International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.12, pp 823-832, 2016

Effect of Gold Nanoparticles on Thermal, Mechanical and Optical Properties of Polysiloxane polymer

[*1]Khalid Al.Ammar, [2]Muneer Abdalh

[1,2]Physics Department-college of Education for pure science, Babylon University, IRAQ

Abstract: We investigated the nonlinearity of liquid crystal cell doped with gold nanoparticales by considering their selective absorption. Such nonlinearities are promising for optical processing applications and optical limiters. Systems displaying thermal nonlinearities are particularly attractive as the maximum nonlinearity m occur in the absence of an applied field and and additionally this nonlinearity can be controlled by the reorientation of the liquid crystal. This study focuses on the electro –optic properties of polymer with a dfferent ratios of gold nanoparticles addition to the polysiloxane polymer, it is fond that there is a strong coupling between the mesogenic side chain groups and the polymer chain that the elasticity of the polymer chain plays a strong role even in the static electro-optic properties. The switching time (on) and (off) have been measured through the period between planer and homotropic alignment which happens under the electrical field effect. Additionally, it is found that adding gold nanoparticales moieties will decrease the phase transition temperatures and thus decreasing of switching times. The variation of the threshold voltage is measured at constant steps below nematic –isotropic transition temperature (T_{NI}) series of polymer. It is found with increasing proportion gold added to the polymer related to reduce the threshold voltage of electro-optic response and this is related to the intrinsic elastic constant of the liquid crystal polymers. The performance of the electro-optical cells has improved after add the barium titanate would reduce the contribution of the dibole moment of the cyano-groub baralle to the molecular long axis of the mesogenic unit and thus reduce density of the mesognic unit attached to polymer chaine and lead to a increase of dielectric anisotropic (ε) and thus enhanced backbone mobility for the system.
Keywords : Gold Nanoparticles, Polysiloxane, electro-Optical Properties.

Introduction

The history of liquid crystals dates back to 1888 when Austrian chemist, Friedrich Reinitzer discovered that cholesterol benzoate seemed to have two melting points (145.5 ^{o}C and 178.5 ^{o}C). At 145.5 ^{o}C, the solid crystal melted into a cloudy liquid which existed until 178.5 ^{o}C where the cloudiness disappeared, giving a clear transparent liquid.

When contacted to unravel the puzzle, Otto Lehmann, a German physicist, discovered that the cloudy liquid has a unique kind of order and that it was a new state of matter, thereby coined its name 'Liquid Crystal[1].

The liquid crystal state is considered to be the 'fourth state of matter' along with solid, liquid and gas. Crystals and liquids are the most common condensed phases of matter and the only difference is the ordering of their molecules. While the molecules in crystal are both positionally and orientationally ordered thereby occupying a specific sites in a lattice, those in a liquid are not. Liquid crystals constitute a fascinating class of condensed matter characterised by both fluidity and long-range order (some degree of orientational and sometimes positional order)[2,3].

Liquid crystals represent a number of different states of matter in which the degree of molecular order lies intermediate between the almost perfect long-range positional and orientational order found in solid crystals and the statistical long-range disorder found in ordinary isotropic amorphous liquids and gases[4].

The properties in a normal liquid are isotropic, that is they are the same in all directions but in liquid crystals, they strongly depend on direction even if the substance itself is a fluid.

French theoretical Georges Friedel 1922,[5]contributed his mesophase states of matter to the Annales des physiques. This 200 pages work established much of the current terminology in mesophase physics. First, the nematic phase he characterized as having microscopic threads. Second, he had coined the term smectic phase for a layered mesophase having the structure of neat soap. Third, used the term cholesteric phase for materials.

The development of liquid crystals displayed in 1960, produced a veritable explosion of research activity which often involved chemists and physicists working closely together. In 1972, Pierre - Gilles de Gennes[6] founded relationship between liquid crystals and superconductors and magnetic materials. His work was rewarded with the Nobel Prize in physics in 1991.

Through the past years noted constantly development in the liquid crystals polymer, this qualitative development, and completed by scientists worked hard to get to these results. So the development in the liquid crystal is continuous.

Experimental

The procedures followed for the construction of electro-optic cells with predefind director orientation in these investigations were similar to those developed for low molecular weight liquid crystal. Blazers Z20 tin oxide –coated glass slides were used for all electro –optic cells constructed in this work. this was easily cut and was sufficiently flat to allow the fabrication of cells with parallel plate separation to within a few seconds of arc the glass was cut into plate of approximately 6cm^2 area, and etched using HCL acid with zinc metal powder as a catalyst to give a 2cm^2 electrode surface. Each glass plate was then washed hand –by- hand in soup and water and cleand in an ultrasonic bath for 30 minutes at 65C.The plates were then rinsed in distilled water and dried in an oven for 20 minutes as 60c.This treatment produced plates sufficiently clean for the surface treatment procedure which is the subject of the next section .in this work One technique was used to achieve uniform planer alignment of the liquid crystal director.

