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Analysis of Dielectric Properties of PVA/PEG/In_2O_3 Nanostructures for Electronics Devices

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ABSTRACT

The dielectric characteristics of PVA/PEG/In_2O_3 nanostructures were tested to use in various electric nanodevices. The films of nanostructures of PVA/PEG/In_2O_3 were synthesized by casting solution technique. The dielectric characters of PVA/PEG/In_2O_3 nanostructures were determined. Results expressed that the dielectric parameters of PVA/PEG were rise with rise in the In_2O_3 NPs ratio. The performance of ε', ε" and σ_{AC} with frequency illustrated that the ε' and ε" reduced whereas the σ_{AC} rises with rise in frequency. The final results demonstrated the PVA/PEG/In_2O_3 nanostructures may be suitable in various electrical nanodevices.

1. INTRODUCTION

Nanocomposites of (inorganic/organic) system include gained a technical robust in the linear and nonlinear optics field, solar cells due to their exceptional characteristics and novel approaches [1]. Composites included excellent potential for different industrial applications as a result of their good characteristics like elevated hardness, elevated melting point (T_m), low density, low thermal expansion coefficient, elevated thermal conductivity, excellent chemical stability and enhanced mechanical characteristics like elevated specific strength, improved wear resistance & specific modulus. Composites are employed in manufacturing optoelectronic device, solar cells, light emitting diodes, laser diodes and industrial fields [2]. Commonly the investigating is viewing extensive attention towards metallic oxide nanostructure as a result of their potential employ in broad range of fields such as optoelectronic, sensors and information storage [3]. Polymer blending is one of the mainly significant contemporary approaches for the enlargement of novel polymeric matters and it is a functional method for design matters with a large variety of characters. The important polymer blends advantages are many exhibit characteristics that are greater compared to the characteristics of every individual element polymer [4]. Polyvinyl alcohol (PVA) is semi-crystalline matter that possesses good biodegradability, functional mechanical characteristics, biocompatibility, good optical characteristics, and non-toxicity, consequently its large series of fields. Other admirable characteristics of PVA include high optical transmission, non-corrosiveness stable of thermal and soluble of water [5]. PVA is soluble polymer material in water that included exacting attention as a result of its hydrophilicity and biocompatibility characteristics. PVA is harmless and has good thermal stability, making it a confident candidate to be employed in biomedicine and biotechnology approaches. PVA presents a good host substance as a result of its excellent morphology of film, joint with elevated flexibility [6]. Polyethylene glycol, PEG is a thermoplastic class of polymer with good crystallinity and excellent solubility of water, nontoxic and it includes high toughness and excellent biocompatibility [7]. Indium oxide, In_2O_3 has many advantages employed for transparent electronic fields, due to the its good optical transparency, broad band gap and low electrical resistivity [8]. Indium oxide, In_2O_3 has been extensively employed in displays of flat board, optoelectronic changer, displays of liquid crystal, solar cells and photovoltaic devices [9]. The studies on the electrical and optical characteristics of polymers substances included attracted much consideration in view of their appliance in optical and electronic devices [10]. Polymer composites based on inorganic oxides have aroused increasing interest in such fields of science as materials science or related fields (physics and chemistry of materials). Polymer/inorganic oxide composites often exhibit different material properties compared to pure polymers. They often differ from pure polymers in their optical, thermal and electrical properties [11]. The present work aims to fabricate of PVA/PEG/In_2O_3 nanostructure from PVA/PEG as matrix and In_2O_3 nanoparticles as additive and studying the A.C electrical properties with different frequencies and In_2O_3 nanoparticles contents to use in various electronics nanodevices.

2. MATERIALS AND METHODS

Films of polyvinyl alcohol (PVA)/ polyethylene glycol (PEG) doped with indium oxide (In_2O_3) were synthesized by casting process. In_2O_3 was used as powder from US Research Nanomaterials with high purity 99.9%. The blend film (70%PVA/30%PEG) was prepared by dissolving of 1 gm in distilled water (30 ml) where the PVA was dissolved at 80°C and let to each at room temperature, then the PEG was added to PVA solution. The nanostructures films were fabricated by adding of the In_2O_3 NPs to solution (PVA/PEG) with contents 1%, 2%, and 3%. The dielectric characteristics of PVA/PEG/ In_2O_3 films tested at (f=100 Hz to 5 ×10^6 Hz) by LCR meter. The dielectric constant, ɛ́ is given by [12, 13]:

$$\acute{\varepsilon} = C_p\, d / \varepsilon_o\, A \qquad (1)$$

wherever, C_p is capacitance of matter, thickness (d in cm), A= (in cm^2), ε_o is the vacuum permittivity.

