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Determination of Optical Parameters of Polymer Blend/Nanoceramics for Electronics Applications

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Preparations of PVA/PEG/zirconium oxide films for biomedical application as antibacterial are investigated for electronics applications. Structural and optical characterizations of PVA/PEG/ZrO_2 nanocomposites are examined. The results indicate that the absorbance and optical parameters of polymer blend are raised, while transmittance and energy-band gap are reduced as ZrO_2 content increases. The results of structural and optical properties show that the PVA/PEG/ZrO_2 nanocomposites may be used for various electronics fields.

Для застосування в електроніці досліджуються препарати оксидних плівок полівініловий спирт/поліетиленгліколь/оксид Цирконію для біомедичних вживань як антибактеріяльних. Розглянуто структурні й оптичні характеристики нанокомпозитів ПВС/ПЕГ/ZrO_2. Результати показують, що абсорбція й оптичні параметри полімерної суміші є підвищеними, в той час як коефіцієнт пропускання та ширина забороненої енергетичної зони зменшуються в міру збільшення вмісту ZrO_2. Результати структурних і оптичних властивостей показують, що нанокомпозити ПВС/ПЕГ/ZrO_2 можуть використовуватися для різних галузей електроніки.

Key words: zirconium oxide, nanocomposites, polymer blend, optoelectronics.

Ключові слова: оксид Цирконію, нанокомпозити,, полімерна суміш, оптоелектроніка.

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1. INTRODUCTION

The nanocomposites materials are promising in the fields of sensors, radiation shielding, antibacterial, thermal energy storage and release, piezoelectric, solar cells, diodes and other fields with low cost and lightweight. The important type of nanocomposites is polymer nanocomposites. The polymer nanocomposites have unique properties, which combine between polymer properties (low cost, dielectric material, good optical properties, low thermal conductivity, and poor mechanical properties in comparison with other materials) and additive properties, that determine the properties of the resulting substance and depends on the concentration of the additive. The nanocomposites are characterized as antibacterial materials. Due to the urgent need to find materials having good antibacterial properties, it is important to determine the resistance of bacterial to the antibiotics by novel antibiotics. The applications of nanotechnology in medicine may be used for fight against many types of diseases [1]. The materials of nanoparticles have promised applications in the different fields of biomedical sciences, which are attributed to their special properties [2].

The synthesis of new polymer nanocomposites has been studied by the modern applications on inorganic nanoparticles as fillers in the several applications [3]. Organic and inorganic nanocomposites have been studied as unique type of hybrid nanomaterials attributed to their structural, electrical, optical, and thermal properties [4]. The optical characterization of nanocomposites is influenced by different factors including filler size, distribution of sizes, dispersion degree, and concentration of filler [5]. Zirconium oxide nanoparticles have a special consideration due to the unique properties for biomedical application as antibacterial material [6]. The improvements in D.C. electrical, dielectric, optical, and thermal properties of composites and nanocomposites are increasing to great potential for highly functional materials having good electrical, dielectric, optical, and thermal characterizations with low weight and low cost [7–23]. This paper deals with preparation and properties of PVA/PEG/ZrO_2 nanocomposites for biomedical applications.

2. MATERIALS AND METHODS

Nanocomposites were prepared from polyvinyl alcohol/polyethylene glycol, and zirconium oxide by means of using casting method. The PVA/PEG/ZrO_2 nanocomposite was prepared with ratios of ZrO_2 nanoparticles and blend: 1 gm of PVA/PEG with ratio 78 wt.%/22 wt.% was dissolved in 20 ml of distilled water. The ZrO_2 was added with ratios 2, 4 and 6 wt.%. Optical properties were measured by the spectrophotometer Shimadzu, UV at 1800 Å.

