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Production and Study of Electrical Characteristics for one of the Dual Estelline Polymers

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ABSTRACT

This study involved the development of a poly-2,4-hexamine-1,5 diol. Conductivity mechanics were investigated by tracking voltage-current characteristics, conductivity (time-current), and conductor motion as a function of temperature between 313 and 353 ok. The principal slopes of (I-t) curves reveal that an increase in temperature results in a rise in conductivity and conductor-carrier mobility (mobility μ). In addition, the activation energy was determined to be 0.897 via a calculation based on the curve formed by (σ-1/T). Also, the hysteresis of electrical conductivity at different temperatures was studied while the voltage stayed the same.

Keywords: Voltage-Current Characteristics, Conductivity, Conductor Motion

I. INTRODUCTION

Polymers are important in the manufacturing business because their properties are better than those of traditional materials. They also have low production costs, are resistant to rust and corrosion, are light, and have good mechanical and electrical properties [1]. Researchers have to put in a lot of work to discover polymer conductivity, even though the mechanism of electrical conductivity for these materials is still a mystery and is thought to be a complicated process. In recent years, most research has been focused on improving the electrical conductivity of certain polymers by using a variety of methods and techniques and keeping impurities under control[2]. In this work, the I-V properties and electrical conductivity of poly (2,4-hexamine-1,6-diol) were studied, as well as how temperature affected those properties. Additionally, research has been done to investigate how temperature affects the mobility of charge carriers. The results were analyzed and compared to those of a study by Cuk on the electrical properties of the polymer poly-1, 1, 6, 6-tetraphenylhexadiinediamine[3] and a study by Pingfan on the electrical conductivity mechanics of polydiacetylene [4]. The poly 2,4-hexamine-1,6 diol only has one orientation. It belongs to the

group of diacetylene compounds that can be grouped as semiconducting materials. Polymers are used a lot in the industrial sector. For example, they are used to mix different chemicals and in optical applications [5].

II. METHODOLOGY FOR THE EXPERIMENT

In a tri-open tube equipped with a reflux condenser, a separation funnel, and a glass tube connecting to an oxygen gas bottle, we combined 2.9 moles of ammonium chloride, 0.6 moles of copper chloride, 1.8 ml of strong hydrochloric acid, and 500 ml of water to create the monomer 2,4-hexadiyne-1,6-diol. After adding 0.214 moles of Brobargel alcohol dissolved in 40 ml of ethanol drop by drop via the funnel for half an hour, oxygen is added to the moving mixture for 24 hours. The color changes from brown to yellow and then to green when it is exposed to light. Following filtering, the organic layer is removed with 4 volumes (mL) of ethylene acetate and dried over non-aqua Sodium Sulfates. The dissolvent is vaporized under unstabilized pressure to yield the precipitate. Using hot water, the precipitate is re-crystallized to make pale yellow crystals of the monomer (2,4-hexadiyne-1,6-diol). To get the polymer, put 0.008 mol and 2 g of the monomer in a clock bottle. Then, expose the bottle to UV rays at a wavelength of 254–266 nm for 35 hours. Then, clean the material with methanol to get rid of the monomer. So, poly 2,4-hexadiyne-1,6-diol crystals, which are brown, can be made by letting the mixture dry in the air[6].

The current-voltage method was used to figure out the electrical conductivity of the polymer model at different temperatures. This technique is summed up in the measurement of the current flowing through the model at a given voltage, with the model's size (1 cm * 1 cm) and thickness (0.1 mm) held constant (0.1 cm). Circular electrodes made of silver and measuring 2 millimetres in diameter were utilised and placed on either side of the model. Direct current (DC) is sent to the model by a type of high-efficiency power supply (FAR NELL) that provides a stable current and voltage. Use a type 2528 ammeter to determine how much current is passing through the model (Philips electrometer). Using a digital multimeter, determine the applied voltage to the model (type 712). An enclosed convection oven with a thermostat was used to heat and measure the sample (RSLTD). To monitor and adjust the sample temperature, a thermocouple of type (k) has been employed.

III.Results and Discussion

Figure 1 depicts the effect of heat on the characters I–V in the temperature range 313–353K for the 2, 4 Hexadiyne–1, 6 Diol model. From curves, we find that by raising the heat, the current increases. In general, we can see that the relationship between I and V with curves at degrees of 313–323 k is linear, and the Ohm regions can be detected in a voltage range lower than 70 v. However, bulk resistance was observed in Ohm regions for curves with temperatures of 333, 343, and 353K ranging between 70 and 150 volts. Figure 2 explains the relationship between log V and log I at different temperatures. The relation between current and voltage is linear until 333 k, which proves that the relation is ohmic. On the other hand, at temperatures of 343 and 353, two regions are shown and explained in the following formula:

$$I \propto V^n \ldots\ldots (1)$$

Where n is a variable that indicates the slope of the curve.

