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EFFECT OF MAGNESIUM CONTENT ON THE GROWTH THICK FILMS OF EPOXY PREPARED BY THE CASTING METHOD

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Abstract

In this study, the magnesium(Mg) content at different concentrations (0, 0.05, 0.10, 0.15 and 0.20 wt. %) with epoxy resins was used to fabricate the polymer blend. The influence of Mg doping epoxy thick films are reported in this study. Thick films were prepared on glass substrate, and the films deposited at lab. temperature by casting method. The effects of polymeric blends were studied carefully investigated on the optical properties of the blends through a variation on the concentration of additions of magnesium. The thick films study results revealed additive of Mg lead to a structure improvement on the polymer blend and then improve optical properties. The optical properties of the blends were characterizes by the clear effect of the additions on the all optical properties coefficients of the polymer blends.

The optical properties were characterized by absorption, transmittance and reflectance spectroscopy measurements.

Transmittance and absorbance measurements in the waves length range(200-1000)nm were used to calculate the refractive index n and extinction coefficient k . The optical band gap E_g , complex dielectric constant ε_1, ε_2, ε_∞ average interband oscillator wave length λ_0,average oscillator strength So, N/m*(N the free charge carrier concentration , m* the effective mass of the free charge carrier). According to Wemple and Didomenico method, the optical dispersion parameters E_o and E_d were determined. For all the films, the average (absorption and transmission) in the U.V wavelength region (200-1000) nm was (increased, decreased) as the magnesium concentration increased. The optical energy band gap of magnesium content different concentrations (0, 0.05, 0.10, 0.15 and 0.20 wt. %) with epoxy resins was used on the growth thick films of epoxy , has been found between (3.6 – 2.95) eV , whereas refractive index controlled between(1.696 – 6.205).

Keywords :thick films; magnesium(Mg); epoxy resins ;optical constant;; UV/VIS spectroscopy; optical properties: energy band gap; refractive index.

1. Introduction

Magnesium is a chemical element with the symbol Mg and atomic number 12. It is a shiny gray solid which bears a close physical resemblance to the other five elements in the second column (group 2, or alkaline earth metals) of the periodic table: all group 2 elements have the same electron configuration in the outer electron shell and a similar crystal structure.

Magnesium is the ninth most abundant element in the universe.[1,2] It is produced in large, aging stars from the sequential addition of three helium nuclei to a carbon nucleus. When such stars explode as supernovas, much of the magnesium is expelled into the interstellar medium where it may recycle into new star systems. Magnesium is the eighth most abundant element in the Earth's crust[3] and the fourth most common element in the Earth (after iron, oxygen and silicon), making up 13% of the planet's mass and a large fraction of the planet's mantle. It is the third most abundant element dissolved in sea water, after sodium and chlorine.[4]

Magnesium belongs to group 2 of the periodic table, along with Be, Ca, Sr and Ba. The element has an atomic number of 12, an atomic mass of 24, one main oxidation state (+2) and three naturally occurring isotopes (24Mg, 25Mg and 26Mg), of which 24Mg is the major isotope at 79% of the total mass. Magnesium is the seventh most abundant element in the Earth's crust with a quoted average of 2.76% [2,3], and the Mg2+ ion is the second most abundant cation in sea water, after Na+. Its chemistry is intermediate between that of Be and the heavier alkali earth elements.

Magnesium occurs naturally only in combination with other elements, where it invariably has a +2 oxidation state. The free element (metal) can be produced artificially, and is highly reactive (though in the atmosphere, it is soon coated in a thin layer of oxide that partly inhibits reactivity – see passivation). The free metal burns with a characteristic brilliant-white light. The metal is now obtained mainly by electrolysis of magnesium salts obtained from brine, and is used primarily as a component in aluminum-magnesium alloys, sometimes called magnalium or magnelium. Magnesium is less dense than aluminum, and the alloy is prized for its combination of lightness and strength.

Magnesium is the eleventh most abundant element by mass in the human body and is essential to all cells and some 300 enzymes.[5] Magnesium ions interact with polyphosphate compounds such as ATP, DNA, and RNA. Hundreds of enzymes require magnesium ions to function. Magnesium compounds are used medicinally as common laxatives, antacids (e.g., milk of magnesia), and to stabilize abnormal nerve excitation or blood vessel spasm in such conditions as eclampsia.[5]

1.1 Physical properties of magnesium

Elemental magnesium(as shown in fig.(1)) is a gray-white lightweight metal, two-thirds the density of aluminum. Magnesium has the lowest melting (923 K (1,202 °F)) and the lowest boiling point 1,363 K (1,994 °F) of all the alkaline earth metals.

Pure polycrystalline magnesium is brittle and easily fractures along shear bands. It becomes much more ductile when alloyed with small amount of other metals, such as 1% aluminum.[6] Ductility of polycrystalline magnesium can also be significantly improved by reducing its grain size to ca. 1 micron or less.[7]

Magnesium is the third-most-commonly-used structural metal, following iron and aluminum.[8] The main applications of magnesium are, in order: aluminum alloys, die-casting (alloyed with zinc)[9] removing sulfur in the production of iron and steel, and the production of titanium in the Kroll process.[10] Magnesium is used in super-strong, lightweight materials and alloys. For example, when infused with silicon carbide nanoparticles, it has extremely high specific strength.[11]

Fig(1) : magnesium element

1.2 Chemical properties(General chemistry) of magnesium

It tarnishes slightly when exposed to air, although, unlike the heavier alkaline earth metals, an oxygen-free environment is unnecessary for storage because magnesium is protected by a thin layer of oxide that is fairly impermeable and difficult to remove.[12]
Magnesium reacts with water at room temperature, though it reacts much more slowly than calcium, a similar group 2 metal. When submerged in water, hydrogen bubbles form slowly on the surface of the metal – though, if powdered, it reacts much more rapidly. The reaction occurs faster with higher temperatures (see safety precautions). Magnesium's reversible reaction with water can be harnessed to store energy and run a magnesium-based engine. Magnesium also reacts exothermically with most acids such as hydrochloric acid (HCl), producing the metal chloride and hydrogen gas, similar to the HCl reaction with aluminum, zinc, and many other metals.[13]

2. Materials and Methods

The thick polymer blends films were fabricate with varying amounts of magnesium 0, 0.05, 0.10, 0.15 and 0.20 by undergoes the following three stages:

2.1 prepare bases:

A glass substrates (of dimensions 2x4 cm^2) were cleaned with acetone and then rinsed thoroughly with ethanol and distilled water .And then dried by hot air.

2.2 Preparation materials:

(0.0, 0.01, 0.015, 0.02, 0.025) gm of crushed magnesium Mg (the additive was magnesium particle size 100 μm) was added with a purity of 100 μm (using sieves with a diameter of 100 μm) as an additive to one gram of polymeric (epoxy) in weight proportions (0.66 gm of (Resin) and 0.33 gm (Hardener)). The ratio of resin to hardening material was (3:1)[14,15], produced by united chemical company Ltd (UNICHEM-Jordan, type 368 WG). The properties of epoxy resin shown in table(1). And use triethylene tetra amine as hardener for epoxy resin product by same company.

Table(1): properties of Epoxy Resin

Molecular weight(gm/mol)	624
Weight per epoxy (Kg/mol)	312
Density (gm/cm^3)	1.27
n-value	0.9 - 1

2.3 Mixing process

The above weight ratios, equivalent to(0%,5%, 10 %, 15%, 20 %) of the additive (magnesium powder) to the epoxy, have been mixed for a period of (10 to 15) min. for the purpose of obtaining homogeneity between the host (epoxy) and the added filling of the magnesium filings .

2.4 Casting method

The homogeneous mixture prepared from the magnesium and epoxy filings was poured on a base of glass slides on a flat surface for the purpose of obtaining a homogeneous surface for the prepared form. The sample was then left for 48 hours for the purpose of obtaining complete solidification of the model and at room temperature where a model with a thickness of 0.3mm was obtained.