The absorption coefficient α was calculated using the equation [24–26]

$$\alpha = 2.303A/t, \tag{1}$$

where A is absorbance, t is thickness of sample. The energy-band gap was determined [27, 28] with

$$\alpha h\nu = Y\left(h\nu - E_g\right)^d; \tag{2}$$

Y is constant, $h\nu$ is energy of photon, E_g is energy gap, $d = 2$ and 3 for indirect allowed and forbidden transitions.

The extinction coefficient (k) of nanocomposites is determined by using [29, 30]

$$K = \alpha\lambda/(4\pi). \tag{3}$$

The refractive index (n) was calculated by using [31]

$$n = \left(1 + x^{1/2}\right)/\left(1 - x^{1/2}\right). \tag{4}$$

The real (ε_1) and imaginary (ε_2) parts of complex dielectric constant are given by using [32]

$$\varepsilon_1 = n^2 - k^2, \tag{5}$$

$$\varepsilon_2 = 2nk. \tag{6}$$

The conductivity is determined by using [33]:

$$\sigma = \frac{\alpha nc}{4\pi}. \tag{7}$$

3. RESULTS AND DISCUSSION

Figure 1 indicates to the absorbance variation with wavelength. The absorbance reduces with increase in wavelength. Figure also shows that the absorbance of PVA/PEG blend rises with raise in ZrO_2 ratios that is related to raise the charge carries [34, 35], as shown in

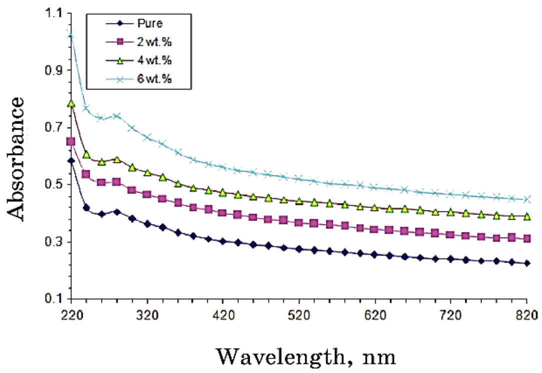

Fig. 1. Absorbance with photon wavelength.

