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RESEARCH ARTICLE

Study of Some Optical Properties of Poly Methylmethacrylate Copper Nanocomposites Films

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Abstract

The addition effect of nano Cu on some optical properties for poly methyl-methacrylate has been investigated. Poly methyl-methacrylate with different weight percentages of nano Cu content and different thickness have been prepared. The wavelength range for which absorption spectra have been recorded is (200-800) nm. For indirect allowed and forbidden transition the absorption coefficient, extinction coefficient and energy gap have been determined. Results show an increasing in absorption coefficient and extinction coefficient and decreasing in the energy gap with the Wt.% concentration of nano Copper. Scanning Electron Microscope (SEM) Measurements certificates the compatibility between various components of the polymers and nano materials through the detection of phase separations and interfaces. All figures show the very detailed three-dimensional images at very high magnifications for all films.

Keywords: *Polymethyl-methacrylate, Nanoparticles, Nano-composites.*

Introduction

Word "Nano" has evoked theory about a seismic move in relatively every part of science and designing with suggestions for morals, financial aspects, global relations, everyday life, and even humankind's origination of its place in the universe. Visionaries tout it as the panacea for every one of our burdens. Scaremongers consider it to be the following stage in natural and compound fighting or, in outrageous cases, as the open door for individuals to make the species that will at last supplant humankind [1].

In nanotechnology, the essential parts of established physical standards are supplanted as sub-atomic and nuclear measurements are drawn closer. Physical specialized and synthetic viewpoints impact the manufacture and the utilization and use of nontechnical structures on an equivalent premise. The impacts of infinitesimal material science, a field that is affected by and utilizes quantum marvels, supplement these perspectives. As opposed to traditional science, little outfits or even individual particles can assume a definitive part [2]. Nanotechnology is the innovation managing both single Nano articles and materials, and gadgets in light of them and with forms that occur in the nanometer extend [3]. Nanotechnology ornanoscale science is worried about the examination of issue at the nano scale, by and large taken as the (1 to 100) nm run. The achievement in both scholarly and modern enthusiasm for these nanoscale materials in the course of recent years has been intrigued due to the surprising varieties in strong state properties. The "Nano" as the word implies predominate (little man) in Greek, Nano as SI unit alludes measure of 10-9, for example, nanometer, nanolitter and nanogram [2].

The reasons of the excitement emerging from the "nanosciences" are various. Among them, the simple huge surface to volume proportion showed by numerous nanoscaled materials opened novel conceivable outcomes in surface-based science, for example, heterogeneous catalysis [4]. Moreover, it is found that the properties of the materials change as their size methodologies the nanoscale, at the end of the day, as the portion of particular molecules at the surface of a material wind up noteworthy.

For instance, dormant materials, for example, platinum progress toward becoming impetuses, semiconductors like silicon move toward becoming conductor, etc.

The utilizations of nanotechnology is just expanding in the ongoing years, and the most astounding potential application is in the field of materials, trailed by hardware and pharmaceutical [5].

Optical Absorption and Absorption Edge

The major retention is the most imperative assimilation process which includes the progress of electrons from the valence band (VB) to the conduction band (CB), which shows itself by a fast ascent in ingestion and this can be utilized to decide the vitality hole of the semiconductor [6].The semiconductor retains photon from the occurrence shaft, the assimilation relies upon the photon vitality (hv), where h is Board's consistent, v is the episode photon frequency.

The assimilation related with the electronic change between the V.B and the C.B in the material beginning at the ingestion edge which compares to least vitality distinction (Eg) between the most reduced least of the C.B. moreover, the most astounding greatest of the V.B [7].

On the off chance that the photon vitality (hv) is equivalent or more than the vitality hole (Eg) at that point, the photon can collaborate with a valence electron, hoists the electron into the C.B and makes an electron–gap match [7].The greatest wavelength (λ_c) of the episode photon which makes the electron opening pair characterized as [8].

$$\lambda(\mu m) = \frac{hc}{E_g} = \frac{1.24}{E_g(eV)} \quad \dots (1)$$

The intensity of the photon flux decreases exponentially with distance through the semiconductor according to the following equation [8].

$$I = I_o exp(-\alpha t) \quad \dots (2)$$

Where I_o, I are the episode and the transmitted photon force respectively,α is the retention coefficient, which is characterized as the relative number of the photons retained per unit separation of semiconductor, and t is the thickness of the material.