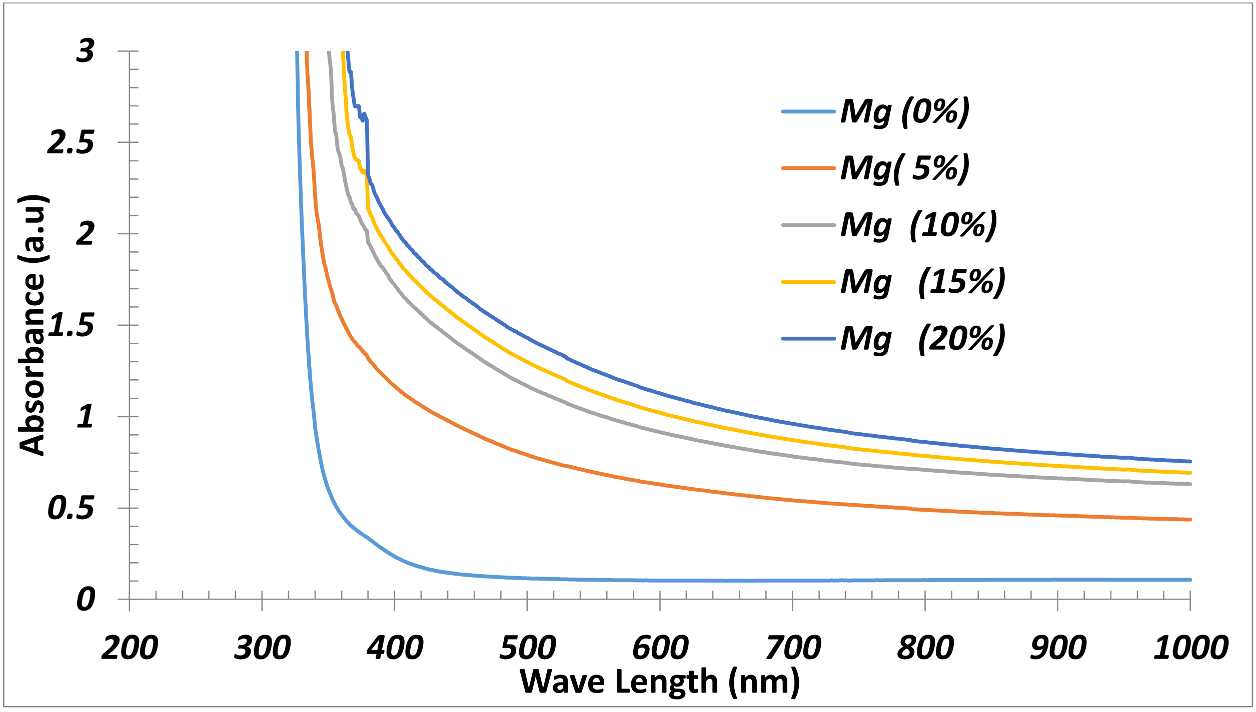
2.5 Optical measurement

The absorption and transmission spectrums of prepared films were studied by using (6800UV/VIS Jenway Double Beam Spectrophotometer – England) UV-VIS spectrophotometer in the wave length range of (200-1000)nm. The data from absorption(A) and transmission(T) spectrums could use in the calculation of the reflection(R) spectrum by using the following equation[16,17]:

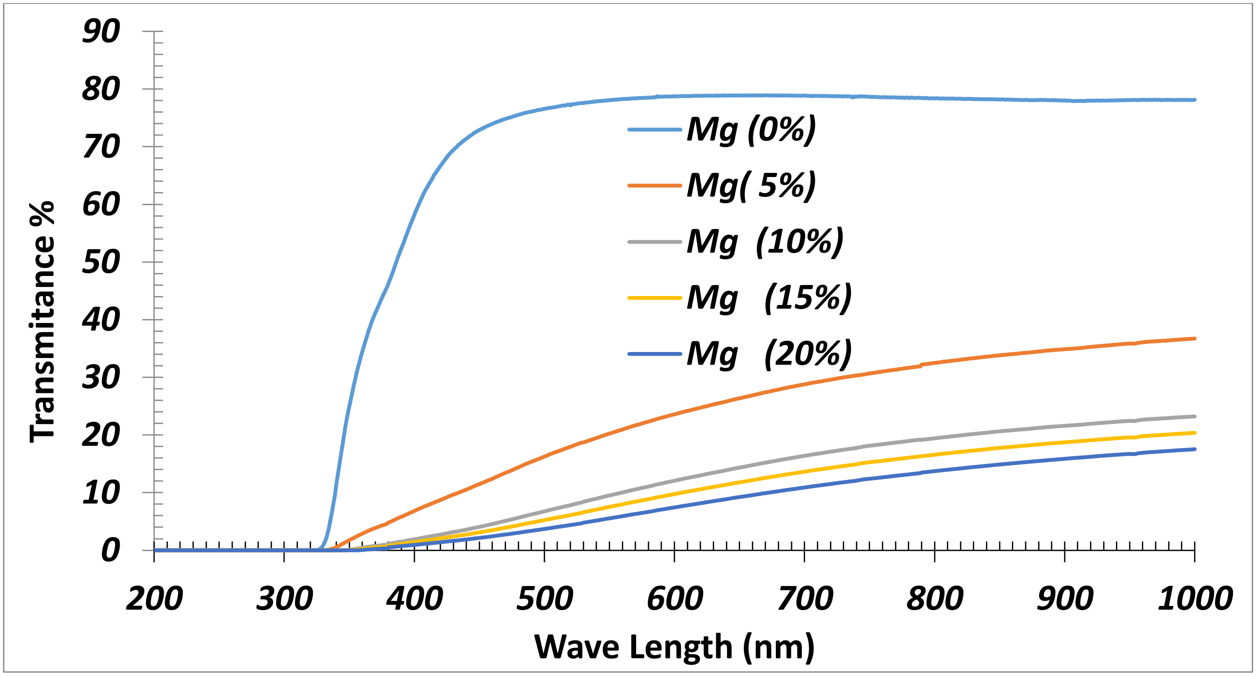
$A + T + R = 1$ .... (1)

3. Results and Discussions

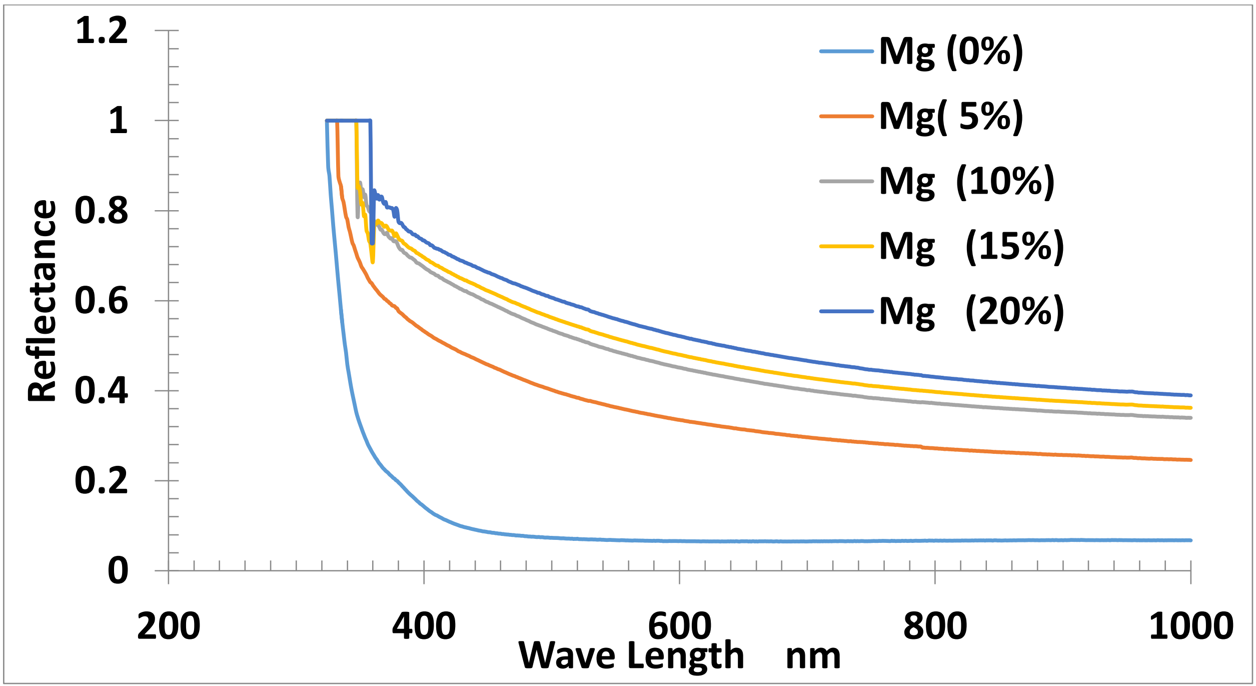
The optical properties of magnesium content different concentrations (0, 0.05, 0.10, 0.15 and 0.20 wt. %) with epoxy resins thick films were determined from transmission and absorption measurements in the range (200-1000) nm were recorded by using UV-VIS spectrophotometer.
The analysis of the absorption coefficient has been carried out to obtain the direct and indirect optical energy gap Eg and also the analysis of the refractive index n with the help of the absorption index k has been carried out to obtain the real and imaginary part of complex dielectric constant (ε_r , ε_i), average interband oscillator wave length λ_o , average oscillator strength S_o and N/m* (N the free charge carrier, m* the effective mass of the free charge carrier).
The optical properties of pure and doped epoxy with magnesium (0.05, 0.10, 0.15 and 0.20 wt. %) thick films is determined from absorbance, transmittance and reflectance in the range (200 – 1000)nm, as shown in fig.(2,4) respectively. While transmittance decrease when doping concentration increases , as shown in fig.(3). In general absorbance and reflectance increase when doping concentration increases as



