# Dielectric Spectroscopy of Ferroelectric Liquid Crystal Mixture Showing Different Temperature Range

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## ABSTRACT

*The complex dielectric spectroscopy has been measured as a function of frequency range: 50Hz to 1MHz. at room temperature for a technologically important ferroelectric liquid crystal mixture in the different phases. The significant contribution of conductance effect at lower frequency side in measured data has observed. Contribution of conductance in dielectric permittivity and dielectric loss due to impurity influence the materials. The dielectric parameter as a function of temperature and result showed Debye- type dispersion.*

*Keywords: Ferroelectric Liquid Crystal Mixture: Surface-like Mode: Dielectric Strength: Relaxation Frequency.*

## 1. Introduction

In 1974 Meyer predicted and experimentally proved the existence of ferroelectricity in the chiral smectic C (SmC\*) phase formed by a chiral compound. The temperature and frequency dependence of the complex dielectric constant of ferroelectric liquid crystal has been studied [1-2].

The unique physical properties of the liquid crystals with dipole ordering and especially ferroelectric liquid crystalline (FLC) materials have opened the future to a large variety of electro-optic applications in real-time optical processing, computing, control and measuring devices, displays, TV screens, *etc*. These future applications put high demands on the understanding of the basic physical properties of ferroelectric liquid crystalline materials [3-5].

FLC materials with high spontaneous polarization, low helix pitch showing broad temperature range of the chiralsmectic C\* phase and the chiralnematic (N\*) phase have been studied [6-8] so far because of the difficulties in obtaining perfect alignment. Several research groups have studied the dielectric spectroscopy of ferroelectric liquid crystal in detail. The dielectric phenomena associated with molecular orientation and relaxation processes have been discussed by several groups [6-10]. Significant conclusion from our results makes and believes that the dielectric permittivity in ferroelectric liquid

crystal phases arises originally due to two reasons: (a) the collective dielectric processes concern with the director reorientation motion, and (b) the molecular reorientation motion concern with the dipolar polarizability of the molecule. The present study, an attempt has been made to investigate the relaxation behaviour of technologically important FLC mixture sample in cell of 10 μm thickness. We observed that the collective conductance effect in measured data.

## 2.0 Theoretical Background

The chiral SmC phase ferroelectric liquid crystal represents a spatially modulated structure, due to their tilt of the long molecular axis processes helicoidally around the layer is normal and going from one smectic layer to another. Locally breaks the symmetry of the axis along the long molecular axis and induces a transverse in plane polarization perpendicular to the direction of the tilt angle [11-15].

The complex dielectric constant

$$\varepsilon^*(\omega, T) = \varepsilon(\omega, T) - j\varepsilon''(\omega, T) \text{ where } \omega = 2\pi f$$

is the angular frequency of the applied electric field and T is the temperature of the system. In general several relaxation mechanisms, each of which is related to a characteristic eigen frequency, are contributing to $\varepsilon^*(\omega, T)$. In the case of SmC\* phase liquid crystal have two relaxation modes and each

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mode, at a given temperature, contribution to the dielectric constant decreases with increasing frequency of the field, from the low frequency value, which is the value adopted when the frequency of the applied electric field is so high, the mode cannot follow the electric field. The difference between the low and high-frequency contribution of the mode to the total dielectric constant is called the dielectric strengths of the mode and will be denoted and the relaxation frequency confirm by using Cole-Cole equation:

$$\frac{v}{u} = (\omega \tau)^{1-\alpha} \qquad \dots (1)$$

for eigen frequency verification. Where α is distribution parameter

$$v = \left[ \{\varepsilon(o) - \varepsilon'(\omega)\}^2 + \{\varepsilon''(\omega)\}^2 \right]^{1/2}$$

$$u = \left[ \{\varepsilon'(\omega) - \varepsilon(\infty)\}^2 + \{\varepsilon''(\omega)\}^2 \right]^{1/2}$$

$\varepsilon'(\omega)$ real dielectric constant at a given frequency and

$\varepsilon''(\omega)$ imaginary dielectric constant at that frequency.

