Effect Magneto – Optic on Ferromagnetic Nanoparticle Polymer Composite Films

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Abstract

Optical properties of a composite material made of ferromagnetic matel nanoparticles embedded in dielectric host are studied. A nonlinear dependence of the optical rotation on magnetic field resulting from the reorientation of nanoparticles is demonstrated. The data of optical properties finding were applied to the magneto – optic experimental data of nickel ferrite ($NiFe_2O_4$) ferromagnetic nanoparticles embedded in polymer (PMMA) host. The magneto – optic is applied at wavelength (540 nm) and magnetic field intensity (450 m T), from result we found the affect magneto – optical on samples.

Key Words: Magnetio-Optical, Optical Properties, (PMMA), Nickel Ferrite ($NiFe_2O_4$), Ferromagnetic Material.

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Introduction

In research of potential applications such as sensors, optical insulators, and the MO system, Magnetio- Optical effect (MO)) is considered more important (Lau et al, 2013; Bi, 2011) as the Faraday effect is defined as the study of the interaction between the intensity of light and matter in The presence of the magnetic field (Belotelov et al, 2007), and thus magnetic nanoparticles (FM) is of interest (Abdulrazzak et. al 2020; Ctistis, 2009; Chin, 2013; Du, 2010).

Materials

(PMMA) Polymer doped with Nickel ferrite ($NiFe_2O_4$) ferromagnetic nanoparticles (size: 20- 30 nm, purity: 99.99%) manufacturer (Hongwu nanometer) is to make solution molding mechanism. the magnetic stirrer used to solute (PMMA/ $NiFe_2O_4$) of many ratios with chloroform, the last step is dried the samples.

The laser used in the study has a wavelength (540 nm) and a spot of light with a radius of about (1 mm), where the polarization of radiation occurs along the direction of propagation in general, so that the ray passes the cell is localized inside a coil having a magnetic flux density of (B = 450 m T), when the laser beam is filled into the cell vertically. We note that the wave vector initially takes the intensity (IO) of the laser spot before applying the external field and after that and upon applying the external field to the cell for all samples and measuring the intensity for spot laser pass the samples (I), this measure was doing again several attempts, each attempt is waited (10 minutes), a (1).s shown in (fig.1).

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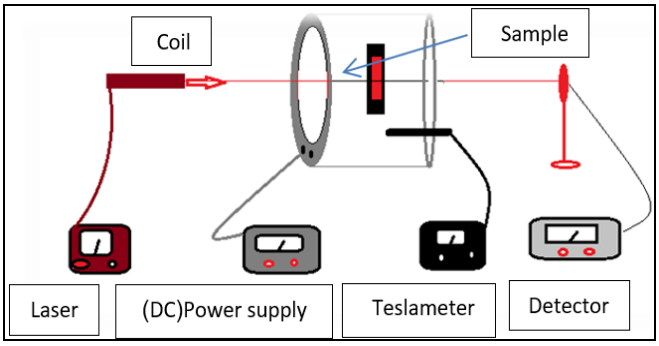

Figure 1. Note a diagram of the magnetic-optical system used in the research

Results

The permeability values (T) were calculated in this study through the equation (T = It / Io) (Eric et al, 1995). Where we note in Fig. (2) the transmission spectrum as pilot of nanoparticle ($NiFe_2O_4$) ratio. The reason for rise of nanoparticles is contain external electron in outside orbits, the photon energy of laser radiation is absorbed form these electrons and excited for high plane.

The decrease in absorption due to the influence of the external field, and for this reason, the permeability characteristic increases, as shown in Figure (2).