The cell electrodes were coated with a thin layer of polyimjde precursor [consisting of a 5% solution of Rodehftal 322 (Rh one poulenc chemical Ltd.) in dimethyl formaimed]in dimethyl formaimed] using a spin-coater running at 4,500 r.p.m these coated slides were heated in an oven for 30 minutes at 80 C they were then rubbed at room temperature in a single direction with a cloth using controlled repeatable procedure , heated again for 30 minutes 130C, finallyn it will be putted for one hourat 200C in the oven.

Experimental Set-up

The most important three devices were used in this work for electro – optic measurement are Mk 1000, ALCT, and HCS 402.

1. Mk 10002 . HCS4023 . ALCT

The Mk 1000 series temperature controller offers precision, accuracy, and stability for temperature measurement and control. It provides temperature control resolution and precision to 0.001°C, accommodates both Platinum RTD and individually calibrated thermistors as temperature sensors, and can optionally control

up to four (4) instec hot and cold stages, plates, or chucks. Two operation modes keypad operation using the front panal of the controller, or software control though pc as well as. Adjustable ramp (rate of heating /cooling) to user set temperature point programmable operation command set precisely controls temperature to 0.001°C option save temperature data to the computer RTD thermositor or thermocouple, LC cell holders for many types of LC cells.

Features :

1-Accurate to (0.001°C) temperature resolution and precision.

2-Two operation modes, keypad operation using the front panel of the controller, or software control though PC .

3-User adjustable ramp (rate of heating / cooling) to user set temperature point .

4-Program able operation command set.

5-Wide temperature range

6-Accurate to (0.001C)temperature resolution and precision preure to 0.001c option savetemperature data to the computer RTD thermistor or thermocouple , LC cell holders for many types of LC cells.

Temperature control system includes MK1000 controller, nitrogen container nitrogen pump (LN2 - p), and hot – cooling stage. Temperature sensor RTD thermistor or thermocouple, (for thermistor sensor, the heating limit is 250 ^{o}C), and operation environment: temperature 0 ~ 50 ^{o}C humidity < 85% RH with minimal electromagnetic interference. Dual pane window for better thermal isolation, integrated aperture window defrost system, inner lid for improved sample temperature uniformity, vertical and horizontal mounting, optional precision X –Y micropositionar for sample positioning and application software win-temp allows remote control from host computer.

Optical test bench subsystem:

This includes light source, polarizer, rotatable hot – cooling stage holder analyzer, and photo detector holder. This test bench allows user to:

1. Arrange polarizer and analyzer perpendicular and parallel to each other.

2. Test cell in side of the hot-cooling stage can be rotated in full 360^{o} range.

3. Light source, polarizer and analyzer are installed in sealed dark sections to prevent the contamination of optical components.

4. Light sealable working chamber shields a way the room lighting.

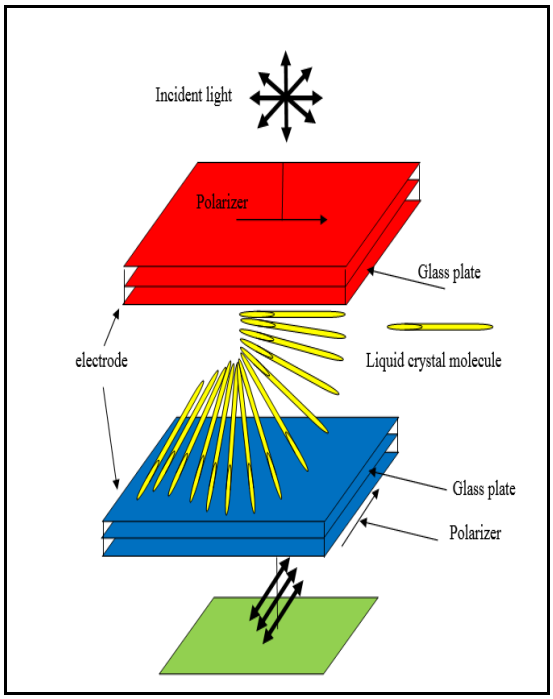

Figure 1: Structure of schematic of electro-optic cell**.**

Figure 2: Picture of advices with optical tast benach subsystem.

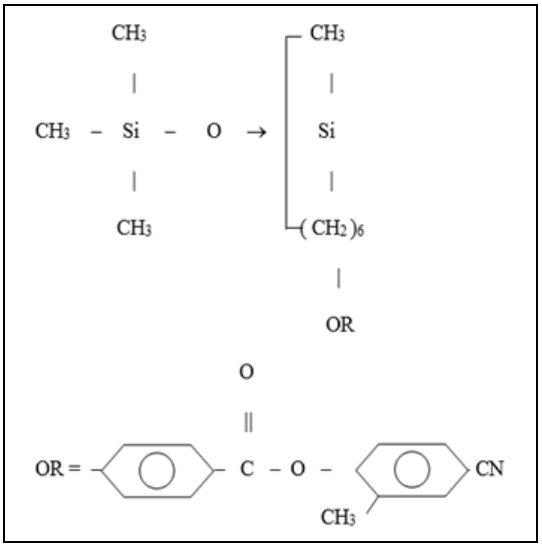

Figure 3: materials chemical structures.