Fig(2):The Absorbance spectra of epoxy doped with magnesium thick films



Fig(3):The Transmittance spectra of epoxy doped with magnesium thick films



Fig(4):The Reflectance spectra of epoxy doped with magnesium thick films

shown in fig.(2-4) respectively, while transmittance decrease when doping concentration increase (see fig.(3)).

The absorption coefficient (α) associated the strong absorption region of the film was calculated from absorbance (A) and the film thickness (t) using relation [18,19]

$$\alpha = 2.3026\,\frac{A}{t} \quad \ldots\ldots\ldots(2)$$

The absorption coefficient (α) cm^{-1} and optical energy band gap (Eg) are related by[20]

$$\alpha h v = A(hv - E_g)^n \quad \ldots\ldots..(3)$$

hv: is the energy of excitation photon (eV) , Eg is the energy band gap (eV) and n=½

The usual method for determine the values of energy band gap Eg are involves by plotting $(\alpha hv)^{½}$ as a function of photon energy (hv) as shown in figs.(5) and determined the values of Eg as shown in table(2) and fig.(6).

The extinction coefficient (k) is a measure of the fraction of light lost due to scattering and absorption per unit distance of the penetration medium. Extinction coefficient is estimated in the range (200-1000)nm from the values of α and λ using the following relation [21]:

$$k = \frac{\alpha\lambda}{4\pi} \quad \ldots\ldots\ldots.(4)$$

Fig(7) shows the dependence of extinction coefficient k on the wavelength for all epoxy films doped with magnesium (0, 5, 10, 15, 20)%.

The refractive index n of pure and epoxy doped with magnesium (0, 5, 10, 15, 20)%. films can be determined from a transmittance spectrum and absorbance spectrum (or reflectance spectrum) in the wave length range (200-1000) nm. by using Swanepoel's method [23] applying the following equation [24]:

$$n = \frac{1+\sqrt{R}}{1-\sqrt{R}} \qquad \dots\dots\dots (5)$$

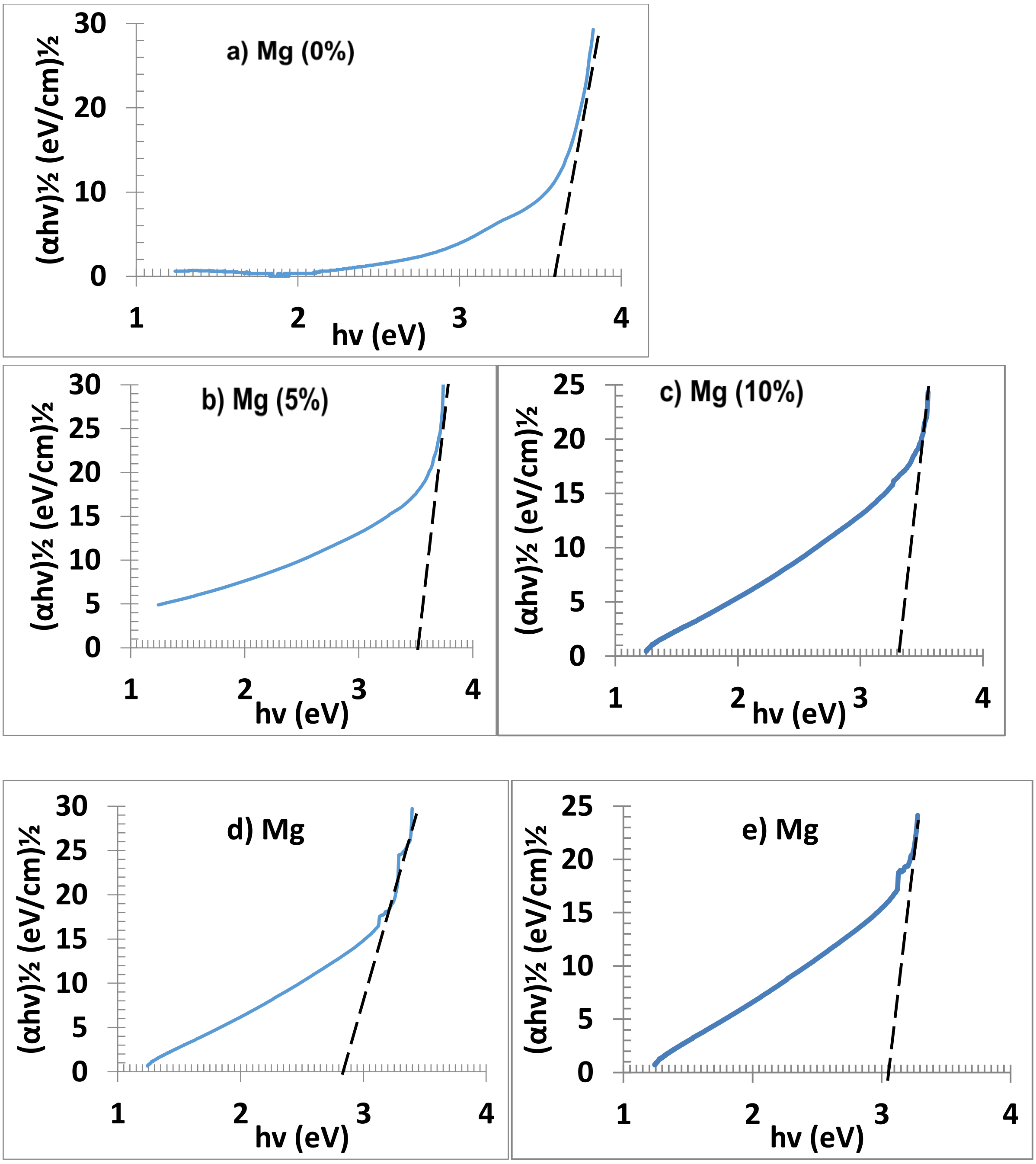
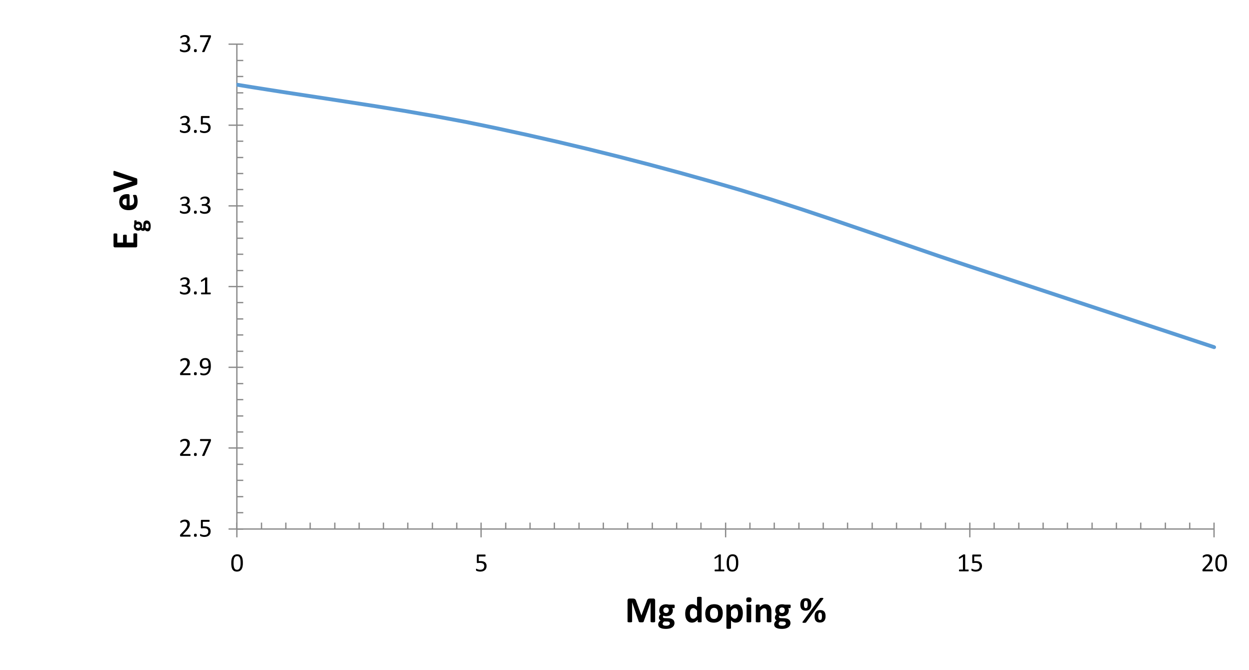