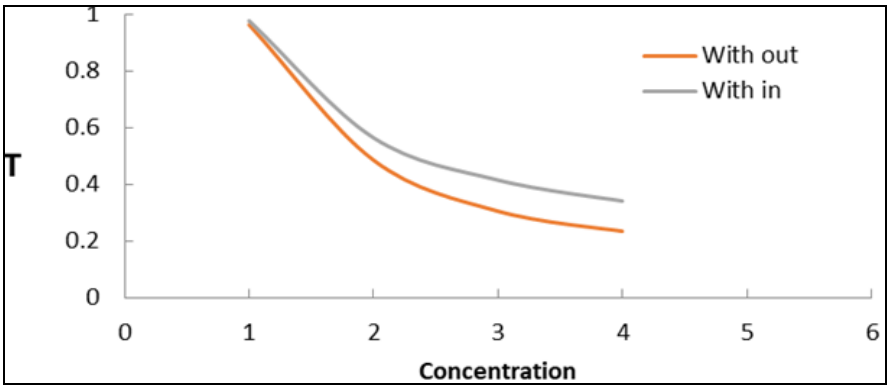

Fig. 2. Note proportionality the transmittance (T) with the amount of ratio (c) for (PMMA / NiFe2 O4) samples.

Absorption (A) is generally appear by the equation (A = log〖1 / T〗) (Eric et al, 1995). By applying this equation to calculate and know the absorbance values, we find that the permeability values are indirectly proportional to the absorption, and we note in Fig. (3) that The relationship absorption with ratio (c) is immediate proportional.

Because of nanocomposite particles (PMMA / NiFe2 O4) has a permanent dipole moment, so the external field affects it, these particles are aligned to the direction of the affect field in general, and because of this phenomenon, the absorption property decreases, and this effect is clearly seen in Figure (3).

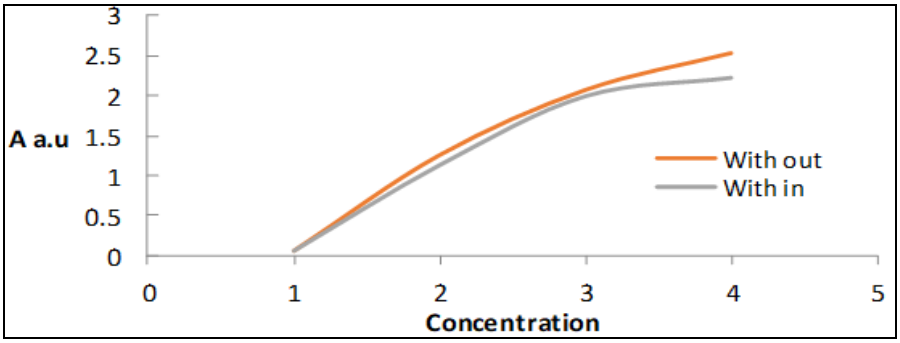

Figure 3. Note the proportionality between the absorbance (A) with the ratio (c) of (PMMA / NiFe2 O4) samples

In general, the correlation relation the ratio of nanoparticles and the (α) is direct and we can see it clearly in Fig. (4). For this reason, the external field is a arrange turn of the nanoparticles metal and as a result, the (α) value decreases in addition to that the correlation the absorption (A) with the absorption coefficient (α) is direct proportional as appear in the equation (∝ = 2.303 a / d) (Zaid et al., 2021) since (d) is the thickness.

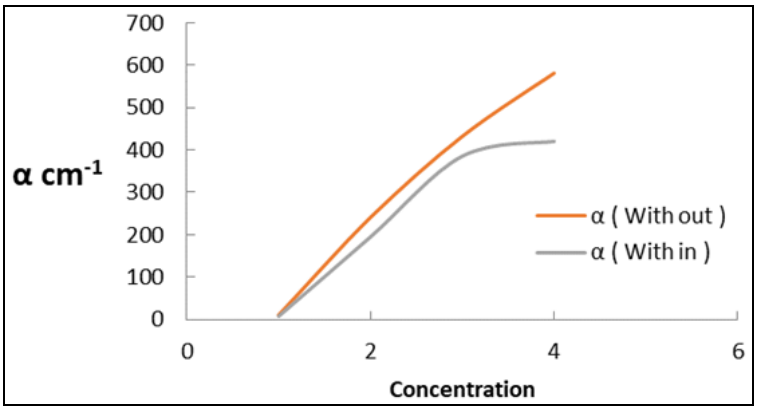

Fig. 4. Note proportionality relation the (α) and the ratio of (PMMA / NiFe2 O4) samples

A value of the (k) is generally obtain of equation (k = (∝ λ) / (4 π)) (Zaid, 2019), and we observe the direct proportional behavior as shown as in Fig. (5) where the external field that is affected by the particles and as a result the absorption coefficient (α) decreases and causes the value of the extinction coefficient to decrease.

