Study the Effect of Magnetic Field on Polymer Doping TiO2 Nanoparticles

Zaid A. Hasan

Abstract

The metal nanoparticles (NPs) so as ferromagnetic (FM)/ Polymers is given to nanostructures importance in many electro- optics devices, a base work for these devices is depend on Faraday rotation. In this study the magnetic field effect is appear.

Key Words: Magnetic Field, Optical Properties, PMMA, TiO2.

DOI Number: 10.14704/nq.2019.17.12.NQ19114 **NeuroQuantology 2019; 17(12):39-43**

Introduction

The Faraday effect (magneto- optic effect (MO2)) is more important specially in potential application research such as optical sensors, optical isolators and MO2 memory system [1–4]. Faraday effect is study the interaction between the intensity of the light with the matter at presence the magnetic field, [5–8] therefore the ferromagnetic (FM) nanoparticles is interest. [9–13]

Materials and Methods

Poly Methyl Meta Acrylate (PMMA) doped with TiO2 nanoparticles (size: 20- 30 nm, purity: 99.99%) manufacturer (Hongwu nanometer) is to make solution molding mechanism. Mixture the (PMMA/TiO2) by ratios (0.2, 0.4, 0.6 wt %) were melted (30 ml) of chloroform using magnetic stirrer, after that the samples dried.

A diode laser at wavelength of (540 nm) and spot of a diameter of approximately (2mm). The radiation is polarized along the propagation direction, the beam pass through the cell (PMMA/TiO2). The film is positional inside a coil has (B= 400 m T), when the operation laser device the laser beam is filled on the cell which is vertically to the wave vector. At first take an intensity (I_0) for laser spot before the applied the magnetic field, after that apply the magnetic field on the cell for all concentrations, and measure the intensity for laser radiation which the passes the cell (I).

Each measurement has been repeated many times, and every time wait about (10 min) see figure (1).

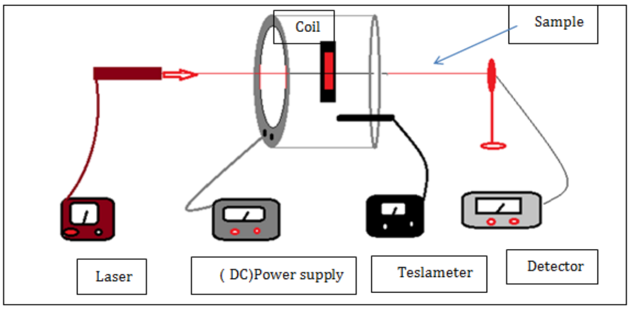

Fig.1. Schematic representation of the magneto – optic system which is used in the search

Corresponding author: Zaid A. Hasan
Address: 1*Department of Physics, College of Education for Pure Sciences, University of Babylon, Iraq.
1*E-mail: Zaid.shimary@yahoo.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 09 October 2019; **Accepted:** 14 November 2019

Results

Transmittance (T) is given by ($T = I_t / I_o$)(14). Figure (2) is appear the optical transmission spectra as an indicator for concentrations of (TiO2) nanoparticles. This is due to the raise nanoparticles molecules that contain the electrons outer orbits, these electrons absorb the energy of the incident photons, and excited to higher levels. Thus part of the incident light is absorbed by the substance and does not passing through it.

As a result of the absorbance is decreased by magnetic field affect, therefore the transmittance property is increasing as shown in fig.(2).

