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Fabrication and improved optical properties of PEG/Fe_2O_3 nanocomposites

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Abstract

In this study, casting technique were used to fabricate of PEG/Fe_2O_3 nanostructures with variant content of Fe_2O_3 NPs to employ in different optical fields. The results showed that the absorbance of PEG increases as the concentrations of Fe_2O_3 nanoparticles increase while the transmittance and energy gap of PEG decrease with increase concentrations of Fe_2O_3 NPs. The optical factors of PEG/Fe_2O_3 nanocomposites are enhanced with adding of the Fe_2O_3 NPs content. The optical characteristics results of the PEG/Fe_2O_3 nanocomposites proved that may be employed in optoelectronic detector.

Keywords: PEG; Optical properties; Fe_2O_3; Nanocomposites

1. Introduction

Composite materials based on a polymeric matrix with embedded metal nanoparticles have attracted attention for use in the development of biomedical devices, solar cells, sensors, and capacitors, among other things, due to their distinct electrical, mechanical, optical, and chemical properties. It is possible to create a hybrid material with exceptional mechanical, optoelectronic, and dielectric capabilities as a thin film on a range of substrates by combining organic and inorganic components. As a result, there has been a lot of interest in the field of materials research in developing composite material based on polymers and nanoparticles that have high permittivity, low cost, and easily programmable properties [1].Due to their covalent bond topologies, polymer materials often have undesired low dielectric permittivity and poor heat tolerance but desirable high breakdown strength and facile processability. In contrast to polymer materials, high-k ceramic materials have a desirable high permittivity and great thermal resistance, but due to their ionic link architectures, they also have an unfavorable low breakdown strength and a high level of mechanical brittleness [2].Recently, the phrase "nanotechnology" has appeared, and it has drawn the attention of numerous researchers. As a result, various medical and technical sciences, among others, have advanced significantly [3]. The word "nanocomposites" refers to the end result of mixing nanoparticles with other common materials to create novel substances with unique physical characteristics [4].The matrices materials that can show the interactions between the matrix and the second phase as well as nanoscale dimensions, dispersion, size, and form [5], is a key factor in determining the properties of nanocomposites. The concept of combining two or more different components into a single material offers virtually endless possibilities to create innovative engineering substances distinguished by a variety of different features. Composite materials are successfully used in practically all fields of study and commerce because of their vast variety of features. The automotive, electronics and electrical, aerospace and machine building, sport and leisure, civil engineering, etc. industries were particularly fond of composite materials [6–10]. PEG has a variety of useful properties, including great water solubility, minimal immunogenicity, and low toxicity [11]. It also has excellent protein adsorption resistance. Due to its unique magnetic, optical, and catalytic properties, iron oxide (III) (Fe_2O_3) is a material that has received extensive research. Excellent transport characteristics may be shown in the iron oxide nanoparticle. Numerous topics have attracted a lot of scientific attention, including catalysis, eco-friendly,

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magnetic storage media, clinical diagnosis, and cancer treatment [12,13]. This work deals with fabrication and improved optical properties of PEG/Fe_2O_3nanocomposites to use in various optical applications.

2. Material and methods

Nanocomposites from poly (ethylene glycol) (PEG) doped with Fe_2O_3 nanoparticles (size: 20- 30 nm, purity: 99.99%) were prepared by solution casting method. ThePEG polymer solution prepared by dissolving of 1 gm in distilled water (50 ml). The Fe_2O_3 NPs were added to the polymersolution (PEG) with various contents 2.5%, 5%, and 7.5%.The optical characteristics of PEG/Fe_2O_3nanocomposites were tested using spectrophotometer (UV-1800^{0}A-Shimdzu).

The coefficient of absorption (α) is calculated by [14]:

$$\alpha = 2.303 \left(\frac{A}{d}\right) \quad \text{……….(1)}$$

which: A is the absorbance and d is the thickness. The gap of energy is given by [15]:

$$(\alpha hv)^{1/m} = C\left(hv - E_g\right) \quad \text{… … … … ….(2)}$$

which C is constant, hυ is the photon energy, E_g is the gap of energy, m = 2 and 3 to indirect transition of allowed and forbidden.

