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# Studying The Optical Constants for ZnO/PMMA Composite Material

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***Abstract*—** Zinc Oxide powder with different concentration was mixed carefully with PMMA. Manual mixing and molding processes were used to prepare the circular shape composites with the same diameter and thickness at the ambient temperature by using ultra sonic water bath. UV-VIS technique was used to investigate the optical constants; the result showed that the absorption and extinction coefficients increased when the ZnO particles increased but the refractive index suffered reduction due to ZnO particles increasing.

***Keywords*—*Zno/PMMA Composite; Optical; Refractive Index***

## I. INTRODUCTION

Composite materials represent intermediate groups in solid material classification [1] which made from two or more constituent materials, the big ratio called matrix materials and the small ratios called reinforcement or additives materials [2]. Polymers can be used as organic matrix materials [3] from these polymers poly mathyl methacrylate which considered a transparent material with transmittance lay between (80-93) % [4] also has refractive index about 1.49 high weather ability because of these properties it was used instead of glass [5].

Zinc oxide represent a metallic component with energy gap about 3.4 eV which shows semiconducting [6] and because of this wide energy gap it is suitable for optical application in short wavelength range[7].

## II. EXPERMENTAL PART

### *A. Materials*

Acrylic powder with methyl methacrylate liquid (monomer) from marlic industries Co., Iran was used to prepare PMMA matrix material, zinc oxide with particle size about 315nm was used as an additive which was from Fulka, honywell Inc, US.

### *B. Preparation and Examination of the ZnO/PMMA composite material*

Poly mythel methacrylate resin prepared by mixing (50 to 50) % powder to liquid from the total weight when the total weight was equal to1.4 g, the process done by hand lay method for 4 minutes and then casting in circular aluminum mold with diameter 33mm after that it was putted inside ultra sonic path for 30 minutes to insure drying with degassing. ZnO/PMMA composites prepared with different concentration of ZnO (4%,8%,10%,12%) from the total weight as state in table(1)

Table 1: Concentration of the matrix materials and the additive

| Materials / Samples | Powder (g) | Liquid (ml) | ZnO (g) |
|---|---|---|---|
| PMMA | 0.7 | 0.75 | 0 |
| PZ1 | 0.672 | 0.71 | 0.056 |
| PZ2 | 0.644 | 0.685 | 0.112 |
| PZ3 | 0.63 | 0.67 | 0.14 |
| PZ4 | 0.616 | 0.655 | 0.168 |

where the ZnO powder mixed with acrylic powder for 45 minutes by using magnetic stirrer and then the same process done to prepare the PMMA resin repeated with the composite, prepared samples were in circular form with diameter 33mm and thickness about (1.5 ± 0.05) mm.

UV-VIS technique used to find the optical constant by recording the absorbance versus the wavelength by using UV-160 IPC model with wavelength range (200-800) nm from shimadzu, Japan.

## III. RESULTS AND DISCUSSION

Absorption coefficient was calculated by using the equation [8]:

$$\alpha = \frac{2.303\, A}{t}$$

Where t is the thickness and A is the absorbance

Fig. 1 shows the absorption coefficient versus the wavelength from it one can notice that the absorption coefficient increased and the absorption edge shifted near the visible region when the concentration of the ZnO increased, that because the energy of the incident photon was enough to transit the electron from the valance band to the conduction band, this energy was enough especially when the concentration of the ZnO particles increased because of the localized levels which configured between the valance band and the conduction band, these levels made Fermi level shifted near the conduction band of the composite material.

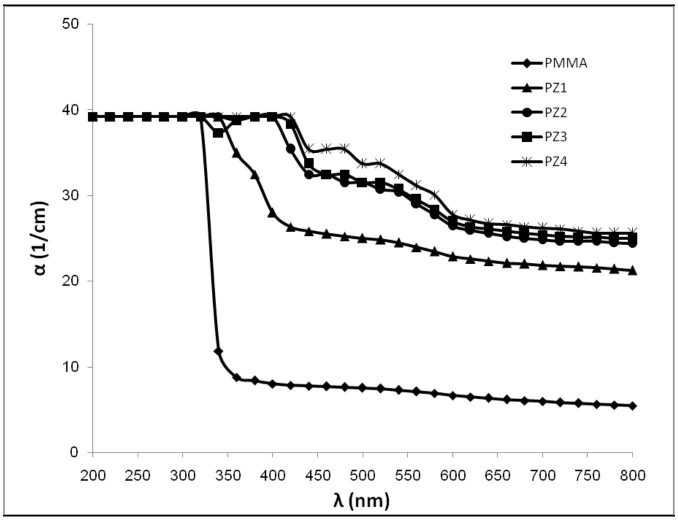


Figure 1: Absorption coefficient for PMMA and ZnO/PMMA composite materials.

