Study of AC electrical properties of (PVA-PEG-Sb_2O_3) Composites

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ABSTRACT

The aim of this study is investigation of AC electrical properties for (PVA-PEG- Sb_2O_3) composite material at different frequencies which they ranged from 100 Hz - 6 MHz. The PVA-PEG- Sb_2O_3 composite prepared using solution casting method. The experimental results have shown that the dielectric constant (ε) and dielectric loss (δ) decreases with increasing the frequency, it also appeared that ε and δ are increased with the increasing of antimony oxide (Sb_2O_3) content. The electrical conductivity (σ) increased with the increasing of frequency and decreased with the increasing of Sb_2O_3 content in the PVA-PEG- Sb_2O_3 composites.

KEY WORDS: electrical properties, dielectric properties, electrical conductivity.

1. INTRODUCTION

Polymers form a very important class of materials for our life they have very low concentration of free charge carriers, thus are nonconductive. The drawbacks of polymers as electric materials are they have transparency for the electromagnetic radiation; moreover, they provide protection against electrostatic discharge in handling sensitive electronic devices. To overcome those this drawback of polymers, the electrical properties of polymers are represent by responding to when an applied electric field, (and the subject of electrical properties of polymers covers a diverse range of molecular phenomena). The behavior of polymers under an electric field varies from that of metals. Where the molecules of polymers are rotated in the direction of the applied electric field in a phenomena called polarization. Examination study of the polarization phenomena does not give any valuable insight into the nature of the electrical response of polymers, but it also provides an effective way to probe molecular dynamics.

Mixing two polymers or more (as blends) can enhance the electrical properties of the final product. However, the appearance of more properties depends upon the miscibility of blend. Blending can, however, have profound and sometimes unexpected effects on thermal stability which cannot simply be projected on the base of behavior of the components and their relative proportions. Conductive polymers are have more applications in television sets, cellular telephones, displays, light emitting diodes, solar cells, batteries, actuators, sensors, electromagnetic shielding, and microelectronic devices. Another kind of materials is the polymer-based composite. A composite material is defined as usually calculated for use as structural materials. While structural composites emphasize high strength and high modulus, electronic composites stress high thermal conductivity, low thermal expansion, low dielectric constant, and electromagnetic interference protective efficiency, depending on the actual electronic application. In these materials the environment is formed from polymer and the second chapter is filler. In this application the filler is conductive particles. The aim of current research prepare and characterize the electrical properties of (PVA-PEG-Sb_2O_3) composite material.

2. EXPERIMENTAL PART

The materials that were used in this study are polyvinyl alcohol (PVA) (Merck, Germany molecular weight (14,000)), poly ethylene glycol (PEG) (wt%), and antimony oxide (Sb_2O_3) which was used as additive, has been added to mixture of polymers with different weight percentages are (0, 6, and 8) wt%. The (PVA-PEG- Sb_2O_3) composites material prepared by using casting method to make sample with a thickness of 1.5 µm. The dielectric properties of (PVA-PEG- Sb_2O_3) composites were measured using LCR meter in the frequency (f) of (100 Hz-6 MHz) at room temperature was used to measure the dielectric constant. The capacitance (C) was calculated according to the following equation:

$$c = \acute{\varepsilon} - \varepsilon_{\circ} \frac{A}{t} \qquad (1)$$

Where, $\acute{\varepsilon}$ is the dielectric constant; t is the sample thickness, and $\varepsilon_{\circ}$ is the vacuum permittivity. The loss factor (D) was calculated as:

$$D = \frac{\varepsilon''}{\acute{\varepsilon}} \qquad (2)$$

And this represents the loss of electrical energy which is dissipated as heat in an insulator. The importance of determining the power factor is very useful in electrical applications. The dielectric constant can be calculated from the following equation:

$$\acute{\boldsymbol{\varepsilon}} = \frac{\mathrm{Cp}}{\mathrm{Co}} \qquad (3)$$

Where, C_p is parallel capacitance and C_o is vacuum capacitor.

The dissipated power in the insulator is represented by the existence of alternating potential as a function of the alternating conductivity:

$$\sigma_{A.C} = w\, \varepsilon''\, \varepsilon_o \quad (4)$$

Where, w is angular frequency and ε'' is dielectric loss.

3. RESULTS AND DISCUSSION

Figure.1, shows the variation of the dielectric constant with the frequency. The Figure shows that the dielectric constant decreases with increasing the applied frequency. The increase of frequencies results in decreasing of space the polarized. In fact, the dielectric constant is affected by the polarization mechanism. Where at low frequencies the dielectric constant increases, since the material molecules will be partially polarized. While the dielectric constant increased with the increasing of Sb_2O_3 content in the PVA-PEG-Sb_2O_3 composite, more clarity can be seen in figure.2. The increases of dielectric constant attributed to the particles of Sb_2O_3 connected together to form a network inside the polymers mixture. Therefore the value of the dielectric constant increases as the weight ratio of Sb_2O_3 increased.

