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# The Effect of changing Molar Concentration of Cux Fe(1-x) O2 Nano Thin Films on Their Optical and Electrical Properties

**Mahmoud Bashir Ali Dawra[1], Mubarak Dirar Abd-Alla[1], A. E. Mohamed Osman[1], Mohammed Idriss Ahmed[2]**
[1] Department of physics, Faculty of Science, Sudan University of Science and Technology, Khartoum, Sudan
[2] Department of Physics, Faculty of Education Alzaim Alazhari University, Khartoum, Sudan

**Abstract**
Iron oxide is doped with Aluminum using molar concentrations x(0.1, 0.3, 0.5,0.7, 0.9). Some of their optical and electrical properties were investigated using XRD, UV-VIS and FTIR techniques. The results obtained indicates that the optical energy gap and magnetic permeability decreases upon increasing the nano crystal size, while the refractive index, electrical conductivity, optical conductivity and electric permittivity increase upon increasing the nano crystal size.

Keywords : Nano, magnetic permeability, energy gap, refractive index electric permittivity, optical conductivity, electrical conductivity

The optical properties of material are useful in different application, such as domestic, medicine astronomy, manufacturing[1]. Optical property of a material is defined as it is interaction with electromagnetic variation spans the wide range from r-range with wavelength as 10-12m, through X-rays, ultraviolet visible, infrared, and family radio waves with wavelengths as a long as 10 visible light is one from electromagnetic radiation with wavelengths ranging from 0.39 to 0.77m[2]. Light can be considered as having waves and consisting of particles called photons with a material leads to a number of phenomena.The photos may give their energy to the material (absorption) photons of identical energy immediately emitted by the material (reflection) .The interaction of matter with electromagnetic radiation or electric field may result in a generation of electic current. The materials are can classified according to their electrical properties to conductor, semiconductors, insulators and superconductors [3].The electric permittivity and magnic permeability reflect the ability of the medium to allow electric and magnetic fields to pentrate [4, 5]. optical properties and the electrical properties of matter are important in solar cells [6,7].Solar cells are nowadays widely used in solving the energy problem [8,9].The silicon solar cells are now the widely used and available source of energy free from pollution [10].Unfortunately the silicon solar cells are very expensive and have low efficiency. This encourages researchers to search for new solar cells types. The most promising alternative is the so called nano solar cells. Nano solar cells are based on the so called nano science [11] . To no what is the meaning of nano technology, we have to bear in mind that particle is a minute piece of matter with defined physical boundaries. A particle can move as a unit. This general particle definition applies to nano-objects.

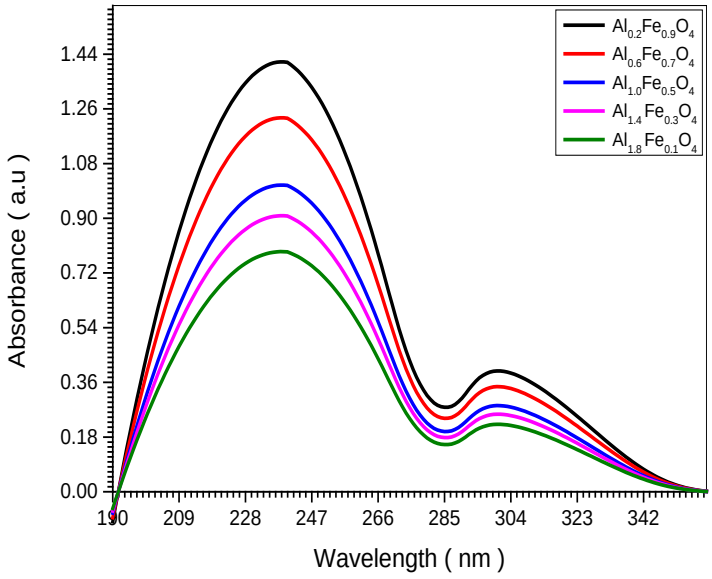
Nanoparticle is a nano-object with all three external dimensions in the nanoscale. Nanoparticles can have amorphous or crystalline form and their surfaces can act as carriers for

liquid droplets or gases.Nanoparticulate matter is refers to a collection of nanoparticles, emphasizing their collective behavior.