Table (1) : Molecular weight and the Ratios of addition Gold nanoparticles material.

Polymer	Molecular weight	Ratios addition Au material
1	**$1.7x10^6$**	***0.7***
2	**$1.7x10^6$**	***0.1***
3	**$1.7x10^6$**	***0.13***
4	**$1.7x10^6$**	***0.16***
5	**$1.7x10^6$**	***0.19***

Results

Voltages necessary to make a complete switching defined by figures (4-8). And from these figures it can be seen the variation of the transmitted light intensity as a function of the applied voltage and the required voltage for each material. For getting on the switching, voltage must be the transmitted light intensity decrement with increasing of the required voltage, so it can be determine to complete switching. the same behavior was observed for the polysiloxane liquid crystal, a though there are some differences in the required voltage. The voltage for the complete orientation are identified, applied to the cell, and calculates the reguired time to the occurrence of complete orientation.where fig(9-13) show swith on-time on as function of the time for which the field is switched off before the t_{off} measurement. Using the system and the method described in work ,we have implemented acyclic experiment in which we use the values of the t_{on} to determine when asteady state is reach .as mentioned in work the approach allows both the t_{on} and the t_{off} to be evaluated. In order to achieve complete switching we typically applied (147-250)volt (peak to peak) at a frequency of $500H_Z$. The variation of the transmitted light intensity as a function of the applied voltage and the required voltage for each material in this work for complete switching. By reducing the temperature TNI the saturation states showed in these figures shifted, the required voltage for complete switching was increased in this case. The same behavior was observed for the materials in work although the materials in this work show lrger differences between the required voltages for each material compared with the materials in work. Reproducible switching effect were observed at temperatures close to the nematic –isotropic transition temperature where the viscosity of the polymer is relatively low and measurement were made in the range of T_{NI} to T_{NI} -4 for matrials no.1 and 2 and no response to the applied field had been observed for these materials in the smectic phase but measurements were made for the materials no .3.4 and 5 in the range of T_{NI} to T_{NI} - 5 at the same time reproducible swiching effects were observed in the smectic phase no.3 show t_{on} as a function of the time for respectively, each set of experiment were made at constant temperature. The experimental arrangement used for the static electro properties is similarly used for the dynamic electro-optic effects .fields with a ferquency of $500H_Z$ were employed for measurements .the static electro-optic properties are important because they contain important experiments between the threshold voltage U_C and curvature elastic constants K_{ii} and their relationship to composition and temperature for the liquid crystal copolymers. The results obtained for the material in this study are presented in fig(14).

There is a marked reduction in the threshold voltage for increasing temperature andIncrease gold nanoparticles additives particles. In this series of polymers, fig(15) makes a direct comparison of the threshold voltage obtained in the nematic phase at a constant step below T_{NI} for the series of polymers prepared . it is clear that there is an decrease in the threshold voltage with increasing (Au) nanoparticles. Indeed if the effect of the end – groups of the polymer chains are taken into account then the trend will be even more marked .it is emphasized that any dynamic effects arising from changing viscosity have been eliminated in the procedures outlined above. A few contributions ,have dealt with measuring the threshold voltage for polysiloxane polymers. threshold voltages reported are broadly similar to those found here .the marked increase of the threshold voltage with temperature follows similar dependence observed of the materials ,in which the mesogenic density along the polymer backbone is changed.it is noticeable that there is no sudden step in the threshold voltage at the transition from nematic to smectic phases for polymers 3. From a smectic phases the value of k_{ii} is usually similar to that observed for the nematic phase, since layer deformation is a relatively facile process.