Fig (5) : The optical energy gap of epoxy doped with magnesium thick films



Fig(6): The relation between Energy band gap(E_g) and epoxy doped with magnesium thick films

Table(1): The values of optical parameters for epoxy doped with magnesium thick films

Mg doping%	E_g (eV)	ε_r	$\varepsilon_{\infty(2)}$	n_o	S_0 (m^{-2})	E_d (eV)	E_0 (eV)	E_{op} (eV)	$\varepsilon_{\infty(1)} = n^2$	N/m*	n
0	3.6	2.87	4.226	2.056	6.67E+1	5.502	3.742	1.87	2.875	1.17E+56	1.696
5	3.5	15	30.85	5.554	5.57E+1	44.384	3.578	1.864	15	1.01E+58	3.873
10	3.35	27	82.967	9.109	1.39E+1	89.443	3.578	1.789	27	1.92E+58	5.196
15	3.15	30	82.967	9.109	1.39E+1	111.80	3.578	1.789	31	2.27E+58	5.568
20	2.95	38	120.04	10.95	1.79E+1	140.30	3.578	1.732	38.5	3.02E+58	6.205

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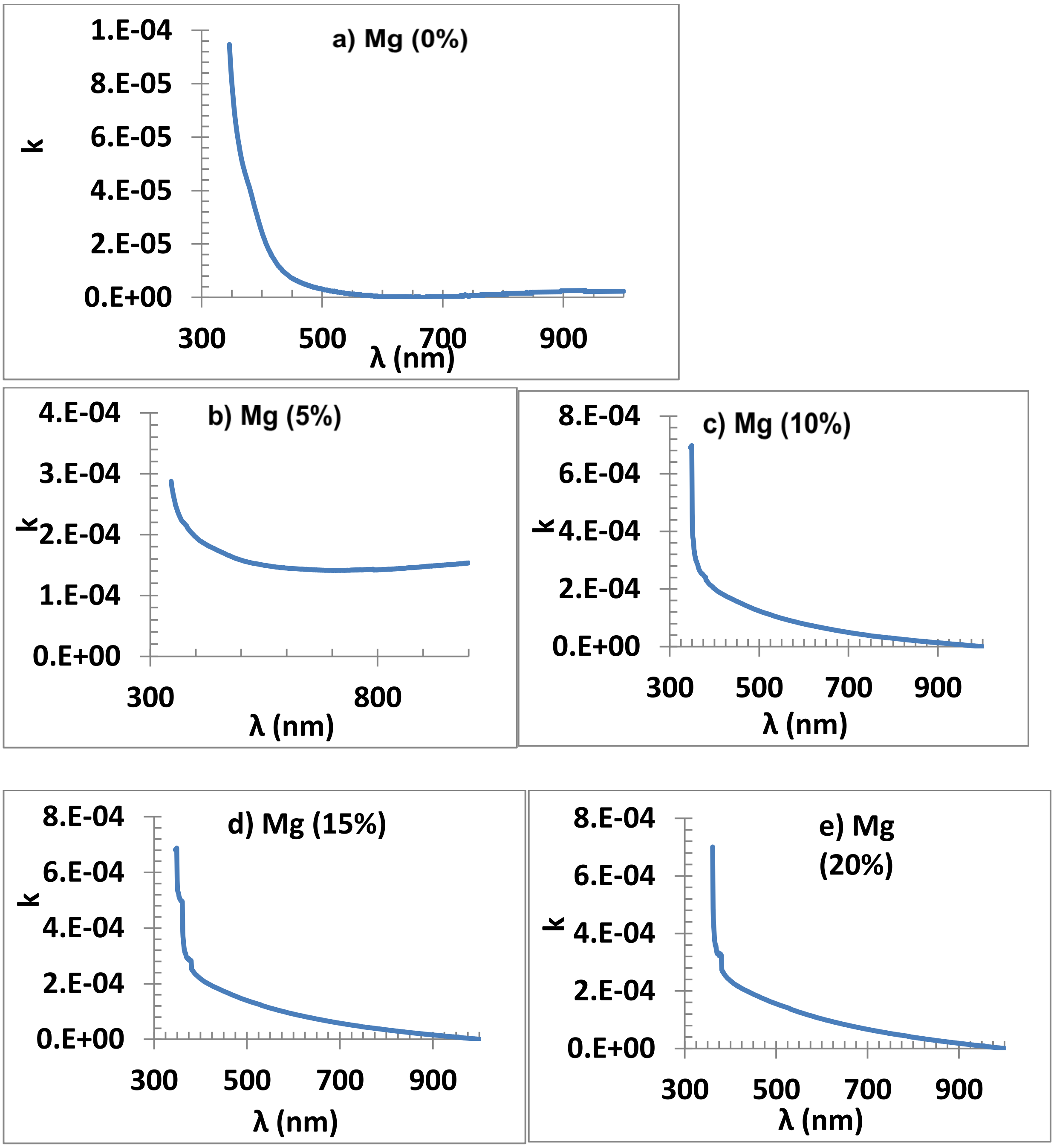


Fig(7): The relation between extinction coefficient k and wave length epoxy doped with magnesium thick films

As shown in figure(8), there is a sharp decrease in the refractive indexes for pure and doped films with magnesium (0, 5, 10, 15, 20)%. in the wave lengths range near 400nm. After that, the refractive indexes decrease slightly and steadily.

The values of [energy band gap E_g, real and imaginary part of complex dielectric constant ($\mathcal{E}_r$,$\mathcal{E}_i$) , average interband oscillator wave length λ_0 , average oscillator strength S_o , N/m^*(N the free charge carrier, m^* the mass of free charge carrier, n the refractive index , E_d single oscillator constants(dispersion energy), E_0 energy of the effective dispersion oscillator] parameters given in table(2) can be calculated as shown in ref.[24] after drawing Figs.(9 – 13).

