Effect of Molecular Weight on Electro – Optic Switching Times of Liquid Crystal Polymer Doped with CeO2 Nanoparticles

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Abstract. Nonlinearity liquid crystal cell which doped with Ferroelectric nanoparticles characters studied in this paper according to their eclectic absorption. Polysiloxin series with side chain liquid polymers used with side chain polymers and molecular weight ran. This study consternate on polymers electro-optic characteristic with various molecular weights by using the mesogenic units and a stable polysiloxane. Suspension sensitivity or Electro-visual response to the mark of the used electric field, a real character to electric liquid crystals. The addition of CeO2, nanoparticles to polymer rise dielectric anisotropy and minimize response times. It observed that the voltages raised with molecular weight rising, and when intensity value rise, we gain voltage operating. Spectrometer used infrared measurements to locate the orientational order parameters, ($\bar{g}$1871) for liquid crystals with a side series. The orientational order parameters ($\bar{g}$1871) rely on temperature with various molecular weights and the threshold voltage.

Key words: CeO2 nanoparticles, polymer polysiloxane, electro – optic response.

1. Introduction
In 1888, Friedrich Reinitzer, an Austrian botanical physiologist, studied the physical-chemical characteristics of cholesterol derivatives. He found that there are two melting points at cholesteryl benzoate. It transforms into an intermediate opaque liquid at 145.5 °C and the murky liquid is transparent at 178.5 °C [1].
In all liquid crystal phases, the molecules in all liquid crystal (LC) phases spread almost similar to those of a liquid, but they retain some orientational order degree and occasionally some positional order as well during the diffusion [2].
There will be distinction between two types between liquid crystals. The former is thermotrope and the latter is lyotropic. Changing the temperature effects of transfer with liquid thermotropic crystals [3]. Recently, liquid crystals are well-known owing to their effective using in the flat...
panel displays applications. LCs have distinctive and attractive characteristics with full range, which provide enormous potential for novel applications [4].

Thermochromic liquid crystals (TLCs) respond to temperature’s changes by color changing. Their molecular structures are chiral (twisted) that are mixtures of optically-active organic chemicals. Chiral Nematic or Cholesteric LCs are the right name of these materials [5]. One of the most used nanoparticles is the ceria that can find many applications such as fuel cell, catalysts, phosphor (as luminescence), microelectronics chemical-mechanical polishing, and ceramic/glass metallurgical applications [6]. The objective of this work is to improve the properties of the LCs polymers by adding CeO2 nanoparticles.

2. Experimental:

The chemical structure and molecular weight of the most important influences on polymer activity and peak speed shows that the substance is rapidly evolving [7][8]. Blazers Z20 tin oxide-painted glass slides have been utilized with all the electro-optical cells that were developed in the current research. It was quickly cut and smooth enough to enable the manufacture of parallel plate cells. The chemical structure and molecular weight of the most important influences on polymer activity and peak speed shows that the substance is rapidly evolving.

The cell electrodes have been covered with a thin film of precursor polyimide [consisting of Rodehtal 322 (Rh one Poulenc chemical Ltd) solution in dimethyl formimed] utilizing a spin coater that operates at 4500 rpm. These coated slides have been heated for 30 minutes inside the oven at 80 °C. At ambient temperature using directed repeatable technique, they were then rubbed with a cloth in one hand and heated again at 130 °C for 30 minutes. Basically, it is put in the oven for one hour at 200 °C [9].

3. MATERIALS AND METHODS

3.1. Experimental Set-up:

- MK 1000
- Hes 402
- ALCT

The temperature controller (MK 1000 series) was used in this work that has high accuracy, precision along with its stability for measuring the temperature and controlling it. Coupling the temperature controller with heating-cooling equipment from instc resulted in an accurate temperature controlling up to 0.001 °C. There are two modes of operation: (i) keypad operation by the controller’s front panel, and (ii) by the pc software control to adjust the heating-cooling rate by the user and program the operating commands. The temperature was controlled to be 0.001°C and the data was saved in the computer. To measure the temperature, RTD thermistor (thermocouple) was used. The LC cell holders for several LC cells types were used to apply the electrical field to LC cells [10].

Temperature management mechanism including the MK 1000 monitor, Nitrogen bottle pump (LN2-p), and hot refrigeration step. It includes a wide double pane opening window for improved optimized thermal insulation such as the opening window defrosting system, gas sample chamber to analyze the gas, internal cover for improving temperature uniformity of the sample, vertical and horizontal mountings, micro positioner used to position the sample, application program, and win temp to permit the computer’s remote controlling [11].

ALCT sub-system was used for calculating liquid crystals, which includes ALCT-EO1 (termed latter as ALCT), holder of testing the cell, head of photo detector and connecting wires. The
mixture can be measured by ALCT system using LC test cell that prepared well and the correct method.

3.2. Physical parameters of the LC mixture:
- Constants of dielectric (g||, gz, g)
- Elastic constants (k11 & k33)
- Voltage of threshold (Vth)
- Current of polarization (IP)
- Viscosity (η)

3.3. LCD devices’s optical performance:
- Voltage-transmittance curve
- Switching speed, rise, falling time

WinLC application software offers the operator with an integrated tool for configuring the measuring system, data, collection, their analysis and visualization. The optical testing stall subsystem comprises light source (white LCD), holders for the rotatable heating-cooling stage and the photo detector, and polarizer. This test bench allows user to (Fig. 1):

![Scheme of the work system.](image-url)
4. Chemical structures:

The chemical structure of the used poly-siloxanes is shown in Fig. 2.

