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Optical properties of (PEG-TiO_2) nanocomposities

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ABSTRACT

In this research, the optical properties for (PEG-TiO_2) nanocompositeshave been studied. For this purpose, solutions were prepared with different percentage (0.05 and 0.1) wt.%of (TiO_2) nanoparticles.
Experimental results for optical properties show that the electronic transitions were indirect, the values of the energy gap has been found, it decreases with the increase of the concentration of the additive. The optical constants absorption coefficient, refractive index, extinction coefficient, real and imaginary dielectric constant have all been measured and it was found out that all these constants increase with the increase of the concentration of (TiO_2) nanoparticles.

KEYWORDS

Optical properties;
Polymer nanocomposities;
PEG;
TiO_2.

INTRODUCTION

Nanomaterial's describe, in principle, materials of which a single unit is sized (in at least one dimension) between 1 and 1000 nanometers (10^{-9}meter) but is usually 1-100 nm (the usual definition of Nano scale).

Nanomaterial's research takes a materials science-based approach to nanotechnology, leveraging advances in materials metrologyand synthesis which have been developed in support of micro fabricationresearch. Materials with structure at the Nano scale often have unique optical, electronic, or mechanical properties[3].

Nanomaterial's have extremely small size which having at least one dimension 100 nm or less. Nanomaterial's can be Nano scale in one dimension (eg. surface films), two dimensions (eg. strands or fibers), or three dimensions (eg. particles). They can exist in single, fused, aggregated or agglomerated forms with spherical, tubular, and irregular shapes. Common types of nanomaterial's include nanotubes, quantum dots and fullerenes[5].

Polymer nano composites (PNC) consist of a polymeror copolymerhaving nanoparticles or Nano fillers dispersed in the polymer matrix. These may be of different shape (e.g., platelets, fibers, spheroids), but at least one dimension must be in the range of 1–50 nm. These PNC's belong to the category of multi-phase systems (MPS, viz. blends, composites, and foams) that consume nearly 95% of plastics production. These systems require controlled mixing/compounding, stabilization of the achieved dispersion, orientation of the dispersedphase, and the compounding strategies for all MPS, including PNC, are similar[7]. The progress in nanocomposites is varied and covers many industries. Nanocompositees can be made with a variety of enhanced physical,thermal and other unique properties. They have properties that are superior to conventional micro scale composites and can be synthesized using simple and inexpensive techniques[8].

The addition of small amounts of nanoparticles to polymer has been able to enable new properties for the composite material, but results are highly dependent on the surface treatment of the nanoparticles and processing used.

It is important to determine whether nano materials coud be integrated into nano composites to enable multiple desirable properties required for a given application[14]

In nanocomposites, at least one dimension of the dispersed particles is in the nanometer range. One can distinguish three types of Nano composites, depending on how many dimensions of the dispersed particles are in the nanometer range[4]

Polyethylene glycol is produced by the interaction of ethylene oxide with water, ethylene glycol, or ethylene glycol oligomers [68]. The reaction is catalyzed by acidic or basic catalysts. Ethylene glycol and its oligomers are preferable as a starting material instead of water, because they allow the creation of polymers with a low polydispersity (narrow molecular weight distribution). Polymer chain length depends on the ratio of reactants[12]

Nanoparticles (NPs) are tiny materials used in a wide range of industrial andmedical applications. Titanium dioxide (TiO2) is a type of nanoparticle that is widely usedin paints, pigments, and cosmetics[17]. Titanium dioxide occurs in nature as well-known minerals rutile, anatine and brookite, and additionally as two high pressure forms, a monoclinicbaddeleyite-like form and an orthorhombicα-PbO_2-like form, both found recently at the Rise crater in Bavaria[1].

EXPERIMENTAL PART

The materials that used in the paper are polyethylene glycol and Titanium dioxide.

Preparationof polymer solutions

The PEG solution was prepared by dissolving known weights of PEG powder in affixed volume (500 mL) of distilled water under stirring at (70 and leaved to (10 min). Then TiO_2 was added with different weights (0.25and 0.5) g to all PEG concentrations. The resulting solution was stirred continuously for (60min) until the solution mixture became a homogeneous and then calculated concentrations of these solutions by the relationships below[13].