Preparation of (PMMA-Cu) nanocomposite

The (PMMA-Cu) nanocomposites have been prepared by the following:

- Nanocomposites have been prepared by solving (0.5gm) of PMMA in (25) ml of the chloroform and using magnetic stirrer to mix the materials to obtain more homogeneous solution.
- The (Cu) nanoparticle was added to poly metheymethacrylate with different weights of percentages are (2.5, 5, and 7.5) wt. % as shown in Table (1), and mixed for1hour to make the mixture more homogenous.
- The Petri dishes dimeter (2.5) cm was cleaned by acetone and DIW.
- The casting method was used to get the nanocomposites cast on these Petri dish placed on horizontal surface, .Thickness measured by using Digital Micro Mitter.

Table: 1 Weight Percentages of (PMMA-CU) Nanocomposites

Wight ratio of additive %	PMMA(gm)	(Cu) nanoparticles(gm)
0	0.5	0
2.5	0.475	0.025
5	0.450	0.050
7.5	0.425	0.075

Copper (Cu) Nanoparticles

It was obtained as powder from (Nano shell USA) company, with size (30 nm) and high purity (99.9%). Nanomaterial (Cu) are tested by using the apparatus (Better size 2000 laser particle size analyzer) existed in Babylon university / college of material engineering , department of electro-chemical.

Results and Discussion

The Absorbance (A)

As shown in the Fig. 1 the relation between absorbance of (PMMA-Cu) nanocomposites and wavelength for incident light, where the highest absorbance appears at the fundamental absorption limit (200nm), then it decreases with the wavelength increment. Obviously, in the visible and near infrared region, the all films have low values of absorbance. The independence of absorbance on wavelength can be understood as follows: at higher wavelengths the incident wave does not have adequate energy to induce atoms, the wave will be transmitted. While at low wavelengths, the interaction between atoms and incident wave will be more likely, causing an increasing in absorbance [9]. This means, the incident wave is absorbed by the free electrons. Consequently, by the increase of the weight percentages of copper nanoparticles, absorbance is increased [10].

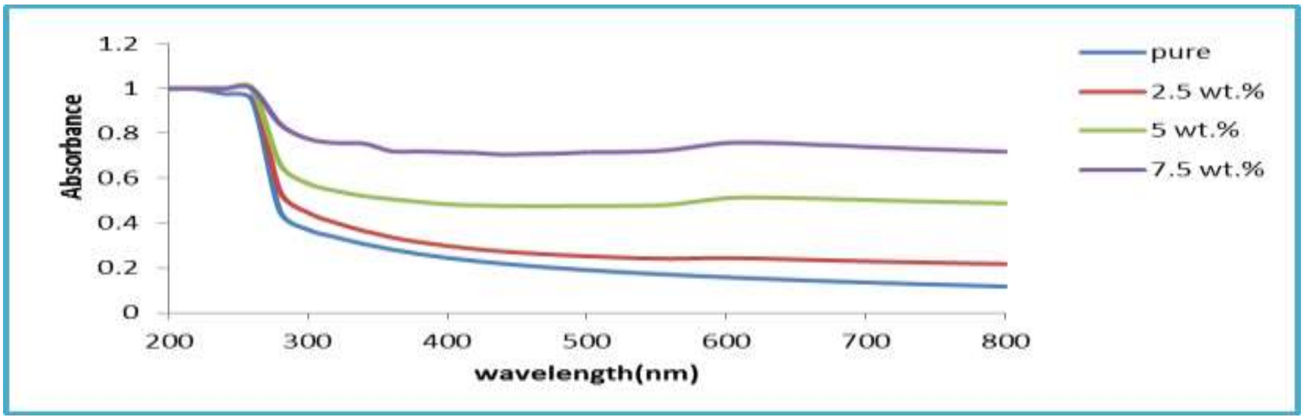

Fig.1: The Absorbance curve of (PMMA-Cu)