The extinction coefficient was calculated by using the equation [9]:

$$k_0 = \frac{\alpha \lambda}{4\pi}$$

It is obvious in Fig (3-2) that the extinction coefficient for polymer and composite in different concentration was decreased when the wavelength increased, and it was increased when the concentration of the ZnO particles increased because of the intensity increasing for the composites leading to attenuate the electromagnetic wave.

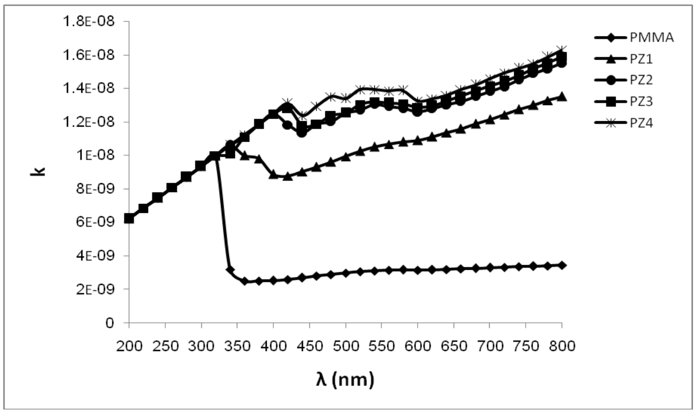


Figure 2: Extinction coefficient for PMMA and ZnO/PMMA composite material

Refractive index was calculated from the below equation [10]:

$$n = \sqrt{\frac{4R - k_0^2}{(R-1)^2}} - \frac{(R+1)}{(R-1)}$$

Fig. 3. shows that the refractive index of the ZnO/PMMA composite with different concentration was decreased when the concentration of the ZnO particles increased, this behavior can be explained depending on Ewald-Oseen extinction theorem [11], that is mean either the phase difference between the emitted electromagnetic wav from the excited electron and the incident electromagnetic wave was $270^0$ then the refractive index decreased and became negative because the phase velocity inside the matter increased, or the phase velocity was $180^0$ then destructive interference happened between the emitted and the incident electromagnetic wave so the refractive index became imaginary[12].

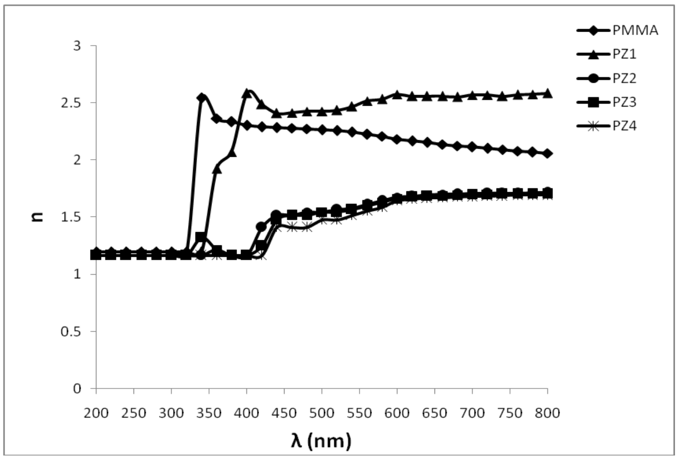


Fig. 3. Refractive index for PMMA and ZnO/PMMA composite material.

## CONCLUSION

From the previous result one can conclude that the absorption increased in the short wave length region and with the increasing of the composite concentration, extinction coefficient increased when the wavelength increased because the energy of the electromagnetic wave decreased in these regions and the phase difference between the emitted electromagnetic wave and the incident electromagnetic wave either close to $180^0$ or lay between ($180^0$-$270^0$) that was made refractive index decreased.


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