Optical properties of (PEG-TiO$_2$) nanocomposites

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ABSTRACT

In this research, the optical properties for (PEG-TiO$_2$) nanocomposites have 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. © 2016 Trade Science Inc. - INDIA

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 metrology and synthesis which have been developed in support of micro fabrication research. 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 polymer or copolymer having 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 dispersed phase, 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 could 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 and medical applications. Titanium dioxide (TiO2) is a type of nanoparticle that is widely used in 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 orthorhombic-PbO2-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.

**Preparation of 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 TiO2 was added with different weights (0.25 and 0.5) g to all PEG concentrations. The resulting solution was stirred continuously for (60 min) until the solution mixture became a homogeneous and then calculated concentrations of these solutions by the relationships below.[13]

Concentration

\[
\text{Concentration} = \frac{\text{mass of solute}}{\text{volume of solution}} \times 100 \% \quad (1)
\]

Molar Concentration

\[
\text{Molar Concentration} = \frac{\text{mass of solute}}{\text{volume of solution} \times \text{molecular weight}} \quad (2)
\]

**RESULTS AND DISCUSSION**

The variation of absorbance spectra of (PEG-
Figure 2: The relationship between absorption coefficient and wavelength of nanocomposites

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

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

<table>
<thead>
<tr>
<th>Silver nanoparticles (wt.%)</th>
<th>Eg\textsuperscript{o}(eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>0.05</td>
<td>3.5</td>
</tr>
<tr>
<td>0.1</td>
<td>3.1</td>
</tr>
</tbody>
</table>

TiO\textsubscript{2} Nano composites with wavelength (200-1100) nm of different concentrations of (PEG-TiO\textsubscript{2}) blend composites are shown in Figures (1 and 2) respectively. From the Figures, the absorbance of (PEG-TiO\textsubscript{2}) polymers composites is increased with increase of the concentrations of magnesium oxide and cobalt oxide nanoparticles which attributed to nanoparticles which absorb the incident light\textsuperscript{19}. The effect of Titanium dioxidenanoparticles concentrations on the absorption coefficient of Nano composites are shown in Figure (2). This figure show that the absorption coefficient of (PEG) polymers composites increases with increase of the Titanium dioxide nanoparticle concentrations, this increase attributed to increase the number of carries charges which causes to increase the absorbance. The absorption coefficient have values are less than $10^4$ cm$^{-1}$ which mean the Nano composites have indirect band gap as shown in Figure (3) for forbidden indirect transition of (PEG-TiO\textsubscript{2}) nanocomposite. The energy band gap for forbidden indirect transition decreases with increase of the Titan-
nium dioxide concentrations which attributed to the increase the localized level in forbidden energy band gap

The variation of refractive index of the (PEG-TiO$_2$) nanocomposite with wavelength for different concentrations of Titanium dioxide nanoparticles are shown in Figure (4). The figure show that the refractive index of (PEG) polymer composites increases with increase of the Titanium dioxide nanoparticles which attributed to increase the scattering of incident photon which causes to increase the reflectance. 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 extinction coefficient of the (PEG-TiO$_2$) nanocomposite with wavelength for different weight percentages of Titanium dioxide nanoparticles. From the figure, the extinction coefficient is increased with increase of the concentrations of Titanium dioxide this behavior attributed to increase of absorption of the incident light. Absorption coefficient has a direct relation with (k) that before 280(nm) the absorbance increases with increasing of wavelength this is because of the presence of defects inside the structure where absorb this energy and organize then after 280(nm) the absorbance decreases with increasing of

![Figure 4: The relationship between refractive index and wavelength of nanocomposites](image1.png)

![Figure 5: The relationship between extinction coefficient and wavelength of nanocomposites](image2.png)
The variation of real and imaginary parts of dielectric constants of the (PEG-TiO$_2$) nanocomposite with wavelength for different concentrations of Titanium dioxide nano particles are shown in Figure (6,7). The figures show that the real and imaginary parts of dielectric constants are increased with increase of the Titanium dioxidenanoparticles concentrations which attributed to increase the absorption and scattering of incident light with increase of the concentrations of Titanium 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$^{[9]}$.

**CONCLUSIONS**

1) The absorbance of (PEG) polymer increases with increase of the Titanium dioxidenanoparticle concentrations.
2) The energy band gap of (PEG) polymer decreases with increase of the Titanium dioxidenanoparticle concentrations.
3) The absorption coefficient ($\alpha$), extinction coefficient ($k$), refractive index ($n$) and real and imaginary dielectric constants are increasing with increase of the weightpercentages of the Titanium dioxide nanoparticle concentrations.
REFERENCES