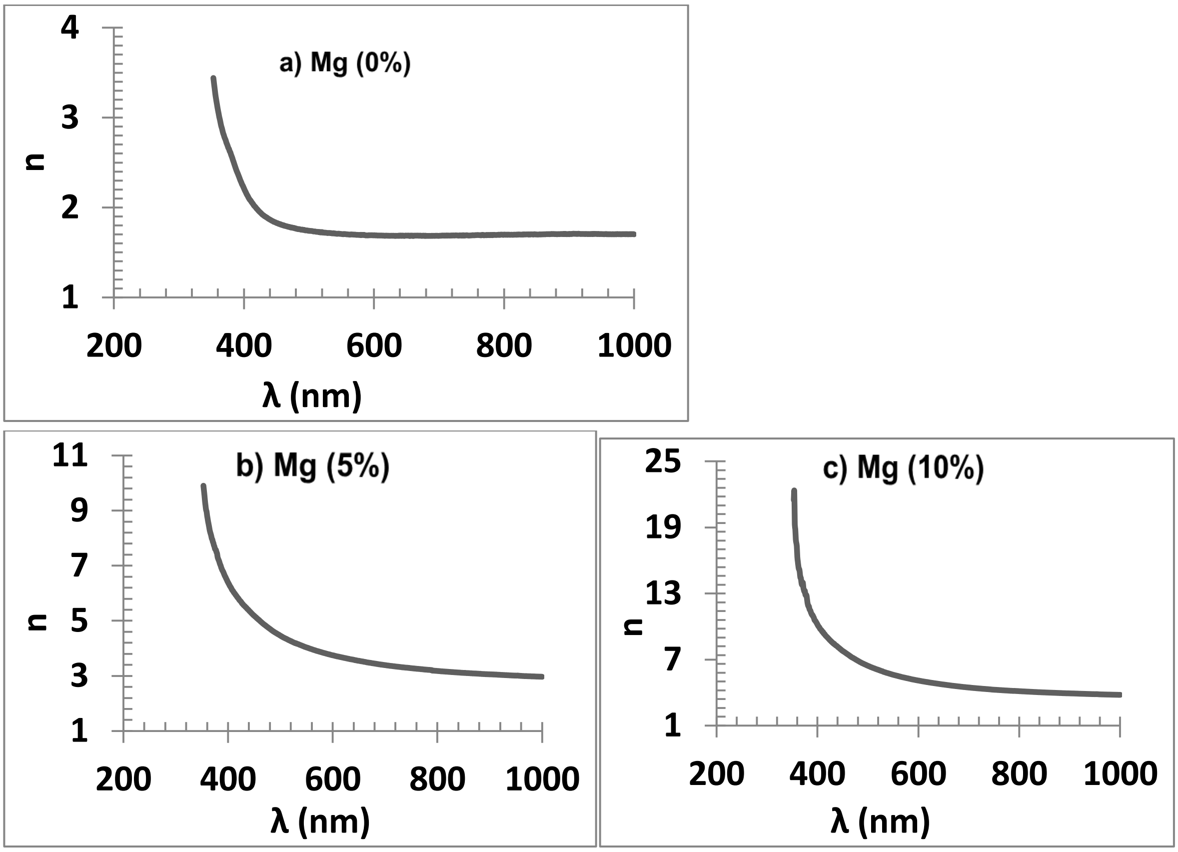
4. Conclusions

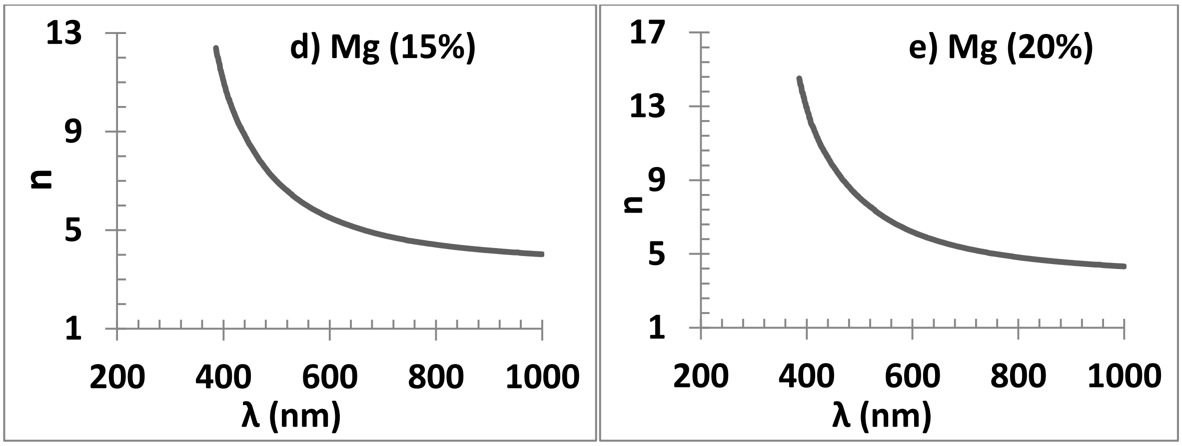
The optical absorbance and transmittance for pure and doped films with magnesium (0, 5, 10, 15, 20)%. was measured by (6800 UV/VIS Jenway Double Beam Spectrophotometer –England) UV-Vis spectrophotometer within the wavelengths range of (200-1000)nm. It was observed that the absorbance increase whereas transmittance decrease with increasing doping concentration of Mg.

The value of band gap decrease from 3.6 eV for pure sample to 2.95 eV for sample 20% doped with Mg .

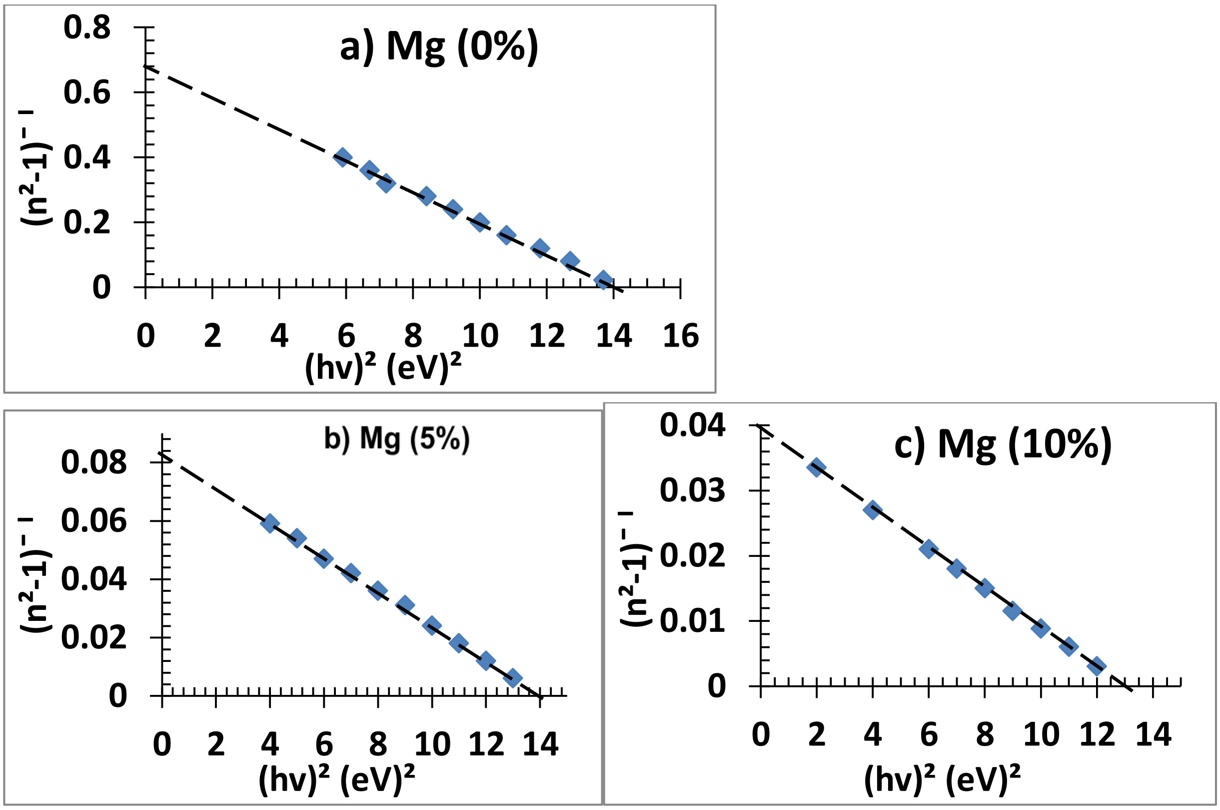
The refractive indexes (n) increase with increase from 1.696 for pure sample to 6.205 for sample 20% doped with Mg .