Naon is the Greek word (meaning dwarf) refers to a reduction of size, or time, by $10^{-9}$, which is one thousand times smaller than a micron. One nanometer (*nm*) is one billionth of a meter and it is also equivalent to ten Angstroms. Nanoscience is a new discipline concerned with the unique properties associated with nanomaterials, which are assemblies of atoms or molecules on a nanoscale. Nanoscience is actually the study of objects/particles and its phenomena at a very small scale, ranging roughly from 1 to 100 nm. “Nano” refers to a scale of size in the metric syste [11].The aim of this work is to study the behavior of Fe oxide doped with Al. This work is exhibited in section 2.Section 3 and 4 are devoted for discussion and conclusion.

## *Results*

### . *Optical Results of ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$)sample*




Fig(1) relation between absorbance and wavelengths of five ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations

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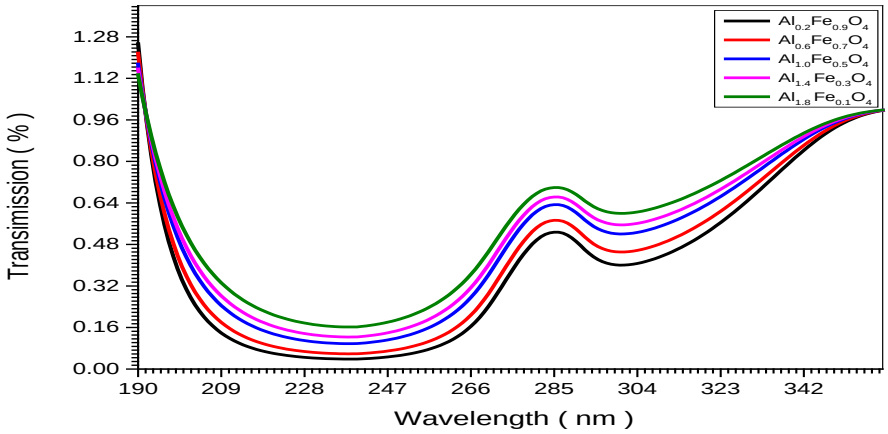
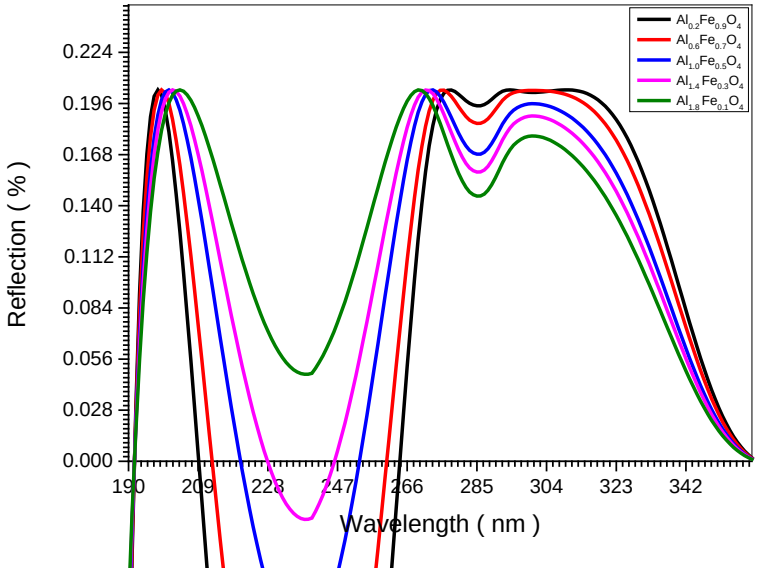
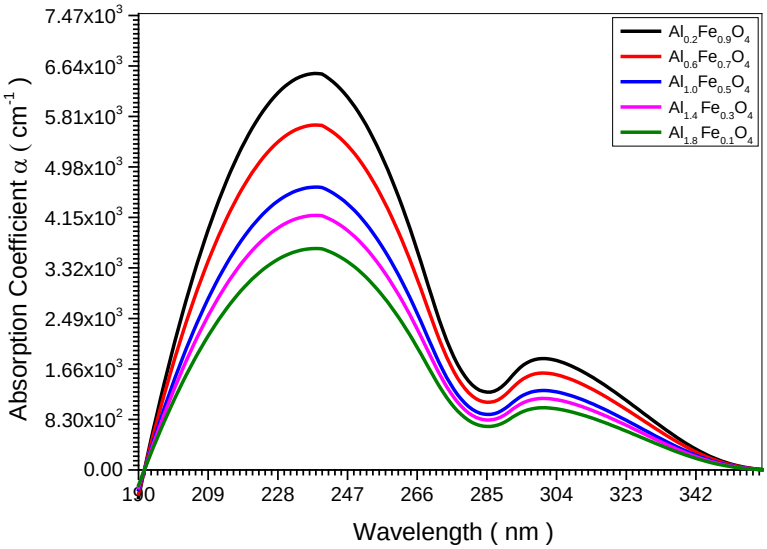