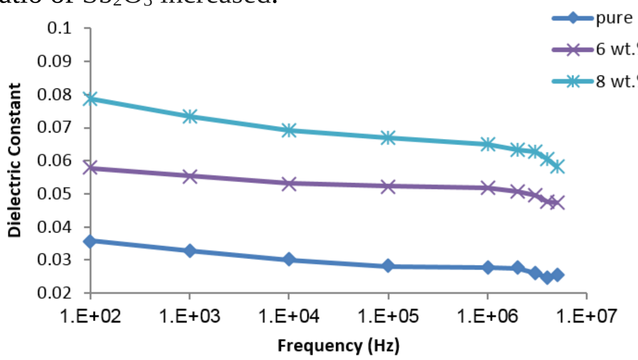

Figure.1. Effect of frequency on the dielectric constant of PVA-PEG-Sb_2O_3 composite

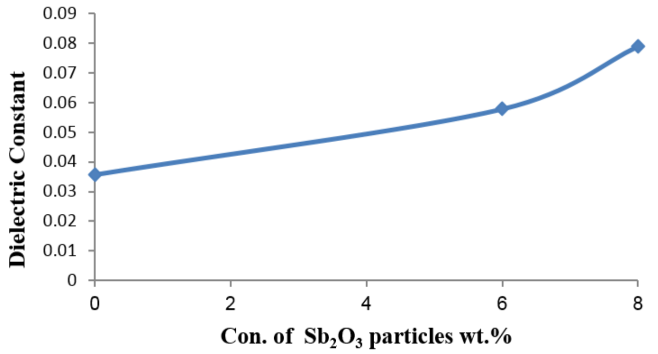

Figure.2. Effect of Sb_2O_3 concentration on the dielectric constant of PVA-PEG-Sb_2O_3 composite

Figure.3, shows the relationship between the dielectric loss (δ) of PVA-PEG-Sb_2O_3 composite with the frequency. It indicates that the dielectric loss decreases with the increasing the frequency. When applied low field frequency, the dielectric loss value is high, and it is decreases when increasing the frequency. This is qualified to the decrease of the galaxy charge polarization influence when increasing the frequency. Also from the figure, the dielectric loss increases with the increasing of Sb_2O_3 in the PVA-PEG-Sb_2O_3 composite (Figure.4). This trend can be attributed to the increase the alignment of the dipole charge.

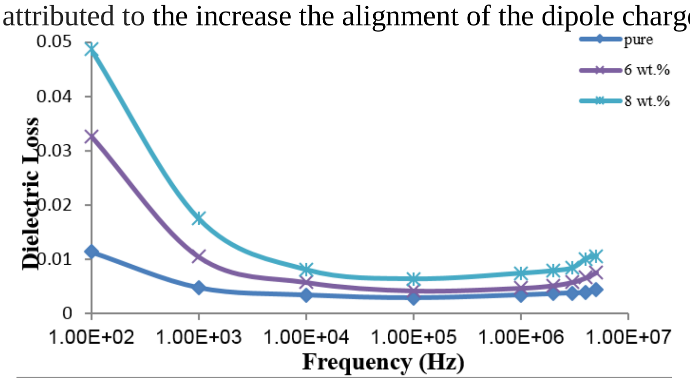

Figure.3. Effect of frequency on the dielectric loss of PVA-PEG-Sb_2O_3 composite

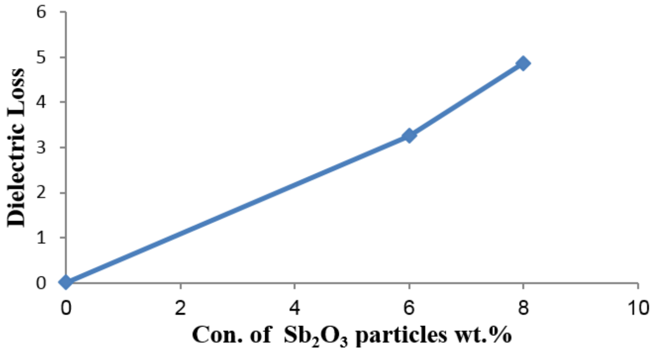

Figure.4. The effect of the Sb_2O_3 concentration on the dielectric loss of PVA-PEG-Sb_2O_3 composite

Figure.5, shows the variation in the electrical conductivity of the yield material as a function of frequency. The Figure reveal that the conductivity of the resulting material increases with increasing of frequency, this can be attributed to the space charge polarization that occurs at low frequencies, in addition to the motion of charge carriers that they move as in hopping process. The increasing of the conductivity is minor at high frequencies, this can belong to the electronic polarization and the charge carriers which travel by hopping process. Consequently, the conductivity is increases when the frequency increases r with the Sb_2O_3 content.

Figure.6, shows the electrical conductivity (σ) as a function of Sb_2O_3 content at the room temperature. The electrical conductivity is increases with the increasing of the fraction of Sb_2O_3 to the polymers mixture, this increase is due to the effect of the space charge. The Sb_2O_3 particles form clusters or separated groups, moreover, the increment of ionic charge carriers and the formation of a continuous network of Sb_2O_3 ions inside the composite have led to raise the conductivity.