The index of refractive (n) is defined by[16]:

$$n = \frac{1+\sqrt{R}}{1-\sqrt{R}} \quad \text{………….(3)}$$

which R is the reflection. The coefficient of extinction (k) is determinedby [17]:

$$k = \frac{\alpha\lambda}{4\pi} \quad \text{……………… (4)}$$

which λ is the wavelength. The dielectric constant parts: real (ε_1), and imaginary (ε_2) are given by [18]:

$$\varepsilon_1 = n^2 - k^2 \quad \text{…………..(5)}$$

$$\varepsilon_2 = 2nk \quad \text{… … … … ….(6)}$$

The conductivity of optical (σ_{op}) is defined by[19].

$$\sigma_{op} = \frac{\alpha n c}{4\pi} \quad \text{………………(7)}$$

3. Results and discussion

Fig.(1) demonstrate the optical absorbance of PEG/Fe_2O_3nanocomposites. The rise in absorbance when the rise of content of Fe_2O_3 NPs. This behaviordue to the rise in charges carriers which absorb the photon [20-22] and therefore the transmittance reduces as shown in fig. (2).

The "coefficient of absorption" (α) expresses on the transition nature. Fig.(3) obtain the values of α for the PEG/Fe_2O_3nanocomposites. it is clear from this figure that the $\alpha<10^4$ cm^{-1} which mean that the happentransition of indirect. Fig. (4,5) demonstrate that the gap of energy for "allowed and forbidden" for the PEG/Fe_2O_3nanocompositeindividually. It is obtained that the E_g reduce when the increase of contented of Fe_2O_3 NPs which due to creation of stageswithin band gap hence the value of E_g will be reduce [23,24].