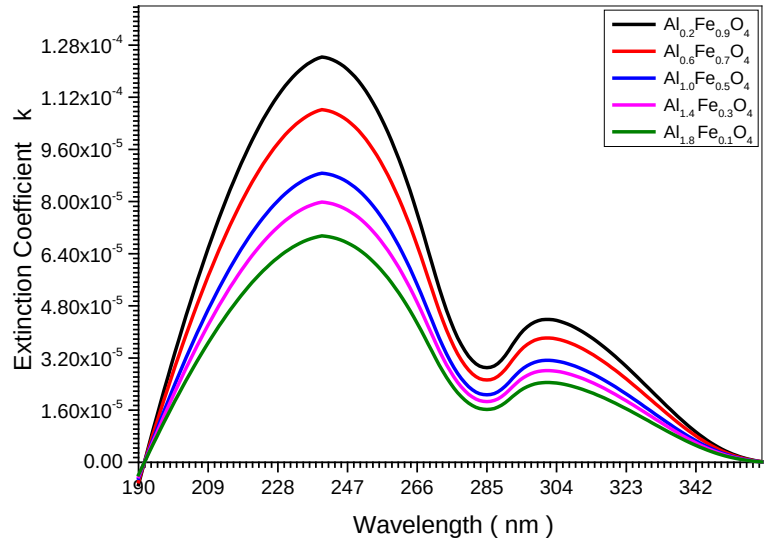

Fig( 2) relation between Transimission and wavelengths of five ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentration



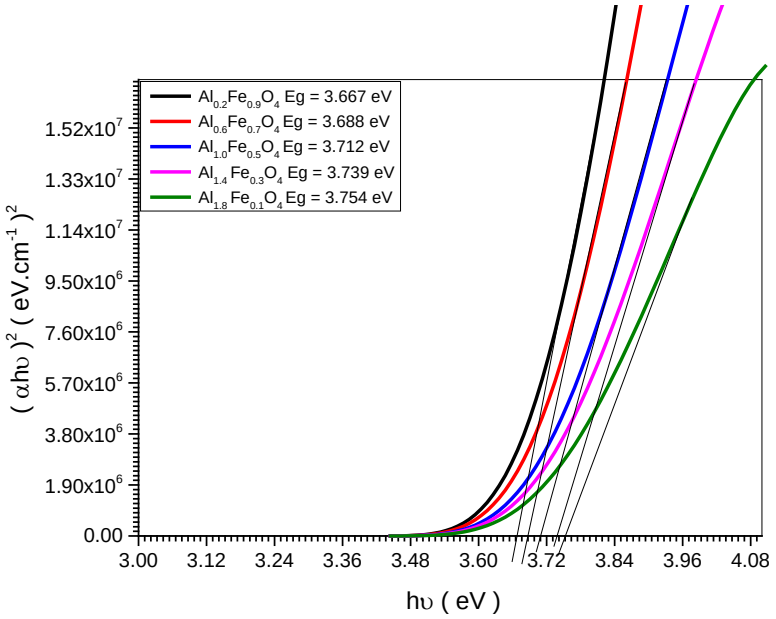

Fig(3) relation between Reflection and wavelengths of five ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations



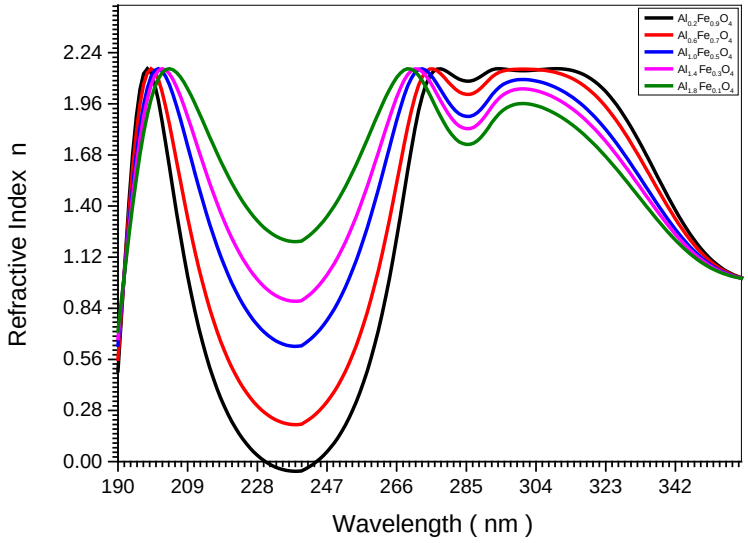

Fig(4) relation between absorption Coefficient and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations



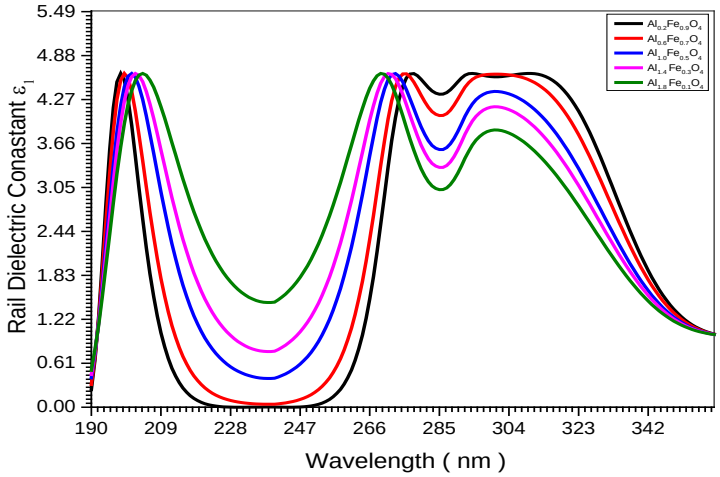

Fig(5) relation between exctintion coefficient and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations



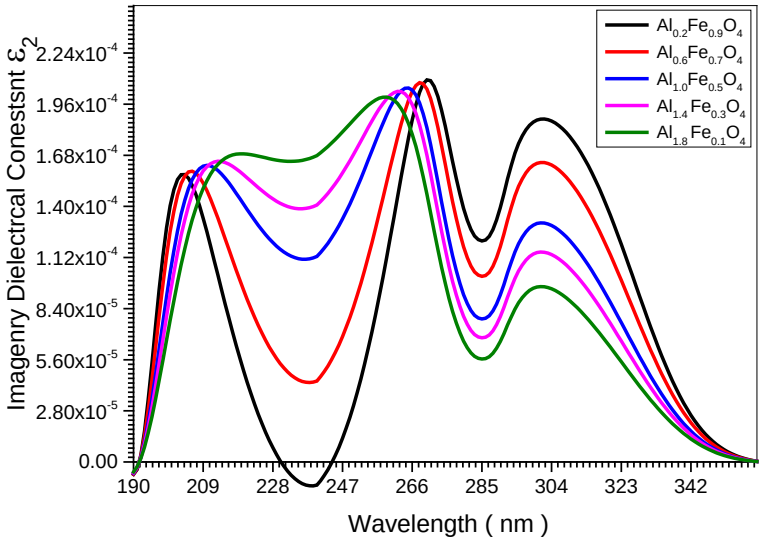

Fig(6) Optical energy band gap of five ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations



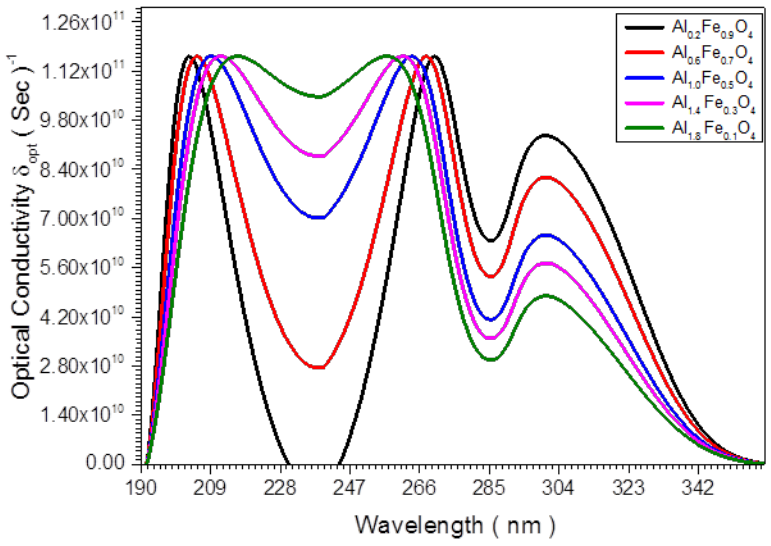

Fig(7) relation between refractive Index and wavelengths of five ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations



