Study addition of Fe$_2$O$_3$ Nanoparticles on Optical Properties for (PMMA-PS) Mixture

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Abstract. In this paper, films of the (PMMA-PS) Mixture doped with Fe$_2$O$_3$ nanoparticles were prepared with variable percentage (0,2,4,6) wt % by Drop casting method and at room temperature. The change in optical and structural properties was observed after deformation using a UV-Spectrophotometer and for a range of wavelengths (190 - 1100) nm. The study showed that increasing the distortion ratio led to an increase in the absorbance, absorption coefficient, extinction coefficient, refractive index, real dielectric constant, imaginary isolation constant, and diminishing permeability.

Keywords: Methyl Metha Acrylate, Polystyrene

1. Introduction
Recently, the term nanotechnology has emerged and has been the focus of wide-ranging attention of researchers and has resulted in a great leap in various medical and engineering sciences ... etc.[1] The term nanocomposites are used to express the product of adding nanoparticles to other ordinary materials to manufacture new materials with distinctive physical properties [2]. PMMA is a colorless transparent thermoplastic that is technically classified as a kind of amorphous glass that is preferred due to its mild properties, ease of handling and handling, and its low cost, but it is fragile under the influence of load, especially under impact strength and is more likely to be scratched than ordinary glass.[3]

In this study, films of PMMA-PS polymeric compounds were prepared by casting technique with the addition Fe$_2$O$_3$ nanoparticles in different weight ratios to improve its mechanical and optical properties.

2. Materials and Methods:
Poly Methyl Metha Acrylate with Polystyrene (PMMA/PS) doped with Fe$_2$O$_3$ nanoparticles (size: 20- 30 nm, purity: 99.99%) manufacturer (Hongwu nanometer) is to make solution molding mechanism. Mixture the (PMMA- PS/Fe2O3) by ratios (0.2, 0.4, 0.6 wt %) were melted (50ml) of chloroform using a magnetic stirrer, after that the samples dried. Using UV Spectrometer (the equipment from the Japanese company Shimadzu) optical properties of the wavelength range (190-1100) nm were measured. The optical measurements are including, absorbance, absorption coefficient, transmittance, refractive index, real and imaginary insulation constant. All measurements were conducted at room temperature.
3. Results and Discussion:

Optical Measurements

3.1. Absorbance (A)

Defined by the following equation:

\[ A = \log \frac{1}{T} \]  

(1)

As displayed in Figure 1, the maximum absorbance values are observed at 220nm and decreases with increasing wavelength due to decreasing light energy with increasing incident wavelength according to Planck's law [5].

![Figure 1. The absorbance spectra of (PS- PMMA- Fe₂O₃) films as a function of incident light wavelength.](image)

3.2. The absorption coefficient (\(\alpha\))

The absorption coefficient was calculated from the relationship below, and the results showed that the absorption coefficient values increased with increasing the added concentrations of Fe₂O₃ nanoparticles as a result of the increase in the incoming light rate according to Lambert's Law [6].

\[ \alpha = 2.303 \frac{A}{t} \]  

(2)
3.3. Permeability

Figure 3 showed an increase in transmittance with increasing wavelength and percentage. It was observed that the permeability decreased with the increase in the doping because it decreases with increasing the absorbance values, which increase with the increase in the doping rates.

Transmittance (T) is given by

\[ T = \frac{I_r}{I_o} \]  

Figure 2. The absorption coefficient of (PMMA-PS –Fe₂O₃ nano) as a function of photon energy.

Figure 3. The transmittance spectra of (PS-PMMA–Fe₂O₃ nano) blend as a function of incident light wavelength.
3.4. Extinction Coefficient of (k)

Figure 4 shows the change of extinction coefficient as a function of wavelength. It was observed that k decreases with decreased doping, due to an increase in the absorption coefficient with an increase in the ratios of added nanoparticles. The extinction coefficient is high at longer wavelengths and larger doping ratios [7].

\[ k = \frac{\alpha \lambda}{4\pi} \] (4)

Figure 4. The relation of extinction coefficient for (PMMA – PS) with nano Fe$_2$O$_3$.

3.5. Refractive index (n)

Figure 5 describes the change by the refractive index as a function of the wavelength with an increase in the deflection ratios. This is because pure PMMA is an amorphous crystalline substance with low density that increases with increasing the concentration of Fe$_2$O$_3$ nanoparticles. The refraction index decreases at the greatest wavelengths and increases at greatest dopant concentration, whose behavior is consistent with our previous work [8].

Figure 5. The refraction index of (PS - PMMA – Fe$_2$O$_3$ nano.) blend films as a function wavelength at different weight ratio.
3.6. Dielectric constant ($\varepsilon$)

It is defined as the polarization of charges due to the interaction of radiation and the charges of the medium, and is calculated using the below relations [11]:

$$\varepsilon = \varepsilon_1 - \varepsilon_2$$  \hspace{1cm} (5)

$$\varepsilon_1 = n_0^2 - k^2$$  \hspace{1cm} (6)

$$\varepsilon_2 = 2n_0k$$  \hspace{1cm} (7)

Figure 6 and Figure 7 illustrates the relationship of the dielectric constant as a function of the wavelength as it increases with increasing doped ratios and is consistent with the findings reported in ref.[8].

![Figure 6](image1)

**Figure 6.** The actual dielectric constant for (PMMA–PS) with Fe$_2$O$_3$ nano.

![Figure 7](image2)

**Figure 7.** The unreal dielectric constant for (PMMA – PS) with Fe$_2$O$_3$ nano.

4. Conclusions

The study is show adding PS to PMMA, obtained a polymeric compound that is bound and cohesive and has a greater impact force, and increasing the ratio of Fe$_2$O$_3$ nanoparticles in PMMA-PS compound led to an increase in absorbance, absorption coefficient, real and imaginary dielectric constant, refractive index and decreased transmittance.
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