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Optical Characteristics of EPOXY/MWCNTS Nanocomposites

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Abstract. : In the present investigation, the optical characteristics epoxy resin reinforced with multi-wall carbon nanotubes (MWCNTs) are were investigated. The influence of the MWCNTs weight percentage (wt.-%) on the optical characteristics of epoxy/MWCNTs nanocomposites. The results revealed that theabsorption intensity of the epoxy resin was improved by the dispersion of the MWCNTs.

Keywords : MWCNTs, Epoxy, Nanocomposites, Optical Characteristics.

1. INTRODUCTION

Nanomaterials have emerged as an area of interest motivated by potential applications of these materials in light emitting diodes, solar cells, polarizers, optical sensors, light–stable color filters, optical data communication and optical data storage [1]. Nanomaterials are of interest as they combine the characteristics of two or more different materials. Understanding and modification such effects may lead to hybrid devices based on these nanocomposites with improved optical characteristics [2].

The optical characteristics of nanocomposites based on ZnO, CdS, and CuO nanoparticles were described by many investigators [3,4]. However, few investigations on the optical characteristics of other nanoparticles such as Al_2O_3 and MWCNTs were reported. *Novruzova et al.* [5] studied the synthesis of hybrid polymer nanocomposites PP+PbS/CdS, their structure characterization and their optical characteristics. Optical and photoluminescence characteristics of nanocomposites were also investigated. From UV spectra of nanocomposites by extrapolation method was calculated the width of the forbidden band of polymer nanocomposites. It was found that for PP/PbS nanocomposites, the band gap is 1.65 eV, for PP/CdS 2.6 eV, whereas for PP+PbS/CdS nanocomposite is 3.0 eV. Photoluminescence analysis of nanocomposites PP+PbS/CdS shows 2 luminescent peaks at the wavelength of 680 nm and 715 nm, respectively, of the luminescence spectra. *Yurkov et al.* [6] reported the optical characteristics of the CeO_2 reinforced polymer nanocomposites. The spectral dependencies of the optical absorption coefficient of the composite nanomaterials with the nanoparticle sizes ranging from

3.3 nm to 4.9 nm. The measured dependences have absorption maxima shifted 15 nm far from each other. The maximum absorption corresponding to the larger nanoparticles is shifted towards the short wavelength region.

2.EXPERIMENTAL PROCEDURES

The matrix material used was the commercial KEMAPOXY 150 epoxy resin manufactured by Chemicals for Modern Buildings (CMB) Company, Egypt. The multi-walled carbon nanotubes (MWCNTs) were used as filler materials. The outer diameters of MWCNTs are less than 80 nm. The MWCNTs nanofillers were dispersed into the epoxy matrix by weight percentages up to 1.5 wt.-%. Figure 1 shows scanning electron microscope (SEM) micrographs of the MWCNTs nanofillers. The epoxy/MWCNTs nanocomposites were fabricated using mechanical stirring casting technique. The optical characteristics of the epoxy/MWCNTs nanocomposites were conducted using a Jasco double-beam UV– vis spectrophotometer (model V-670).

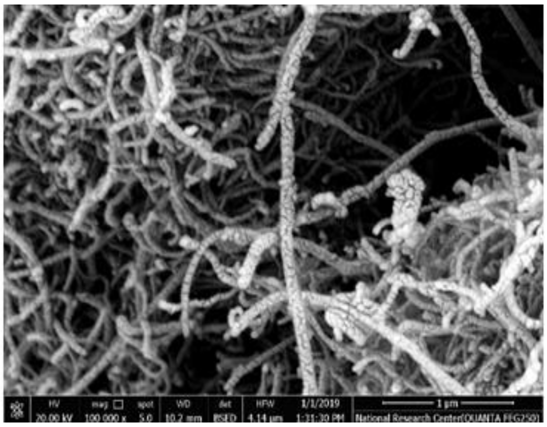

Fig 1. SEM micrographs of the MWCNTs nanofillers.