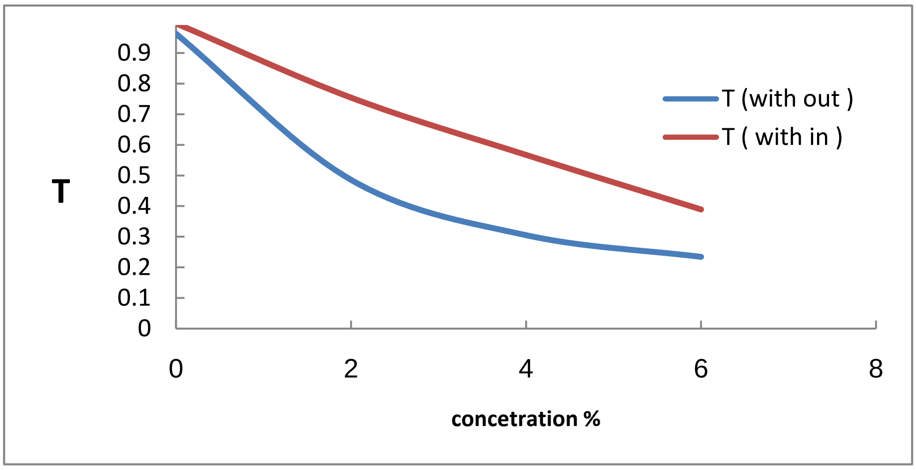

Fig. 2. The relation between transmittance (T) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

Absorbance (A) can be defined by equation ($A = \log\frac{1}{T}$) (14), by applying these equation we find the values of transmittance is indirect proportionality with absorbance, also find from figure (3) the relation between the absorbance and the concentration (c) is direct proportionality.

Because of the molecules of (PMMA / TiO2) composite is have the permanent dipole moment, therefore when the magnetic field is effect on it, this molecules is aligned with the magnetic field direction. This phenomenon is to create the absorbance property is decrease, this effect is clear in figure (3).

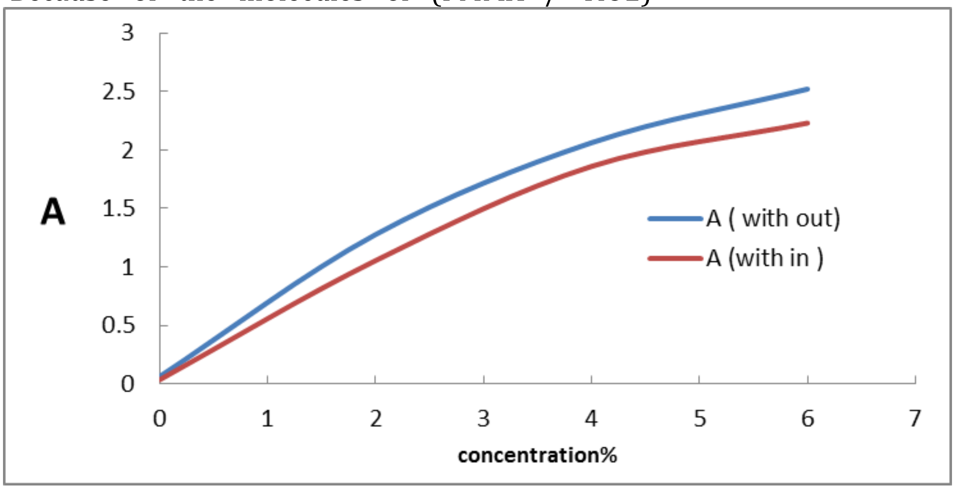

Fig. 3. The relation between absorbance (A) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

The relation between the concentration and the absorption coefficient is direct proportionality as shown in figure (4), and the magnetic field causes better alignment of the dipoles, therefore the absorption coefficient value is decrease. In addition to the relation between the absorbance (A) with the absorption coefficient (α) is direct proportionality as shown in equation ($\alpha = 2.303\frac{A}{d}$) (15)since (d) is the thickness.