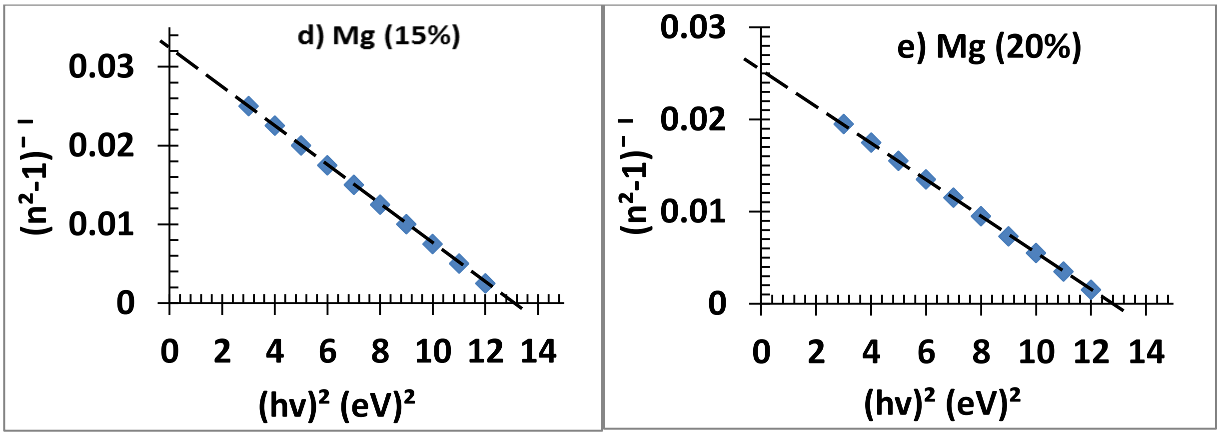
The dielectric constants (real ε_r and imaginary ε_i) are observed be increases from (2.87, 4.226) for pure sample to (38, 120.48) for sample 20% doped with Mg .



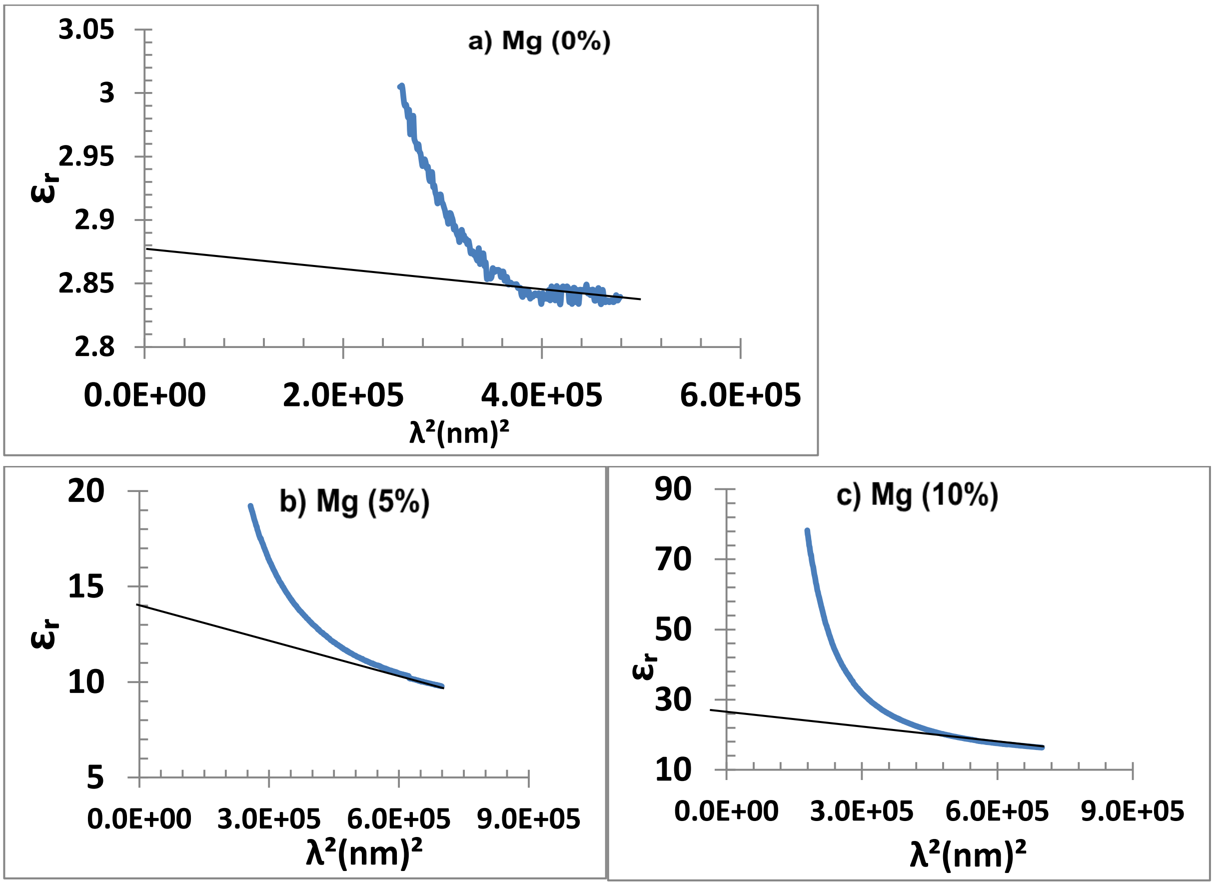


Fig(8): The relation between refractive index n and wave length for epoxy doped with magnesium thick films





Fig(9):A plot of $(hv)^2$ against $(n^2\text{-}1)^{-1}$ length for epoxy doped with magnesium thick films



