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RESEARCH ARTICLE

A Novel Approach in Flexoelectric Measurement.

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Abstract

We describe here the measurement of bulk flexoelectric coefficient for the binary mixtures of two homologues of liquid crystal dimeric compounds of α,ω-bis(4-alkylaniline benzylidene -4′-oxy)alkane (m.OnO.m) series. The rotation angle with the variation of temperature and electric field and the variation of flexoelectric coefficient with temperature is discussed in the light of available literature values.

Introduction:-

Nematic liquid crystals have an apolar director and exhibit flexoelectric effect when its volume electric polarization distorted. R. Meyer in his original paper on flexoelectricity imagined that the polarization was related due to molecular dipoles along pear shaped molecules [1]. Later it was established that in the case of weak distortions, the only flexoelectric bulk effect was due to molecular quadrapolar momentum [2-5]. Nematogenic molecules generally have non-zero electric quadrapole moments and hence nematic liquid crystals exhibit non-zero flexoelectric coefficient.

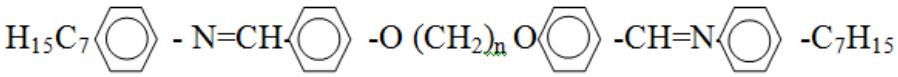
As a part of the discussion of flexoelectric effect we, report here the temperature dependence of flexoelectric coefficient on the Schiff base liquid crystal dimer to exploit the molecular nature using the method of Dozov [6, 7]. The compound chosen for this study is 7.O12O.7 with a mixture to the similar series of 7.O6O.7. The 7.O12O.7 exhibit only nematic phase but 7.O6O.7 have SmA and SmF phase variant.

Experimental:-

The compounds were synthesized following a standard procedure available in the literature [8]. The crude product was repeatedly recrystallized from ethyl acetate until the transition temperatures were found to be constant and reproducible. The differential scanning calorimetric studies (DSC) were carried out on Dupont 2000. Various phases exhibited by these compounds were characterized by observing their optical textures under a polarizing microscope attached with a indigenous hot stage [8]. The temperature resolution in these microscopic studies was 0.1°C. The transition temperatures and entropy change at different phase transitions are found to be in excellent agreement with literature values [9]. The binary mixtures used for the flexoelectric studies in the weight percent of 80% were also recrystallized from ethyl alcohol and filtered under reduced pressure. The flexoelectric studies were carried out in a hybrid aligned cell under a polarizing microscope equipped with a Mettler hot stage [3]. The rotation angle is measured with the variation of temperature and electric field. The permitted cooling rate during the experiment was 2°C hr^{-1} and the temperature accuracy is ±0.1°C.

Results and Discussions:-

The general molecular structure and transition temperatures of dimers studied viz. 7.O6O.7 and 7.O12O.7 are shown below.



7. O6O.7 (n=6) and 7.O12O.7 (n=12)

The phase and phase transition temperatures of the experimental compounds and their binary mixtures are shown in table-1

Table -1 Phase and phase transition temperatures of the dimeric compounds and their binary mixtures

Compounds	Cr – SmF °C	Cr – N °C	SmF – SmA °C	SmA – I °C	SmA – N °C	N – I °C
7.O6O.7	116		143	183		
7.O12O.7		128				133.5
7. O12O.7 + 7.O6O.7 (80% +20%)	119.2		121		131.7	140

The basic requirement for the flexoelectric effect are that the compound must be nematic and it must aligned both homoetropically and homogenously. By filling the nematic dimeric compound 7.O12O.7 in hybrid aligned cell, it was found that the compound became homogenously aligned but had the very low tendency to align homeotropically resulting non-suitability for flexoelecticity. However, an alternate attempt had been made where a lower homologue of similar series of compound, 7.O6O.7 which exhibit SmA and SmF phase sequence mixed with the 7.O12O.7 and found to be well suited at a weight percent of 80%. The binary mixtures were recrystallized from ethyl alcohol and filtered under reduced pressure. The mixture increases the thermal range of nematic phase i.e. from 5.5 ^{O}C to 8 ^{o}C. This mixture filled with the hybrid aligned cell exhibit flexoelectric effect. The rotation angle with the variation of temperature and electric field had been measured and shown in figure -1 and the variation of flexoelectric coefficient with temperature is shown in figure -2.