3. RESULTS AND DISCUSSION

The absorption spectra of epoxy/MWCNTs nanocomposites for various weight percentages of MWCNTs in the wavelength range of 200 – 650 nm are shown in Fig. 2. It is clearly seen that as the MWCNTs weight percentages increases, the absorption increases, due to the significant incorporation for low concentrations of MWCNTs in the epoxy resin. This indicates that in the blend, an electronic interaction takes place between the two materials. The absorption intensity increases nearly 2 times when MWCNTs concentrations increase to 1.5 wt% as compared to the plain epoxy.

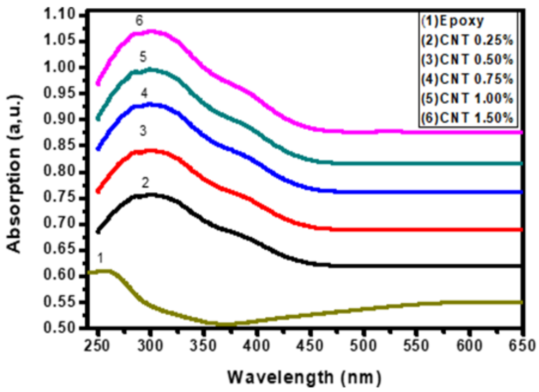

Fig 2. Optical absorption spectra of epoxy/MWCNTs nanocomposites

The absorption coefficient α (ν) was calculated from the optical absorbance A(ν). α(ν) can be calculated using Lambert's formula [7-9]:

$$I = I_o \exp(-\alpha x) \quad \text{.............(1)}$$

$$\alpha = \frac{2.303}{x}\log\left(\frac{I}{I_o}\right) = \frac{2.303}{x}A(\nu) \quad \text{...(2)}$$

Where: I_o and I are the incident and the transmitted intensities, respectively, and x is the sample thickness. At high absorption coefficient, the absorption coefficient α (ν) for non-crystalline materials can be related to the energy of the incident photon h_ν according to the following formula:

$$\alpha(\nu)\, h_\nu = \beta\, (h_\nu - E_g)^r \quad \text{.......................................(3)}$$

where: β is a constant, E_g is the optical energy gap and the exponent r is an index determined by the type of electronic transition causing the optical absorption. For allowed direct transition for theses composite samples r = 1/2 [9,10]. A linear region was obtained when plot of $(\alpha h\nu)^2$ versus photon energy hν is plotted. The interception of the extrapolation of this linear part to the energy axis gives energy band gap E_g. Figure 3 show the variation of $(\alpha h\nu)^2$ with photon energy h_ν for two epoxy/MWCNTs containing 0.25 and 1.5 wt.-% of MWCNTs nanofillers. All other samples show the same behavior. For pure epoxy, the direct band gap was about 4.2 eV. The values of E_g is the same for all epoxy/MWCNTs nanocomposites films (2.6 eV). The decrease in the optical gap (E_g) by MWCNTs may be explained on the basis of the fact that incorporation of small amount of dopant delays or block the charge transfer of existing nanocomposites and defects in the host matrix.

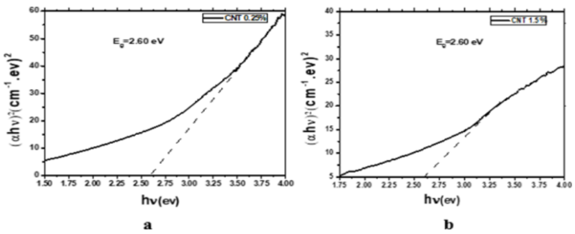

Fig 3. Variation of $(\alpha h\nu)^2$ with photon energy hν for epoxy/MWCNTs nanocomposites containing (a) 0.25 wt.-% and (b) 1.5 wt.-% of MWCNTs nanofillers.

4. CONCLUSIONS

Epoxy/MWCNTs nanocomposites were fabricated using stir casting technique. The epoxy resin were reinforced with MWCNTs with different weight percentages up to 1.5 wt.-%. The results revealed that the absorption intensity of the Epoxy/MWCNTs nanocomposites was enhanced ≈ 2 times compared to the neat epoxy.

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