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Evaluation of the influence of $SrTiO_3$ and CoO nanofillers on the structural and electrical polymer blend characteristics for electronic devices

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Using the casting method, the films of nanocomposites (NCs) are made from a (PEO-PVA) mixture with varying ratios of $SrTio_3$ and CoO nanoparticles (NPs). The results show that increasing the ratio of ($SrTiO_3$-CoO) NPs improved the electrical and structural characteristics of (PEO-PVA-$SrTio_3$-CoO) NCs. The scanning electron microscopy results demonstrate that morphology on surface of the (PEO-PVA-$SrTiO_3$-CoO) NCs is homogeneous and coherent, with several groupings or pieces distributing on the top of the surface at random. According to the dielectric characteristics, dielectric constant and dielectric loss of the NCs reduce with increasing the frequency of the applied electric field and increases with increasing concentration of ($SrTiO_3$-CoO) nanoparticles. As the concentration of ($SrTiO_3$-CoO) and frequency are increased, conductivity increases. The results of structural and electrical characteristics show that the (PEO-PVA-$SrTiO_3$-CoO) NCs may be used for various electronics fields.

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Keywords :Polymer blend , Electrical properties, Nanoafiller, Structural properties

1. Introduction

Nanotechnology is a branch of science that deals with the study at the atomic and molecular scale, and the design of materials and devices. Nanotechnology is concerned with structures with a size of less than 100 nanometers, it also necessitates the creation of large-scale materials or technological devices [1]. Recent advancements in the field of flexible electronic devices have been made possible by the valuable piezoelectric, semiconductor, optical, and electro-optical capabilities found in various polymers.These compounds' charge transport characteristics are determined by their electrical properties. When it comes to optical characteristics, directed at antireflection, superior reflection and polarization characteristics are achieved. Based on their interaction with the polymer matrix, dopant addition can alter the optical and electrical properties of the polymers. Furthermore, when making composite materials, polymer materials' advantages, he advantages of organic components, such as good moldability, high strength, and flexibility, can be combined with the advantages of inorganic materials, such as heat stability, heat strength, high strength, and chemical resistance. [2,3]. Food packaging and biomedical applications will benefit from the production of polymer composites using a polymer matrix that has. In various industries, polyvinyl alcohol (PVA) is gradually replacing nonbiocompatible plastics such as polyethylene, polypropylene, HDPE, and others because of its biocompatibility, nontoxicity, water solubility, and greater tensile strength [3]. Because of its mechanical and chemical durability, polyvinyl alcohol (PVA) is a cost-effective and appealing material for creating electrolyte membranes. [4]. PEO is a linear polymer containing enteric (i.e. ether) links group C-O-C) and can solvate a variety of substances. salts that are made up of inorganic elements. However, the PEO structure has a high order. Its conductivity is limited, so it must be paired with something else polymer that is amorphous [5]. $SrTiO_3$ is a strontium-titanium oxide SrTiO3 is a chemical compound with the formula $SrTiO_3$ and the form SrTiO3 is a chemical called SrTiO3 and the formula At normal temperature, it has a perovskite structure; at low temperatures [6].Cobalt oxide (CoO) is these powders are used in Catalysts, ceramic pigments, gas sensors, magnetic materials, and rechargeable batteries, [7]. The synthesis and properties of (PEO-

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PVA-$SrTiO_3$-CoO) nanocomposites for electrical and electronic applications are discussed in this work.

2. Experimental part

By casting cobalt oxid (CoO) nanoparticles and strontium titanate ($SrTio_3$) into (PEO-PVA) mixture with weight variations (0, 1, 2, 3, and 4) wt percent in 50 ml of water, polymers NCs were created. Dielectric characteristics of (PEO-PVA-$SrTiO_3$-CoO) NCs, dielectric constant, dielectric loss, and conductivity were measured at room temperature using a (LCR Meter) in the frequency (f) range (100Hz -5MHz).