The region with voltages greater than 70V is shown to be independent of Ohm's law in the diagram. The substance's polymer nature may have changed, which would account for these observations. Also, electrical conductivity hysteresis at different temperatures was studied using a model that could be heated and cooled with a constant voltage of 90 V. As seen in Figure 3, conductivity increases as temperature rises. On the other hand, the conductivity value at a given temperature is greater after cooling the model than it

was after heating it to the same degree, indicating that the historization is permanent. The reason for this is that polymeric chains are sensitive to variations in temperature because of their unique structure and form [7].

The connection between conductivity and the inverse of temperature (1/T) is shown in Figure 3. This rises with temperature, as seen in Figure 4. This can be explained by the fact that as temperatures rise, barriers in polymeric construction move around more and sometimes even disappear. This allows charge carriers to more easily flow inside the polymer structure, and an increase in conductivity or temperature may provide charge carriers with extra power, increasing the vibration surrounding their presence and, therefore, the likelihood of jumping over and climbing voltage barriers that are created by the nature of the polymeric chain. This corroborates earlier research that explains how exposure to varied temperatures alters the composition of polymeric materials. According to the following relation [8], the activation value was determined from the slope in figure 4:

$$\sigma = \sigma_{\circ} \exp(-E/K_B T) \ldots\ldots (2)$$

Were (σ) represents conductivity, ($\sigma_{\circ}$) represents constant, K_B represents the Poltzman factor, T represents absolute temperature, E_a represents activation temperature.

The physical meaning of activation energy varies with temperature variation, which is known as the source of increasing conductivity [9]. The conductivity values of poly (2, 4), hexadiyne (1, 6), and diol (313K) were determined to be $1.4 \times 10^{-8}\ \Omega^{-1}.\ m^{-1}$.

The conductivity of this polymer indicates that it is a semi-conducting polymer with a relatively large energy gap. Figure 4 shows the activation energy, which is 0.68 eV, and the energy gap Eg, which is 1.36 eV based on the following formula:

$$E_a = \frac{Eg}{2} \ldots\ldots\ldots (3)$$

Since poly(2,4-hexadiyne)-1,6-diol is a hollow-regular polymer, its high conductivity may be explained by its hollow organization and chain form [10, 11]. With the polymer model, the variation in current and duration with varying temperatures is shown in Figure 5 for a constant voltage of 90 V. To analyze charge carrier variation near electrodes, the first set of curves, represented by linked lines, indicates that current stability occurs after 30 minutes. After 45 minutes, the voltage between the electrodes was switched. After applying a reverse voltage, the (I-t) curves seen in figure 5 (represented by the dotted lines) become visible (5). A formula[12] demonstrating the dependence of (I-t) on temperature may be seen below.

$$j = qn\mu E \ldots\ldots\ldots\ldots (4)$$

where J, q, n, and E* are, respectively, the charge density of current carriers, the density of current carriers, the movement of current carriers (mobility), and the force needed to make a field on opposite sides of the polymer. The "cleaning" effect of the buildup of current carriers at the electrodes may cause the density of current carriers (n) in the model to go down over time, which could explain why the value of the current goes down over time. In the second case, the model's prediction of the electric field fails because of the effect of the local field caused by the vacuum current of carriers moving away from the poles. Since the current is constantly proportional to E and n, it declines over time. This signifies that the current reduces after applying a voltage [13]. After reversing the voltage poles, as depicted in Figure 5, carriers will flow freely, generating current due to a dramatic increase in carrier concentration at the poles. Through applying a negative voltage, the currier movement M was discovered, and its value was determined using the following formula:

$$J = J_0 \exp(-\mu E_t / L) \ldots\ldots\ldots (5)$$

The principal slope of the curves of (I - t) in Figure 5 can be used to calculate carrier movement (mobility), where $J_0 = q\ M_0\ E$, M_0 is the density of charge carriers when t = 0, and L is the model thickness. The

correlation between mobility (μ) and the inverse of temperature (*1/T*) is seen in Figure 6. Rising temperatures increase mobility.

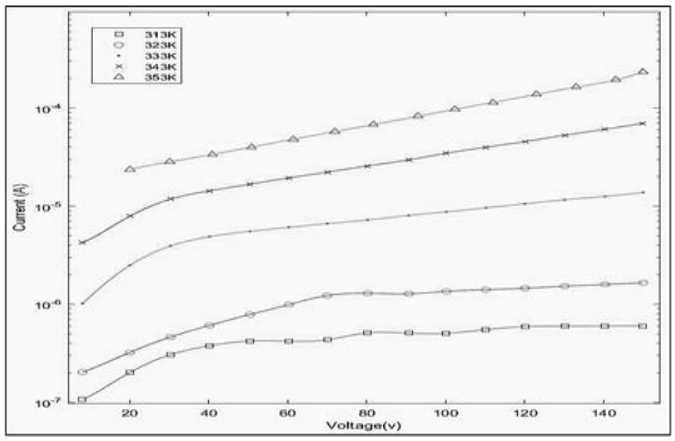

Figure 1: Current as a function of voltage for poly 2, 4-hexadiyen-1,6 diol at varying temperatures