Dielectric loss; ε″ is calculated by [14, 15]:

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

wherever, D: dispersion factor.

The A.C electrical conductivity is determined by [16, 17]:

$$\sigma_{A.C} = 2\pi f\, \acute{\varepsilon}\, D\, \varepsilon_o \qquad (3)$$

3. RESULTS AND DISCUSSION

Figures 1 and 2 demonstrate the behaviors of ε' and ε" with frequency of blend/In_2O_3 nanomaterials. The dielectric constant and loss are reduced when the frequency rises. The ε' and ε" values of blend/In_2O_3 nanostructures at a low frequency may be related to the effect of interfacial polarization or Maxwell– Wagner–Sillars. The influence of In_2O_3 NPs content on the ε' and ε" of PVA/PEG/In_2O_3 nanostructures are illustrated in Figures 3 and 4. The rise in values of ε' and ε" related to increase the charge carriers [18-25]. On the other hand, at high frequencies, dielectric constant and dielectric loss were found to be relatively constant with frequency. This is lead to the field periodical reversal takes place so quickly that the charge carriers will hardly be able to orient themselves in the direction of field resultant in the reduce in dielectric constant and dielectric loss. At low In_2O_3 NPs concentration, the dielectric constant and dielectric loss values are less. The rise of In_2O_3NPs concentration led to rise in the average number of concentrations among the In_2O_3 NPs. At higher concentrations of In_2O_3 NPs, the dielectric constant and dielectric loss are as a result of a continuous network formation of nanostructures during the nanocomposite [26].

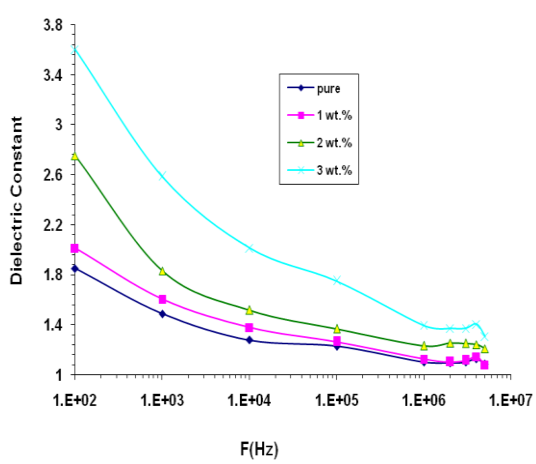

Figure 1. Behavior of ε' with frequency of blend/In_2O_3 nanomaterials

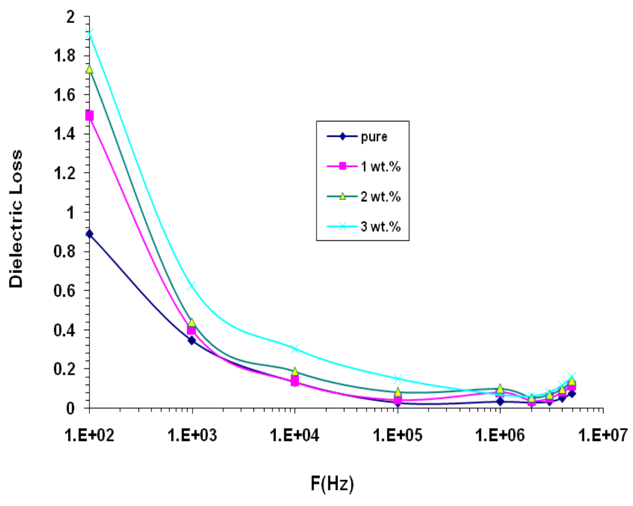

Figure 2. Behavior of ε" with frequency of blend/In_2O_3 nanostructures

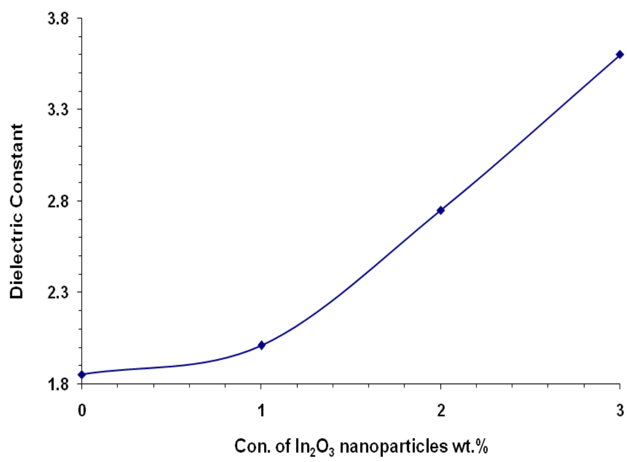

Figure 3. Influence of In_2O_3 NPs content on the ε' of PVA/PEG/In_2O_3 nanostructures at 100Hz