Dielectric constant (ε') is calculated using the formula [8,9]

$$\varepsilon' = C_p / C_o \tag{1}$$

where (C_p) denotes capacitance and (C_o) denotes a vacuum capacitor. The dielectric loss (ε") calculated from equation [10]

$$\varepsilon'' = \varepsilon' D \tag{2}$$

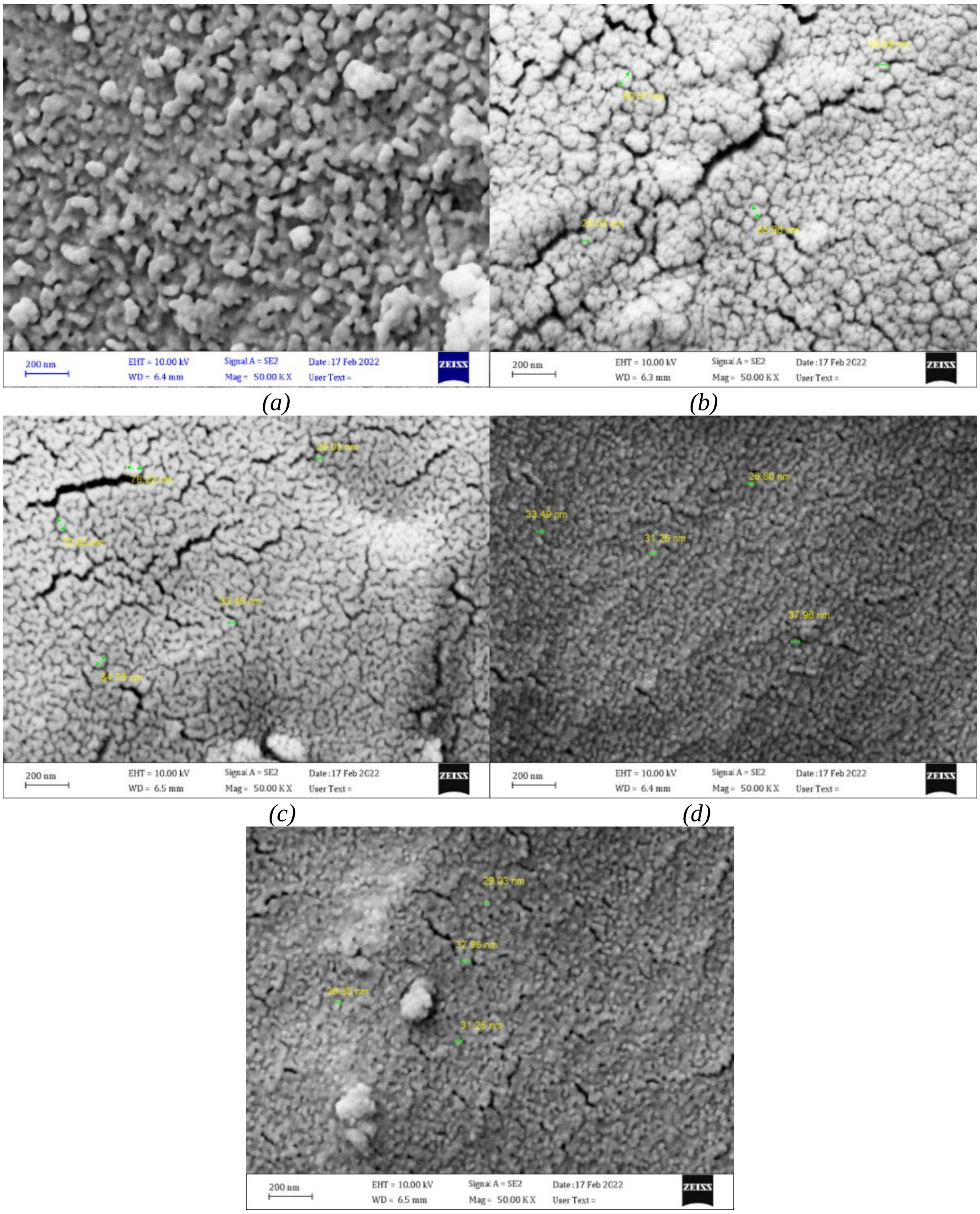
The dispersion factor (D) is used here gives the (A.C) electrical conductivity [11]