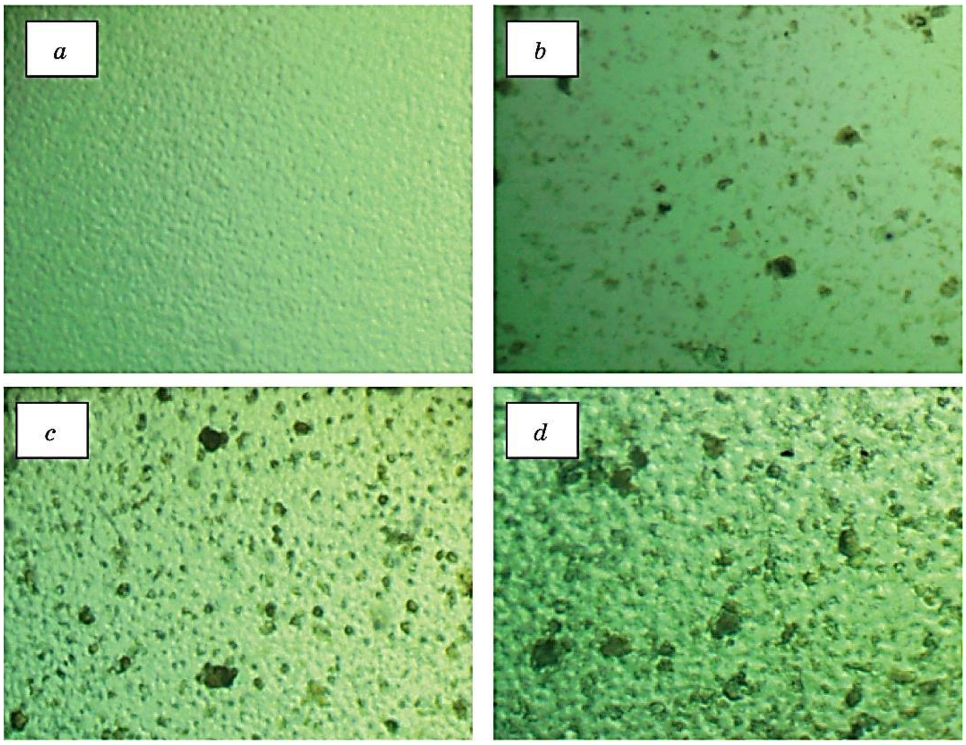

Fig. 2. Microscope images (×10): (*a*) for pure blend, (*b*) for 2 wt.% ZrO_2, (*c*) for 4 wt.% ZrO_2, (*d*) for 6 wt.% ZrO_2.

Fig. 2. These are consistent with the results of Refs. [36–40].

The absorption coefficient of nanocomposites is shown in Fig. 3. It increases with an increase in ZrO_2 nanoparticles. The energy gap

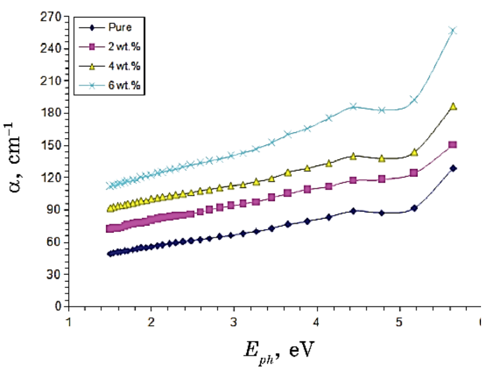

Fig. 3. Absorption coefficient for PVA/PEG/ZrO_2 nanocomposites.

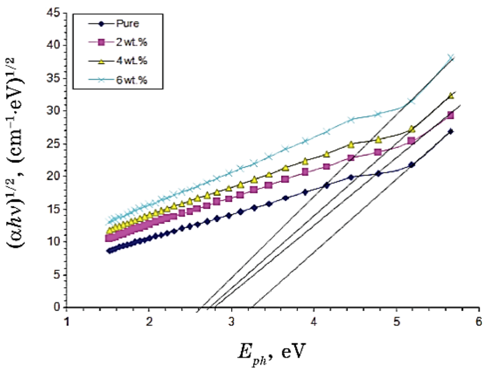

Fig. 4. Energy gap for allowed transition.

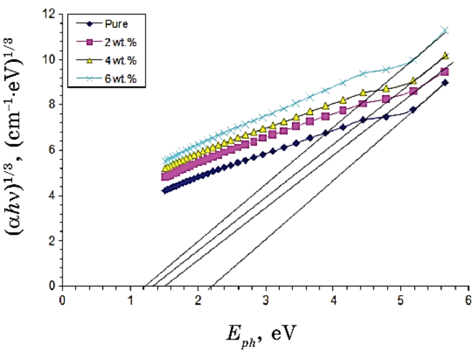

Fig. 5. Energy gap for forbidden transition.

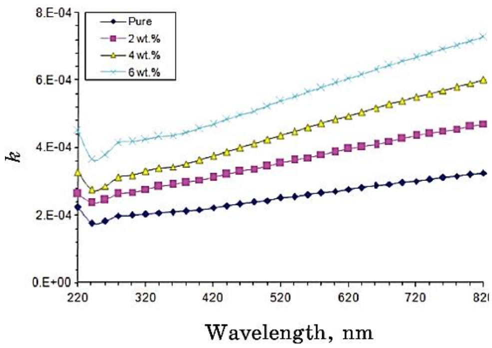

Fig. 6. Extinction coefficient for PVA/PEG/ZrO_2 nanocomposites.

may be calculated by the values of absorption coefficient; they show that the PVA/PEG/ZrO_2 nanocomposites have indirect band gap for allowed indirect (Fig. 4) and for forbidden indirect (Fig. 5) transitions. The energy-band gaps of polymers decrease with increase in ZrO_2 concentrations; this behaviour may be attributed to raise the localized level [41–46].