eISSN 1303-5150

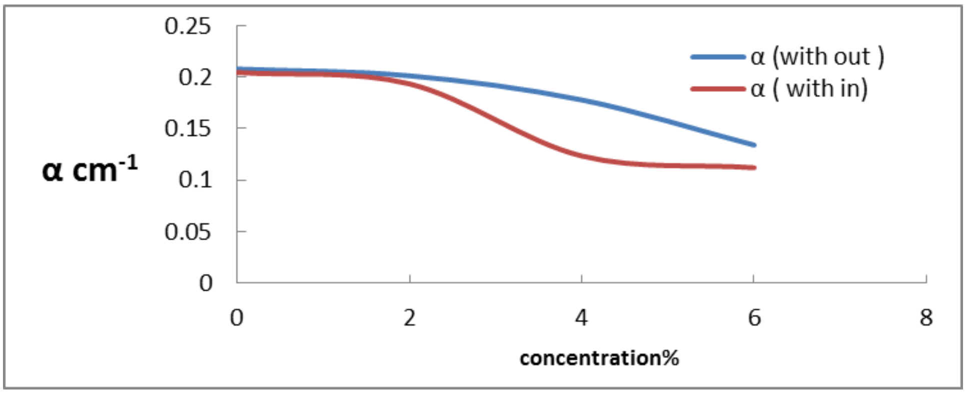

Fig. 4. The relation between Absorption coefficient (α) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

The extinction coefficient value is calculated from equation ($k = \frac{\propto \lambda}{4\pi}$) [16], the behavior shows direct proportionality as it in illustrated in figure (5), the magnetic field which is affected on the molecules, therefore the absorption coefficient (α) decrease and caused to extinction coefficient value to be decrease.

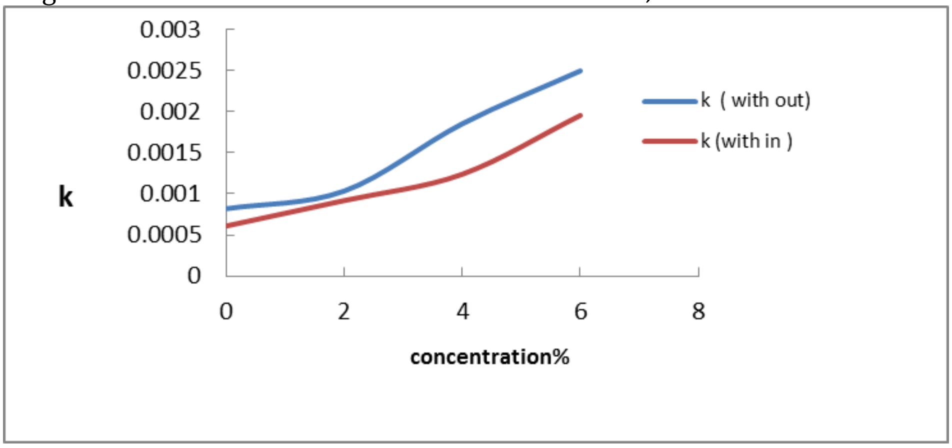

Fig.5. The relation between extinction coefficient (k) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

Form figure (6) the relation between the refractive index and the concentration for the samples is direct proportionality. The magnetic field causes better alignment of the dipoles, therefore the impedance of matter is became less than for the photons of the light, and we find the transmittance is increased.