$$a.c = \omega\, \varepsilon''\, \varepsilon' \tag{3}$$

3. Results and Discussion

3.1. Scanning Electron Microscope (SEM) Measurements

Fig. 1 displays typical SEM imags of (PEO-PVA-SrTiO3-CoO) NCs. Scanning electron micrographs of pure (PEO-PVA) blend and (1,2,3,4) wt. percent of ($SrTiO_3$-CoO) nanoparticles are indicatet in fig. 1 (A.B.C.D and E). Various alterations have been discovered, ranging from pure PEO with PVA to low concentrations of PEO with PVA, moderate, and high quantities of ($SrTiO_3$-CoO) nanoparticles. In the pure (PEO-PVA) mixture, the smooth surface of the (PEO-PVA) blend film can be seen. In (fig. 1 B), which contained 1 wt. percent of ($SrTiO_3$-CoO) nanoparticles, tiny and inconspicuous few agglomerations of ($SrTiO_3$-CoO) nanoparticles were observed, implying that ($SrTiO_3$-CoO) particles can be widely disseminated in (PEO-PVA) blend, and the produced film is uniform and dense, with no discernible phases with a ratio of 0.2 wt% ($SrTiO_3$-CoO) nanoparticles, agglomerations appeared. (fig.1C). In (PEO-PVA) 3wt. percent of ($SrTiO_3$-CoO) nanoparticles produced samples, several semi-tori with varying diameters in the range, bright spots developed in all of them with varying degrees of roughness. (fig. 1D). The bright spots in the figure appear to be agglomerates of ($SrTiO_3$-CoO) nanoparticles that grow in size when the concentration of ($SrTiO_3$-CoO) nanoparticles increases. As the concentration of a substance increases, (SrTiO3-CoO) nanoparticles increase the degree of roughness of the film surface, as seen in (fig. 1E). This suggests filler segregation in the host matrix, which can be validated by additive-polymer interaction and complication. It could also relate to the formation of ($SrTiO_3$-CoO) nanoparticles in a matrix of (PEO-PVA) [12,13,14]



(a) *(b)*

(c) *(d)*

(e)

Fig. 1. SEM images for (PEO-PVA-SrTiO$_3$-CoO) nanocomposites: (A) for (PEO-PVA), (B) for 1 wt% SrTiO$_3$-CoO, (C) for 2wt% SrTiO$_3$-CoO, (D) for 3 wt% SrTiO$_3$-CoO (E) for 4 wt% SrTiO$_3$-CoO.

3.2. The A.C electrical properties of (PEO-PVA-SrTiO$_3$-CoO) nanocomposites

Fig. 2. indicatet difference of the dielectric constant with frequency. As can be seen, the dielectric constant values drop as the applied frequency increases, as a result, the ratio of space charge polarization to total polarization decreases.. At low frequencies, space charge polarization is the most important sort of polarization, and as frequency increases, it becomes less important [15]. As the electric field frequency increases, the dielectric constant values for all samples of (PEO-PVA-SrTiO3-CoO) NCs decrease, and different types of polarizations occur at higher frequencies. Since an ion's mass is greater than that of an electron, ionic polarized reacts to changes in field frequency in a somewhat different way than electronic polarization. This causes the electrons to react [16].

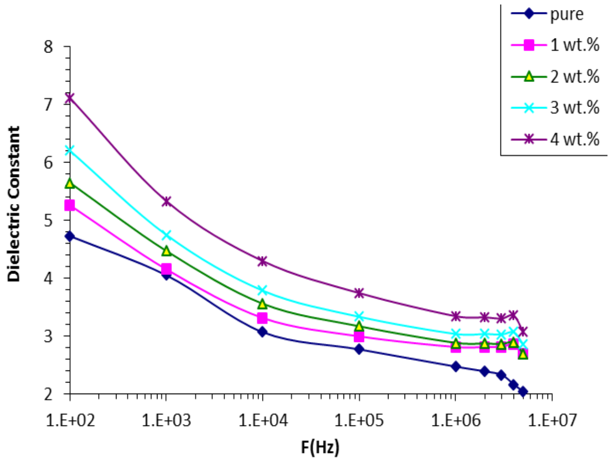


Fig. 2. Dielectric constant of (PEO- PVA-$SrTiO_3$-CoO) NCs varies with frequency.