Absorption Coefficient (α)

Fig.2 shows that small values of absorption coefficient $\alpha (cm)^{-1}$appear at higher wavelengths(lower energies), then the chance of an electron moving is low since the incident photon does not have the sufficient energy required to move the electron from (VB) to (CB)**(**$h\upsilon<E_g$).The absorption becomes high at high energies, therefore a great possibility for electron transitions. Consequently, the incident photon has adequate energy to induce an electron to move from (VB) to (CB). This behavior helps to figure out the electron transition nature, when the absorption coefficient has values less than (10^4) $(cm)^{-1}$ at low energies, then the indirect transition is predominant, and due the phonon existence the electronic momentum is maintained, among other results is that the coefficient of absorption for the (PMMA-Cu) nanocomposites is less than$(10^4)(cm)^{-1}$[10].

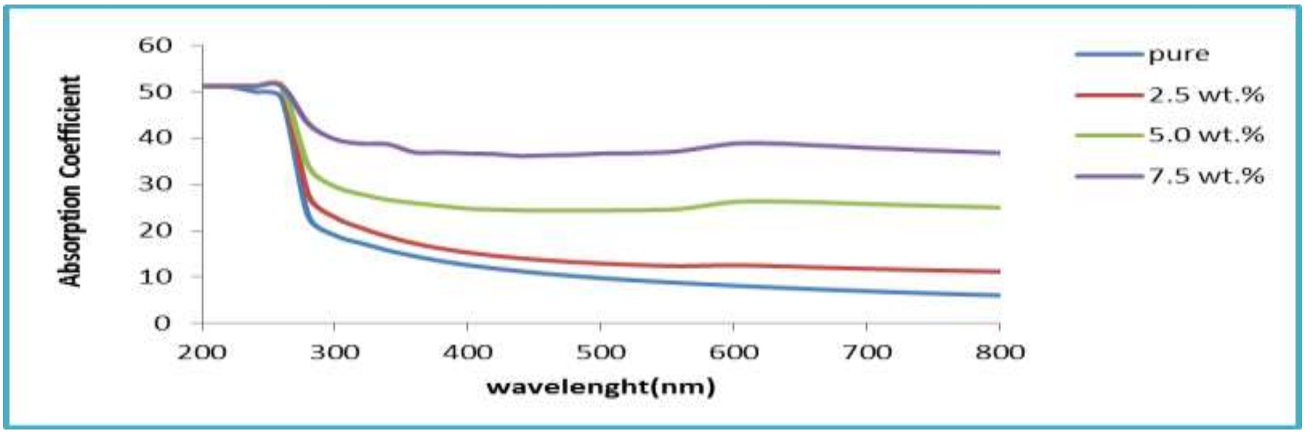

Fig.2: The absorption coefficient $\alpha (cm)^{-1}$for (PMMA-Cu)

Optical Energy Gap (OEG) of the (allowed and forbidden) Indirect Transition

OEG of two indirect transitions(allowed and forbidden)is investigated. The allowed indirect transition band optical energy gap is calculated at r = 2 , and r =3, the OEG of forbidden indirect transition band is calculated. Fig. 3shows the relation between absorption limit $(\alpha h\nu)^{1/2}$and photon energy for (PMMA-Cu) nanocomposites. For the allowed indirect transition by finding the intersection point of straight line drawing along highest inclined part of the curve with x-axis at the value$(\alpha h\nu)^{1/2}$ =1. It can be seen that the values of OEG decrease with the increasing of copper nanoparticles content [11].