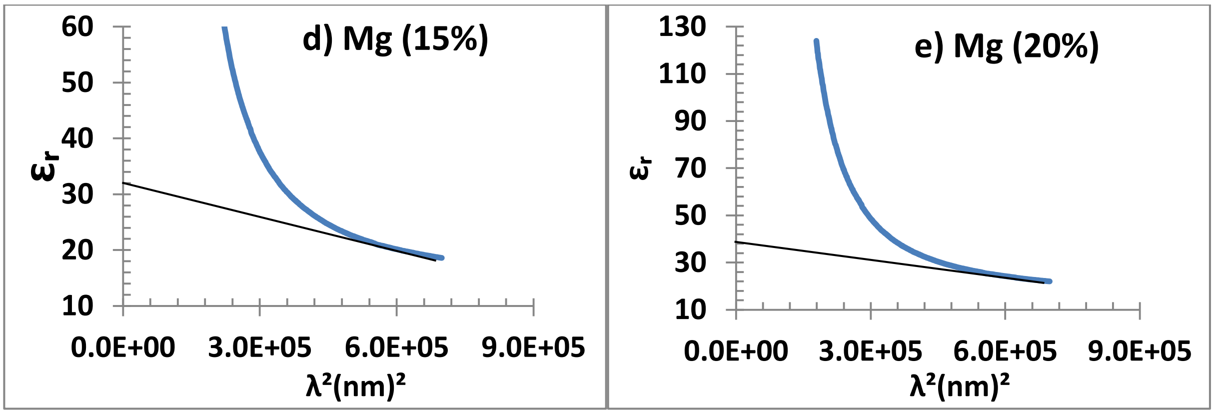
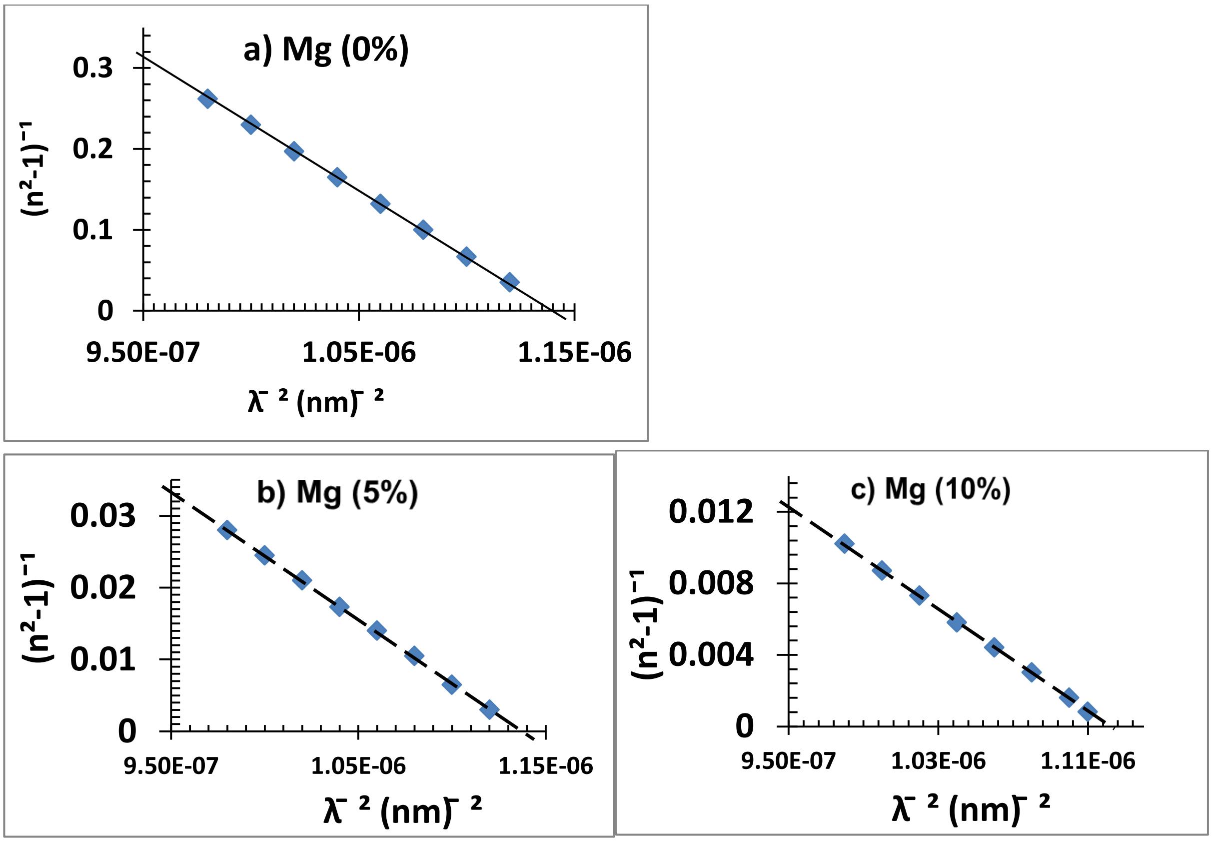


Fig (10) : A plot of ($\varepsilon_r = n^2$) as a function of λ^2 for epoxy doped with magnesium thick films