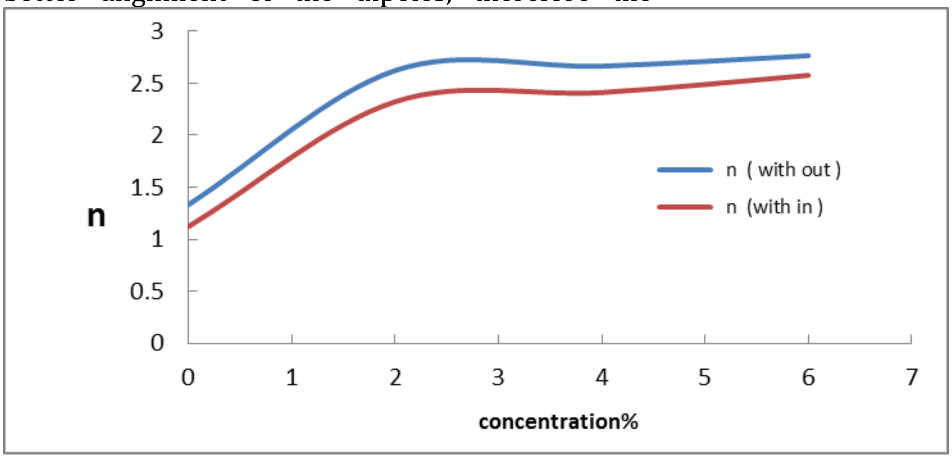

Fig.6. The relation between refractive index (n) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

The complex dielectric function is ($\varepsilon = \varepsilon_1 + \varepsilon_2$) [16], where($\varepsilon_1$, ε_2) is the real and imaginary of dielectric constant, the real part is refer to the dispersal, as must be taken in to account the actual motion of the electrons in the optical medium which the light is traveling, and the imaginary parts to indicate the missing ratio electromagnetic wave traveling in the optical medium, the both parts depend on photon energy of samples and also on the refractive index of samples due to the magnetic field make the decrease (n), therefore we find the both dielectric constant are decreased, this clear in figures (7,8).

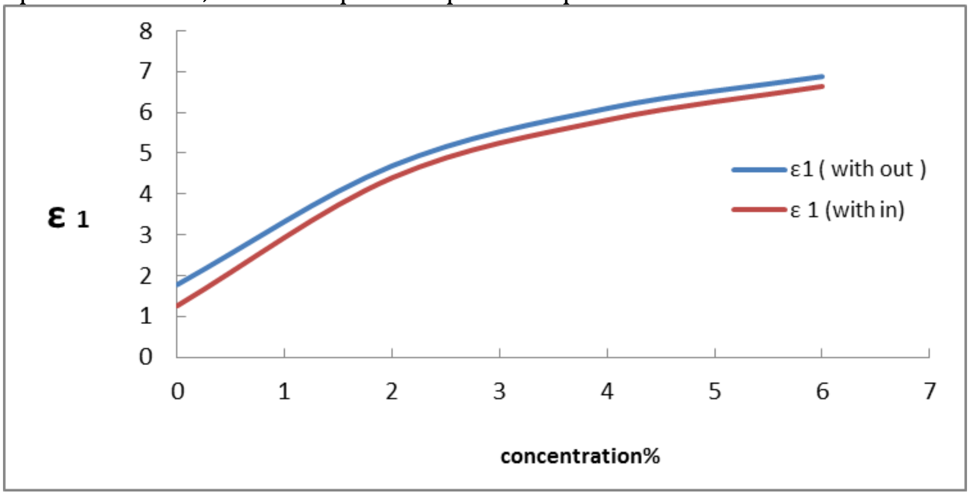

Fig. 7. The relation between real dielectric constant (ε_1) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

