Study Effect change amount addition of Sn2P2S6 nanoparticles on Thermal , Mechanical and Optical Properties of Polysiloxane Polymer

Zahraa Kazem Rodhan and Ansam Ali Hashem
Physics/ Electro-optic material engineering/ ceramic Iraq
AL-Furat Al-Awsat Technical University, Babylon technical institute
Alaa_hilla2020@yahoo.com
zahraaph2018@gmail.com

Abstract
The paper included the influence of addition of Sn2P2S6 nanoparticles on the Mechanical, Thermal, and Optical characteristics of liquid crystalline polymers with side chain. A constant Molecular weight was used (1.7 × 10^6). The additive ratios were five different ratios of the added Sn2P2S6 nanoparticles. It was noted that the voltage operation decreased with the increase of the ratio of the additive. The optical response (τ'on) was measured in opening case (when the electric field was applied) and closing time (τ'off) (when removing the electric field) by calculating the time interval between the primary and the new classification for liquid crystal polymer molecules caused by the electric field, Laser light while passing through the electrophoresis cell. The different addition ratio of Sn2P2S6 particles, which had a fixed molecular weight from polymer , increased the density of the mesogenetic group associated with the polymer chain. This increased the effect of dipole torque in the C≡N group parallel to longitudinal axis of mesogenous unit, The dielectric anisotropy Δε has a lower optical response time (τ'on), (τ'off), thus improving the electro-optical properties of the system. The change in threshold voltage was measured at constant steps and under TNI for a series of different additives' and found that the high additive additives had a small threshold voltage and this had to do with the polymer elasticity constant . Infrared spectrometer measurements were used to determine the coefficient of the directional arrangement of liquid crystals with a side chain. By determining the vibration of a specific package (C≡N) for absorption, it was found that the coefficient of the guideline is based on the temperature.

Keywords : Sn2P2S6 nanoparticle , polysiloxane , Thermal, Mechanical and Optical Properties

Introduction
The dynamic relaxation response characteristics of polymeric materials give valuable knowledge about local relaxation environment and polymer architecture. Motional
relaxations in polymers (i.e., the glass-rubber relaxation; sub-glass relaxations) are highly-sensitive to polymer structure and morphology, and often reflect subtle changes in composition or motional constraint that can have significant ramifications for material attributes related to mechanical performance, thermal resistance and membrane transport. In Nano composites, the inclusion of Nano scale filler and the creation of large amounts of internal surface area may produce dramatic shifts in glass transition temperature, for example, that correlate with the properties of the filler, the quality of the internal interfaces, and the physical confinement imposed by the filler on the responding polymer chains. Nano-materials have features with dimensions from sub-nanometer to several hundred nanometers [1,2]. Although ‘Nano’ is a popular word in everyday life of 21st century, not everyone understands what it really means. For comparison, if you are trying to see a 1 nm feature in a 1 cm×1 cm sample, the difficulty is no less than trying to find a human hair in Tiananmen Square. However, thanks to the advanced technologies, like scanning tunneling microscope (STM), scanning electron microscope (SEM), transmission electron microscope (TEM), people nowadays are able to visualize, and even manipulate, atoms under 1 nanometer[3,4]. It is hard to predict how nanotechnology could change our life over the next decade, but no one will doubt that it’s a key technology for the future.[5,6]

Inclusion of nanofillers in polymers is important because the combined properties that can be achieved are often significantly enhanced over those of the neat polymer, as well as composites based on conventional fillers. Nanofillers are much smaller than traditional micro-fillers. Their size is typically 1-100 nm in dimension. One primary factor that gives nanocomposites their superior properties is the higher aspect ratios of nanofillers relative to micro-fillers. This creates much more surface area between the filler and the polymer, as governed with filler size, shape, and volume fraction [7].

Nanofillers are available in different geometries (i.e., particles, platelets, and carbon nanotubes) and surface chemistries. Researchers have studied particle fillers that include metal oxides such as TiO2, Fe2O3, SiO2, etc. [8]. Platelets have the advantage over fibers or particles in that they can reinforce a composite biaxially. Examples include organoclay, and nanoceramics [9,10]. Studies show that three times as much glass fiber and four times as much conventional talc can be required to achieve the same mechanical reinforcement that is obtained in nanocomposite materials using montmorillonite platelets as filler [11]. Fundamental insight regarding
the character of the particle-polymer interface and the quality of the particle dispersion can be obtained by investigating the dynamic relaxation properties of the nanocomposite, and specifically the glass transition. Shifts in glass transition temperature (Tg) relative to that of unfilled polymer might potentially reflect specific particle-polymer interactions, as well as physical confinement effects. If there’s a strong attraction between the particles and the polymer, Tg’s value may increase [12,13].