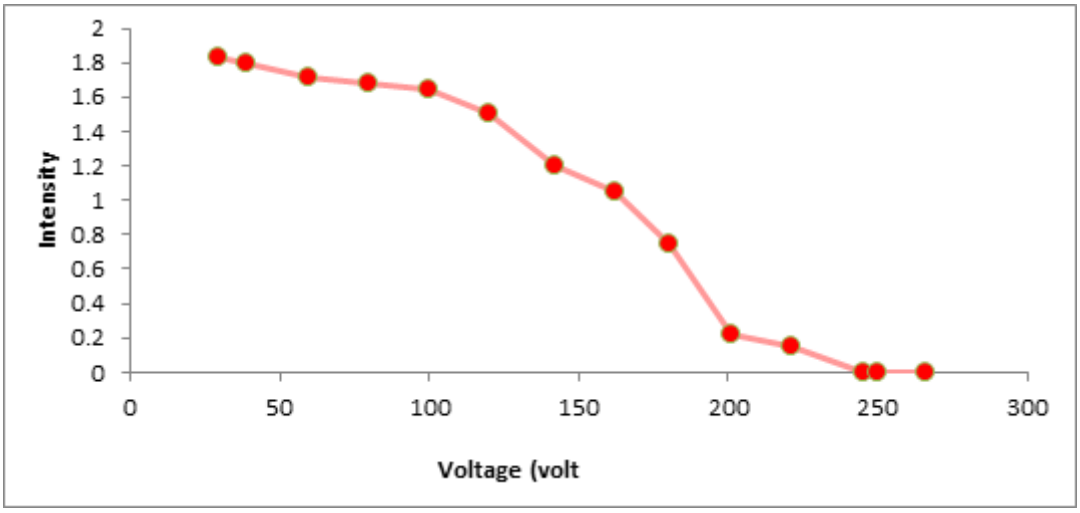

Figure 4: Variation of the normalized intensity with voltage for polymer 1.

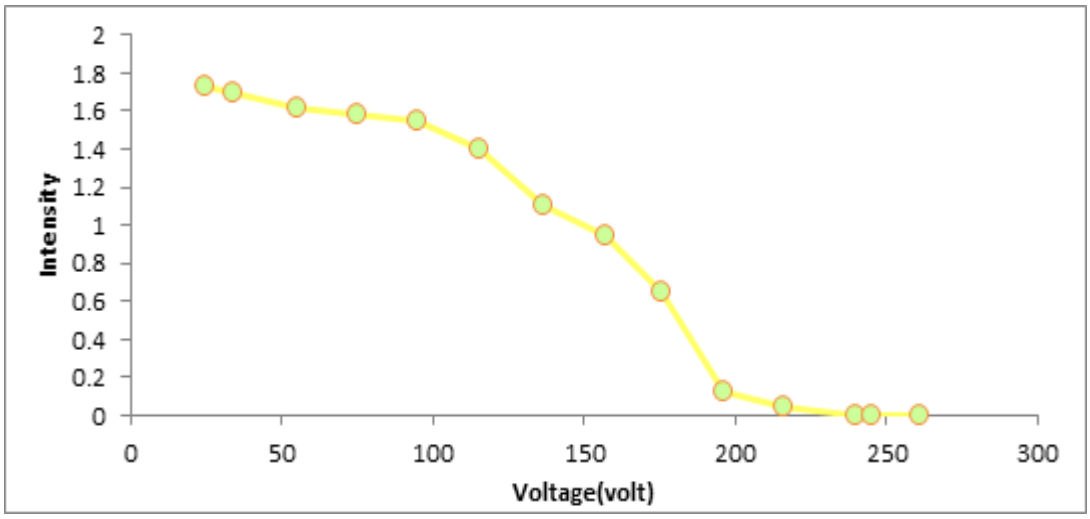

Figure 5: Variation of the normalized intensity with voltage for polymer 2 .

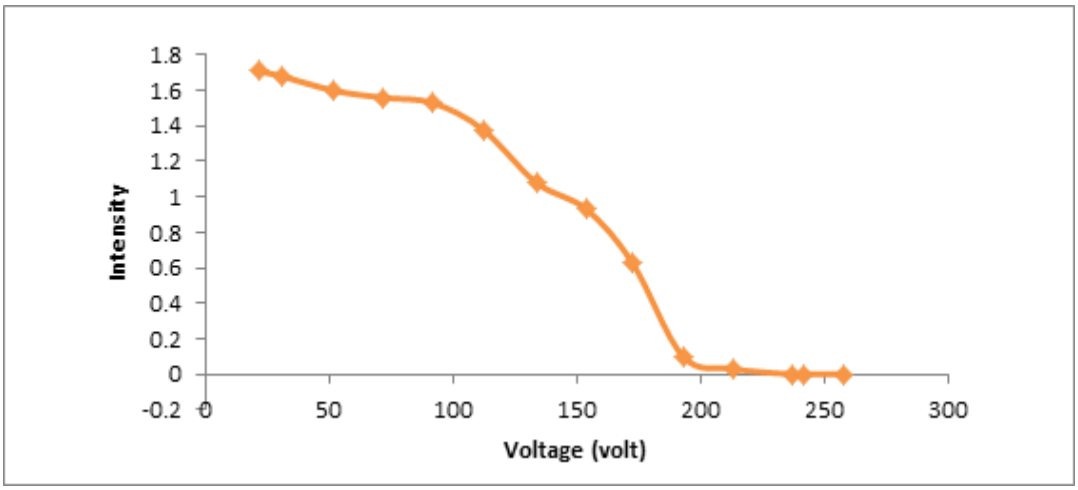

Figure 6: Variation of the normalized intensity with voltage for polymer 3.