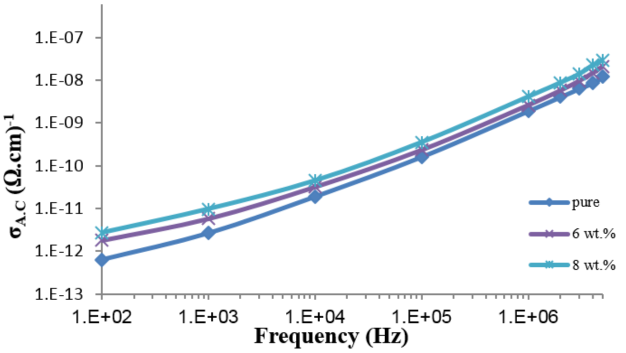

Figure.5. Effect of frequency on electrical conductivity of PVA-PEG-Sb_2O_3 composite

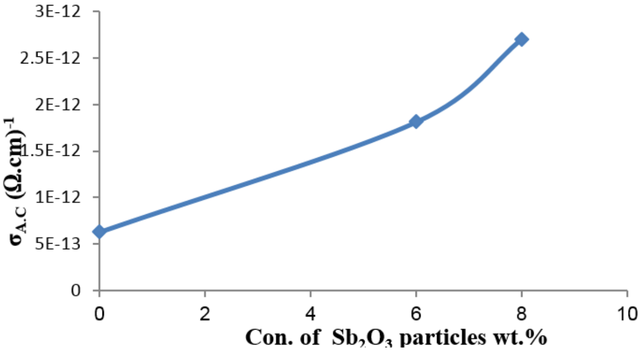

Figure.6. Variation of A.C conductivity of PVA-PEG- Sb_2O_3 composites with Sb_2O_3 content

4. CONCLUSIONS

The PVA-PEG-Sb_2O_3 composite prepared by casting method with various content of Sb_2O_3. From this work it can concluded:

The dielectric constant, dielectric loss, and electrical conductivity of the resulting material (PVA-PEG-Sb_2O_3) are increased with the increasing of the Antimony oxide (Sb_2O_3) content.

The dielectric constant and dielectric loss are decreased with the increase of frequency of the applied electric field.

The electrical conductivity of the resulting material was increased with the increasing of the frequency of the applied electrical field.

REFERENCES

Alvarez M.P, Poblete V.H, Pilleux M.E, and Fuenzalida V.M, Submicron Copper- Low- Density polyethylene conducting composites: Structural, Electrical and percolation Threshold, Comision Chilena de Energia Nuclear, Chile, 2008.

Blyth A.R, Electrical Properties of Polymers, John Wiley & Sons, New York, Chapman & Hall, London von Hippel AR (ed), 1979.

Chuang F.Y, Yang S.M, Cerium dioxide/polyaniline core–shell nanocomposites, J. Colloid Interface Sci., 320, 2008, 194–201.

Jafar H.I, Ali N.A, and Shawky A, Study of A.C Electrical Properties of Aluminum–Epoxy Composites, Journal of Al-Nahrain University, 14 (3), 2008, 77-82.

Jovic N, Dudic D, Montone A, Vittori M, and Djokovic V, Electrical conductivity behaviour of the Epoxy / Graphite nanosheets composites, XVII Symposium on condensed Matter physics, Vrsac, Serbia, 2007.

Kwan S.H, Shin F.G, and Tsul W.L, Dielectric constant of silver-thermosetting polyester composites, Journal of Material Science, 19 (12), 1984, 4093-4098.

Manjunath A, Deepa T, Supreetha N.K, and Irfan M, Studies on AC Electrical Conductivity and Dielectric Properties of PVA/NH_4NO_3 Solid Polymer Electrolyte Films, Advances in Materials Physics and Chemistry, 5, 2015, 295-301.

Markiewicz E, Paukstu D, Borisak S, Dielectric properties of lignocellulosic materials– polypropylene composites, Journal Materials Science-Poland, 27 (2), 2009.

Mohd Hamzah Harun, Elias Saion, Anuar Kassim, Muhd Yousuf Hussain, Iskandar Shahrim Mustafa and Muhd Ahmad Ali Omer, Temperature Dependence of AC Electrical Conductivity of PVA-PPy-$FeCl_3$ Composite Polymer Films, Malaysian Polymer Journal, 3 (2), 2008, 24-31.

Pillal P.K.C, and Rashmi, Dielectric properties of Polystyrene and some related polymers, Intern. J. polymeric mater, 8, 1980, 255- 263, 1980.

Reda S.M, Al-Ghannam S.M, Synthesis and electrical properties of polyaniline composite with silver nanoparticles, Adv. Mater. Phys. Chem., 2, 2012, 75–81.

Singh Vishal, Kulkarni A.R, Ramamohan T.R, Dielectric properties of aluminum-epoxy composites, Journal of applied polymer Science, 90, 2003, 3602-3608.