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Effect of Nanoparticles ($BaTiO_3$) on the Optical Properties of Liquid Crystal (Acrylate)

Khalid Al. Ammar and Baidaa Y. Mohemed
Department of Physics, College of Education for Pure Sciences, University of Babylon, Hillah, Iraq
baidaayehia@yahoo.com

Abstract: This study focused on the electro-optical properties of a liquid crystal containing an acrylate back bone. Five different proportions of nanoparticles ($BaTiO_3$) were added to a constant molecular weight of liquid crystal acrylate, affecting the electro-optical properties of the liquid crystal. The added nanoparticles will reduce the temperature of the glass transition, resulting in a reduction in the transformation time due to an increase in the viscosity of the polymer that has greatly affected the optical properties of the liquid crystal polymer. In this recearch, we note that by increasing the added nanoparticles, the light intensity of the lasers will decrease and therefore, the opening time will be reduced.

Key words: ($BaTiO_3$), acrylate, liquid crystal, nanoparticles, optical properties, lasers

INTRODUCTION

There are many researchers who used different polymers and attended them in different ways and got different applications (Ammar and Salih, 2017, 2018; Ammar and Al-Jamal, 2018; Blumstein, 1978; De Gennes and Prost, 1993; Drexler, 1989; Finkelmann *et al*., 1979; Gray and Goodby, 1984). The history of liquid crystals began in the twentieth century, specifically in 1888 (McArdle, 1989). When the world revealed Frederick Rinzer that the cholesterol Benzoie fused at a temperature of 145.5°C (Obaid *et al*., 2016; Saengsuwan *et al*., 2003).

In 1890, German physicist Etoileman described the fluid formed between solid and liquid (unclear) states that it was added to the states of the known cases (solid, liquid and gaseous). Lehmann called this situation a liquid crystal state, this label came from its molecular structure similar to fluids (Shibaev, 1981).

The necessary condition to be available in the compound to be liquid crystal is to have the crystalline form of molecules of different properties there is a contrast in the physical properties of the liquid crystal.

These different qualities of the liquid crystal are: birefringence, elasticity, electrical conductivity, viscosity and refractive index. These properties vary from solid to liquid properties (Obaid *et al*., 2016).

A liquid crystalline phase is generally, defined in terms of the intermolecular order exhibited by its constituent molecules. In a crystalline phase there are 3° of long-range positional order. In a liquid crystalline phase at least one of these degrees is removed and in a liquid phase there in no long-range positional order. There may, however, exist short-range rotation or orientational order (Finkelmann *et al*., 1979).

As anisotropy shape is a prerequisite in this definition we might expect macroscopic properties such as refractive index, electric conductivity, viscosity and elasticity also, to be anisotropic. Since, liquid crystalline phases are also fluid, external fields (magnetic, electrical, optical, mechanical and thermal) may be used to induce changes in these properties. It was the interdependence of the optical and electrical properties and the quest as anisotropy shape is a prerequisite in this definition we might expect macroscopic properties such as refractive index, electric conductivity, viscosity and elasticity also, to be anisotropic. Since, liquid crystalline phases are also fluid, external fields (magnetic, electrical, optical, mechanical and thermal) may be used to induce changes in these properties. It was the interdependence of the optical and electrical properties and the quest for new electro-optic devices that led to the recent resurgence of interest in liquid crystalline phases.

MATERIALS AND METHODS

In this research, slides must be styled for liquid crystal material to calculate electro-optical properties. The

Corresponding Author: Khalid Al. Ammar, Department of Physics, College of Education for Pure Sciences, University of Babylon, Hillah, Iraq, baidaayehia@yahoo.com

glass is selected, cleaned and dyed with a (tin-oxide) material (material conductive). The glass plate is wrapped and then cut into glass slides of 6 cm. The Etched mixture is placed on the (2 cm) glass slide to dispose of the conductive material on both ends of the glass panels. The glass is then, washed with water and then cleaned with an ultrasound device for 30 min and then dried in an (80°C) oven for (30 min). Then, wipe it with a piece of cloth in one direction. The cell is then filled with an acrylate polymer and heated for (10-15 min) for a temperature $>T_C$. The second glass plate is then used as a buffer between the two plates. Kapton (0.025 mm) thickness is used to connect the conductive wires to the cell. The cell is ready (Gray and Goodby, 1984).