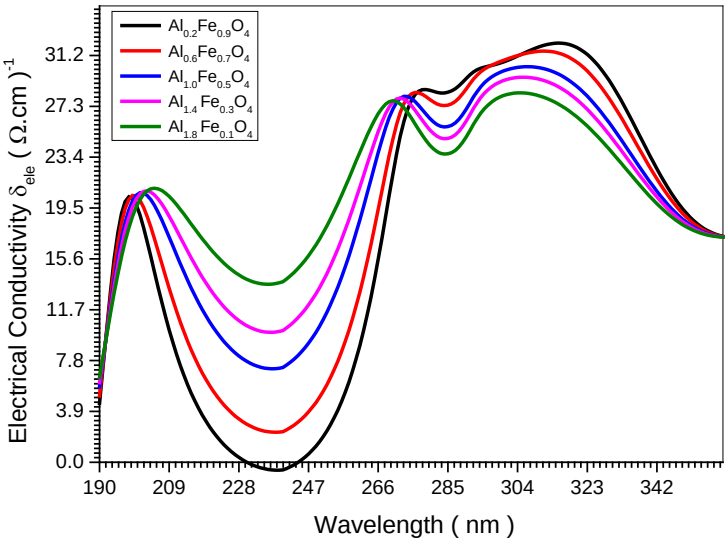

Fig(8) relation between rail dielectrcal constant and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations




Fig(9) relation between Imagenary dielectracal conastant and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations




Fig(10) relation between Optical conductivity and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations




Fig(11) relation between electrical conductivity and wavelengths of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar concentrations

### *4.6 Effect of the Nano scales Size on Electrical and Magnetic Properties Results of ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$ samples*

The XRD spectra for all samples are displayed in figures.

Table (1) optical, electrical and magneticpropertiesof ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples

| No | Sample | Eg (eV) | N | Opt-Condu( $10^{10}$(Sec)$^{-1}$ | Ele-Condu (Ω.cm)$^{-1}$ | e $10^{-12}$ ( F/cm$^{-1}$) | μ $10^{-6}$ ( H.cm$^{-1}$) | $X_s$ (nm) |
|---|---|---|---|---|---|---|---|---|
| 1 | $Al_{0.2}fe_{0.9}o_4$ | 3.667 | 2.17 | 9.44 | 31.14 | 41.67 | 0.267 | 100 |
| 2 | $Al_{0.6}fe_{0.7}o_4$ | 3.688 | 2.13 | 8.2 | 30.74 | 40.15 | 0.277 | 78.78 |
| 3 | $Al_{1.0}fe_{0.5}o_4$ | 3.712 | 2.09 | 6.57 | 30.07 | 38.66 | 0.217 | 73.88 |
| 4 | $Al_{1.4}fe_{0.3}o_4$ | 3.739 | 2.05 | 5.78 | 29.14 | 37.19 | 0.299 | 72.46 |
| 5 | $Al_{1.8}fe_{0.1}o_4$ | 3.754 | 1.95 | 4.79 | 28.21 | 33.65 | 0.331 | 69.74 |

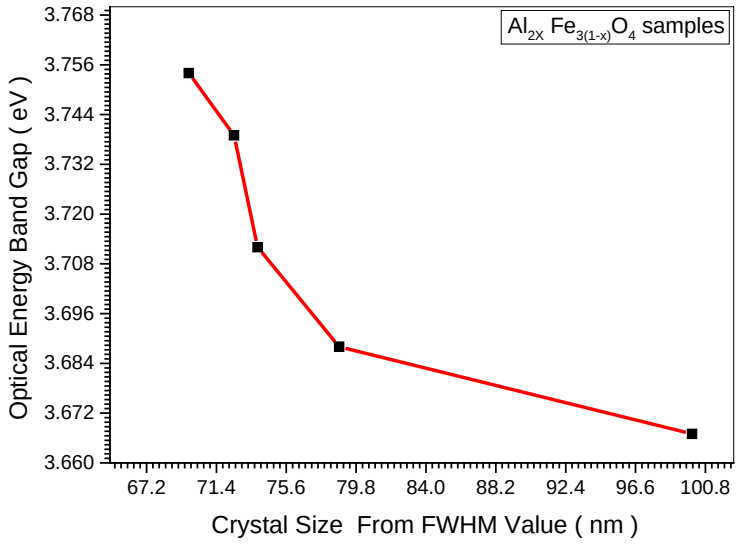



Fig (12) relationship between Crystal Size and Optical Energy Band Gap offive ($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar