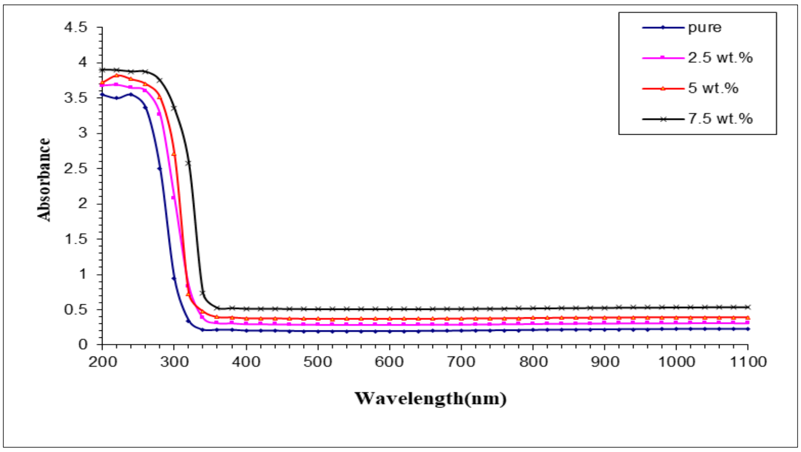

Figure 1 Absorbance pattern of PEG/Fe_2O_3nanocomposites

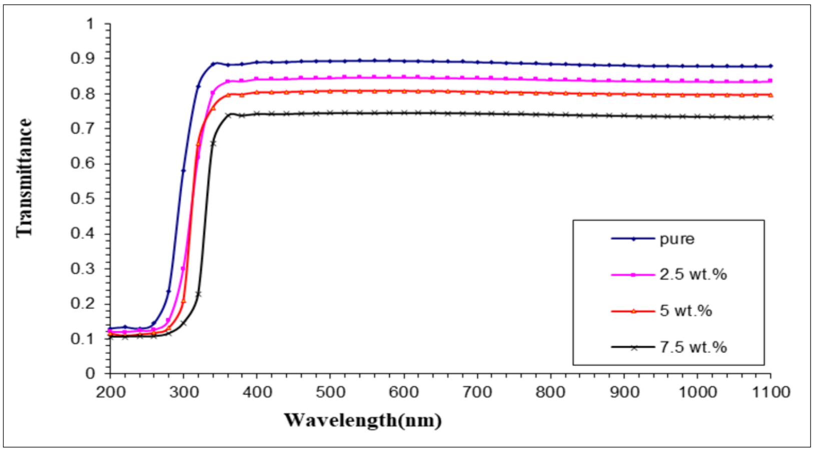

Figure 2 Transmittance pattern of PEG/Fe_2O_3nanocomposites

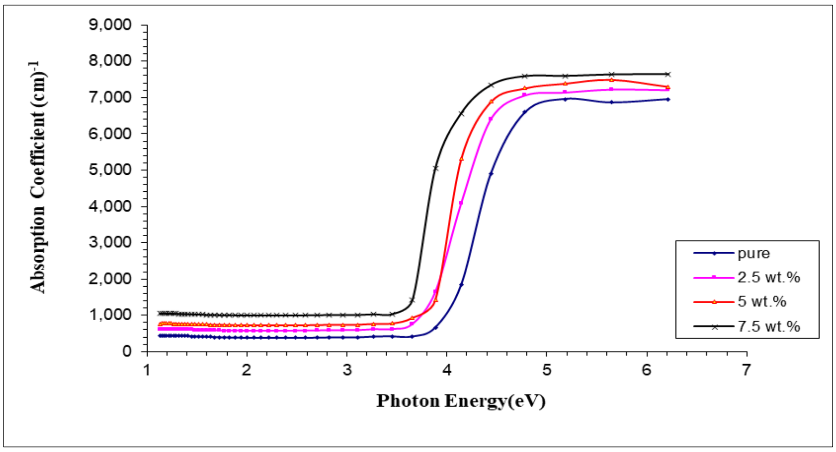

Figure 3 The coefficient of absorbance pattern of PEG/Fe_2O_3nanocomposite

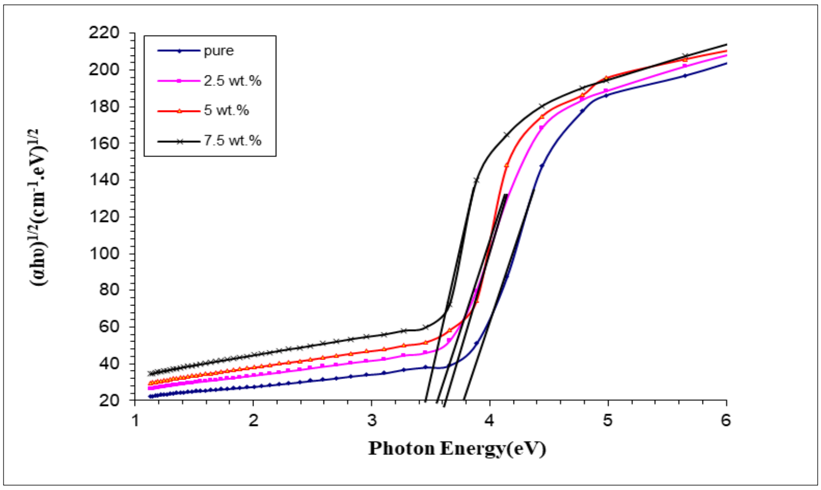

Figure 4 Allowed energy band gap value of PEG/Fe_2O_3nanocomposite

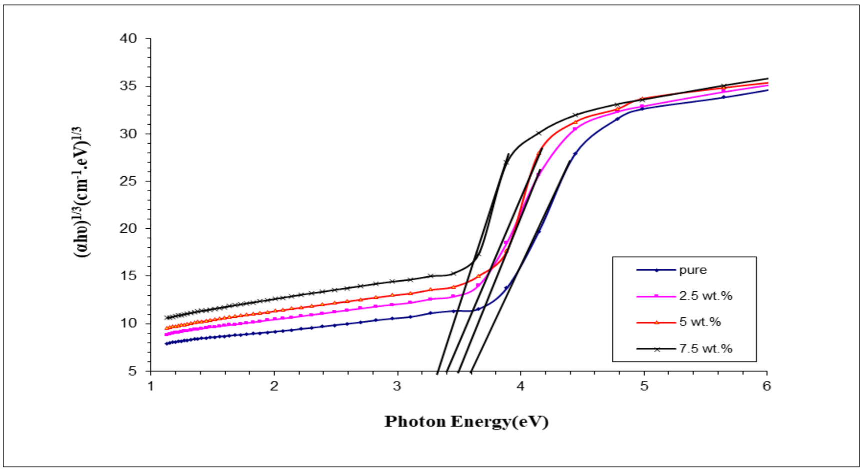

Figure 5 Forbidden energy band gap value of PEG/Fe_2O_3nanocomposite

The "coefficient extinction" (k) and "index of refractive" (n) of PEG/Fe_2O_3nanocomposites are represent in figs. (6, 7). it is clear that the value of n and K rise when the rising content in Fe_2O_3NPs which due to rise of α and films density [25,26].