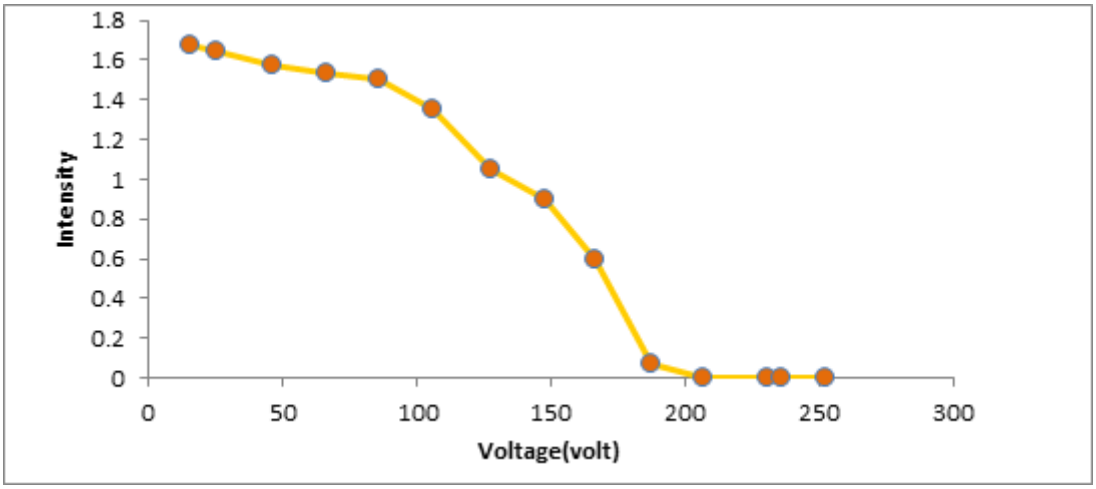

Figure 7: Variation of the normalized intensity with voltage for polymer 4.

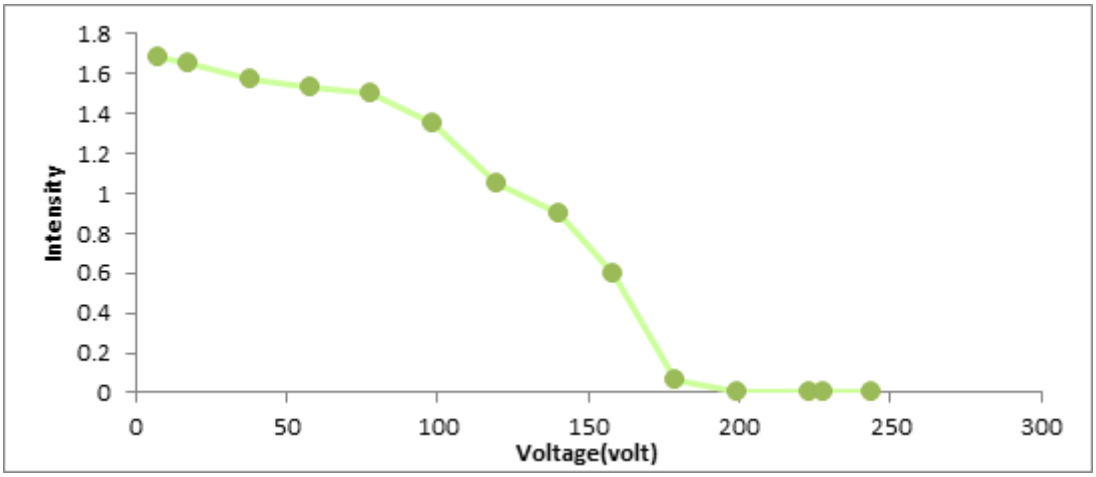

Fig. (8): Variation of the normalized intensity with voltage for polymer 5.

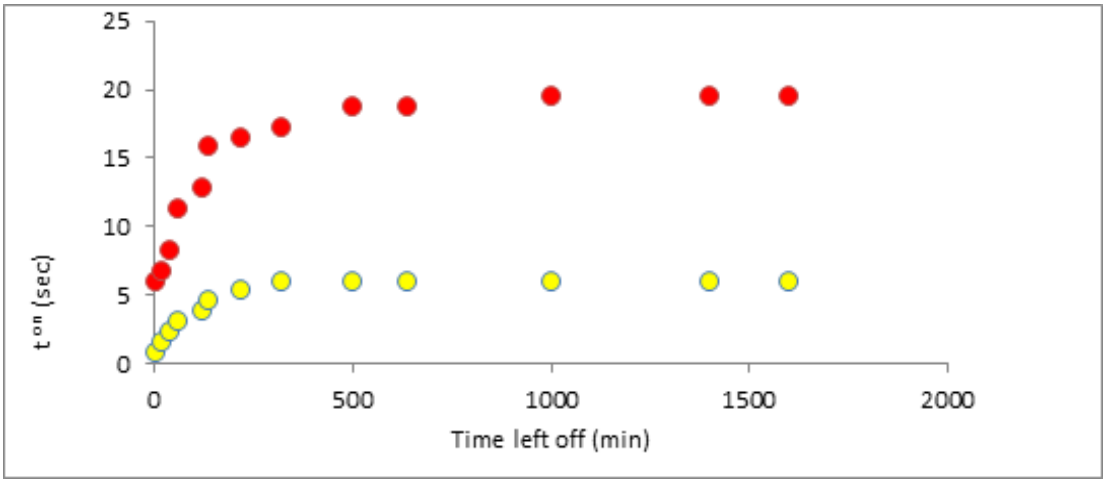

Figure 9: Switching – on (τ^{on}) and time left off (τ^{off}) at constant temperature below T_{NI} for polymer 1.