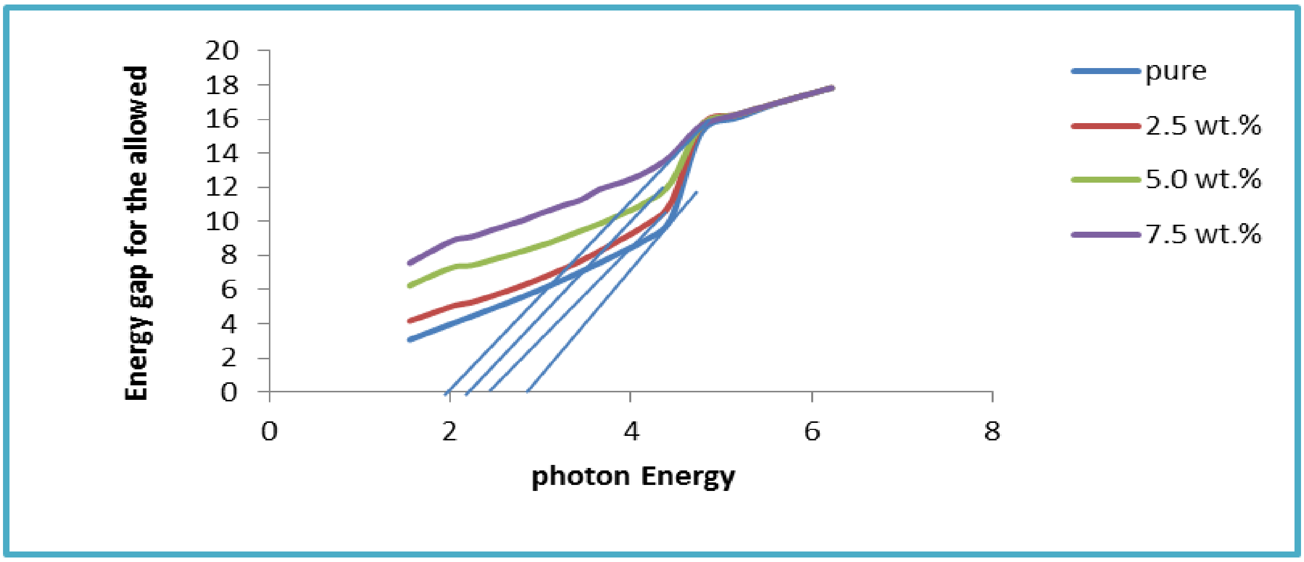

Fig.3:The OEG for the allowed indirect transition (αhυ) 1/2for (PMMA-Cu)

The same way has been used to estimate the forbidden transition of the indirect optical energy gap.

It is noticed from Fig.4that forbidden transition of the indirect OEG for the (PMMA-Cu) nanocomposites.