Concentration

$$= \frac{(\text{mass of solute})}{(\text{volume of solution})} \times 100\ \% \qquad (1)$$

Molar Concentration

$$= \frac{(\text{mass of solute})}{(\text{volume of solution})} \times \frac{1}{\text{molecular weight}} \qquad (2)$$

RESULTS AND DISCUSSION

The variation of absorbance spectra of (PEG-

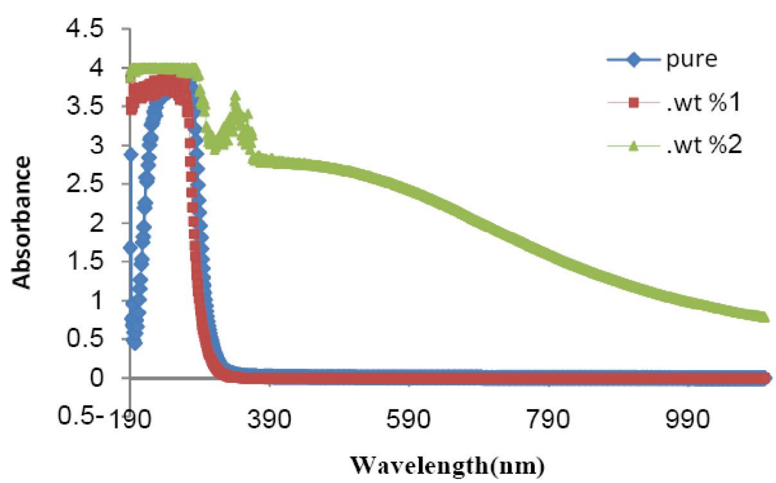

Figure 1 : The relationship between absorbance and wavelength of nanocomposities

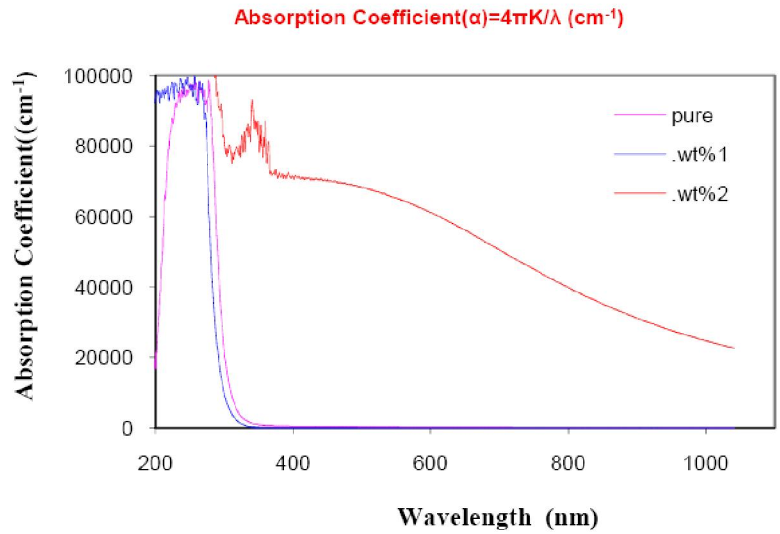

Figure 2 : The relationship between absorption coefficient and wavelength of namocomposities

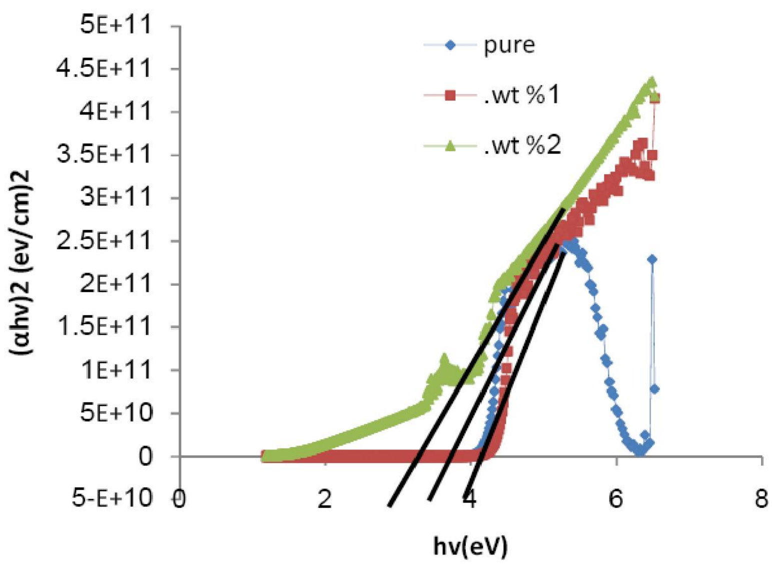

Figure 3 : The relationship between optical energy band gap and photon energy of namocomposities

TABLE 1 : The values of optical energy gap for the allowed and forbidden indirect transition for (PVA-PVP-Ag)Nano composites

ilver nanoparticles (wt.%)	Eg°(eV) Forbidden
0	4
0.05	3.5
0.1	3.1

TiO_2) Nano composites with wavelength (200-1100) nmof different concentrations of(PEG-TiO_2) blend composites are shown in Figures (1 and 2)respectively. From the Figures the absorbance of (PEG-TiO_2)polymers composites is increased with increase theconcentrations of magnesium oxide and cobalt oxidenanoparticles which attributed to nanoparticles which absorbthe incident light[19].

