International Journal of Scientific Research in Modern Science and Technology
ISSN: 2583 -7605 (Online)
© IJSRMST \ Vol. 2 \ Issue 4 \ 2023
Available online at: www.ijsrmst.com

Electrical Parameters of a Single Mode Antiferroelectric Liquid Crystalline Material

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Abstract:

The electrical properties of 7F6Bi, a liquid crystalline single-mode antiferroelectric, have been studied. The material has antiferroelectric SmC* phases alongside paraelectric SmA* and ferroelectric SmC* at low temperatures (83 °C). Since the SmA* phase's dielectric strength grows with decreasing temperature and follows the Curie-Weiss equation, molecular tilt fluctuations in the MHz area have caused the appearance of the first relaxation mode. The SmC* phase exhibits a second relaxation mode as a result of molecular phase fluctuations. The anti-ferroelectric arrangement of the molecules resulted in the SmC* phase's single relaxation mode. At 104.3 degrees Celsius, its dielectric strength is 0.55.

Keywords: Switching time, dielectric permittivity and loss, soft and Goldstone modes, spontaneous polarisation, and ant ferroelectric liquid crystal.

1. Introduction:

The quick switching behaviour of liquid crystals has made them useful in display and opto-electronics [1]. It has many subphases, in which antiferroelectric liquid crystal (AFLC) phase attract to researchers, scientist and engineers in improvement of the electro-optic (E-O) properties of LC displays. Many attempts were made to alter the E-O characteristics of nematic liquid crystal (NLC) by doping it with various materials [2, 3], but currently, nematic is seen as a worse alternative than nematic for high resolution displays [4, 5]. While many desirable properties exist at this stage (including complete grey scale capability, dc correction, broad viewing angle, etc.), static light leakage and low contrast ratio resulting from improper alignment have kept AFLC devices from widespread commercial usage. Use of an orthoconic antiferroelectric liquid crystal (OAFLC) material, which is effective against the static dark state issue regardless of alignment quality [8-9]. High spontaneous polarisation (PS), extremely short helical pitch, and high rotational viscosity are all characteristics of the favourable dark state found in these AFLC materials, however they lead to a host of technical issues, such as expensive driver costs, lengthy switching times, etc. Different optical characteristics and numerous memory states are provided by its intricate architecture, which may find future usage in a

variety of contexts [10].

Understanding how surfaces influence phase behaviour and phase sequence has made electrical spectroscopy an increasingly essential method in the area of liquid crystals [11]. There is a lot that can be learned about the surface-stabilized state's quality from the dielectric spectrum [10]. In this paper, we provide the first detailed account of the electric properties of the fluorinated liquid crystalline substance 7F6Bi. Figure 1 shows the nuclear construction of the substance under study.

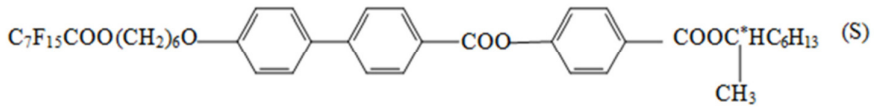


Figure 1 Molecular structure of 7F6Bi.

2. Experimental Technique

We have been using a Differential Scanning Calorimeter (DSC) from NETZSCH (model DSC 200 F3 Maia) to compute the temperatures and enthalpies of stage advances. Utilizing an optical polarizing magnifying lens, we were able to determine the existence of distinct phases inside the material. A dielectric cell manufactured by AWAT in Warsaw, Poland, was used to conduct the electrical tests for the sample that was plane-aligned. With a functioning capacitance (CA) of 36.5 pF, the cell's terminals are gold-covered glass plates [12-17] isolated by a spacer of thickness 8.8 m. All through the scope of 1 Hz to 35 MHz, electric data have been assembled using a Newton's Stage Fragile Multimeter (model-1735) and an Impedance Examination Association point (model-1257). A hot stage (Instec model HCS 302) and temperature controller (Instec model mK 1000) were used to maintain a constant temperature for the sample. To get an accurate reading of the temperature in the area around the sample, we utilized a six and a half digit multimeter from Agilent (model-34410A) to check the thermo-emf of a copper-constantan thermocouple to an exactness of 0.1 C. Dielectric permittivity () and losses () are measured in the same way, and the formulas used to do so are described in more depth in our previous papers [17, 18].