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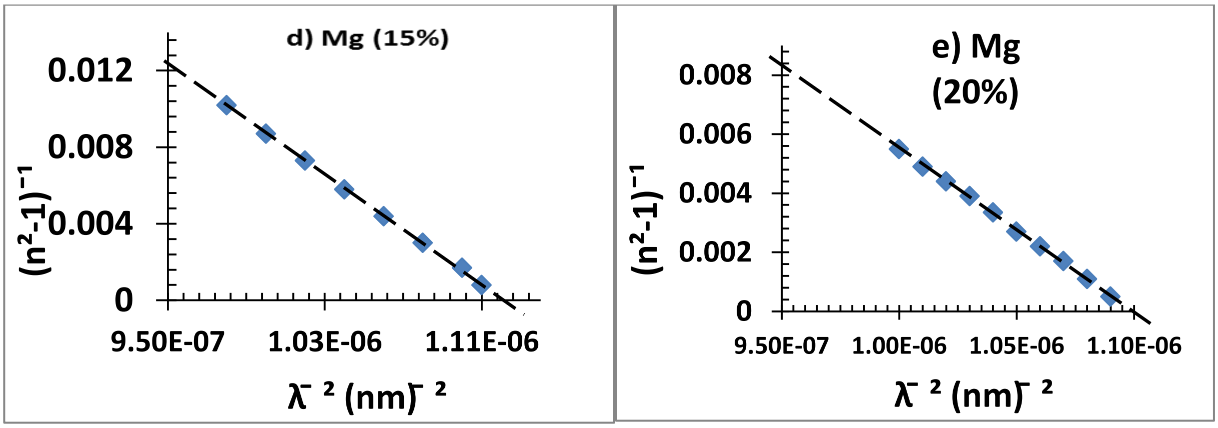
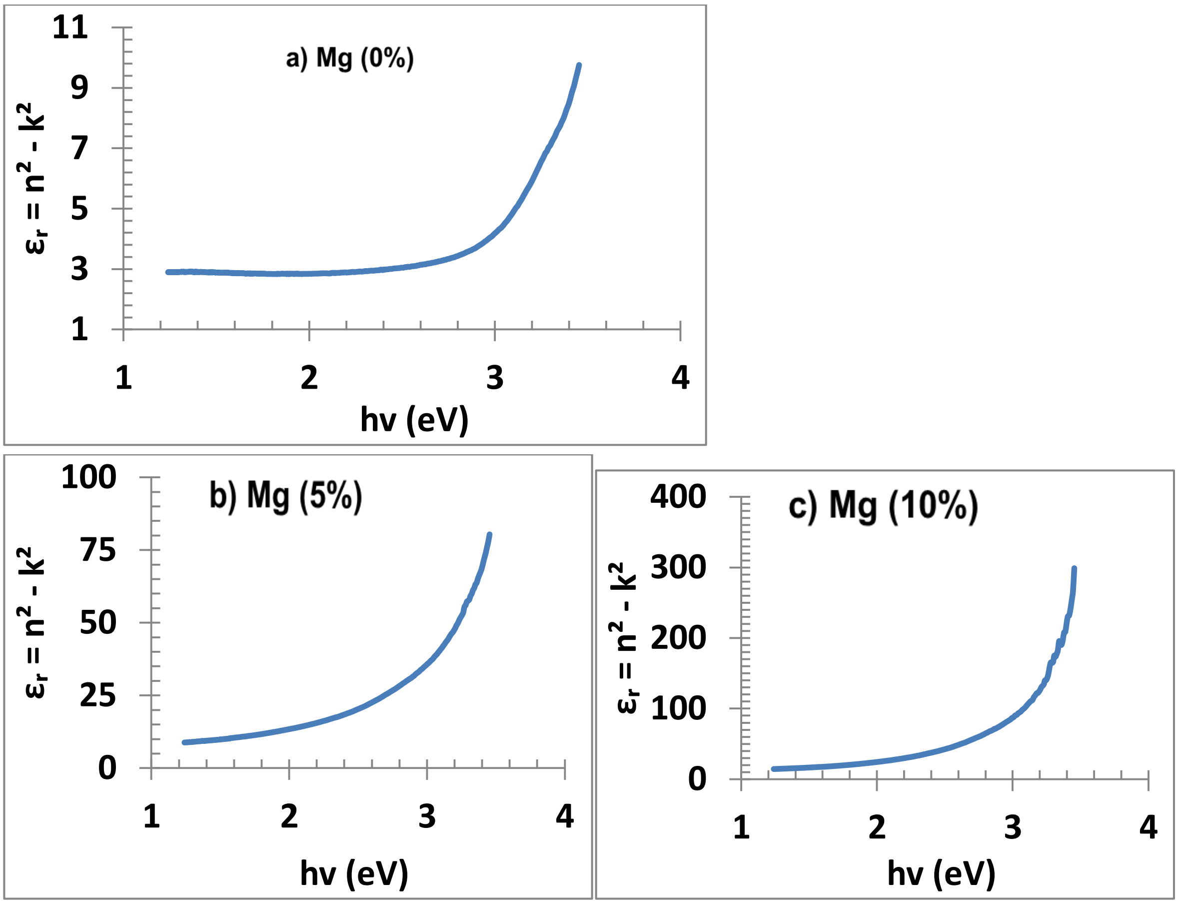
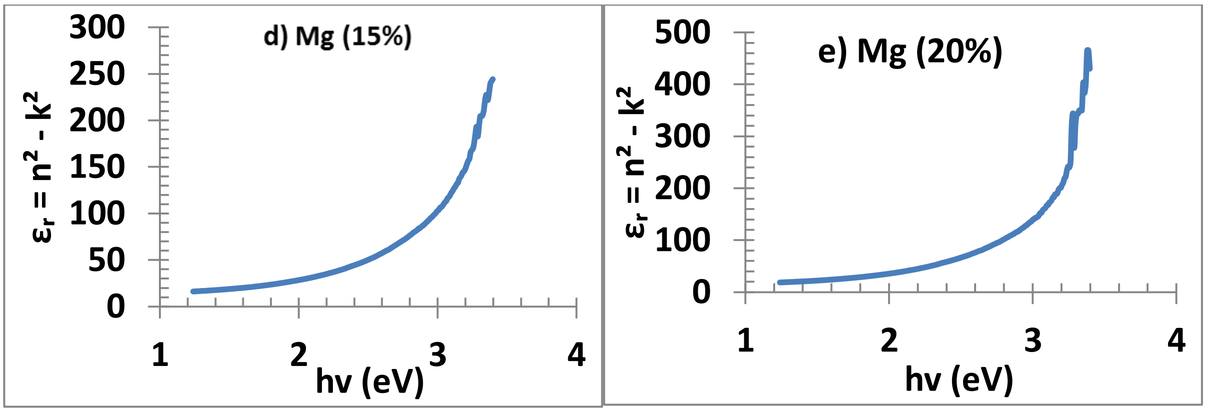
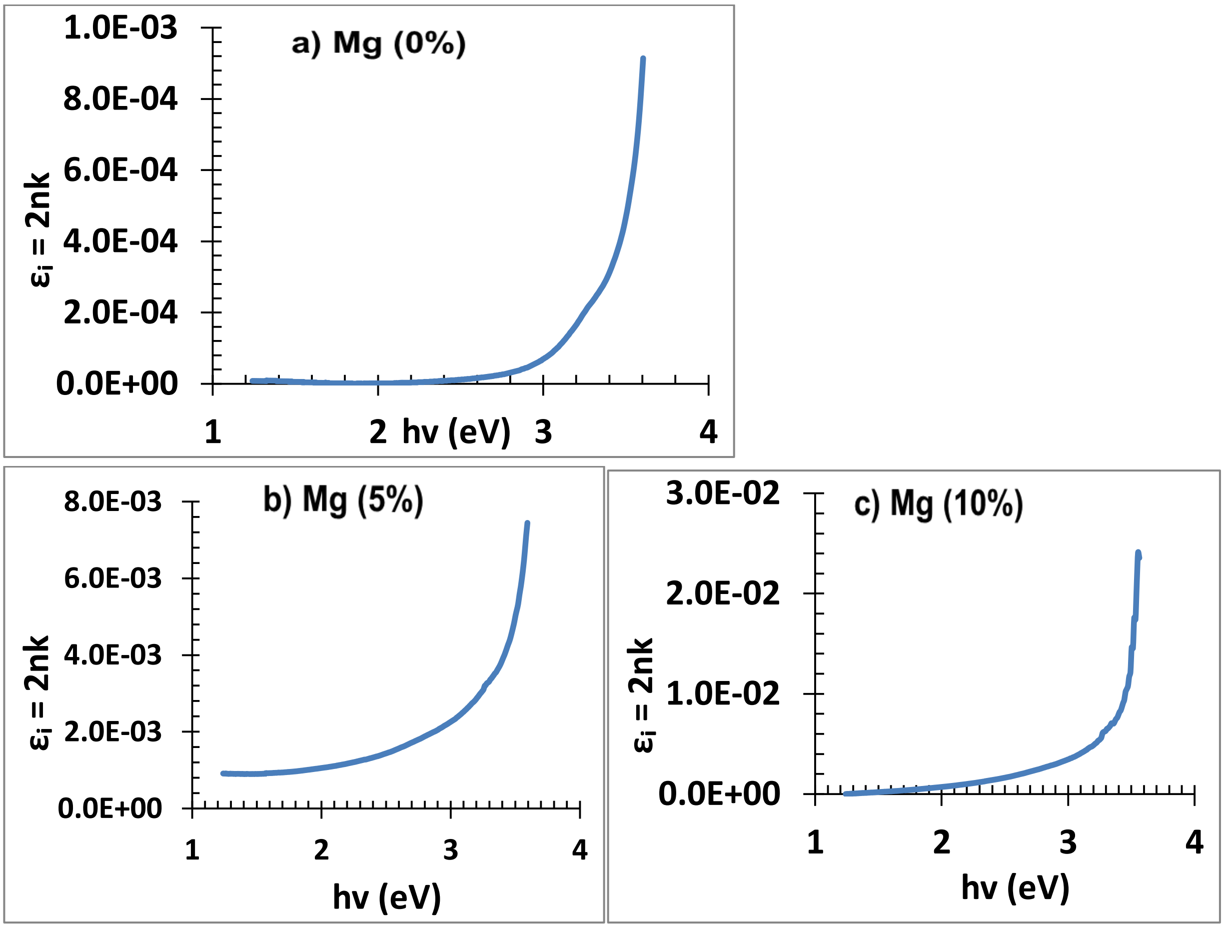


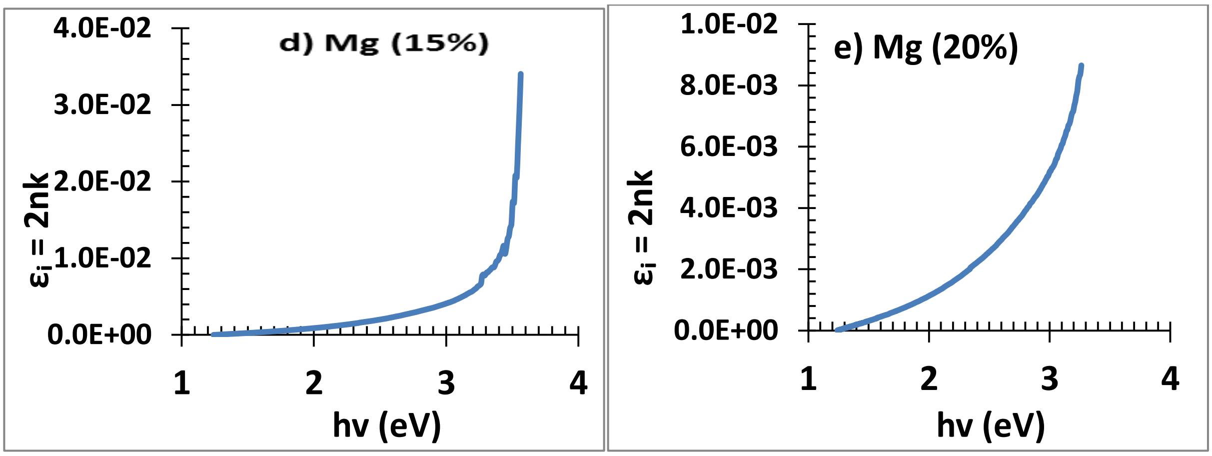
Fig (11) : A plot of λ^{-2}against $(n^2-1)^{-1}$ for epoxy doped with magnesium thick films





Fig(12): Real dielectric constant as a function of photon energy for epoxy doped with magnesium thick films





Fig(13): Imaginary dielectric constant as a function of photon energy for epoxy doped with magnesium thick films

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