$\varepsilon(o)$ : low frequency dielectric constant where the Cole-Cole plot intercept the abscissa at the lower frequency side
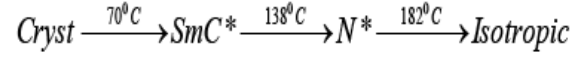
and $^{|}$ $\varepsilon(\infty)$ high frequency dielectric constant where the Cole-Cole plot intercept the abscissa at the higher frequency side.

Acquired data of capacitance (C) and Dissipation (D) in planar alignment were used to determine the frequency dependent dielectric permittivity $(\varepsilon'(\omega))$ and $(\varepsilon''(\omega))$ as follows:

$$\varepsilon'(\omega) = \frac{[C_m - C_{air}]}{C_{eff}} + 1 \qquad \dots (2)$$

$$\varepsilon''(\omega) = \frac{\sigma}{\varepsilon_0 \omega} = \frac{[G_m - G_{air}]}{\omega C_{eff}} \qquad \dots (3)$$

## 3.0 Experimental Method

$$Cryst \xrightarrow{70^0 C} SmC^* \xrightarrow{138^0 C} N^* \xrightarrow{182^0 C} Isotropic$$

This material has a wide temperature range of ferroelectric (SmC*) liquid crystalline phase. The phase sequence and transition temperatures were studied using the differential scanning calorimeter (DSC-7) and optical polarization thermal microscopy method both have good agreement. The sample cells consist of conducting indium tin oxide (ITO) coated glass substrate pre-treated with the polyamide (spin coating ~ 1000 rpm) at the surfaces. The distance between the plates was kept around 10 m by means of a mylar spacer. The cell was first calibrated using air and benzene as standard references, which allowed us to calculate the absolute value of real and imaginary parts of complex dielectric. The device was assembled in the planar orientation. The FLC material was introduced into the cell by means of the capillary action in its isotropic phase. The cell temperature was controlled using a temperature programmer interfaced to hot stage (LINKAM model TP94 & THMS 600) with an inaccuracy of ± 0.1°C. The orientation of molecule was observed through polarizing microscope (OLYMPUS BX 51.P). The complex dielectric permittivity was measured in planar orientation using a programmable automatic RCL meter (FLUKE PM 6306) in the frequency range 50 Hz to 1 MHz. The measurements were fully automated. The temperature, frequency, and bias field dependences of real and imaginary parts of the complex dielectric permittivity have been studied for FLC mixture.

## 4.0 Results and Discussion

The dielectric spectroscopy of this material has been reported in an ITO-coated cell of planar alignment, which was done in surface treated samples in the presence of an electric field. The temperature and frequency dependences of the principal components of the complex dielectric permittivity in the planar alignment $(\varepsilon_\perp)$ has been studied in SmC* phase. Thus the complex dielectric is given by $\varepsilon^*(\omega, T) = \varepsilon(\omega, T) - j\varepsilon''(\omega, T)$

Where $\omega = 2\pi f$ the angular frequency of the applied electric field and T is is the temperature, $f$ is the characteristic frequency connected to

relaxation mechanism which contribute to $\varepsilon^*(\omega, T)$ and is given by [16-22].