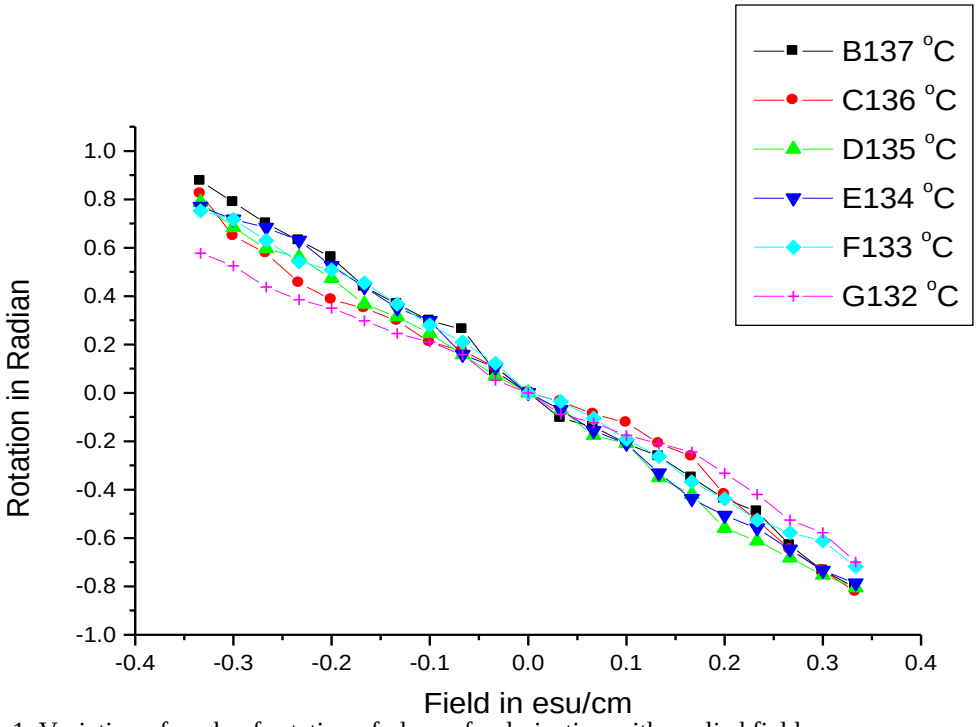


Figure 1. Variation of angle of rotation of plane of polarization with applied field

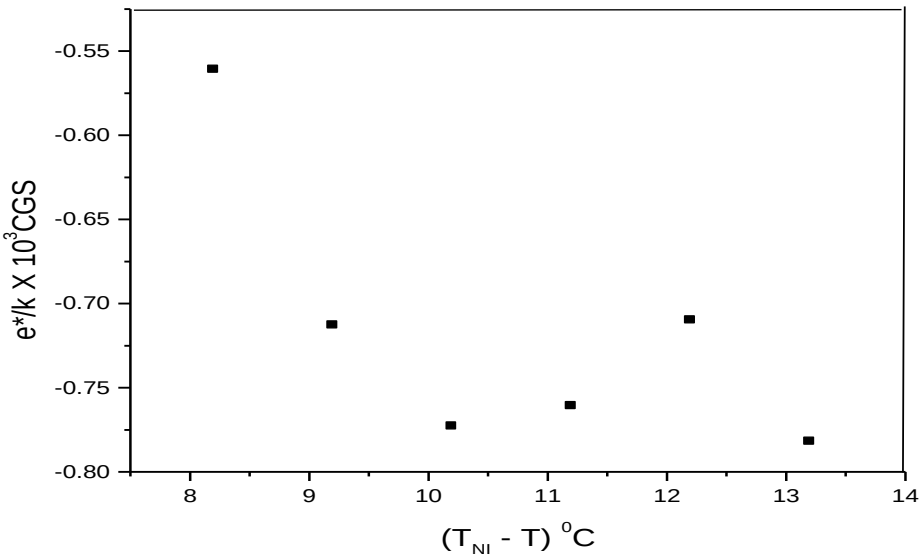


Figure 2. Variation of (e*/k) with relative temperature ($T_{NI} - T$)

We obtain the flexoelectric coefficient e*/k from the field induced twist of hybrid aligned cell of thickness d through the relation $e^*/k = \pi\theta / Ed$ as described by Dozov *et al*[6]. It was seen from our experiment that the slopes of the plot of angle versus field were changed with the variation of temperature and the measurement e*/k was determined from the slopes. It may arise due to the molecular topology of the dimeric compounds. The flexoelectric coefficient was found negative but little less than 8OCB. It may be due to that unlike 8OCB having strong polar CN group, this dimeric mixture do not have such strong group to make more distortion. The comparison of bulk flexoelectric coefficient is shown in table 2.

Table -2: The comparison of bulk flexoelectric coefficient

Compound	Bulk Flexoelectric Coefficient (e*/k)	Reference
Methyloxybenzylidenebutylaniline (MBBA)	$+0.25x10^{3}$CGS	5
Octylcynobiphenyl (8CB)	$+0.227x10^{3}$ CGS	6
Octyloxycynobiphenyl (8OCB)	$-1.40x10^{3}$CGS	6
7. O12O.7 + 7.O6O.7 (80% +20%)	$-0.76x10^{3}$CGS at 135^{0}C	Present work

Conclusion:-

In conclusion, we have measured the bulk flexoelectric coefficient of a liquid crystal dimer which have shown flexoelectric properties when it was mixed with another similar type of compound. The flexoelectric coefficient was found to be negative and little smaller than other available data.

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