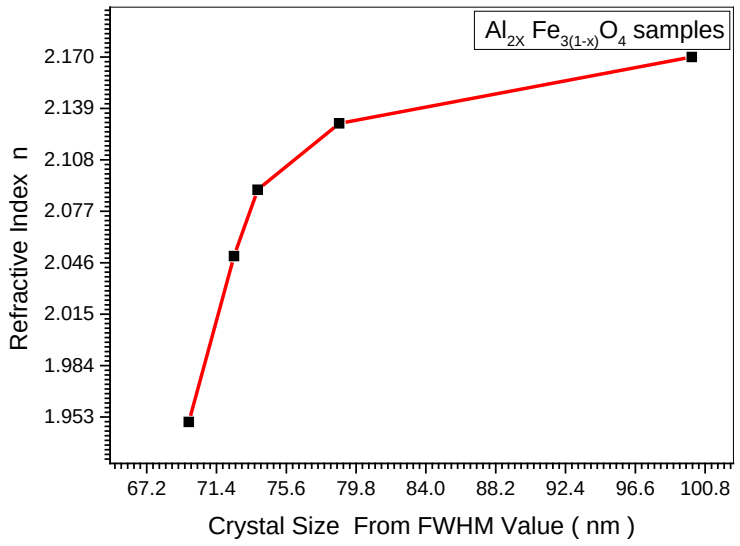



Fig (13) relationship between Crystal Size and Refractive Index of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1, 0.3, 0.5, 0.7 and 0.9) Molar

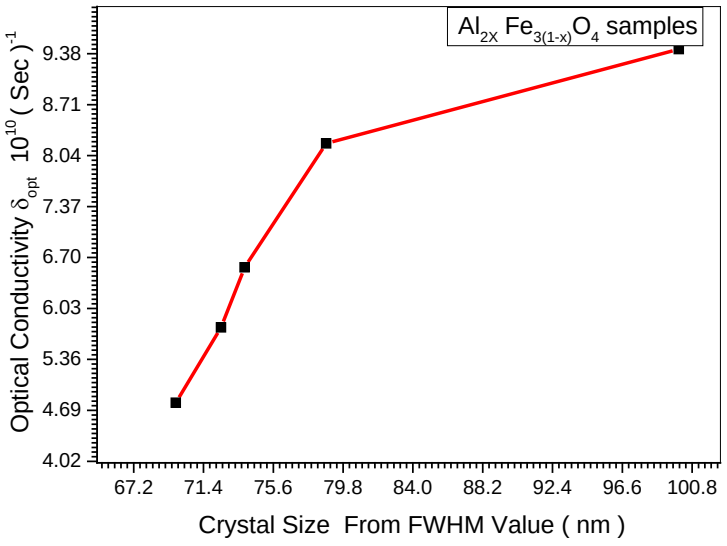



Fig (14) relationship between Crystal Size and Optical Conductivity offive ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar

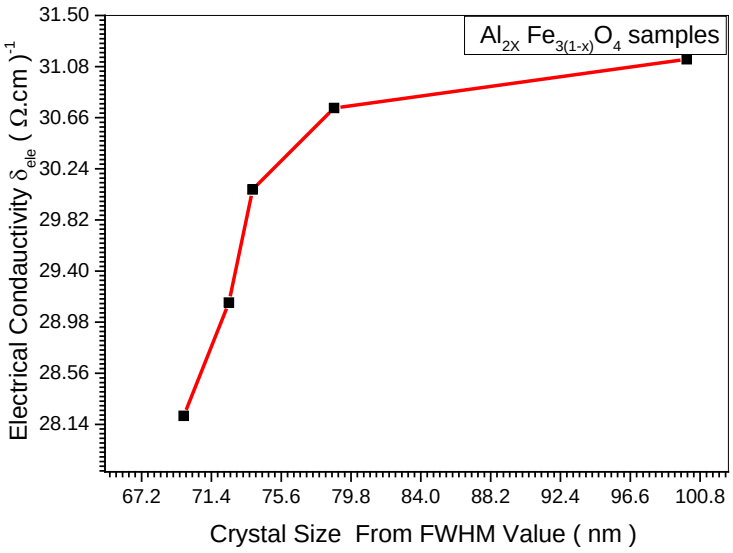



Fig (15) relationship between Crystal Size and Electrical Conductivityof five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar

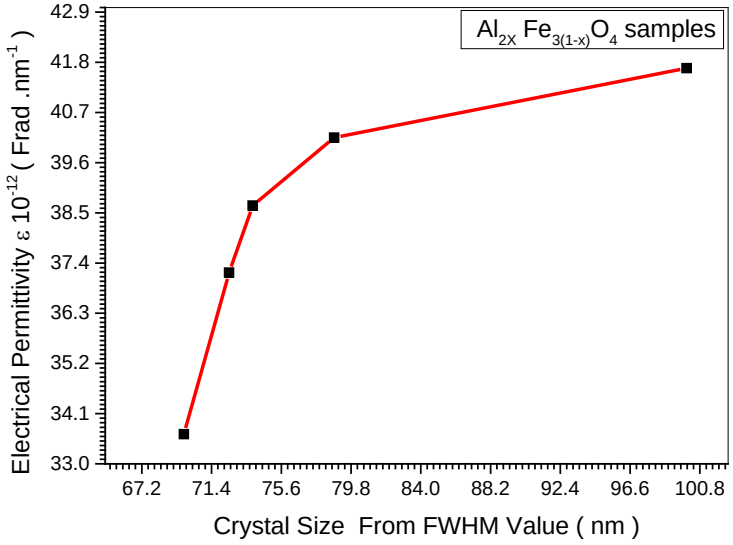



Fig (16) relationship between Crystal Size and Electrical Permittivity of five ($Al_{2x}\ Fe_{3(1-x)}\ O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar

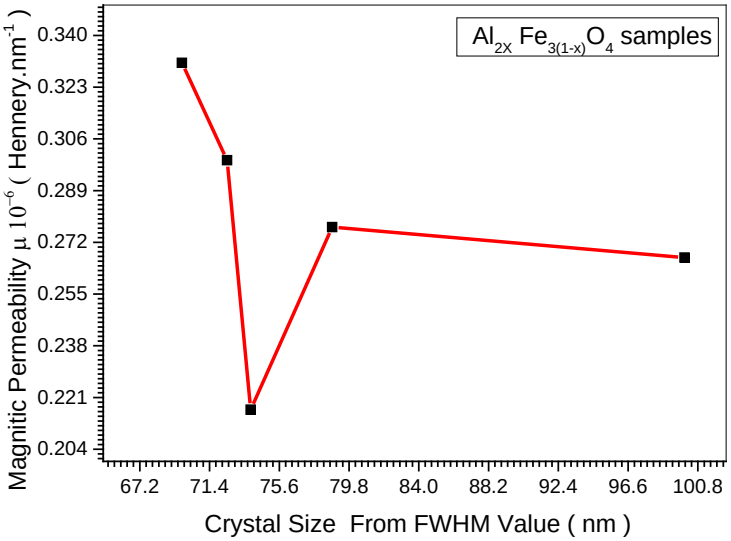



Fig (17) relationship between Crystal Size and Magnetic Permeability offive

($Al_{2x}$ $Fe_{3(1-x)}$ $O_4$) samples (0.1 ,0.3 ,0.5 ,0.7 and 0.9) Molar

Table (2)

| No | Wavenumber ( $cm^{-1}$) | Functional Group Names | Type of Vibration |
|---|---|---|---|
| 1 | 775.96 | Ortho distributer aromatic | C-HStretch |
| 2 | 1019.23 | Carbon Bonds | C-X stretch |
| 3 | 1161.54 | Alkoxy | C-O Stretch |
| 4 | 1657.69 | Carboxylic acid | C=OStretch |
| 5 | 2342.31 | Methane nitrite | CΞN Stretch |
| 6 | 3350 | Alkynes | CΞC Stretch |
| 7 | 3829.91 | Alcohol | O-HStretch |
| 8 | 3932.69 | Water | O-H Stretch |

The infrared spectra of synthesized ( $Al_{2x}$ $Fe_{1-x}O_4$) samples were recorded by mattson Fourier Transform Infrared Spectrophotometer in the range of 700 to 4000 $cm^{-1}$ which shown in Fig(--) . The spectra of all the samples have been used to locate the band positions which are given in the Table (--) . In the present study the absorption bands ν1, ν2, ν3 , ν4 , ν5 , ν6 , ν7 and ν8 are found to be around 775.96 $cm^{-1}$ , 1019.23 $cm^{-1}$ ,1161.54 $cm^{-1}$ , 1657.69 $cm^{-1}$ , 2342.31 $cm^{-1}$, 3350 $cm^{-1}$, 3829.91 $cm^{-1}$ and 3932.69 $cm^{-1}$respectively for all the compositions. The transmiattance bands within these specific limits reveal the formation of single-phase spinel structure having two sub-lattices tetrahedral (A) site and octahedral (B) site. The (ν1) band around775.96 $cm^{-1}$ is caused by the Ortho distributer aromatic sides. The band (ν2) around 1019.23 $cm^{-1}$ is due to C-X stretchCarbon Bonds. The band (ν3) around 1161.54 $cm^{-1}$ is associated with the C-O Stretchvibration. The band (ν4) around 1657.69 $cm^{-1}$is due to C= O stretching. The band (ν5)