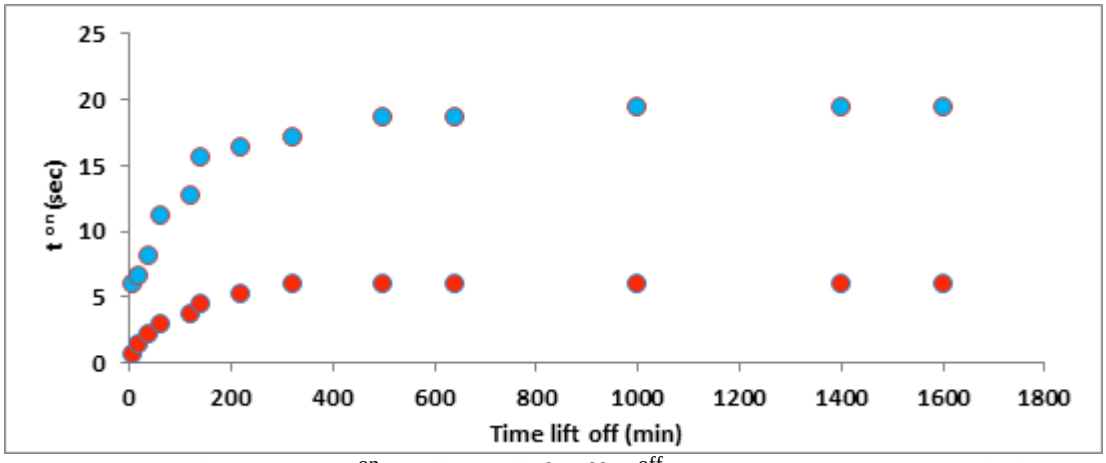

Figure 10: Switching – on (τ^{on}) and time left off (τ^{off}) at constant temperature below T_{NI} for polymer 2.

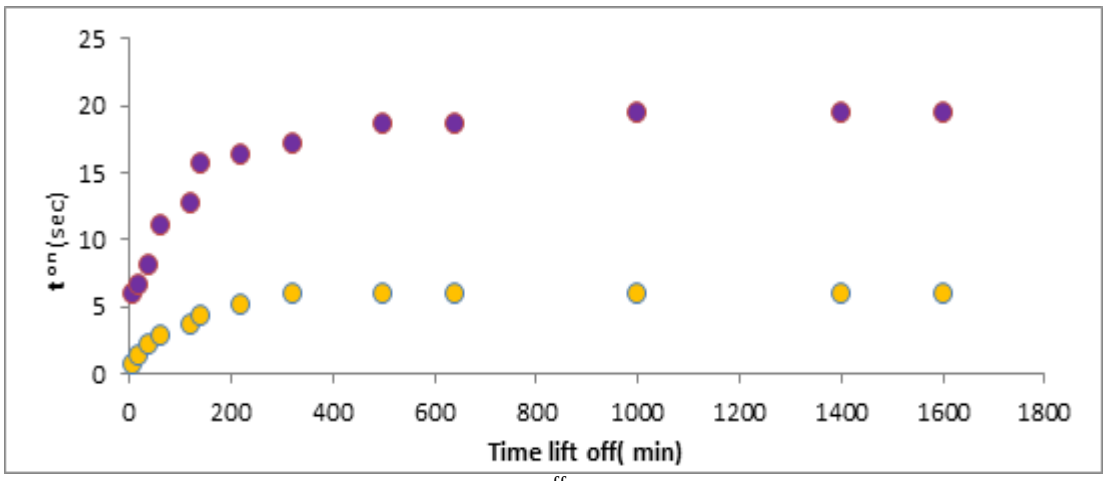

Figure 11: Switching – on (τ^{on}) and time left off (τ^{off}) at constant temperature below T_{NI} for polymer 3

