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Fabrication of PVA–Fe₂O₃/Co₂O₃ Nanocomposites and Improved Dielectric Properties for Flexible Electronics Fields

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Films of PVA and PVA doped with Fe₂O₃/Co₂O₃ nanoparticles are fabricated to employ in different electronics fields. The dielectric properties of (PVA–Fe₂O₃/Co₂O₃) nanocomposites are investigated in frequency range from 100 Hz to 5 MHz. The results show that both the dielectric constant and the dielectric loss of (PVA–Fe₂O₃/Co₂O₃) nanocomposites are reduced, while the A.C. electrical conductivity increases with increasing of the frequency of applied electric field. The dielectric constant, the dielectric loss and the A.C. electrical conductivity of PVA increases with increasing of the Fe₂O₃/Co₂O₃-nanoparticles' content. The dielectric-properties' results show that the (PVA–Fe₂O₃/Co₂O₃) nanocomposites can be suitable for different electronics fields.

Плівки ПВС і ПВС, леговані наночастинками Fe₂O₃/Co₂O₃, виготовляються для використання в різних галузях електроніки. Досліджено діелектричні властивості нанокомпозитів (ПВС–Fe₂O₃/Co₂O₃) в діапазоні частот від 100 Гц до 5 МГц. Результати показують, що як діелектрична проникність, так і діелектричні втрати нанокомпозитів (ПВС–Fe₂O₃/Co₂O₃) зменшуються, тоді як електропровідність змінного струму зростає зі збільшенням частоти прикладеного електричного поля. Діелектрична проникність, діелектричні втрати й електропровідність змінного струму ПВС зростають із збільшенням вмісту наночастинок

$\text{Fe}_2\text{O}_3/\text{Co}_2\text{O}_3$. Результати діелектричних властивостей показують, що наноккомпозити (ПВС- $\text{Fe}_2\text{O}_3/\text{Co}_2\text{O}_3$) можуть бути придатними для різних галузей електроніки.

Key words: PVA, $\text{Fe}_2\text{O}_3/\text{Co}_2\text{O}_3$ nanoparticles, nanocomposites, dielectric properties.

Ключові слова: полівініловий спирт, наночастинки $\text{Fe}_2\text{O}_3/\text{Co}_2\text{O}_3$, наноккомпозити, діелектричні властивості.

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1. INTRODUCTION

Polymers have limited application in the manufacturing of goods and buildings on their own since their qualities are inferior to those of other materials, such as most metals. Polymers are materials with low-density flexible, fast treatment, easy to synthesized, lightweight and superior in dielectric breakdown strength. When a polymer system (matrix) is coupled with reinforcing material (filler), the characteristics of the composite are enhanced. In terms of matrix properties, the features of the composite are heavily influenced by filler features, with the size of the filler playing the most important impact. The polymer nanocomposites (PNC) in the associated technology (nanotechnology) are polymer composites with filler sizes in the nanoscale domain [1–4].

In the type of new substances, nanocomposites with polymer matrix have grabbed more attention due to their enhanced electrical, optical and magnetic properties. These materials possess increased modulus and flame resistance, and are capable to preclude oxidation and agglomeration. These enhancements in properties are due to interaction between nanoparticles and polymer matrix. Addition of nanoparticles into polymer matrix improves lifetime of nanoparticles, modifies the surface of nanoparticles by passivation defect states, provide low cost, ease of device fabrication and tuneable optical and electronic properties. Nanocomposites on base of semiconductor nanoparticles and polymer matrix are prospective materials for application in optoelectronics, for creation of luminescent materials, sensor, *etc.* [5–14].

Fe_2O_3 nanoparticles (NPs) have special properties like good electron mobility, magnetic ability, and a 2.2 eV optical energy band gap, which are useful for optoelectronic applications. Fe_2O_3 NPs have potential applications in the fields of medicine, life sciences and computer technology like magnetic resonance imaging (MRI), drug carriers in delivery, gene carriers in gene therapy, nanofertilizers, non-fungicides, nanopesticides, nanofood, food packing,

nanocoatings, nanosensors, nanoscale memory, nanowires, spintronics, *etc.* They can be used as filters in sunscreens, biosensors [15].