around 2342.31 $cm^{-1}$is due to CΞN Stretch stretching.The band (ν6) around 3350 $cm^{-1}$is associated with the CΞC Stretch vibration . The (ν7, ν8) around 3829.91 $cm^{-1}$ and 3932.69 $cm^{-1}$ is due to the stretching mode of O-H Stretch bending vibration of free or absorbed water and Alcohol which implies that the hydroxyl groups are retained in samples.

**Discussion:**

Table (1) shows the change of some electrical, magnetic and optical properties of $Al_{2x}Fe_{3(1-x)}O_4$ with x (0.1, 0.3, 0.5,0.7, 0.9). representing the molar concentration index. According to table (1) increasing AL molar concentration decreases the nano crystal size $x_s$. figure (12) indicates that the band gap decreases upon increasing nano crystal size, decreasing AL concentration and increasing Fe concentration. This may be attributed to the fact that increasing Fe concentration which act as magnetic dipole increases the strength of magnetic field which increases in turn the spiting sublevels at the upper and lower edge of the forbidden band leading to increase the number of sub bands insidethe forbidden band at the upper and lower edges thus causing narrowing the forbidden band which leads to Eg decrease. According to figure (13) the refractive index n increases upon increasing the crystal size and increasing Fe concentration. This maybe due to the fact that increasing Fe concentration decreases the speed of light $v$ inside the film as far as Fe is heavier than AL and since $(n = c/v)$. The FTIR analysis for AL shows existence of water, alchol, Methane intrite and carboxylic acid which increases absorption and provides vibrational energies that can be transferred to the carriers.

Figures (14) and (15) for the optical and electrical conductivity shows an increase of both of them with the nano crystal size. This may be related to the fact that the increase of the crystal size decreases the energy gap thus leading to increase of conductivity. Figure (16) shows that the electric permittivity $\varepsilon$ increases upon increasing the crystal size. This may be related to the fact the refractive index $(n = c/v = c\sqrt{\mu\varepsilon})$ increases upon increasing the nano crystal size. Figure (17) indicates that the magnetic permeability decreases upon increasing the nano crystal size.

**Conclusion:**

The increase of AL molar concentration decreases the nano crystal size, decreases the energy gap. For AL the increase of nano crystal size increases the refractive index, optical and electrical conductivity and the electric permittivity. However the magnetic permeability for Al decreases upon increasing the nano crystal size.

**References**

[1] Serway, Raymond A., and John W. Jewett., Principles of physics. Vol. 1,Saunders (College Pub.,USA (1998.

[2] Beiser, Arthur. Concepts of modern physics. Tata McGraw-Hill Education (2003)

[3] Dalven, Richard. "Introduction to applied solid state physics. Topics in the applications of semiconductors, superconductors and the nonlinear optical porperties of solids." New York: Plenum Press (1980).

[4] Seeger, Karlheinz. Semiconductor physics. Springer Science & Business Media, 2013.

[5] Born, Max, and Emil Wolf. "Principles of Optics Second (revised) Edition." Macmillan Co., New York (1964)

[6] G. Burns, Solid State Physics, Academic Press, Inc, London (1985)

[7]Wu, Jyh-Ming, et al. "Thermal evaporation growth and the luminescence property of TiO2 nanowires." Journal of crystal Growth 281.2-4 (2005): 384-390.

[8] Kidowaki, H., T. Oku, and T. Akiyama. "Fabrication and characterization of CuO/ZnO solar cells." Journal of Physics: Conference Series. Vol. 352. No. 1. IOP Publishing, 2012.

[9] Mittiga, Alberto, et al. "Heterojunction solar cell with 2% efficiency based on a Cu 2 O substrate." Applied physics letters 88.16 (2006): 163502.

[10] Bose, Sarita, Virendra Soni, and K. R. Genwa. "Recent advances and future prospects for dye sensitized solar cells: A review." International Journal of Scientific and Research Publications 5.4 (2015).

[11] Ratna Tantra, Nanomaterial characterization, Wiley &Sons, Inc9, New York (2016)

[12].Askeland, Donald R., Pradeep P. Fulay, and Wendelin J. Wright. The science and engineering of materials." (2011).