Fig. 3. shows the dielectric constant change with nanoparticle concentrations for (PEO-PVA-SrTiO3-CoO) NCs, at 100Hz. The dielectric constant of nanocomposites rises as the concentration increases of ($SrTiO_3$-CoO) nanoparticles. This activity could be explained by interfacial polarization, a phenomenon that happens when two surfaces within NCs are separated by an alternating electric field, resulting in an increase in charge carriers [17].

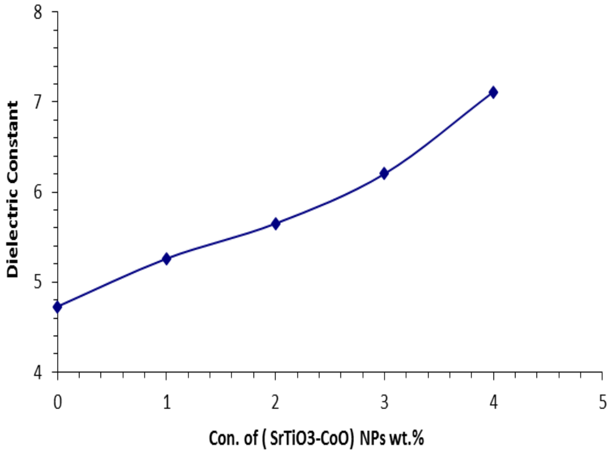


Fig 3. Difference of dielectric constant with concentration of ($SrTiO_3$-CoO) NPs for (PEO- PVA -$SrTiO_3$-CoO) NCs.

Fig. 4. For (PEO- PVA -SrTiO3-CoO) NCs, shows the relationship between dielectric loss and frequency. It's self-evident that dielectric loss values are substantial at low applied frequencies, but decrease as frequency increases.. When the frequency is increased, the contribution of space charge polarization decreases. The maximum dielectric loss for nanocomposites at f=100Hz; this figure represents the highest dielectric loss at a specific frequency, indicating significant applied field absorption, the Maxwell-Wagner phenomenon causes this to happen, which is a condition caused by alternating current due to dielectric constant differences between the phases in NCs [18].

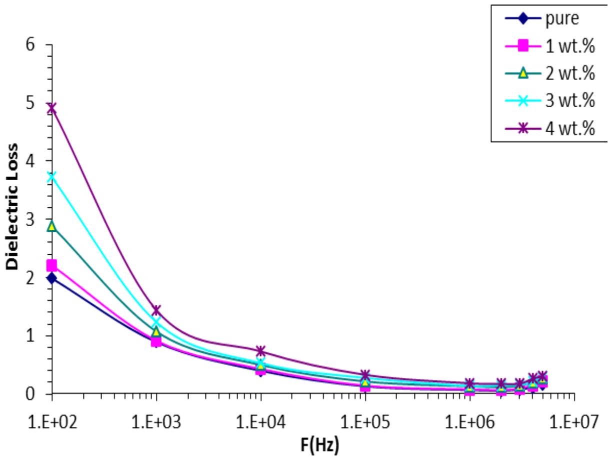


Fig. 4. Difference of the dielectric loss with frequency for (PEO- PVA -$SrTiO_3$-CoO) NCs.

Fig. 5 illustrate the link between ($SrTiO_3$-CoO) NPs concentration and dielectric loss. The dielectric loss of (PEO-PVA-$SrTiO_3$-CoO) NCs increases as the concentration of NPs increases, which is linked to an increase in the number of charge carriers. It forms clusters at low concentrations of NPs, but when the concentration of nanoparticles approaches 4 wt.%, the NPs form a continuous net work in the NCs [19].

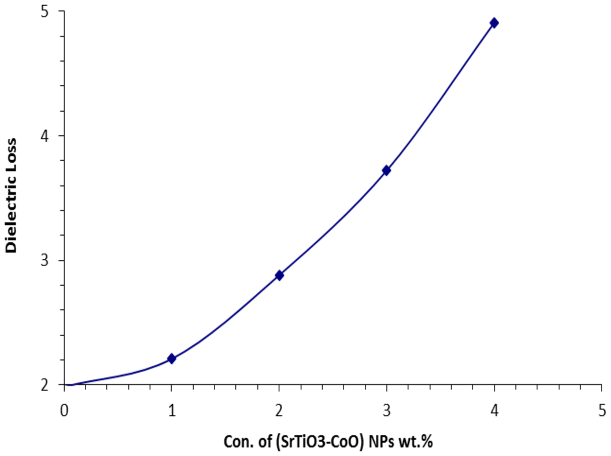


Fig. 5. Difference of dielectric loss for (PEO- PVA -$SrTiO_3$-CoO) NCs with different concentrations of ($SrTiO_3$-CoO) NPs.