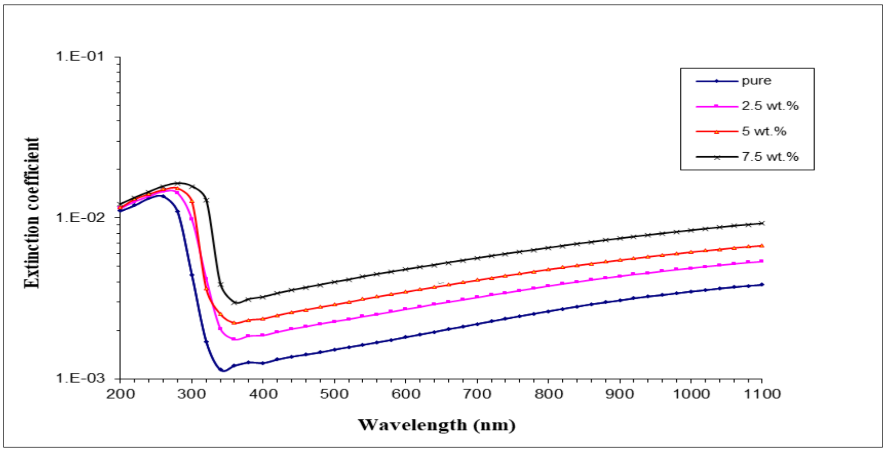

Figure 6 The extinction coefficient values of PEG/Fe_2O_3nanocomposites

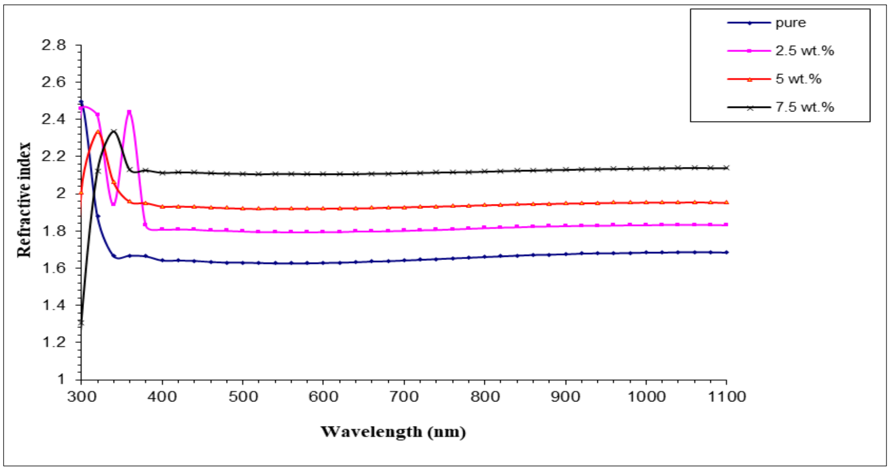

Figure 7 The refractive index values of PEG/Fe_2O_3nanocomposites

The "dielectric constant" include "real and imaginary" of the PEG/Fe_2O_3nanocomposite are presentation in fig.(8,9). It is show that the ε_1 and $\varepsilon_2$improve when increase of the content of Fe_2O_3 NPs which attributed torise of the value of n and k[27].