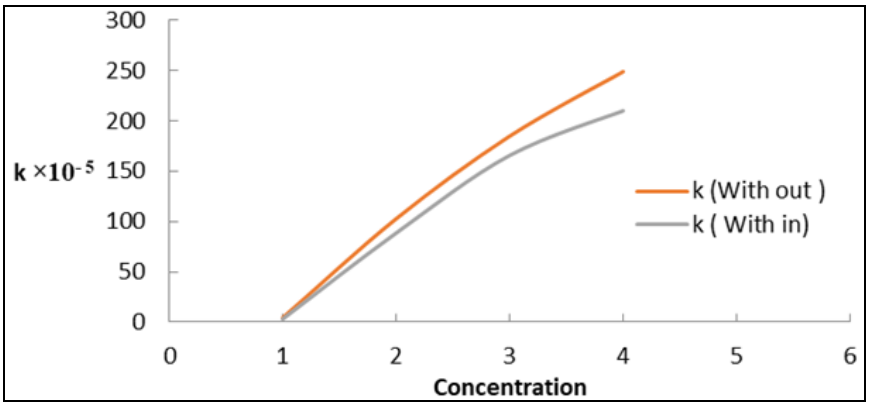

Fig. 5. Note proportionality the (k) and ratio of (PMMA / NiFe2 O4) samples.

Fig. (6) we note that proportionality the refractive index(n) and the ratio of nanoparticles the samples is a immediate proportion, and that the external field produce a arrange turn nanoparticles metal, which means that resistance the material becomes less opposite the electromagnetic radiation, therefore the transmission increases.

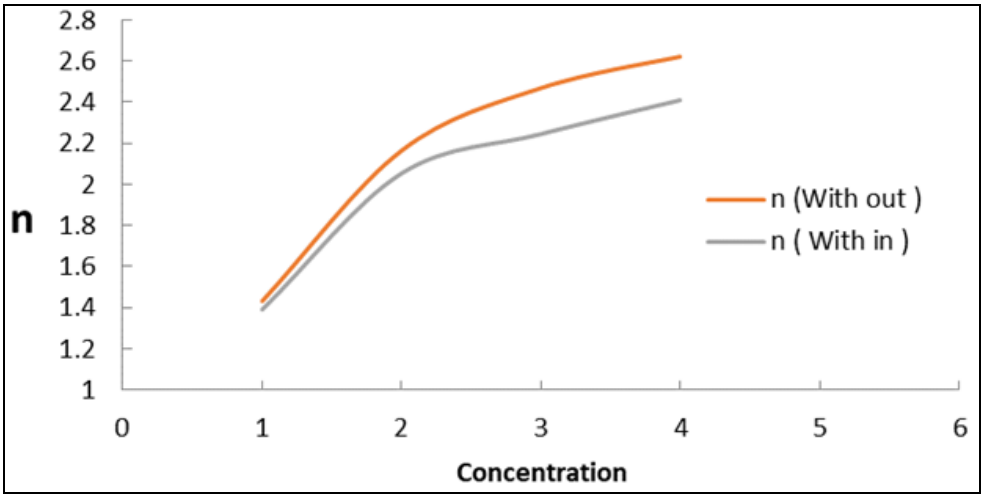

Fig. 6. Express proportion refractive index (n) with ratio of (PMMA / NiFe2 O4) samples

We note that the complex dielectric constant is ($\varepsilon = \varepsilon_1 + \varepsilon_2$), where ($\varepsilon_1$, ε_2) is dielectric parts constant (fact, imaginary), where intersection of the fact part with scattering appears with the taking of the movement of negative charges in samples, the imaginary part mean expresses the amount of the lost ratio of An electromagnetic wave that travels in the samples. In general, the two parts for samples depend on the electromagnetic radiation energy, and also on the refractive index of the samples under study due to the external field make to reduced (n), so we find that both the dielectric constant has reduced, and this result is identical to the results of the reference (Zaid, 2019) and this is clear In figures (7, 8).