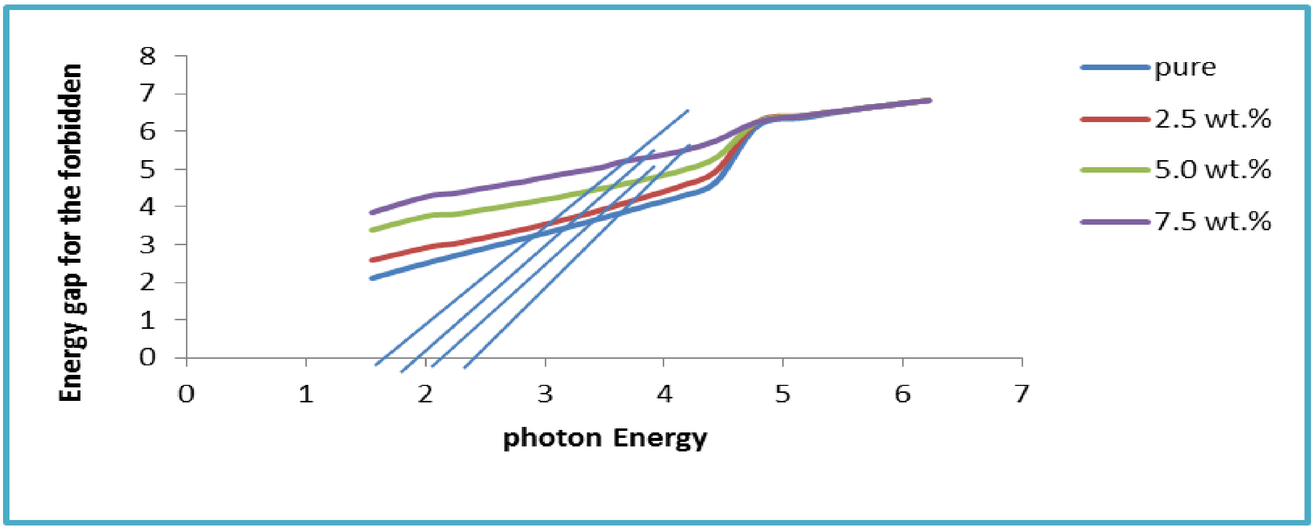

Fig.4: The optical energy gap for the forbidden indirect transition (αhυ) 1/3for (PMMA-Cu)

Table:2: The Values of OEG for the Allowed and Forbidden Indirect transition for(PMMA-CU)Nanocomposites

Nano Cu wt%	E_g(eV)	
	Allowed	forbidden
0	3	2.7
2.5	2.5	2.4
5.0	2.2	1.95
7.5	2	1.8

Extinction Coefficient(k)

The variation of the extinction coefficient with wavelength is obvious in Fig.5 for (PMMA-Cu) nanocomposites. Clearly the (k) has a low value of low concentration, but it grows with the rising in the (Cu) nanoparticles concentration. This is referred to increase the absorption coefficient with the increase of the (Cu) nanoparticles weight percentage.

Absorption coefficient has an explicit relevance with (k). Fig.2 shows that before 300(nm) the absorbance increases with wavelength increment, this is due to the defects in the internal structure where absorb this energy and organize themselves to stabilizing then after 300 (nm) the absorbance decreases with wave length increment [9].

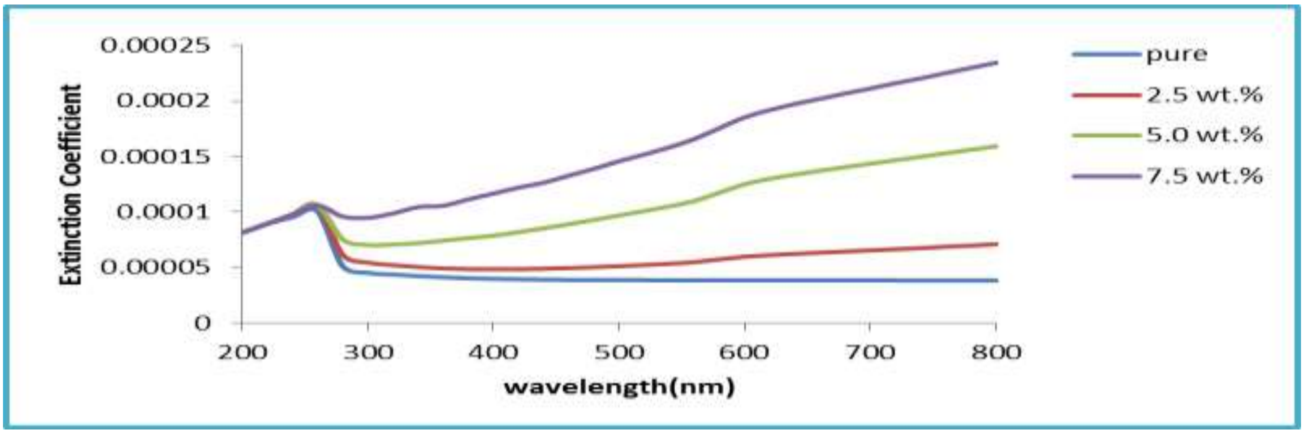

Fig.5: The termination coefficient for (PMMA-Cu)

Real and Imaginary Part of Dielectric Constant

The dielectric constant for (PMMA-Cu) nanocomposites divides into two parts, real ε1 and imaginary ε2. Fig.6 shows the variation of (ε1) with wavelength. It is observed from Fig.6 that (ε1) depends on (n2) because the low value of (K2) so (ε1) increases with the increase of the (Cu) nanoparticles concentrations and decreases at high wavelength. Fig.7 shows the variation of (ε2) with wavelength. Obviously, (ε2) is dependent on (k) that varies with the absorption coefficient change due to the correlation between (α) and (k).