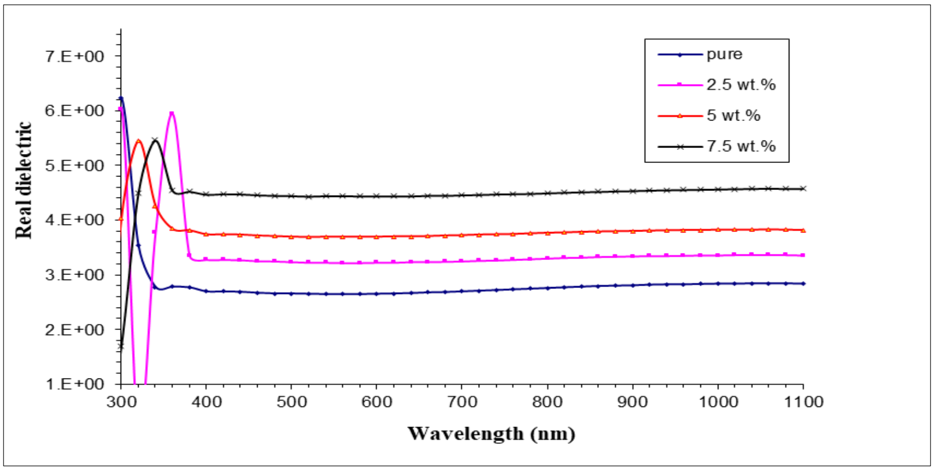

Figure 8 Real dielectric constant values of PEG/Fe_2O_3nanocomposites

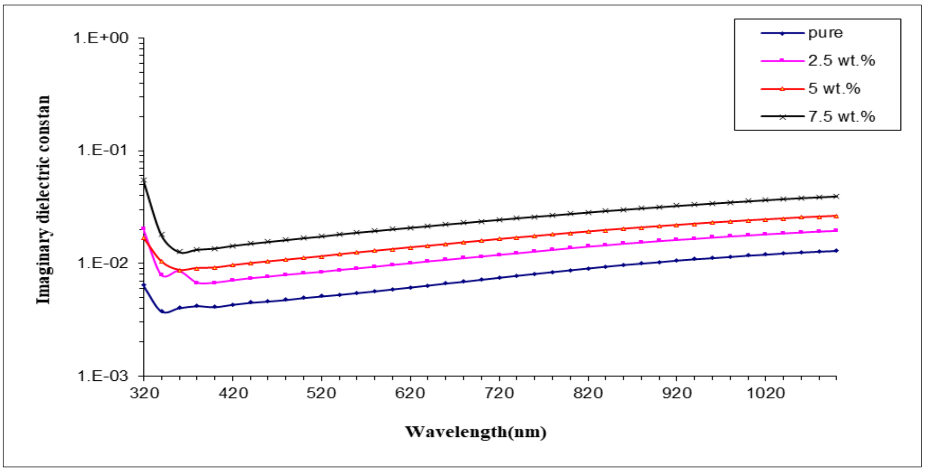

Figure 9 Imaginary dielectric constant of PEG/Fe_2O_3nanocomposites

The "conductivity of optical" of PEG/Fe_2O_3nanocomposite isestablished in fig.(10). The σ_{op} of PEG rises with rise of Fe_2O_3NPs content which due to related to the density and α[28].

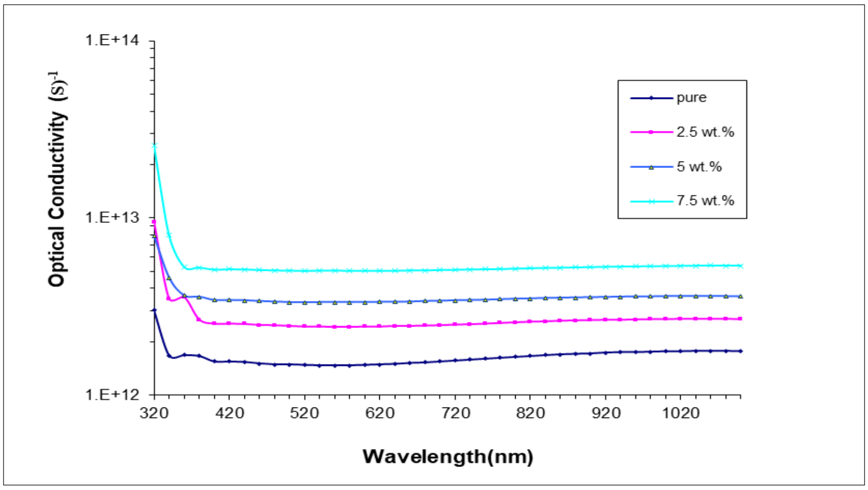

Figure 10 Optical conductivity values of PEG/Fe_2O_3nanocomposites

4. Conclusion

This research includes the creation of PEG/Fe_2O_3 nanocomposites and examination of their optical properties for use in optoelectronic detectors. The obtained results demonstrated that as Fe_2O_3 NP content increases, absorption of PEG raised and transmission decreased. With a rise of Fe_2O_3 NPs, the gap of energy reduced. The optical factors of PEG/Fe_2O_3nanocomposites are enhanced with adding of the Fe_2O_3 NPs content. The PEG/Fe_2O_3 nanocomposites' optical properties studies demonstrated that these nanocomposites may be used in optoelectronic detectors.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest

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