Fig. 6. indicatet the difference of conductivity with frequency of (PVA-PEO-$SrTiO_3$-CoO) NCs, these figure show that conductivity increases significantly with increasing frequency, this is due to space charge polarization, which occurs at low frequencies, and the hopping process, which causes charge carriers to move around. Because of electronic polarization and charge carriers that travel by hopping process, the increase in conductivity is modest at high frequencies [20].

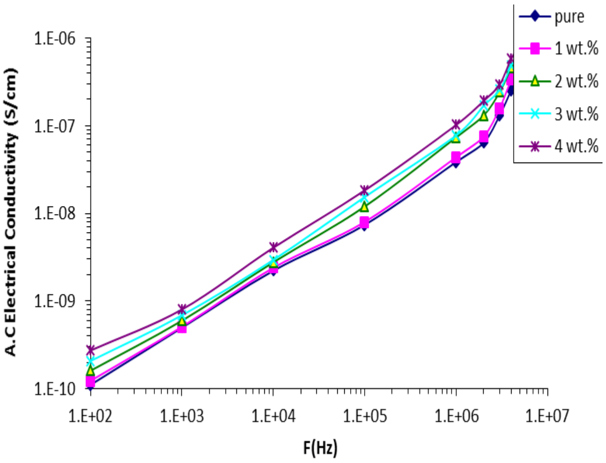


Fig. 6. Difference of A.C electrical conductivity with frequency for (PEO- PVA -$SrTiO_3$-CoO) NCs.

Fig. 7. At 100 Hz, the conductivity of (PEO-PVA-$SrTiO_3$-CoO) NCs varies with the concentration of ($SrTiO_3$-CoO) nanoparticles. The conductivity of NCs increases as the concentration of ($SrTiO_3$-CoO) nanoparticles increases, as can be seen. Because of the dopant nanoparticles' composition, the number of charge carriers increases, lowering NCs resistance and increasing conductivity [21,22,23].

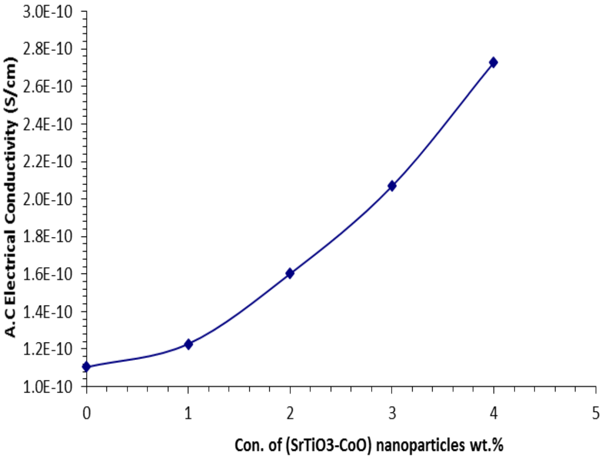


Fig.7. Difference of A.C electrical conductivity with ($SrTiO_3$-CoO) NPs for (PEO- PVA -$SrTiO_3$-CoO) NCs.

4. Conclusion

The surface morphology of the (PVA-PEO-$SrTiO_3$-CoO) nanocomposites films is shown by scanning electron microscopy (SEM), which reveals several aggregates or chunks randomly dispersed on the top of the surface, homogeneous and coherent. With increasing frequency, the dielectric constant and dielectric loss of (PVA-PEO-$SrTiO_3$-CoO) NCs decreases. Furthermore, increasing the concentration of (SrTiO3-CoO) nanoparticles increases the dielectric constant and dielectric loss, the conductivity of (PVA-PEO-$SrTiO_3$-CoO) NCs increase as the frequency and concentration of these nanoparticles ($SrTiO_3$-CoO) increases. These characteristics can be applied to films in a variety of electrical applications.

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