The great interest in cobalt oxides and the derived compounds is due to their exceptional physical and chemical properties, which make them promising materials widely applied in different fields, such as ceramics, optics or catalysis [16]. Polyvinyl alcohol (PVA) is nontoxic, semi-crystalline material, high flexibility and water soluble with excellent mechanical and thermal characterizations. PVA has wide uses in fields such as building, electronics, medicine and other industries. PVA has found applications in number of fields including fuel cells, membranes, papermaking, coatings, adhesives, sensors, batteries, textiles, and biomedical frameworks [17–25]. This work aims to prepare of (PVA-Fe₂O₃/Co₂O₃) nanocomposites to use in the electronics devices.

2. MATERIALS AND METHODS

Nanocomposites of PVA doped with iron oxide nanoparticles (Fe₂O₃ NPs) and cobalt oxide nanoparticles (Co₂O₃ NPs) were fabricated by casting method. The PVA film was prepared by dissolving of 0.5 gm in distilled water (20 ml). The Fe₂O₃/Co₂O₃ NPs were added to the PVA solution with ratio 1:1 and different concentrations: 1.9%, 3.8%, and 5.7%. The dielectric characteristics of PVA-Fe₂O₃/Co₂O₃ nanocomposites films measured at frequency range from 100 Hz to 5·10⁶ Hz by LCR meter (HIOKI 3532-50 LCR HI TESTER). The dielectric constant ϵ' was determined [26] as

$$\epsilon' = C_p d / (\epsilon_0 A), \quad (1)$$

where C_p is the capacitance of matter, d is the thickness, A is the area. Dielectric loss ϵ'' was found [27] as

$$\epsilon'' = \epsilon' D, \quad (2)$$

where D represents the dispersion factor. The A.C. electrical conductivity was calculated [28] as

$$\sigma_{A.C.} = 2\pi f \epsilon' D \epsilon_0. \quad (3)$$

3. RESULTS AND DISCUSSION

Figures 1 and 2 demonstrate the variation of dielectric constant and dielectric loss for PVA-Fe₂O₃/Co₂O₃ nanocomposites with frequency, respectively. With increasing frequency, the ϵ' values decrease,

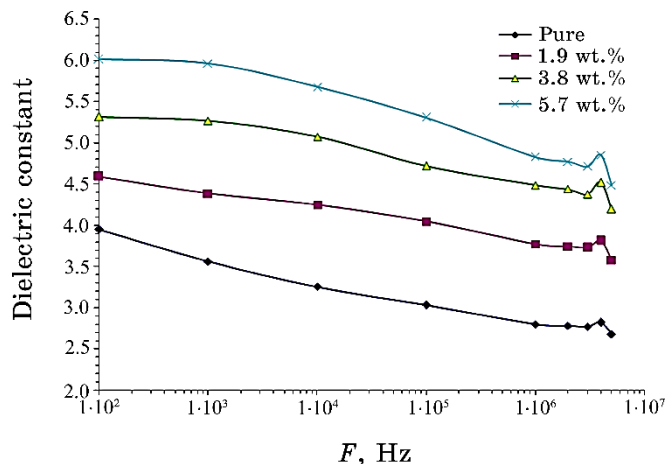


Fig. 1. Variation of dielectric constant for PVA-Fe₂O₃/Co₂O₃ nanocomposites with frequency.