The effect of Titanium dioxidenanoparticles concentrations on the absorption coefficient ofNano composites are shown in Figure (2). This figure show that the absorption coefficient of (PEG) polymers composites increases with increase ofthe Titanium dioxide nanoparticleconcentrations, this increase attributed to increase thenumber of carries charges which causes to increase theabsorbance. The absorption coefficient have values are lessthan 10^4 cm^{-1} which mean the Nano composites have indirectenergy band gap as shown in Figure (3) for forbidden indirect transition of (PEG-TiO_2)nanocompsite. Theenergy band gap forbidden indirecttransition decreases with increase of the Tita-

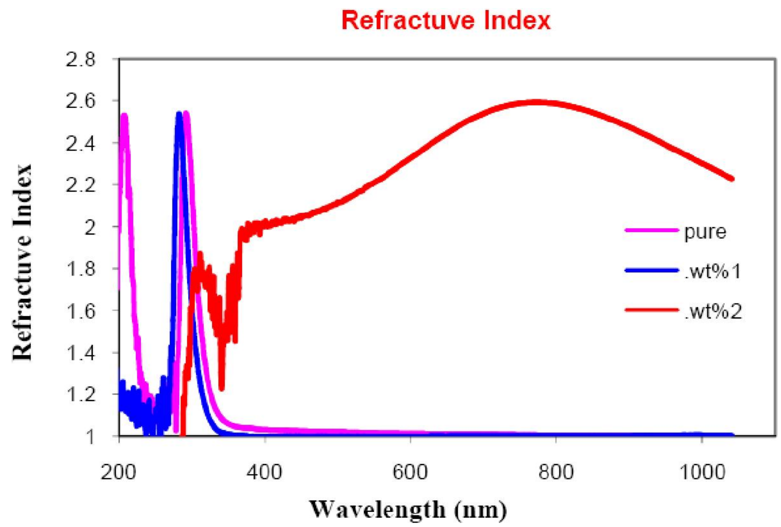

Figure 4 : The relationship between refractive index and wavelength of namocompositeies

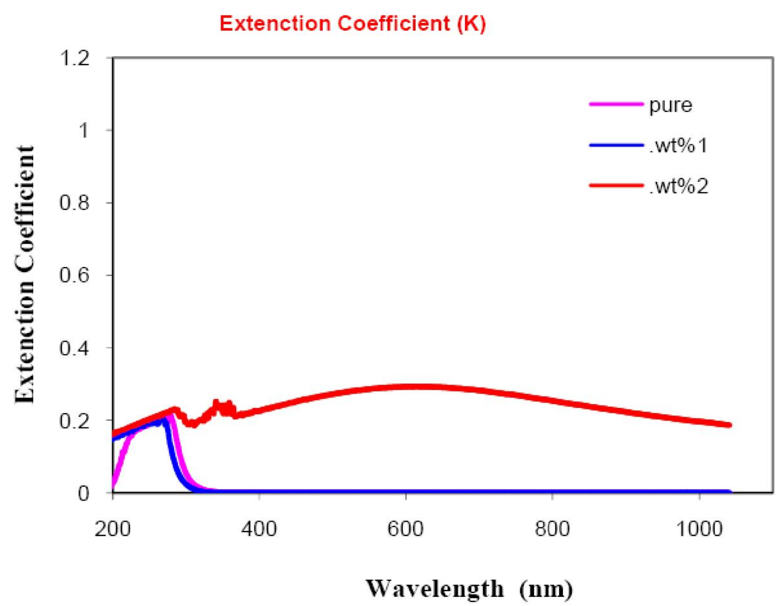

Figure 5 : The relationship between extinction coefficient and wavelength of namocompositeies

nium dioxideconcentrations whichattributed to the increase the localized level in forbiddenenergy band gap[18].