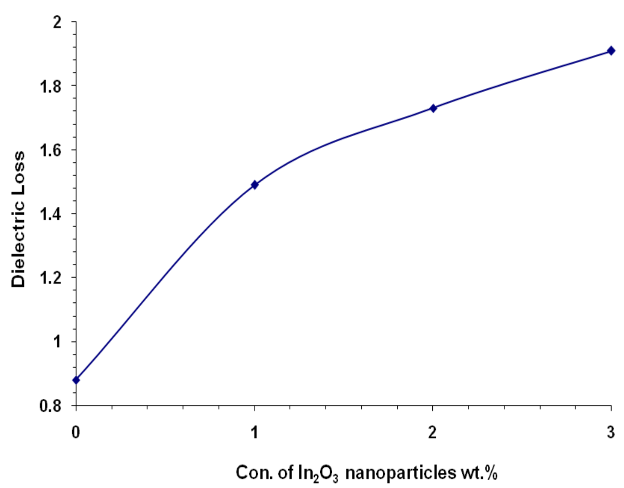

Figure 4. Influence of In_2O_3 NPs content on the ε" of PVA/PEG/In_2O_3 nanostructures at 100Hz

Figures 5 and 6 illustrate the performance of A conductivity of PVA/PEG/In_2O_3 nanostructures with frequency(f) and contents of In_2O_3 NPs. The $\sigma_{A.C}$ of nanostructures rises with rise in In_2O_3 NPs ratio and frequency. The rise in conductivity with frequency due to increase of charge carriers mobility. The increase in values of conductivity when the In_2O_3 NPs content rises relate to improve the electrons number [27-33].

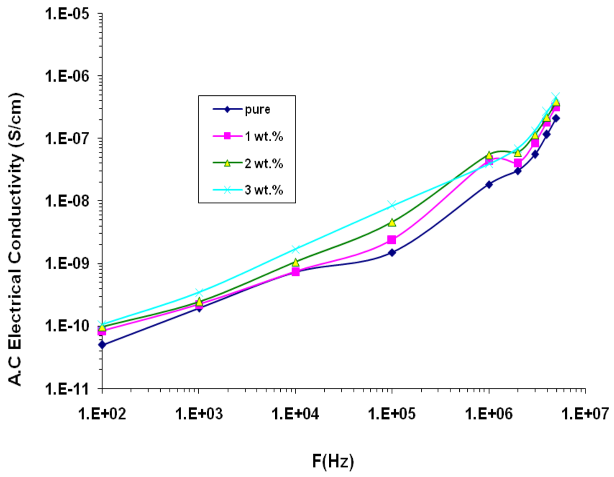

Figure 5. Performance of conductivity of blend/In_2O_3 nanostructures with frequency(f)

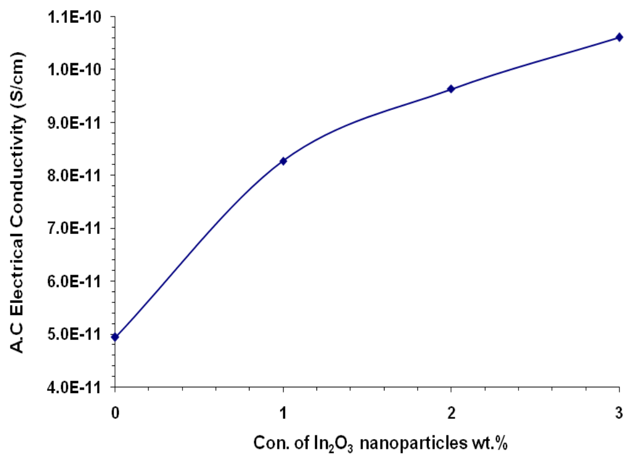

Figure 6. Performance of conductivity of blend/In_2O_3 nanostructures with of In_2O_3 NPs contents

4. CONCLUSIONS

The present work includes of fabricating the PVA/PEG/In_2O_3 nanostructures and investigating their dielectric characteristics. The dielectric properties (ε', ε" and $\sigma_{A.C}$) of PVA/PEG/In_2O_3 nanostructures were calculated to utilize in electric nanodevices. Results of dielectric characteristics of PVA/PEG/In_2O_3 nanostructures expressed the ε', ε" and $\sigma_{A.C}$ of PVA/PEG were rise when the In_2O_3 NPs content rises. The ε' and ε" are reduced while the $\sigma_{A.C}$ rises when the frequency rises. The results of dielectric characteristics showed the PVA/PEG/In_2O_3 nanostructures may be utilized in various electric nanodevices.

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