$$\varepsilon^{*} = \varepsilon^{'} - j\varepsilon^{''} = \varepsilon(\infty) + \sum_{i} \frac{(\Delta\varepsilon)_i}{1+(j\omega\tau_i)^{(1-h_i)}} + \frac{A}{\omega^{n}} - j\frac{\sigma ion}{\varepsilon_0 \omega^{k}} - jBf^{m} \qquad (1)$$

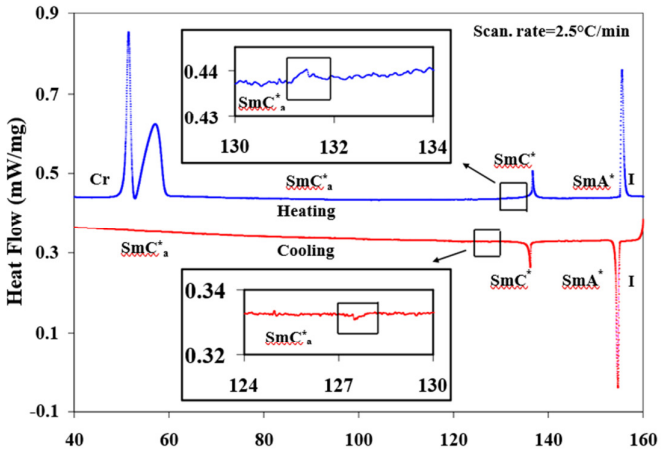
where $(\Delta\varepsilon)_i$, τ_i and h_i are the dielectric strength, the unwinding time (reverse of unwinding recurrence) and the symmetric dissemination boundary ($0 \le h_i \le 1$) of the i^{th} mode, respectively, $\varepsilon(0)$ and $\varepsilon(\infty)$, The third and fourth parts in condition (1) portray the obligation of the cathode polarization capacitance and ionic conductance at low frequencies where An and n are constants [19]. The worth of consistent not entirely settled to be 1 for amazing ohmic conductivity. As examined in [20, 21], the high-recurrence parasitic impact attributable to the anode surface opposition might be somewhat represented by adding the fifth fanciful term Bf m to condition (1), where B and m are constants a similar length as the change is irrelevant and 0 (=8.85 pF/m) is the free space permittivity. Estimated information have had the low and high recurrence remedy factors inferable from anode polarization capacitance [19] and surface opposition [20,

21] removed in order to investigate the relaxation process in the different phases observed.

3. Discussion and Results

a. Thermodynamic and optic study

The peak transition temperatures, as measured by DSC thermo-gram, fluctuate linearly with scanning rate, and this trend holds for scanning speeds ranging from 2.5 to 15.0 C/min. Heat and cool cycles recorded by differential scanning calorimetry (DSC) at a filtering pace of 2.5 C/min are displayed in figure 2.



The SmC*a-SmC* change top is weak and couldn't be distinguished obviously like different advances in light of the fact that to obscuring of the progress tops at high filtering speeds. At a sweep pace of 2.5 C/min (see inset in Figure 2), the SmC*a-SmC* progress pinnacle might be seen with the right amplification of the warming and cooling thermo grammes.

b. Dielectric spectroscopy

Figure 3 portrays the temperature reliance of the $d\varepsilon'_{\perp}$/dT of the particular stages at 100 Hz frequency, where the dielectric conduct of three fluid glasslike stages, specifically SmA*, SmC*, and SmC*a, can be clearly identified based on the magnitudes of $d\varepsilon'/dT$. Figure 3 shows that the SmC* phase has the largest negative d/dT value.