**4.1 Frequency and temperature dependence of dielectric permittivity and dielectric loss:**

The dielectric spectroscopy curve is shown Fig. (1) in the form of absorption curves absorption curve reflect conductance effect on low frequency region, it is also clear represent in Fig. 1. The dielectric absorption and combined conductance effect curves is shown in Figs. (2). These curves are gives dielectric parameters such as the relaxation frequency and dielectric strength of the ferroelectric material Figs. 3 and (4) shows the temperature dependent of dielectric permittivity and dielectric absorption in different phases.
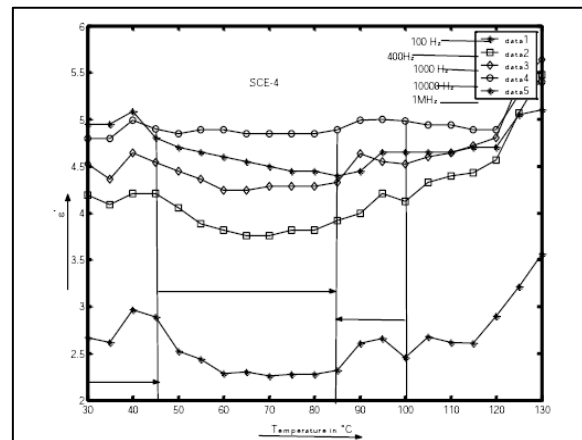
**Fig 1: Dielectric Permittivity (Real) as a Function of Frequency**
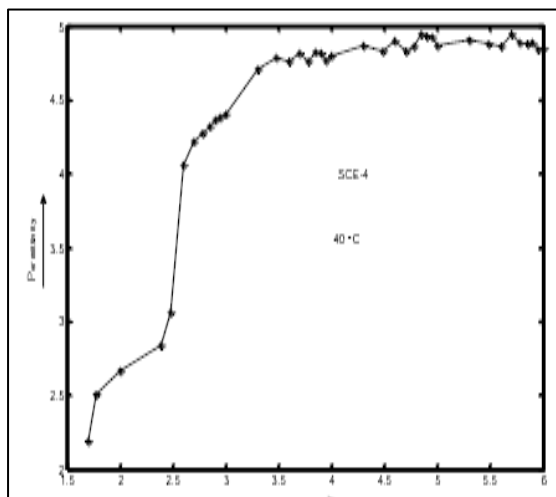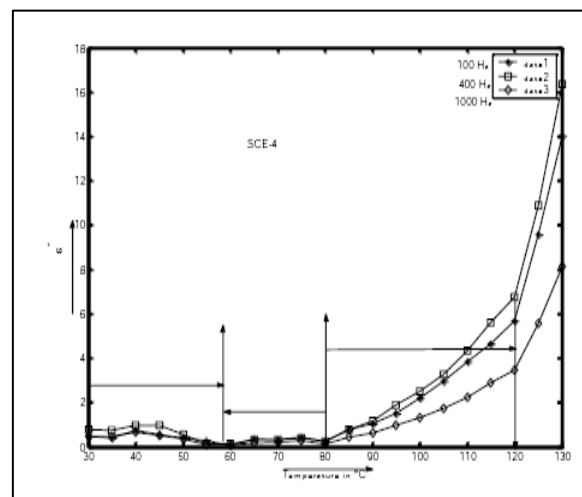


**Fig 2: Dielectric Permittivity (Imaginary) as a Function of Frequency**
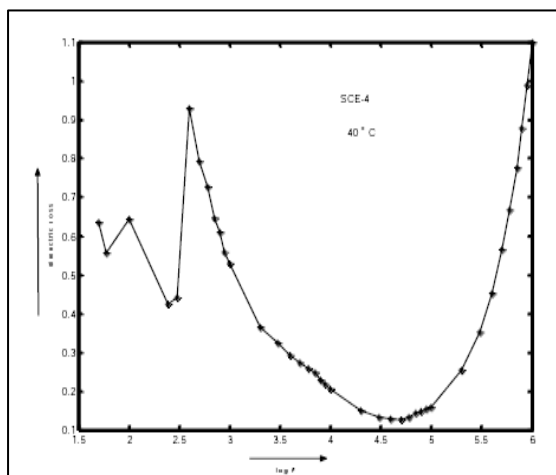


**Fig 3: Temperature Dependence of Dielectric Permittivity**



**Fig 4: Temperature Dependence of Material Phases and Dielectric Absorption**



**5.0 Summary**

1 A ferroelectric liquid crystalline material containing a lateral methyl group on the aromatic ring unit has been studied by dielectric spectroscopy. This material exhibits a broad transition temperature range.

2 The ITO conductance effect shown in lower frequency range clearly seen in fig (2). The relaxation frequency is found slightly independent of temperature in SmC*.

3 The result indicate that $\varepsilon_s'$ varies slowly with increasing the temperature for GM and slightly independent of temperature for SLM in SmC* while $\varepsilon_s'$ decreases suddenly at Tc* and follow the Curie Weiss law. Dielectric strength decreases with increasing the cell thickness in both phases.

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