**Experimental Setup:**

The 3 most significant devices that have been utilized in the present study for the electro–optic measure are:

1. HCS 402
2. ALCT
3. MK 1000

**1- MK1000** series of temperature controllers presents accuracy, stability, and precision for the measurement and control of temperature. It ensures resolution and precision of temperature up to 0.001°C, which accommodates each of the Platinum RTD and separately calibrated thermistors as temperatures sen, and is capable of optionally controlling (4) instec cold and hot plates, chucks, or stages. Two modes of operation, key-pad operation with the use of front panel of controller, or software control via computer and an adjustable ramp (heating /cooling rate) for user set point of temperature. Programmable command set of operations. Accurately regulates the temperature up to 0.001°C option save temperature data to PC. RTD thermistor or thermo-couple, holders of LC cell for numerous LC cell kinds.

**2-Automatic liquid crystal property tester -ALCT**

The ALCT measure systems are USB based tools that may be conveniently connected with each of the desktops and laptops (Instec Company). According to the options, ALCTs are easily used software which allow measuring parameters of material for positive as well as negative di-electric liquid crystals, and liquid crystals’ material parameters like the di-electric constant $\varepsilon_{\perp}$ and the di-electric constant $\varepsilon_{||}$, elastic constants splay and bend ($K_{33}$ and $K_{11}$), voltage holding system of ratio measure, time of optic switching, optical transmittance v.s. voltage - threshold voltage $U_c$, polarization current $I_p$ and Viscosity, ALCT may as well be integrated to instec’s microscope hot stage and cold stage and controllers of temperature, which enable users at analyzing temperature dependence of the parameters above.
3- Microscope hot /cold Stages – HCS-302

HCS-302 is known for the following characteristics (Instec Company):

1. Programmable control of precision temperature in the range between (200ºC and 600ºC).
2. Dual-heater microscope hot and cold stages for increasing the uniformity of temperature gradient.
3. Large viewing aperture.
4. Regulated fast heating and cooling rates.
5. Easy side sample loading with standard slides of the microscope.
6. Variable height of the sample chamber.

Figure 1: Electro – optic cell
Materials:

Chemical structures: used in this work.

![Figure 2: a photo of work system](image)

![Figure 3: materials chemical structures](image)
Results:
When twinkle a voltage frequency fixed value (500) Hz on the polymer used in this paper and at temperature below $T_{NI}$ based on fixed polymer molecular weight and proportions of $\text{Sn}_2\text{P}_2\text{S}_6$ added, we get the following figure (4) notes of forms that each polymer voltage threshold (smaller effort required to obtain an optical change, the beginning of directing crystalline molecules). Figure shows (6) the relationship between voltage and operating ratios between $\text{BaTiO}_3$ added to the polymer Polysiloxane. Furthermore has a voltage operation or the so-called voltage full guidance (voltages necessary for downhill light intensity to a lower value approximately almost zero) [14] The shapes explain that the increase in $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles added material leads to a decrease in the voltage threshold values and voltage operation and reason for this is that the particles $\text{Sn}_2\text{P}_2\text{S}_6$ added lead to increase group mesogenic density associated with in a series polymer. This leads to increased dipole contribution in Senao group which is parallel to axis of the addition longitudinal unit mesogenic, and also contributes to the anisotropic increase isolation and $\text{Sn}_2\text{P}_2\text{S}_6$ added particles are working to increase the connectivity of the polymer when shed alternting field [15].

