Effect of Cerium Oxide (CeO₂) nanoparticles on electro-optic responses of acrylate liquid crystal polymer

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Abstract:
This study focused on the electro-optical properties of a liquid crystal which contains a back bone of acrylate. A fixed molecular weight of liquid crystal acrylate was applied to five separate amounts of nanoparticles (CeO₂), impacting the electro-optical properties of the liquid crystal. The added nanoparticles can lower the glass transfer temperature, resulting in a decrease in the processing period leading to an improvement in the polymer’s viscosity which has significantly influenced the liquid crystal polymer’s optic properties.
In this work we notice that the light strength of the lasers will decrease by growing the added nanoparticles, and thus the opening period will be decreased.

Key words: CeO₂ nanoparticles, polymer polysiloxane, electro-optic response

1. Introduction
The history of liquid crystals began in the 20th century, especially in 1888. When Frederick Rinzer was revealed by the world that the Benzoie cholesterol fused at a temperature of 145.5 C [1]. The fluid produced between solids and liquid (unclear) was defined as a fourth case of matter by the German physicist Ituilmann, added to the known solid, liquid, and gaseous states. The physicist Lehman called this situation a liquid crystalline state, and this designation stemmed from its liquid-like molecular structure[2]. The requisite requirement to be present in the compound to be liquid crystal is that there is a difference in the physical properties of the liquid crystal with the crystalline shape of molecules with specific properties[3].

Such various characteristics of liquid crystal are: birefringence, elasticity, electrical conductivity, viscosity and refractive index [4]. In general, a
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The liquid crystalline phase is characterized in terms of the intermolecular order that its constituent molecules show. There are three degrees of long-range positional order in a crystalline phase. At least one of these degrees is removed in a liquid crystalline phase and in no long-range positional order in a liquid phase. However, short-range rotation or orientation order can exist[5]. As anisotropy shape is a prerequisite in this definition, we could expect also anisotropic macroscopic properties such as refractive index, electrical conductivity, viscosity and elasticity. Since liquid crystalline substances are often fluid, it is possible to use external forces (magnetic, electrical, optical, mechanical and thermal) to produce changes in these properties. It was the interdependence of the optical and electrical properties and the search for modern electro-optical technologies that culminated in the recent revival of interest in liquid crystalline phases[6].

2. Experimental Methods

In this study, slides must be constructed to measure electro-optical properties for liquid crystal content, the glass being picked, washed and colored with a substrate (tin-oxide) (conductive material). The glass plate is rolled and then sliced into 6 cm glass plates. On the (2 cm) glass sheet, the Etched paste is positioned to dispose of the conductive substance on all ends of the glass sheets. The glass is first washed with water and then cleaned with an ultrasound system for 30min, then dried in an oven (80°C) for (30 min) and then rubbed in one direction with a sheet of fabric. The container is then packed with an acrylate polymer and heated for (10-15 min) at a temperature greater than $T_C$. Afterwards the second glass layer is used as a shield between the two ones. The thickness of KAPTON (0.025 mm) is used to link the conductive wires to the core. The cell is ready for that[7]. The operating system consists of a sensitive
laser (He-Ne Laser gas) of 0.95 mw and wavelength (632 nm), as well as a polarizer for determining the direction of the laser light and a heating chamber in which the cell is placed and also the analyzer, Which is vertically oriented towards the direction of the polarizer and also the source of electricity (function generator) for generating the sinusoidal wave and amplifying this wave by the amplifier The alternating voltages are determined by the signal generator to be mounted on the cell, and a thermo-controller maintains the cell at a constant temperature and for a specific time[8,9].

![Figure 1](image_url)

*Figure(1). illustrates the working system used*

The electro-optical properties are measured through three main instruments: Device HCS302, ALCT, MK1000
This method is used to calculate reaction times using optics. The cell is positioned within a hot stage in order to test the voltages under which we get a full orientation called switching voltage.

That is perpendicular to the liquid-crystalline molecules longitudinal axis. It then goes into the analyzer that is outside the heating chamber to travel as intensively as possible through the laser spectrum. The Photovoltaic Cell calculates this intensity. This way, various voltage values are retrieved. Note that laser light intensity is diminishing as the voltages increase.

The voltage reduces until the voltages exceed the value where complete switching is then considered final. This cycle is replicated for all models with various concentrations of nanoparticles (CeO$_2$) and then the time interval is determined between the highest and the lowest strength and this duration is called the opening time, Full routing voltage and opening times are calculated for each cell.

Additionally, the closure time, the time needed to return the laser beam strength to its first condition, is determined before the voltages are applied[10,11].

3. Results

The electro-optical properties are measured for each model, we studied the side-chain liquid crystal made of acrylate polymer. The liquid crystal's molecular weight is stable (1.7106 g / mol). We get 5 separate types of polymer (P1,P2,P3,P4,P5).

Different amounts of nanoparticles (CeO$_2$) are applied to the liquid crystals which increase the conductivity of polymers when the application for electricity is filed, Which improvement The guideline system status was evaluated, and the electrical and optical properties improved.

The results are obtained in figures ((4.1),(4.2),(4.3),(4.4) and (4.5) by adding different proportions of nanotubes (CeO$_2$) to a liquid crystal (acrylate) and with a constant frequency voltage (500 Hz) and a temperature below T$_{NI}$.
Figure. (2): Variation of the normalized intensity for addition P1

Figure. (3): Variation of the normalized intensity for addition P2
Figure (4): Variation of the normalized intensity for addition P 3.

Figure (5): Variation of the normalized intensity for addition P 4.
Figure (6): Variation of the normalized intensity for addition P 5.

The results indicate that, with the increase in the ratio of the added nanoparticles, the threshold voltage and operating voltage value decreases. As applied to the liquid crystal polymer, nanoparticles raise the tangency of the substance, which decreases its mass, decreases the dipole group and therefore improves the insulation properties.

Threshold voltage lower and operating voltage lower. As shown in figures (7) and (8).

Figure (7): shows the relationship of the threshold voltage is added with the five used in this study ratios.
Fig (8): shows the operating voltage as a function of rates CeO$_2$ added to the polymer

Optical reaction times are improved by increasing the amounts of nanoparticles applied to liquid crystal acrylate (CeO$_2$).

Notice that the visual reaction becomes quicker (opening time faster) by inserting CeO$_2$ nanoparticles as it decreases the degree of curi transformation resulting in decreased optical response times and the following shapes demonstrate the association between response times and...
Figure (9): Switching-on ($\tau_{on}$) and time left off ($\tau_{off}$) for addition P 1

Figure (10): Switching-on ($\tau_{on}$) and time left off ($\tau_{off}$) for addition P 2
Figure (11): Switching-on ($\tau_{on}$) and time left off ($\tau_{off}$) for addition P3.

Figure (12): Switching-on ($\tau_{on}$) and time left off ($\tau_{off}$) for addition P4.
As the percentage of nanomaterial added rises, the opening period decreases, and this is seen in Figure (14).

Figure (13): Switching–on ($\tau_{on}$) and time left off ($\tau_{off}$) for addition P 5

Figure (14): Switching – on ($\tau_{on}$) as a function of the ratios addition.
4. Conclusion

The effect of nanoparticles adding on the acrylite crystalline polymer has been studied in this study. A constant molecular weight of liquid crystal polymer has been added to diverse proportions of nanoparticles.

It was found that the added nanoparticles affect the elasticity of the polymer chain, which plays a significant role in electro-optical properties, which increases the polymer ’s viscosity and thus reduces the degree of polymer transmission, which reduces the opening time of the liquid crystal polymer.

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