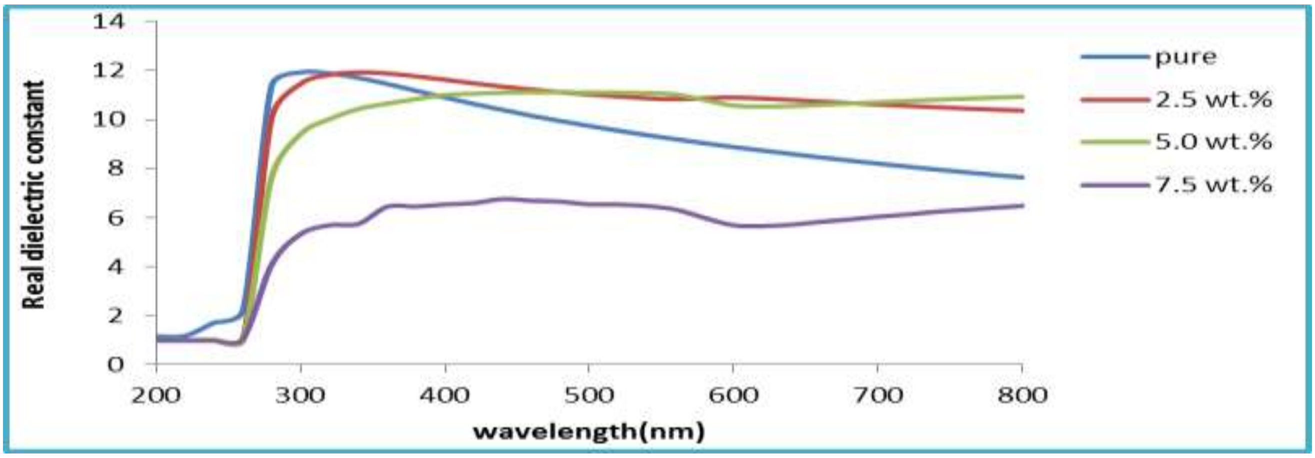

Fig.6: The real dielectric constant(ε_1) for (PMMA-Cu)

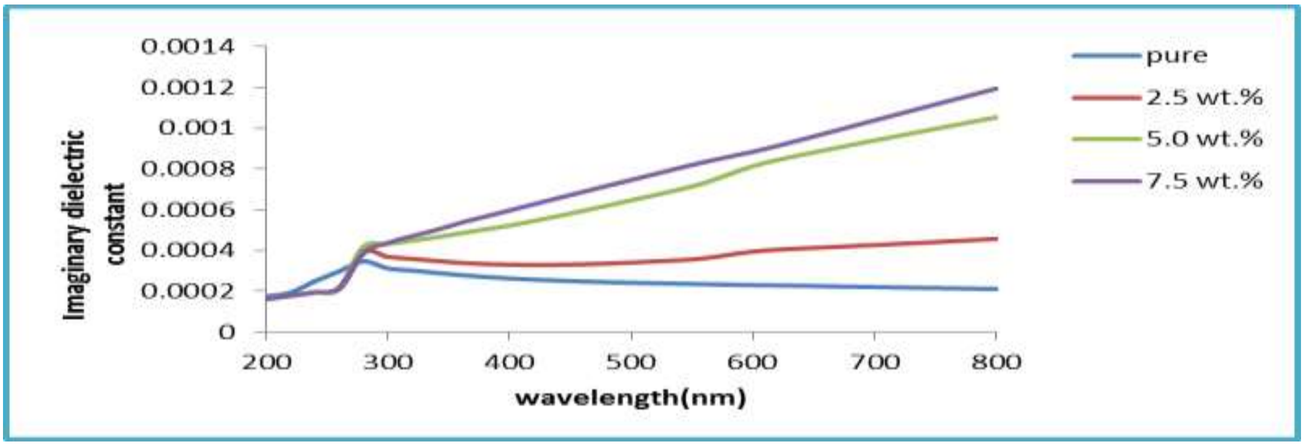

Fig.7: The imaginary dielectric constant(ε_2) for (PMMA-Cu)