Figure 6 represents the extinction coefficient for PVA/PEG/ZrO_2 nanocomposites. There is increased extinction coefficient with increasing of the zirconium oxide concentrations that is due to increase of the absorbance [47, 48].

Figure 7 shows refractive index of PVA/PEG/ZrO_2 nanocomposites. Refractive index of blend rises with raise in ZrO_2 ratio because of raising the light scattering [49–51].

The real and imaginary parts of complex dielectric constant with wavelength are represented in Figs. 8 and 9. These parts increase

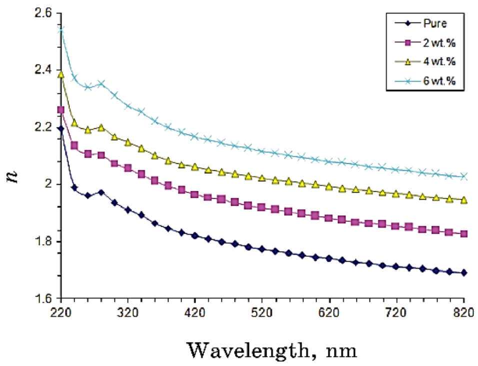

Fig. 7. Refractive index of PVA/PEG/ZrO_2 nanocomposites.

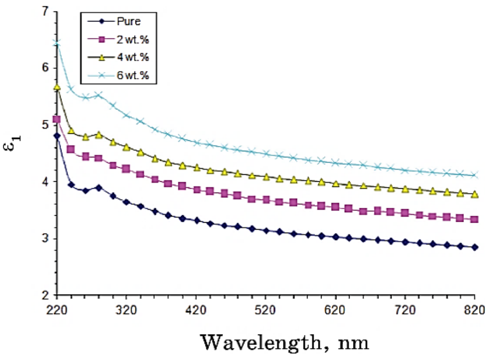

Fig. 8. Relationship between the real part and photon wavelength.

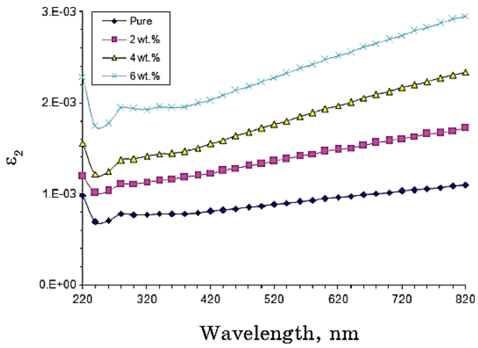

Fig. 9. Relationship between the imaginary part and photon wavelength.

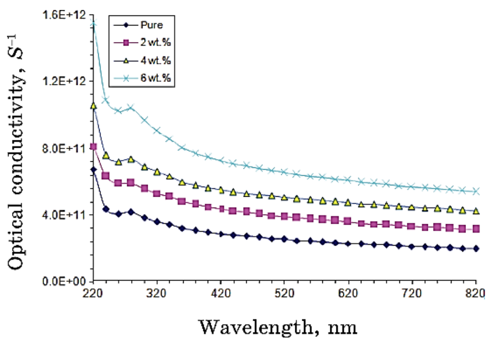

Fig. 10. Conductivity with wavelength of photon.

with the increase in ZrO_2 ratios that is due to the increase in refractive index and extinction coefficient [52, 53].

Figure 10 indicates to the conductivity variation with energy of photon. The conductivity of polymer blend increases as ZrO_2 concentration increases that is attributed to increase of refractive index and absorption coefficient [54].

4. CONCLUSION

Absorbance of PVA/PEG blend rises as ZrO_2 content increase.

The energy gap of PVA/PEG blend reduces with raise in ZrO_2 ratio.

The optical parameters are changed with raise in ZrO_2 nanoparticles ratio.

The structural and optical properties indicated that the PVA/PEG/ZrO_2 nanocomposites might be used for different electrical and electronic applications.

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