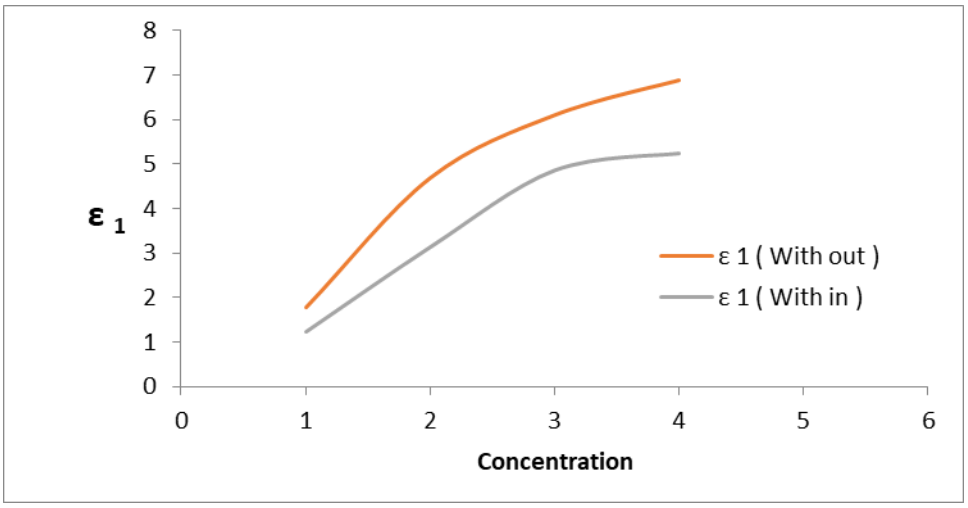

Fig. 7. Note proportionality the fact dielectric constant (ε1) and the ratio of the (PMMA /NiFe2 O4) samples

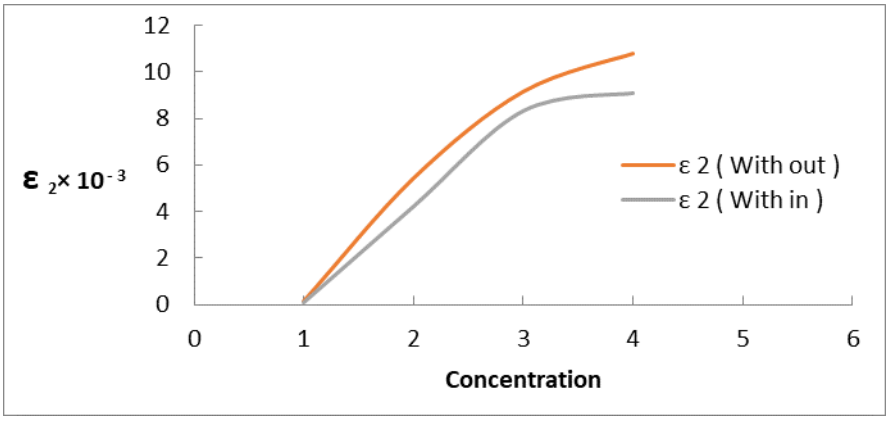

Fig. 8. Shows the proportionality the imaginary dielectric constant (ε 2) and the ratio of (PMMA / NiFe2 O4) samples

Conclusion

It was observed that the optical properties before the effect of the magneto - optic field in relation to the absorption are directly proportional to the focus, but the other optical properties are changed inversely. Optical properties generally.

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