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Optical Studies of Titania Nanoparticle filled PET/PS Blends

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Abstract: The present work reports the synthesis and optical studies of TiO_2 nanoparticles filled PET/PS blends. TiO_2 nanoparticles have been synthesized by simple chemical method and PET/PS blends have been prepared using solution casting method. The shape and size of titania nanoparticles have been determined with the help of Transmission Electron Microscopy (TEM) which found to be 16 nm. The optical studies of PET/PS blends have been carried out using UV-Vis spectroscopy. When calculated the band gap of blends from absorption spectra, the decrement in band gap has been found with increasing the TiO_2 filler content in PET/PS blends.

Keywords: Bandgap, TEM, Polymer Blends etc.

INTRODUCTION

Basically, Polymer blends are mixture of two polymers, blended together to create a new material with different physical properties [1]. Capability of a mixture to form a single phase over certain ranges of temperature, pressure, and composition is said to be miscibility while inability of a mixture to form a single phase is known as immiscibility [2]. Polymer blending has become an important field for finding new commercial plastic materials for achieving cost/performance balances in last two decades.

Polyethylene terephthalate (PET) is an engineering plastic that is ubiquitous in soft drink bottles, packaging, electronics, and many other applications [3]. Both PET and polystyrene (PS) are low-cost commodity polymers that possess unique properties individually. The blends of PET and PS are expected to be highly desirable due to great commercial potential [4]. Polymer blends of PET and PS are immiscible and incompatible, which has been well recognized by Chyn-Tein Maa et al [5]. The compatibilized PET/PS blend has a smaller phase domain and higher viscosity than those the corresponding non-compatibilized blend.

Metal oxides can be used as filler in polymer matrix to improve optical, mechanical, electrical and various properties. Titanium Oxide is semiconductor material having wide bandgap (E_g=3.2 eV) with extensive properties in white pigment, photochemical stability as well as in solar cells. So, it can be used to enhance the optical properties of PET/PS blends. The presented paper emphasizes on the synthesis and optical studies of titania nanoparticles filled PET/PS blend.

EXPERIMENTAL DETAILS

In the present study, chemically synthesized titania nanoparticles have been incorporated in PET and PS matrix and nanocomposite blends have been prepared via solution casting method [6]. 50% PET and 50% PS, of desired eight sample, has been dissolved in Dichloro methane (DCM) by stirring for 2 hrs at room temperature, separately. These two solutions have been mixed and TiO_2 nanoparticles have been added to this solution. This nanoparticle dispersed solution then casted on petri dish. In this way, ~70µm films of said sample have been casted for further characterization.

RESULTS AND DISCUSSION

In order to determine shape and size of chemically synthesized TiO_2 nanoparticles, Transmission Electron Microscopy (TEM) has been used. Figure 1 shows the spherical shape of TiO_2 nanoparticles. The average diameter of titania nanoparticles has been observed as ~16.5 nm.

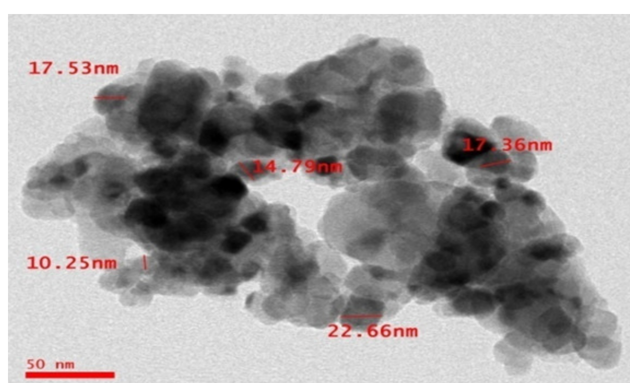

Fig 1: TEM image of titania nanoparticles.

The absorption spectra of as casted nanocomposite blend films has been recorded at room temperature using UV-Vis spectrometer (Perkin Elmer Lambda 750) and the band gap [7, 8] has been calculated for these spectra using the formula;

$$E = hc/\lambda \quad (1)$$

Where, E is the band gap energy of titania filled PET/PS blends, h is Plank constant, c is the speed of light and λ is the wavelength of incident light. Figure 2 shows the absorption spectra of PET/PS blends with different concentration of titania nanoparticles. The band gap values for these samples have been listed in table1. It is evident from table 1 that titania nanoparticles cause to reduce the band gap energy of PET/PS blends which indicates the increase in conductivity of samples. It may be due to less band gap filler content i.e. TiO_2 nanoparticles.