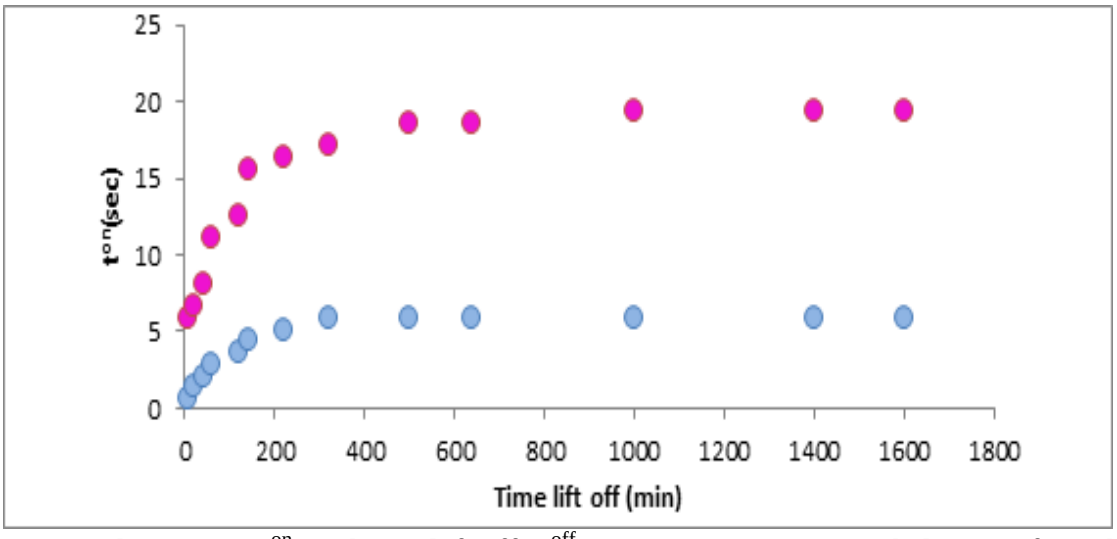

Figure 12: Switching – on (τ^{on}) and time left off (τ^{off}) at constanttemperature below T_{NI} for polymer 4.

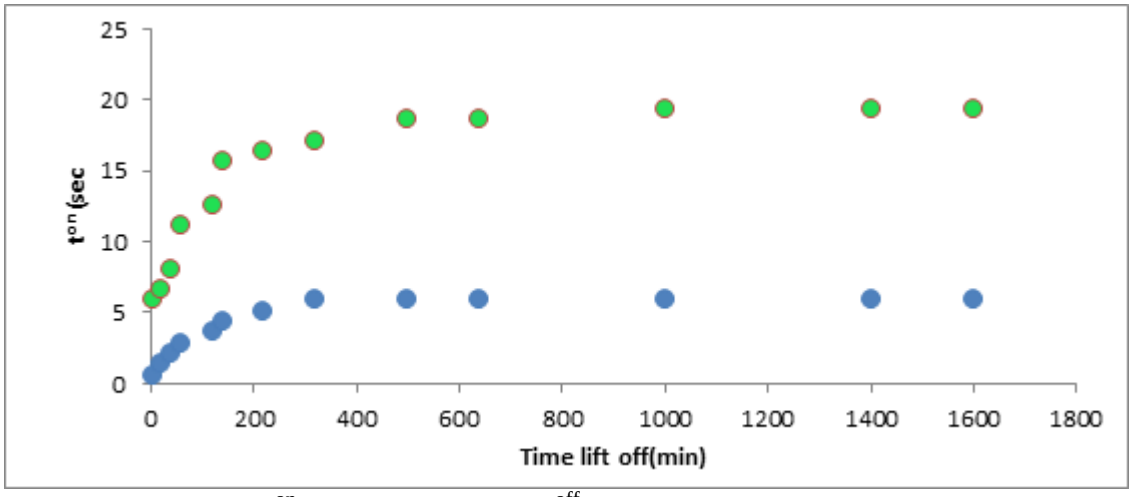

Figure 13: Switching – on (τ^{on}) and time left off (τ^{off}) at constant temperature below T_{NI} for polymer 5.