Refractive Index

Fig.8 shows the variation of refraction index for (PMMA-Cu) nanocomposites with wavelength. From this Figure it can be realized that there is an increasing in refractive index along the increasing in weight percentages of (Cu) nanoparticles in (PMMA) films. The cause is the increasing of the (Cu) concentration produces an increasing in the nanocomposites density. Clearly, the refractive index is the smallest at high wavelength [12].

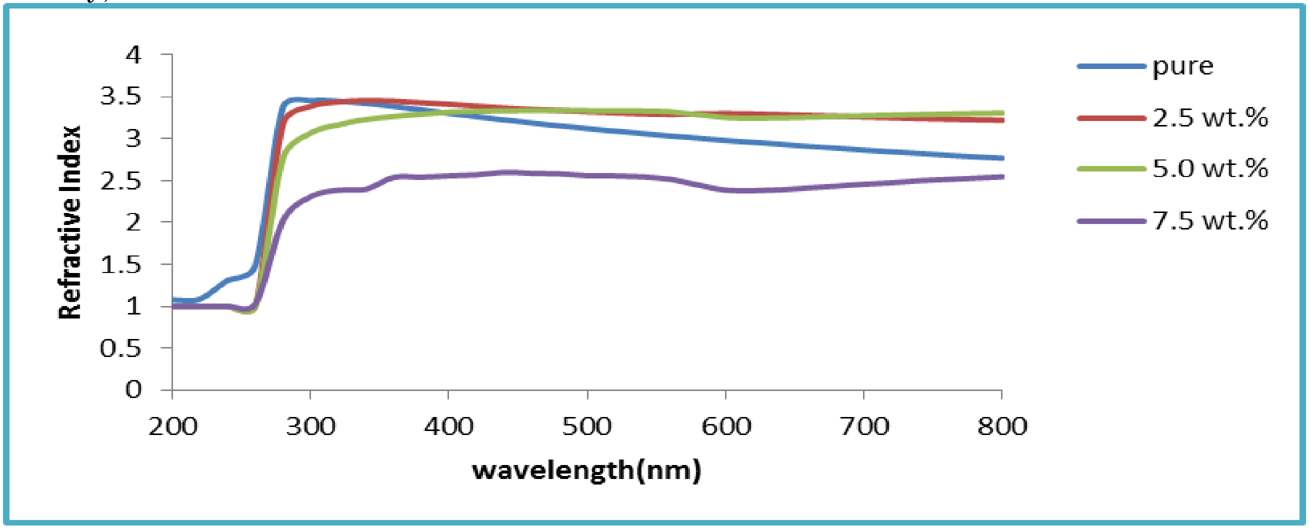

Fig.:8 The refractive index(n) for (PMMA-Cu)

Scanning Electron Microscope (SEM) Measurements

SEM demonstrates the morphology of film at high amplifications. The surface structure poly metheymethacrylate and (PMMA-Cu) nanocomposites can be imaged through SEM with high lucidity. SEM pictures portray the surface morphology of poly metheymethacrylate when the expansion centralization of Cu nanoparticles which are appeared in Fig.9. The movies display uniform thickness of grain dissemination at surface morphology. The surface morphology of the (PMMA-Cu) nanocomposite films demonstrates numerous totals or pieces haphazardly circulated of Cu nanoparticles on the best surface the movies. The outcomes demonstrate that the Cu nanoparticles tended to frame totals and great scattered at (PMMA-Cu) nanocomposites films as appeared in the Figs. (9 b, c, and d).When adding 7.5wt.% of Cu nanoparticles to poly metheymethacrylate its frame a persistent system inside the polymers as appeared in Fig (9 d).This arrange has ways where charge bearers are permitted to go through the ways that have low electrical resistance[13,14].