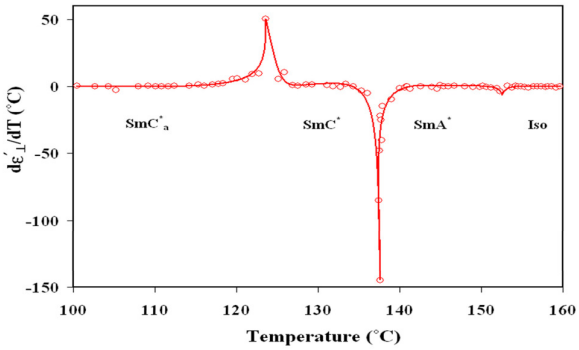


Figure 3 The $d\varepsilon'_{\perp}/dT$ at 100 Hz as a function of temperature. The antiferroelectric SmC*a stage (left) and the paraelectric SmA* stage (right) are effortlessly recognized by the most minimal worth of the d/dT in the ferroelectric SmC* stage.

The transitions from SmA* to SmC* and SmC* to SmC*a cause significant changes in d/dT

because of the paraelectric to ferroelectric and ferroelectric to against ferroelectric stage changes, individually. Material has crystallised at or near room temperature (33 oC) after being cooled further in the SmC*a.

By using the extended version of equations 1, we have been able to derive the distinctive boundaries of the multitude of modes noticed all through every one of the stages. The Curie-Weiss decide states that the dielectric strength of the sensitive strategy for the SmA*stage is relative to the temperature distinction between the SmA* and SmC* stages, T = C/(T-TC), where C is a consistent and TC is the Curie temperature for the advancement. The change temperature (TC) from SmA* to SmC*is calculated using the Curie-Weiss equation and corresponds very well with the other electrical characteristics measured directly.

In the SmC* stage, a cunning dielectric loosening up mode (M2) has been found. The loosening up repeat (fR) is around 5 kHz 100 Hz and the dielectric strength is 7.75 0.07at the SmC* phase transition. fR is rather stable (5.6–7.6 kHz) during the SmC* phase.

200 Hz), whereas just before the SmC*-to-SmC* transition, rises (from 7.7 to 14.6 5%). Several additional AFLC materials have been shown to have the GM penetrate into the SmC* phase [22-24].

Cole-Cole plots are drawn for all the mesophases, showing the various relaxation modes as a function of temperature. Except at the lowest and highest frequencies, all of the data points cluster in a circular pattern. Even in the middle frequency range, the correction factors inherent in the experimental data cause the corrected data points to deviate from the observed data points.

4. Conclusions

The experimental result of the studied antiferroelecrtric material is summarized in the followingpoints:

- Thermodynamic, optical, and dielectric experiments have all shown that the material is useful in a broad variety of temperatures (~127.8 ºC to 18.4 ºC) antiferroelectric (SmC^*_a) phase with paraelectric (SmA^*), and ferroelectric (SmC^*) phase.
- Three distinct relaxation modes are shown by electric spectroscopy at various times. In the SmA* stage, a delicate mode has been identified. The temperature altogether affects the unwinding recurrence and dielectric strength of this mode. The Goldstone mode may be found in the SmC* stage, and its unwinding not entirely settled to be nearly temperature-autonomous. The SmC*a stage shows antiferroelectric Goldstone mode because of against work variances in the azimuthal point of hostile to shift matches. No evidence of the mode caused by azimuthal angle fluctuations out of phase with the SmC*a phase has been found.

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Cite this Article:

***Avneesh Mishra, Jitendra Singh, R. Dabrowski, R. Dhar, " Electrical Parameters of a Single Mode Antiferroelectric Liquid Crystalline Material** ", International Journal of Scientific Research in Modern Science and Technology (IJSRMST), **ISSN:** 2583-7605 **(Online)**, Volume 2, Issue4, pp. 11-15, April 2023. **Journal URL:** https://ijsrmst.com/*