The working system consists of a sensitive laser (He-Ne Laser gas) of 0.95 mW and wavelength (632 nm) as well as a polarizer to determine the direction of the laser light and also, a heating chamber into which the cell is placed and also, the analyzer which is oriented vertically on the direction of the polarizer and also a source of electricity (function generator) to generate the sinusoidal wave and amplify this wave by the amplifier. The alternating voltages are calculated by the signal generator to be placed on the cell and the cell is maintained at a constant temperature and for a specific time by a thermo-controller (Blumstein, 1978; Saengsuman *et al*., 2003). There are three main instruments for measuring the electro-optical properties:

- HCS302 device
- MK1000
- ALCT

This system is used to measure optic response times. The cell is placed inside a hot stage to measure the voltages where we get a complete orientation called switching voltage. The polarized laser is then placed on the cell which is perpendicular to the longitudinal axis of the liquid crystalline molecules. It then passes through the analyzer that is outside the heating chamber to pass the laser light through it as intensely as possible. This intensity is calculated by the photovoltaic cell.

This method returns different voltage values. Note that the intensity of the laser light decreases as the voltages increase. The voltage decreases until the voltages reach the value at which full routing is then called complete switching.

This process is repeated for all models containing different proportions of nanoparticals $(BaTiO_3)$ and then the time period is calculated between the highest and lowest intensity and this time is called the opening time, the full routing voltage and the opening time of each cell are calculated. Also, the closing time, the time required for the return of the intensity of the laser beam to its first, state is calculated before the voltages are applied.

RESULTS AND DISCUSSION

The electro-optical properties of each model are measured. We studied the liquid crystal with a side chain made of acrylate polymer. The molecular weight of the liquid crystal is stabilized amount (1.7×10^6 g/mol). Different proportions of nanoparticle $(BaTiO_3)$ (0.07, 0.1, 0.13, 0.16, 0.19%) are added to the liquid crystals, we obtain five measurement models (P_1-P_5) which increase the polymer conductivity when the electric filed application which improve. It evaluated the guideline system state and improve the electrical and optical properties. When adding different proportions of nanotubes $(BaTiO_3)$ to a liquid crystal (acrylate) and with a constant frequency voltage (500 Hz) and a temperature below than T_{NI}, we obtain the results in Fig. 1-5.

