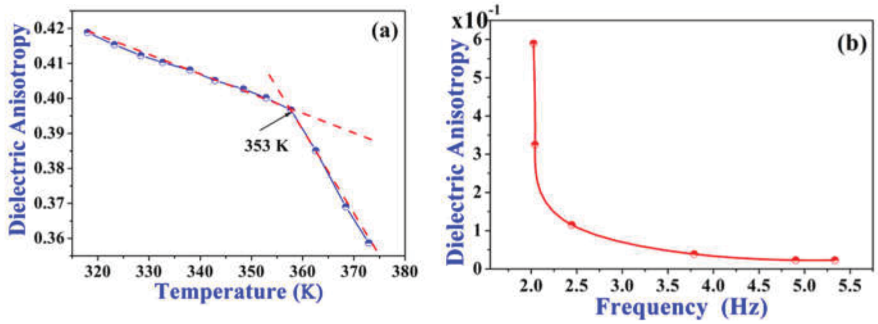

FIGURE 6. Dielectric anisotropy as (a) a function of temperature, (b) a function of frequency.

The Optical Limiting Properties

Here this setup of optical restrictive was arranged as described in Hussain A.Badran et al [7] .A CW solid state laser SDL beam (TEM00 mode-Shanghai Dream Laser Technology) of 532 nm wavelength was achieved to calculations the optical limiting. A +5 cm focal length positive lens was applied, focusing the laser beam on the sample. The schiff-base liquid crystal solution was prepared by dissolving the schiff-base liquid crystal powder dissolved in DMSO as a solvent. The schiff-base liquid crystal concentration is 0.03mM.The transmitted beam was captured using a Photo Detector (PD) connected to a power meter. Optical limiting was achieved by monitoring output power according to varying input power. The input power is in the range of 0-20 mW.

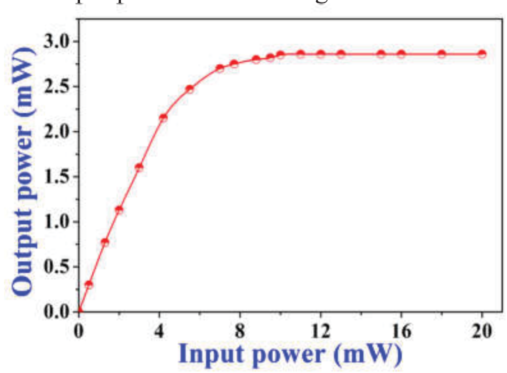

FIGURE 7.Optical limiting behaviour for liquid crystal.

Figure 7 shows the variation of the output power as a function of the input power, which points out the optical limiting behavior of schiff-base liquid crystal solution. It can be seen from the curve that the sample shows obvious optical limiting behaviors. The transmitted output intensity was state to be differing linearly with the incident input intensities at low input intensities but begins to vary at high incident intensities [8-10]. With further increment increase of the input power, the transmitted intensity ranges a plateau and is saturated at a point known as the limiting amplitude: i.e. the maximum output power, viewing noticeable limiting property [11-14].

CONCLUSIONS

For this study, we found that our samples show the smectic liquid crystalline phase at relatively low temperatures 72 –115 °C with a transition temperature range of about 44 °C which is suitable for the most physical applications. Dielectric effect studies for the prepared samples show that our samples are with positive dielectric anisotropy of about, $\Delta\varepsilon = 0.38$, together with a liquid crystalline temperature range of about 44 °C with an enthalpy (H) of 681.51 mj. The results stated above we may conclude that this is because the dipole moment which is present due to the chloride group of the amino is acting beside the long molecular axis of the molecule. Consequently, this is the main reason that the samples show their positive dielectric anisotropy mentioned above. Optical limiting outcomes approve that the smectic schiff-base liquid crystalline sample is a respectable applicant for optical limiting at 532nm cw lasers. The findings indicate that E-2- chloroethyl4 (4-hydroxy benzylidene) aminobenzoate is a capable material for applications in nonlinear optical devices including optical limiter device.

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