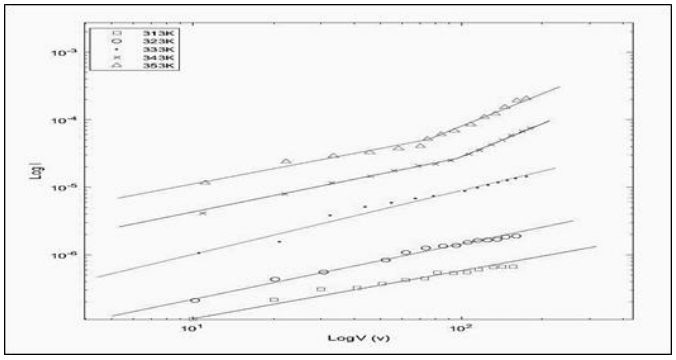

Figure 2: Log I as a function of Log V for poly 2, 4-hexadiyen-1, 6-diol at different temperatures

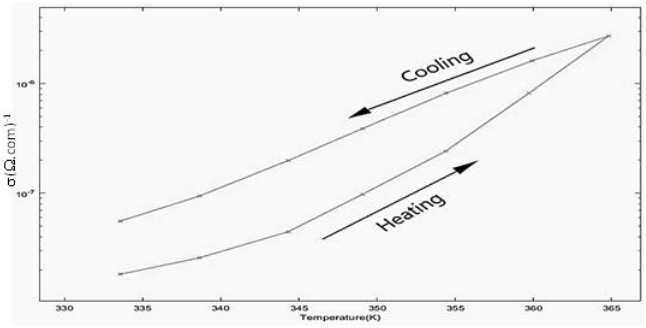

Figure 3: shows the fluctuation in electrical conductivity during heating and cooling

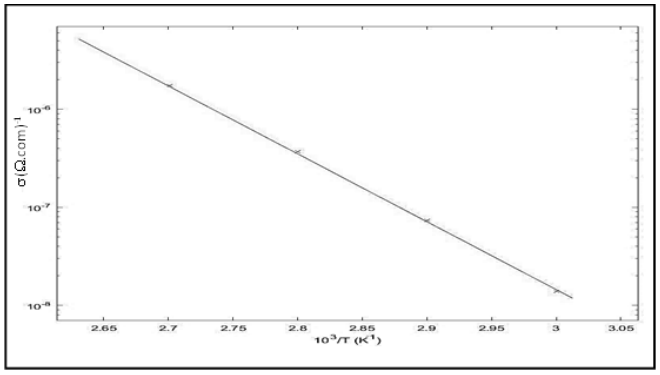

Figure 4: The temperature dependency of electrical conductivity (δ) for (poly 2, 4- Hexadiyen -1,6 diol)

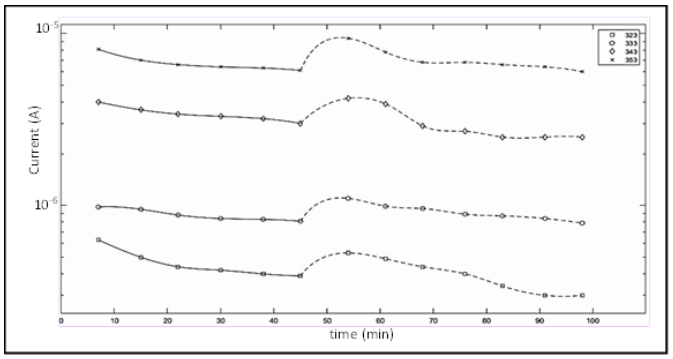

Figure 5: Temperature influence on (I-t) plots for poly 2, 4-hexadiyne-1, 6 diol with forward (solid lines) and reverse (dashed lines) (Dotted lines)

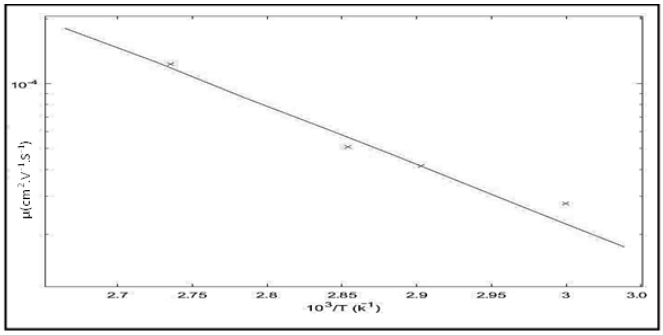

Figure 6: Mobility (μ) as a function of temperature for (poly 2, 4 Hexadiyne-1,6 diol)

IV. CONCLUSION

The examining of the developed poly-2,4-hexamine-1,5 diol lead to a group of results . Linearity between voltage and current is maintained throughout a wide range of temperatures,Specific ohm zones are available for voltages below 70 volts, and Temperature enhances the conductivity of polymers.This polymer is a semiconducting polymer with a rather large energy gap, as shown by its conductivity and the historicization of

temperature-dependent conductivity is irreversible and finally , the Current decreases over time because the electric field of the model between the two poles falls due to the effect of the local field, which is caused by carriers moving away from the poles.

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