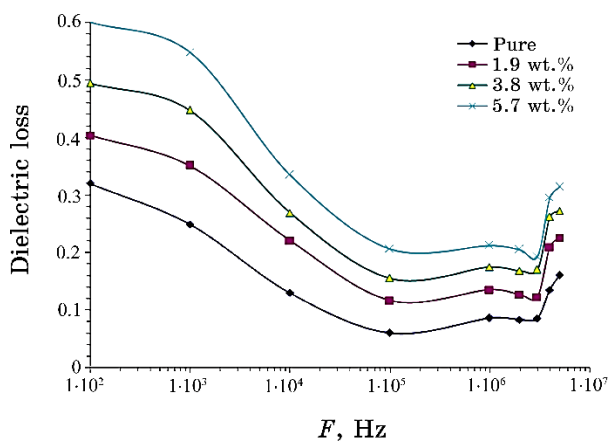


Fig. 2. Dielectric loss performance for PVA-Fe₂O₃/Co₂O₃ nanocomposites with frequency.

causing the dipole to lose its ability to spin, and its oscillation to begin to lie after this field.

Because of the mobility of ions, which is the fundamental basis of nanocomposite, dielectric loss has a reduction in high frequency as shown in Fig. 2; the dielectric loss has reduction in high frequency. As a result, at lower frequency values, a large dielectric loss value implies the effect of ion hopping and the loss of ion movement conduction, as well as the loss of ion polarization [29]. The dielectric constant and dielectric loss of PVA increase with an increase in the

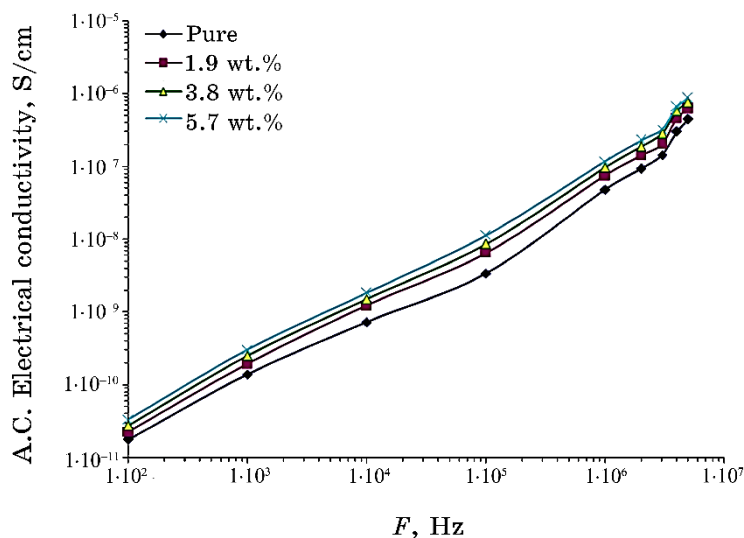


Fig. 3. Behaviour of A.C. electrical conductivity for PVA-Fe₂O₃/Co₂O₃ nanocomposites with frequency.

Fe₂O₃/Co₂O₃ NPs' content due to the rise of the charge carriers [30, 31].

The performance of A.C. electrical conductivity for PVA-Fe₂O₃/Co₂O₃ nanocomposites with frequency is shown in Fig. 3. At high frequency, the A.C. conductivity increases due to the excess charge carriers produced, which are assigned to the trapped charge activation in the polymeric material that undergoes localized motion. The highest value of conductivity was at highest content of Fe₂O₃/Co₂O₃ NPs, which can be assigned efficient conductive networks created, when Fe₂O₃/Co₂O₃ is loaded in polymeric matrix [32].

4. CONCLUSIONS

The present work involves preparation of (PVA-Fe₂O₃/Co₂O₃) nanocomposites films to employ in different electronics fields.

The results show that the dielectric constant and dielectric loss of (PVA-Fe₂O₃/Co₂O₃) nanocomposites is reduced, while the A.C. electrical conductivity increases with increasing of the frequency of applied electric field.

The dielectric constant, the dielectric loss and the A.C. electrical conductivity of PVA is increased with an increase in the Fe₂O₃/Co₂O₃ nanoparticles' content.

Finally, the dielectric properties results show that the (PVA-Fe₂O₃/Co₂O₃) nanocomposites can be suitable for different electron-

ics fields.

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