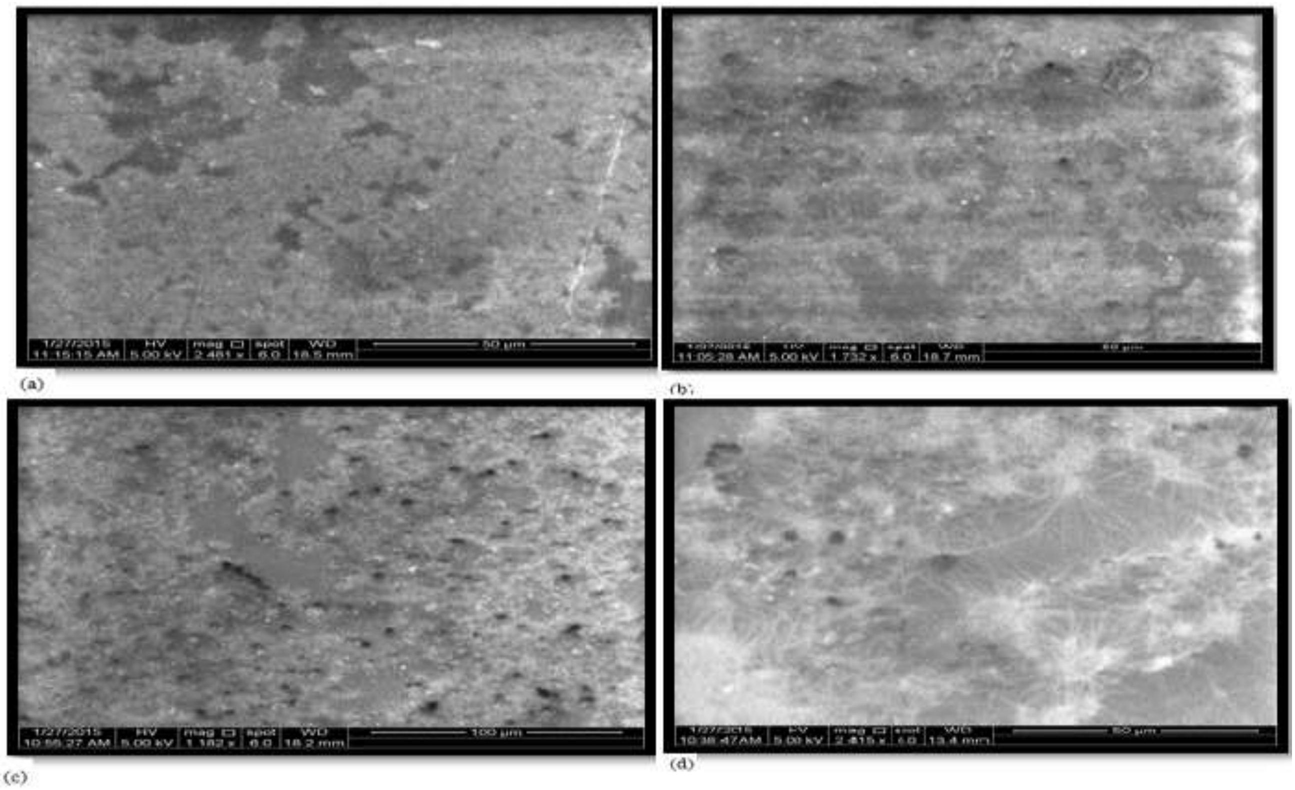

Fig.9: SEM image of (PMMA-Cu) nanocomposites films.(a) for pure. (b) 2.5 wt.% Cu. (c) 5.0 wt.%Cu. (d) 7.5 wt.%Cu

Conclusions

- The absorption coefficient increases with increasing of the filler wt% contained .
- The forbidden energy band qap decreases with increasing of the wt% filler.
- The extinction coefficient increases with increasing of the wt% filler.

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