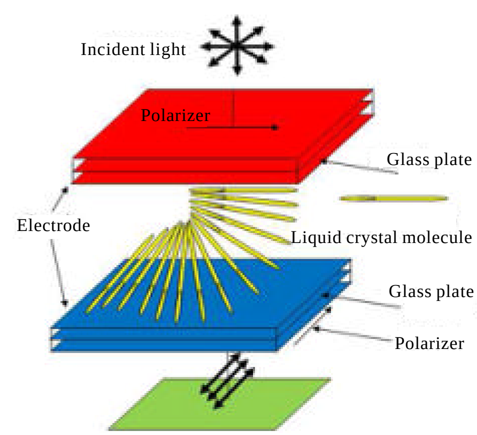

Fig. 1: The working system used

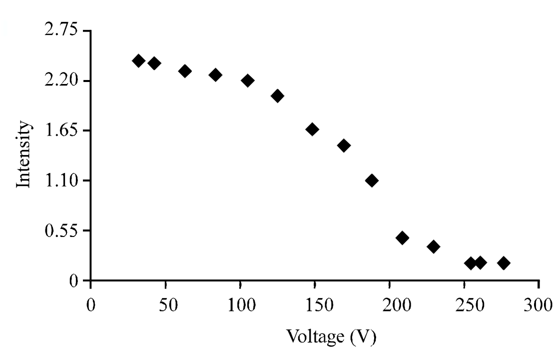

Fig. 2: Variation of the normalized intensity for addition P1

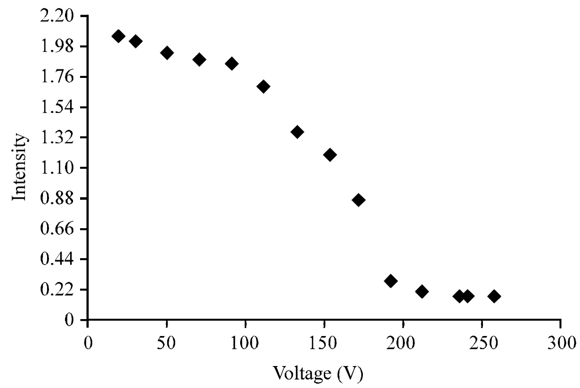

Fig. 3: Variation of the normalized intensity for addition P2

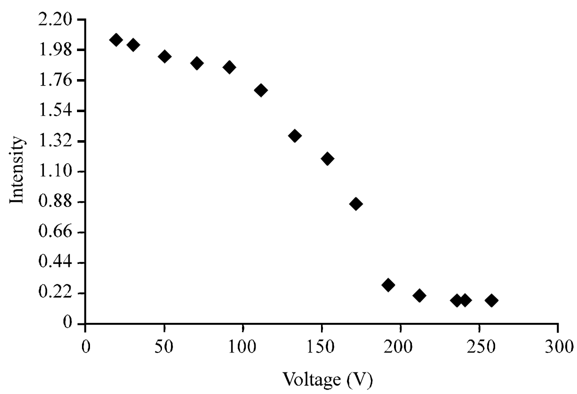

Fig. 4: Variation of the normalized intensity for addition P3

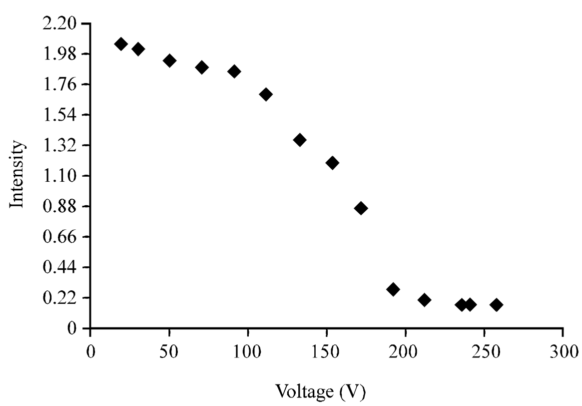

Fig. 5: Variation of the normalized intensity for addition P4

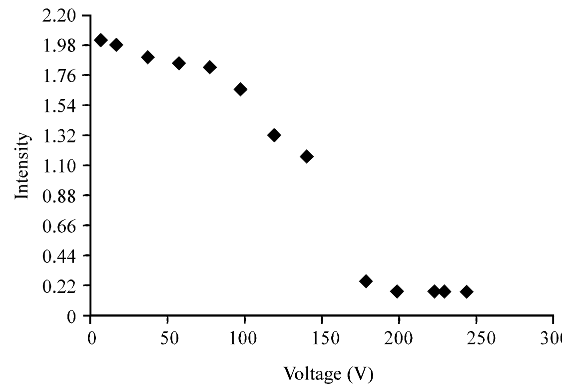

Fig. 6: Variation of the normalized intensity for addition P5

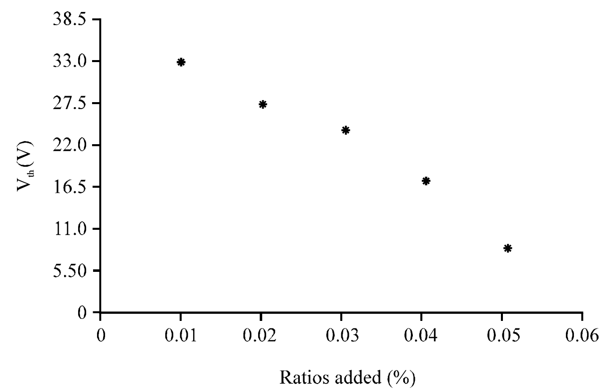

Fig. 7: The relationship of the threshold voltage is added with the five used in this study ratios

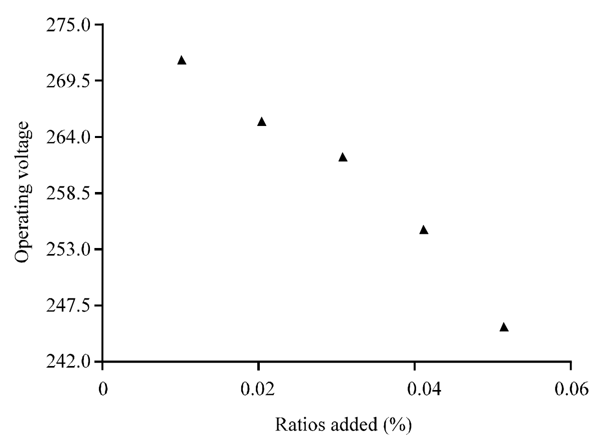

Fig. 8: The operating voltage as a function of rates $BaTiO_3$ added to the polymer

We note that, we obtained the threshold voltage for the polymer used and another effort is called full-voltage guidance or operating voltages.

The results indicate that the value of the threshold voltage and operating voltage decreases with the increase in the ratio of the added nanoparticles. The nanoparticles will increase the material's tangency when added to the liquid crystal polymer which increases its density, increasing the dipole group and also increasing the isolation properties. As in Fig. 6-8 optical response times are increased by increasing the added ratios of

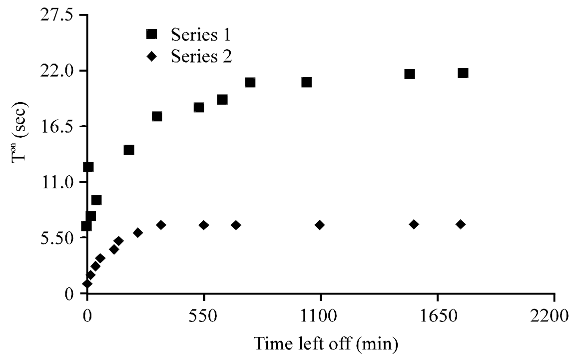

Fig. 9: Switching-on ($\bullet^{on}$) and time left off ($\bullet^{off}$) for addition P1