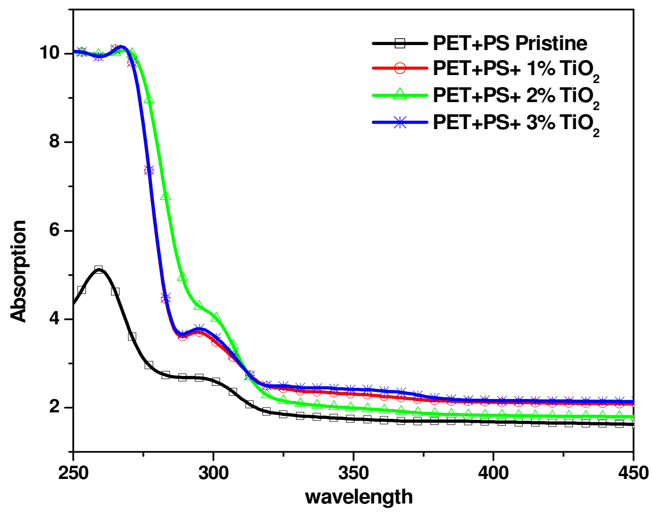

Fig 2: Absorption spectra of PET/PS blend with different concentration of titania nanoparticles.

Table 1: Band gap of TiO_2 nanoparticles filled PET/PS blends.

Sample	**Bandgap (eV)**
PET+PS pristine	4.47
PET+PS+1%TiO_2	4.34
PET+PS+2%TiO_2	4.29
PET+PS+3%TiO_2	4.25

Basically, the extinction coefficient refers to the imaginary part of complex index of refraction, which is also related to light absorption. The extinction coefficient (K) for titania filled PET/PS blends is determined using the following equation;

$$K = \alpha\lambda/4\pi \quad (2)$$

Where, $\alpha = 2.303A/\log t$; A is absorbance of light and t is thickness of film and λ is wavelength of light. Figure 3 shows the variation of extinction coefficient with photon energy (hν) for PET/PS blends with different concentration of TiO_2 nanoparticles.

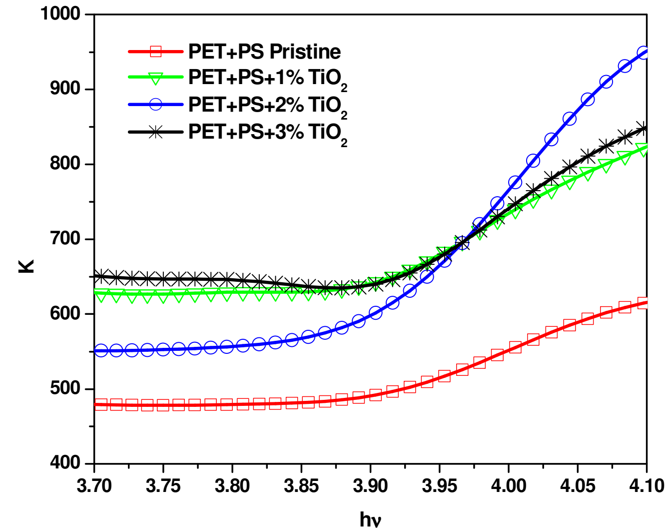

Fig 3: Variation of extinction coefficient with photon energy for PET/PS blends with titania nanoparticles.

The increase in extinction coefficient with increasing concentration of the TiO_2 nanoparticles can be explained on the basis of increase in the number of charge carries.

CONCLUSION

Main inferences from the study can be listed as follows:

1. TiO_2 nanoparticles have been synthesized via chemical route and examined by TEM, which confirms the spherical shape of nanoparticles with average diameter ~16.5 nm.
2. Solution casting method has been used to prepare blends of 50% PET and 50% PS with different concentration of TiO_2 nanoparticles.
3. The absorption spectra of these blends have been recorded at room temperature using UV-Vis spectrophotometer and band gap is found to be decrease with increasing filler content. This could be accounted to less band gap of titania nanoparticles (~ 3.2 eV).
4. At 3 wt % TiO_2 in PET/PS blends, values of K are highest, this can be attributed to the higher concentration of TiO_2 nanoparticles in blends, and more charge carriers are playing their role.

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