To increase the proportion of $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles increase from the times of the optical response and also in forms (7-11) for Article liquid crystal used in the search with $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles and represent these shapes the relationship between the times of operation and the times of the closing of the polymer at temperature below $T_{NI}$. Where the addition of $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles helped to get times faster response (time of conquest faster) and the reason goes back to that $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles reducing the degree of transition Curi and this is leading to reduce the times of the optical response of the following forms that can clarify the relationship between response times and the temperature Figure(12). The measured relaxatn time ($t^{\text{off}}$) of the five different additions ratios that were used in this work using the method of iterative method and optical $t$ is the exponential decrease of the expense of the signal intensity of light passing after removing the hanging electric field show in Figure (13). And in order to have a comparison between the threshold voltage, ($V_{th}$), we must have the a knowlge about the variation of dielectric anisotropy $\Delta \varepsilon$ values, it is known that ($\Delta \varepsilon$) variation for the mesogenic units is important, and the added $\text{Sn}_2\text{P}_2\text{S}_6$ nanoparticles will affect the value of the ($\Delta \varepsilon$) variation. This effect is included in the increase of the value of the $\Delta \varepsilon$ it variation. [15] and because of this increase in the
value of \( \Delta \varepsilon \) leads to a decrease in the values of the optical response times (\( t_{\text{on}} \) and \( t_{\text{off}} \)) depending on the equation of \( t_{\text{on}} \) in the analysis of these results Figure(14).

In this research, the use of infra-red di-chroism for the analysis of orientational liquid crystalline side-chain polymers ordering on the pre-aligned cells, in addition to that, the use of one molecular weight with the addition five ratios of \( \text{Sn}_2\text{P}_2\text{S}_6 \) nanoparticles to the polymer for obtaining data concerning head part orientational order, with the observation of bands that correspond to related functional groups vibrations, where the main band of vibration absorption \( \text{C}≡\text{N} \) occurs in the area of 2,235 cm\(^{-1}\). This test has been accomplished after making sure that the conditions of equilibrium have been satisfied and as a result, real values of \( S̅ \) are measured. Here, focusing on \( S̅ \) variations with the temperature. For the sake of ensuring that for Reach the conditions of the temperature equilibrium have been established held sample at every one of the temperatures for time intervals up to 100 hrs throughout which repeated measures have been conducted for the sake of establishing the value of the steady state for the dichroic ratio Fig. (15) shows the \( S̅ \) depending on the temperature.

![Figure 4: Variations of the normalized intensity with the voltage for polymers (1,2,3,4&5)](image-url)
Figure (5): the operating voltage as function of rates BaTiO$_3$ added to the polymer.

Figure (6): shows the relationship of the threshold voltage is added with the five used in this study ratios.
Figure (7): Switching-on ($\tau_{\text{on}}$) and time left off ($\tau_{\text{off}}$) at constant temperature less than $T_{NI}$ for addition $P_1$.

Figure (8): Switching-on ($\tau_{\text{on}}$) and time left off ($\tau_{\text{off}}$) at constant temperature under $T_{NI}$ for addition $P_2$. 

Figure 9: Switching-on ($\tau_{\text{on}}$) and time left off ($\tau_{\text{off}}$) at constant temperature under $T_{N1}$ for addition P₃.

Figure (10): Switching-on ($\tau_{\text{on}}$) and time left off ($\tau_{\text{off}}$) at constant temperature under $T_{N1}$ for addition P₄.
Figure (11): Switching–on ($\tau^{on}$) and time left off ($\tau^{off}$) at the constant temperature under $T_{NI}$ for addition $P_5$.

Fig (12): Switching – on ($\tau^{on}$) as a function of the ratios addition for polymer polysiloxanes.
Fig. (13): Switching – off ($\tau_{\text{off}}$) as a function of BaTiO$_3$ additives ratios with the use of cyclic electro-optic

Fig. (14): Threshold voltages as a temperature function for polymer polysiloxanes.
Conclusions:

1. The mesogens units that contain a cyano group where liquid crystals demonstrate that particular mesogens (i.e. particular chemical structures) have the tendency of forming specific mesophases.
2. The operating voltage is less than adding Sn$_2$P$_2$S$_6$ nanoparticles to the polysiloxane.
3. It is found that adding Sn$_2$P$_2$S$_6$ nanoparticles to the polymers chains leads to the effect of cyano- group dipole moment parallel to mesogenic unit’s molecular long axis and result in the increase in the density of mesogenic units attached to the polymer chains.
4. Sn$_2$P$_2$S$_6$ nanoparticles are added to the polymer which are contributed in reduction the time responses the optical due to increase the dielectric anistropic ($\Delta \varepsilon$) and as a result, improved system mobility.
5. The order parameter is slightly affected by adding nanoparticles.
6. Fixed flexibility $K_{ii}$ depends on the order parameter.

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