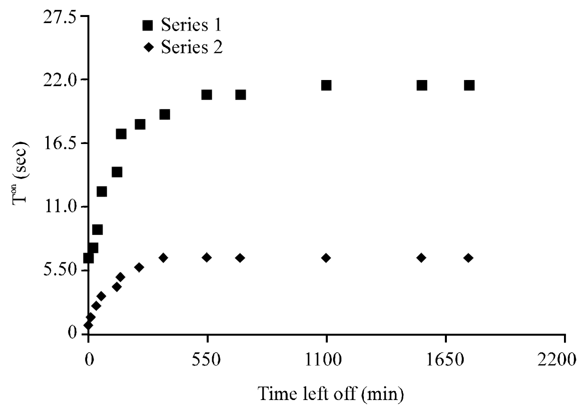

Fig. 10: Switching-on ($\bullet^{on}$) and time left off ($\bullet^{off}$) for addition P2

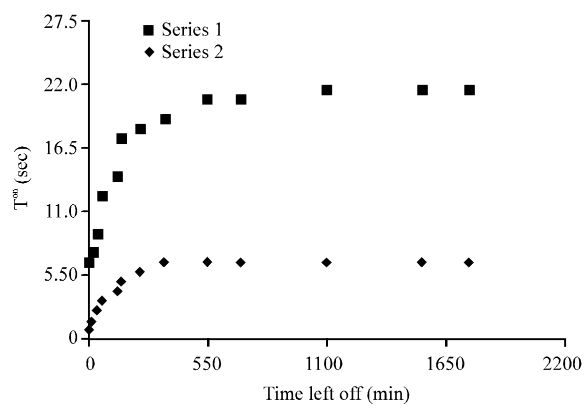

Fig. 11: Switching-on ($\bullet^{on}$) and time left off ($\bullet$ ^{off} for addition P3

nanoparticals ($BaTiO_3$) to liquid crystal acrylate (Fig. 9-13) note that, the visual response is faster times (opening time faster) when adding nanoparticles $BaTiO_3$ because it reduces the curi transition degree which leads to reduced optical response times and the following shapes illustrate the relationship between response times and temperature.

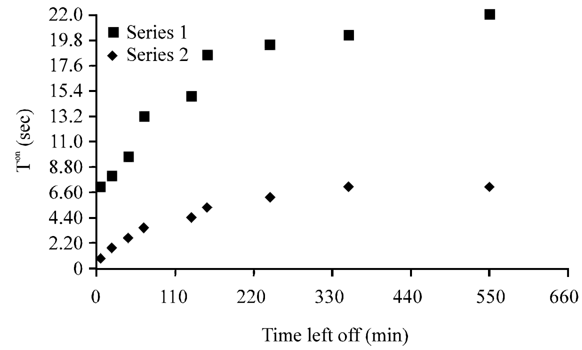

Fig. 12: Switching-on ($\bullet^{on}$) and time left off ($\bullet^{off}$) for addition P4

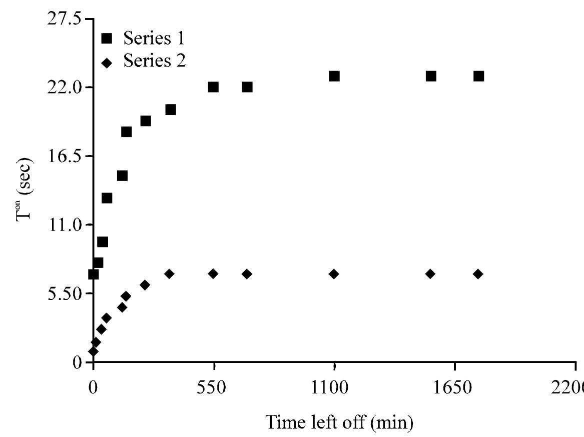

Fig. 13: Switching-on ($\bullet^{on}$) and time left off ($\bullet^{off}$) for addition P5

CONCLUSION

In this study, the effect of addition of nanoparticles on the acrylite crystalline polymer was studied. Various proportions of nanoparticles were added to a constant molecular weight of liquid crystal polymer. It was found that the nanoparticles added affect the elasticity of the polymer chain which plays an important role in electro-optical properties which increases the viscosity of the polymer and thus, reduces the degree of polymer transmission which reduces the opening time of the liquid crystal polymer.

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