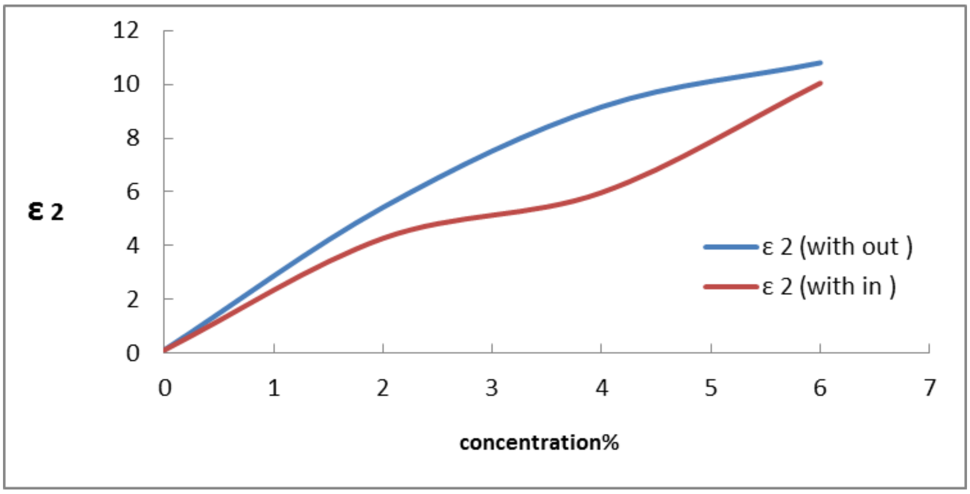

Fig. 8. The relation between imaginary dielectric constant (ε_2) and the concentration at magnetic field (B = 400m T) and wavelength (540 nm)

Conclusion

The optical properties test without magnetic field is appear the absorptance is direct proportionality with the concentration, while find the anther optical properties is inversely proportionality, but when applying the magnetic field on the all samples the transmittance is have more value for all samples, while the other optical properties value is became less than, therefore the magnetic field is make on the better of optical properties.

References

Lau M, Zhang X. Plasmon-boosted magnetio-optics. Nat. Photonics2013; 7: 430-431.

Bi L. On-chip optical isolation in monolithically integrated non-reciprocal optical resonators. Nat. Photonics 2011; 5: 758-762.

Du T, De L, Gignoux E, Schlenker D. Magneto-optical effect, Magnetism fundamentals, Ch. Springer – Verlag Gmb H 2005; 13: 399-442.

Lin X, Wang Z, Gao F, Zhang B, Chen H. Atomically thin nonreciprocal optical isolation. Sci. Rep., 2014; 4.

Gonzalez Diaz JB. Plasmonic Au/ Co / Au nan sandwiches with enhanced magneto- optical activity, Small 2008; 4: 202-205.

Belotelov VI, Doskolovich, I.I.& Zwezdin, A.K., Extraordinary magneto – optical effect and transmission through metal – dielectric plasmonic systems. Phys. Rev. Lett., 2007; 98: 077401.

Tian J. Infrared – induced variation of the magnetic properties of magneto plasmonic film with a 3 D sub-micron periodic triangular roof – type anti reflection structure, Sci. Rep., 2015; 5.

42

Zvezdin AK, Kotov VA. Metals and allays and Bi layer, multilayer, super lattice and granular structures, Modern magneto – optics and magneto – optical materials, Ch. 10& Ch. 1997; 12: 201-258.

Ctistis G. Optical and magnetic properties of hexagonal arrays of subwavelength holes in optically thin cobalt films, Nano Lett., 2009; 9: 1-6.

Chin JY, Steinle T, Wehlus T, Dregely D, Weiss T, Belotelov VI, Giessen H. Nonreciprocal plasmonics enables giant enhancement of thin-film Faraday rotation. Nature communications 2013; 4.

Du GX. Evidence of localized surface plasmon enhanced magneto-optical effect in Nano disk array. Appl. Phys. Lett., 2010; 96.

Safarov VI. Magneto-optical effects enhanced by surface plasmons in metallic multilayer films. Phys. Rev. Lett., 1994; 73: 3584- 3587.

Caminale M. Tuning the magneto – optical response of iron oxide Nanocrystals in Au and Ag biased plasmonic media, ACS Appl. Mater. Inter., 2013; 5: 1955-1960.

Eric WV, David RW, William LW, Handbook of optics, Michael Bass, McGraw Hill, USA 1995.

Zaid AH, Maryam FO. Study of Effect Magnetic field on the optical properties of poly (Methyl Metha Acrylate) Doped with copper Nanoparticles. Journal of Engineering and Applied Sciences 2018; 13(13): 10551-10554.

Zaid AH, Al Azzawi SS, Abdullah MM. Magnetic field effect on refractive indices for high birefringence liquid crystal (UCF). J. Babylon Univ. Pure Appl. Sci., 2016; 2: 409–417.