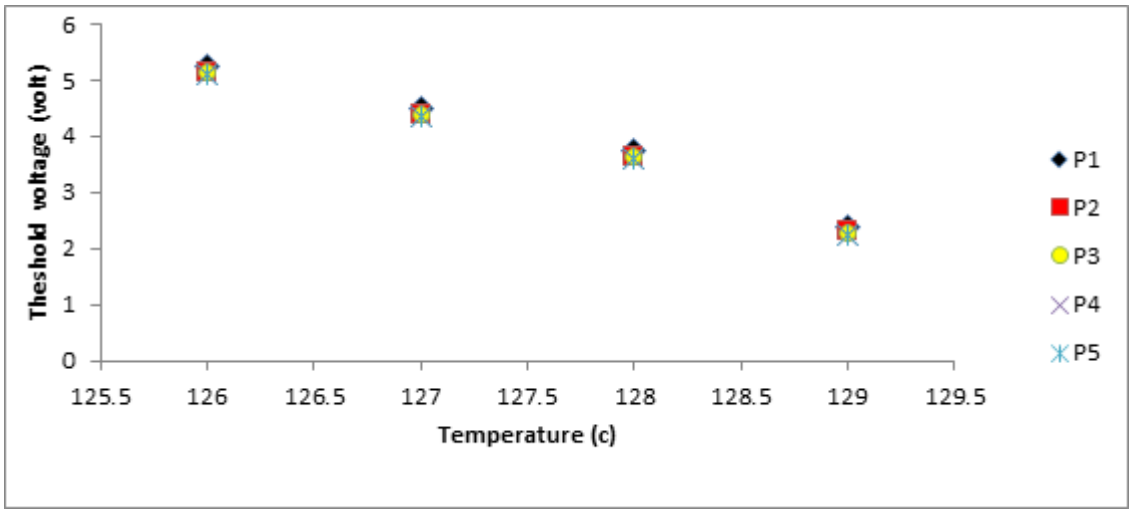

Figure 14: Threshold voltages a function of temperature for polymer poly - siloxanes.

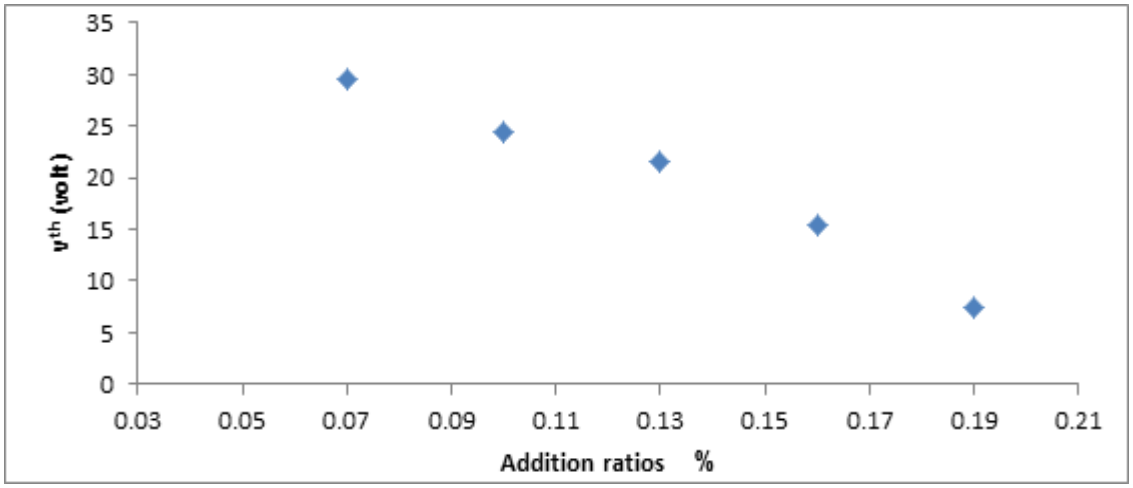

Figure 15: Threshold voltages as a function of the addition ratios**.**

Discussion

The important attributes that characterize nanomaterial, these materials have captured the attention of researchers working in the field of optics and scientists, when adding material Au nanoparticles to the polymer

polysiloxane with side chain will work to increase the viscosity of polymer, as well as the works of thesenanoparticles added to increase the viscosity of the polymer shed when an electric field ,and working to reduce the degree phase transition of polymer, this leads to reduce the visual response time (t_{on} ,t_{off}).

Finally redeeming range C-C was chosen because of the interest in electrical characteristics of the polymer could make it particularly suitable for applications, and in any case add Au possible increase the density mesogen units which are connected with a series polymer to increase the contribution of dual –electrode parallel group C-C molecules torque along the axis mesogen Group this in turn increases the dielectric anisotropy (1,2).

With the increase in Au material added to the polymer there is a decrease in the degree of the phase transition and the operating voltage and optical response times(t_{on} ,t_{off}). larger proportions since the optical response times and operating voltage of polymer (4,5) is less than polymer (1,2)because the proportion of Au material added to the polymer (4,5)be greater the ratio of added the polymer (1,2).

References

1. ‘Liquid Crystals’, Nobelprize.org. http://www.nobleprize.org/educational/physics/liquid_crystals/history/index.html. Accessed 05/01/2013.
2. P. Collings and M. Hird, Introduction to Liquid Crystals: Chemistry and Physics, Taylor & Francis London, 1997.
3. J. P. F. Largewall and G. Scalia, Current Applied Physics, 2012, 12, 1388
4. G. W. Gray and P. A. Winsor, Liquid Crystal & Plastic Crystals- Preparation, Constitution & Application, Vol.1, Ellis Horwood Ltd, Chichester, 1974.
5. Dunmur, D. and Sluckin, T., "Soap, and Flat-Screen TVs: A History of Liquid Crystals," Taylor & Francis, Doi: 10.1080/00107514, Vol.52, Issue 6, (2011). aa
6. De Gennes P. G and Prost. J, "The Physics of Liquid Crystals." 2nd, Oxford, UK, (1993).aa
7. G. H. Brown and J. J. Wolken, "Liquid Crystals and Biological Structures", 3rd. Edition, Academic Press, London, 1979. Sss

*****