The variation of refractive index of the (PEG-TiO_2) nanocompsite withwavelength for different concentrations of Titanium dioxide nanoparticles are shown in Figure (4). The figure show that the refractiveindex of (PEG) polymer composites increaseswith increase of the Titanium dioxidenanoparticles which attributed to increase the scattering ofincident photon which causes to increase the reflectance[12]. The increase of the (TiO_2) concentration leads to increase the density of the Nano composite. It can be seen that the refractive index is the smallest at high wavelength. These results are in agreement with Iviaeva*et al*., 2010]. Figure (5) show that the variation of the extinctioncoefficient of the (PEG-TiO_2) nanocompsite with wavelength for differentweight percentages of Titanium dioxidenanoparticles. From the figure, the extinctioncoefficient is increased with increase of the concentrations ofTitanium dioxide thisbehavior attributed to increase of absorption of the incidentlight[11]. Absorption coefficient has a direct relation with (k) that before 280(nm) the absorbance increases with increasing of wavelength,this is because ofthe presence of defects inside the structure whereabsorbthis energyandorganize them selves to stabilizing then after 280 (nm) the absorbance decreases with increasing of

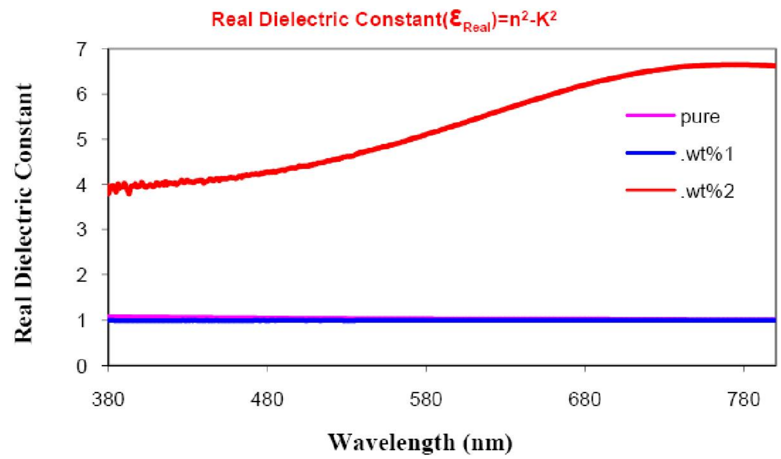

Figure 6 : The relationship between real dielectric constant and wavelength of namocomposities

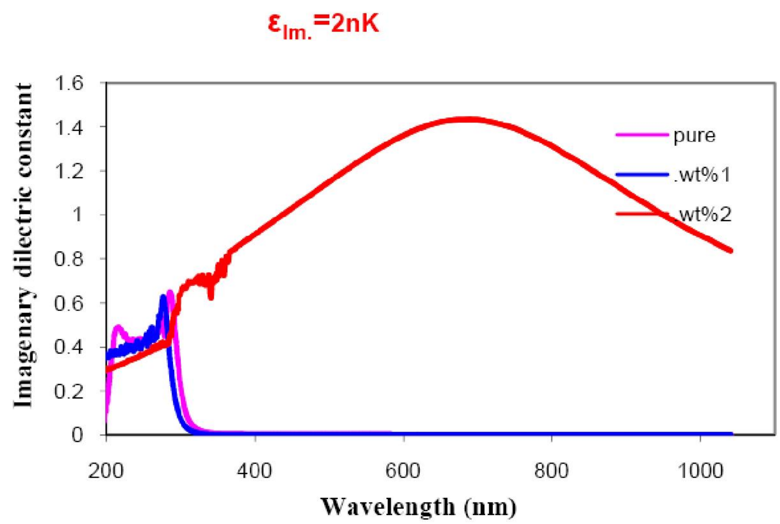

Figure 7 : The relationship between imaginary dielectric constant and wavelength of namocomposities

wavel-ength. These results are in agreement with[15]. The variation of real and imaginary parts of dielectricconstants of the (PEG-TiO_2) nanocompsite with wavelength for differentconcentrations of Titanium dioxide nano particles are shown in Figure (6,7). Thefigures show that the real and imaginary parts of dielectric constants are increased with increase of the Titanium dioxidenanoparticles concentrations whichattributed to increase the absorption and scattering ofincident light with increase of the concentrations ofTitanium dioxidenanoparticle[2]. It can be seen that(real dielectric constant) considerably depends on (square refractive index) due to low value of (square extinction coefficient) so, the real dielectric constant increased with the increase of the concentrations of (TiO_2)nanoparticle and it is smallest at high wavelength. Figure (7) show the change of (imaginary dielectric constant) as a function of the wavelength.

It can be seen that (imaginary dielectric constant) is dependent on(extinction coefficient) values that change with the change of the absorption coefficient due to the relation between them it[9].

CONCLUSIONS

1) The absorbance of (PEG) polymerincreases with increase of the Titanium dioxidenanoparticle concentrations.
2) The energy band gap of (PEG) polymer decreases with increase of theTitanium dioxidenanoparticle concentrations
3) The absorption coefficient (á), extinction coefficient (k), refractive index (n) and real and imaginary dielectricconstants are increasing with increase of the weightpercentages of the Titanium dioxide nanoparticle concentrations.

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