![Chemical structure of poly-siloxanes](image)

**Fig. 2.** Picture of a device.

5. Results

At the beginning of the transformation process, the variance in the intensity of the transmitted light in terms of the used voltage and the voltage that needed for each substance can be seen in the figures. The intensity of the transmitted light decreased with an increase in the required voltage that must be used to start the switching voltage, so that complete switching can be determined. With the increase of molecular weight Mw, the required voltage is increased. The degree of interconnection between the molecules is strong due to the viscosity $\eta$. The same performance has been reported for the liquid crystal poly-siloxane even though there were some variations in the voltage needed. The voltages required for complete orientation were defined, useful for the cell, and the needed time for complete orientation was determined.

Where Figs. (5-9) exhibit the relationship between the switching on-time on with the time that required to field is switched off the field prior the off measurement. We conducted cyclic experiments utilizing the system and method mentioned in the study, where we use $\tau_{on}$ values to check whether a steady state is achieved. Depending on the adopted system and the presented
methodology, a periodic experiment was applied at different values in order to specify the conditions at which the system reaches the stable state. It is worth to mention that the presented procedure allows to evaluate and sake of a complete transformation process. A peak to peak of (147-250) V is applied at 500 Hz frequency. The variation in the intensity of the light is transmitted as an applied voltage dependent function as well as the voltage required for completing the switching of every single material. As the TNI temperature decreased (TNI Nematic – isotropic transition temperature), the voltage required for complete switching had increased. Similar behavior was found for the materials used in the present work; however, materials used this work displayed significant variations in the required voltages. At temperatures close to isotropic nematic transition temperatures, where the polymer’s viscosity is relatively small, the effect of reproducible switching has been noted. Effect of reproducible switch is noticed close to the temperature of transition at which the polymer viscosity is comparatively low measured within the range of TNI-TNI-4 for the military vehicles 1 and 2. The applications has not been responded and the field for these materials was observed in the smectic phase. While, the measurements of materials No. 3, 4, and 5 were performed within the range of TNI-TNI-5. Both experiment sets were performed at constant temperature. The experimental system utilized for measuring the static electro characteristics was similarly applied for fluid electro-optical effects. Field measurements of 500Hz frequency have been used. In this work, infrared dichroism was utilized for analyzing the orientational ordering of the LC side-chain polymers on prealigned cells. To know the head portion orientation, various molecular weights have been used. This was achieved by monitoring the bands related to the vibrations of the relevant functional groups, where the main vibration absorption band $\text{C≡N}$ occurred in the $2235 \text{ cm}^{-1}$ region. LCs are temperature dependence due to their various molecular weights. Obviously, polymers having higher molecular weight showed the lower reflection for the formation of incomplete mono owing to the high value of viscosity. No experimental proof existed that the measurements were anything other than true stable value. Fig. (10) demonstrates that there are still significant differences in these molecular weight series, although the variations in order parameters are taken into consideration. The slope variation points out that the mesogenic side groups are closely coupled with the polymer chain, that has an important role also for the static electro-optic properties.

Fig. (4): Variation of the normalized intensity with voltage for polymer 1,2,3,4,5
Fig. (5): Switching – on ($\tau^{on}$) and time left off ($\tau^{off}$) at constant temperature below TNI for polymer 1

Fig. (6): Switching – on ($\tau^{on}$) and time left off ($\tau^{off}$) at constant temperature below TNI for polymer 2

Fig. (7): Switching – on ($\tau^{on}$) and time left off ($\tau^{off}$) at constant temperature below TNI for polymer 3
Fig. (8): Switching – on ($\tau^{on}$) and time left off ($\tau^{off}$) at constant temperature below TNI for polymer 4

Fig. (9): The variation of the measured order parameter $S$ obtained through Measurement of the infra-red dichroism

Fig.(10): Threshold voltages a function of temperature for polymer poly - siloxanes.
6. Discussion

This research focused on the electro-optic characteristics of polymers’ series having various molecular weights on the basis of the polysiloxane backbone by attaching CeO₂ nanoparticles equivalent to the polymer polysiloxane with the side chain (0.1% weight). The chemical structure and molecular weight of the most important influences on polymer activity and peak speed shows that the substance is rapidly evolving. Nanoparticles tend to increase polymer viscosity and enhance the connectivity of polymer shedding when an electrical field is applied. This would decrease the switching times and help to reduce the grade step transfer of polymers (τ\textsubscript{on}, τ\textsubscript{off}). The mesogenic units in the polymer did not reacted on the same time scale. Chains of polymer might need more time for reaching equilibrium state and might take three days or more to remove the electric field because of its nature of coupling. This relatively slow polymer chain relaxation was detected only in the case when the subsequent is affected by the electrical field.

Clearly, increasing the molecular weight have no influence on the Δε value; therefore, the threshold voltage will be constant in the case that the constant of elastic curvature is not influenced by the polymerization degree. On the other hand, it was observed that U\textsubscript{c} increasing of the intrinsic molecular weight led to increase the elastic constant (K\textsubscript{11}).

Variation in the degree of polymerisation in the polysiloxane-based side chain LC polymers influenced the phase behavior, the order parameter, and the electro-optic properties. The decrease in molecular weight was seen to be lower. For high molecular weight polymers (materials No.1, 2 and 3), the transition temperature phase was noticed with a little nematic range whereas only the nematic process was observed for low molecular weight materials (i.e. No.4 and 5).

Finally, adding nanoparticles of CeO₂ led to increase the density of the mesogen units in either situation. Connected to a series of polymers for increasing the dual-electrode parallel group Syano molecules torque along the mesogenic axis region, the dielectric anisotropy is in effect increased Δε.

7. References

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