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The Change of Absorbance, Transmission, and Reflection due to the Change of Concentration of $Ag_x Cu_{(1-x)} Fe_2O_4$

Safwa.Yagoub[1], Mubarak Yagoup [2], Abdalsakhi sulaiman[3], Nuha. Alalam [4]

[1] Department of Physics, Sudan University of Science and Technology,
Khartoum, Khartoum, P.O. Box 407/Khartoum, Sudan

[2] Department of Physics, Sudan University of Science and Technology,
Khartoum, Khartoum, P.O. Box 407/Khartoum, Sudan

[3] Department of Physics, Al-Neelain University, Khartoum,
Khartoum, P.O. Box 11121/Khartoum, Sudan

[4] Chemistry Department, Faculty of Science, Northern Border University,
Arar, State P.O. Pox1321/ Northern Border, Saudi Arabia

Abstract

Five $Ag_xCu_{(1-x)}$ Fe_2O_4 samples with molar concentrations x=0.1,0.3,0.5,0.7,0.9 were prepared. The optical properties of them were studied. The crystal structure was determined using the XRD technique indicating that the crystal nano spacing decreases upon decreasing the concentration of Cu and increasing the Ag concentration x. The UV-VIS spectrometer results showed that the absorbance increases upon increasing the Ag concentration and decreasing the Cu concentration. The transmission decreases when the Ag concentration rises, which is associated with decreased Cu concentration. The FTIR results showed that the transmission to Infrared radiation increases as the Ag concentration decreases and the Cu concentration increases

Keywords: *Nano, crystal structure, absorption, transmission, energy gap, cupper.*

1. Introduction

The optical properties of matter like scattering, absorption, transmission, and reflection play an important role in our lives [1,2]. The electrical and optical properties rely heavily on the electron transitions between energy levels or energy bands [3,4,5]. The electrons transition between energy levels and bands are responsible for absorption and emission processes, which are related to the reflection and refraction processes [6,7,8]. This indicates that the changes in the energy levels or band structure can change the optical properties of matter [9,10,11]. Unfortunately, the change of the optical for bulk matter to satisfy the required technological needs is extremely difficult. This forces scientists to use a new approach based on nanoscience [12].

Nanoscience is concerned with the study, of nanomaterials. Nanomaterials are in the form of a very large number of isolated particles having dimensions ranging from one nanometer up to three hundred nanometers. Nanomaterials cannot be described using classical laws but can described using the laws of quantum mechanics [13]. Changing the nano size, geometry, chemical composition, and concentration can change the physical properties of the nanomaterial. This is because changing these parameters changes the band structure and the atomic bonds according to the quantum laws [14].

The optical properties of matter are widely used in energy generation. The most popular energy generation technology is the one based on solar energy technology. The most preferred one is the one that converts solar energy to electricity. This comes from the fact that electric energy can be converted easily to other useful energy forms. The commercially available cells are silicon solar cells which are expensive and have complex fabrication processes. This encourages to search for new cell types [15]. Nano-solar cells represent the best candidate [16]. Different nano cells were suggested including polymer cells, and zinc and copper oxide cells [17].

The work done by M.Schnaiter et al [18]. , use a long path extinction spectrometer (LOPES) to determine the absorption coefficient for aerosols. The results obtained found that the absorption coefficient is dependent on the wavelength The absorption coefficient decreases upon increasing the wavelength for large wavelengths. The results of Giorgio Dall'Olmo, et al [19] indicated that in the surface open ocean, the absorption coefficient of chromophoric dissolved organic matter decreases upon increasing wavelength. The wavelength range is (400-950nm) Herve Claustre et al [20] studied the absorption coefficient of phytoplankton, nonalgal particles, and dissolved organic matter in coastal waters around Europe. They found that the absorption coefficient decreases when the wavelength increases in the range (400-750nm). In their work, Anette, Karlsson, et al indicated that the absorption coefficient decreases when the wavelength increases for mechanical pulps [21]. The paper of Ernesto, et al showed that the elemental carbon (EC) concentration increase caused the atmospheric absorption coefficient of light to increase also [22]. The relation between wavelength and absorption coefficient of E. Weingartner, et al [23] indicated also that increasing the wavelength decreases the absorption coefficient for soot particles using an aethalometer.

Ahmed A. A. et al [24] studied the properties of thin films formed when ZnS was doped with Al. The results obtained showed that changing AL concentration changes the absorption coefficient. The same samples were tested by M. H. Eisa et al [25] to show that the ZnAl is in the form of nanoparticles. The morphology of these samples when studied by Ahmed and others again [26] indicates the change of the roughness with the change of AL concentration. Such roughness affects the absorption coefficient. The fact that thin films nano materials play an important role in modern technology encourages us to do this work, where sections 2 and 3 are concerned with the experimental procedures and results. Sections 4 and 5 are devoted to discussion and conclusion

2. Experimental procedures

High purities of sliver nitrate [Ag $(NO_3)_2$ (96%)], Copper nitrate hexahydrate [Cu $(NO_3)_2{\cdot}6H_2O$ (99%)], Iron nitrate [Fe $(NO_3)_3$ (98%)] and Nitric Acid (HNO_3, 99% were used as raw materials. All materials were reagent graded and distilled water was used in the preparation process.
Five samples of $Ag_x\ Cu_{(1-X)}\ Fe_2O_4$ were prepared in different concentrations using the sol-gel method. The amount of metal nitrates in distilled water was homogenized and separatism of metal ions was achieved by the use of sodium hydroxide. A required amount of nitric acid was added to the solution to modify the pH value to be less than 5. The solution was constantly stirred and heated at 80˚C in a magnetic stirrer for an hour to condense into a gel. The obtained sol was then kept for 24 hours at room temperature to avoid reverse interactions, the samples were dried at 300 ^{O}C for 3 hours to get powder. Then, the obtained powders were grained by agate mortar and finally sintered at 750˚C for 4 h in a programmable furnace to remove any organic material present in samples. The final products were characterized using X-ray diffraction (XRD), and UV-VIS spectrometer.

- Compounds ($Ag_xCu_{1-x}\ Fe_2\ O_4$) were prepared using the gel-sol method at the concentrations shown.
- The study was carried out using XRD technology, through which its crystalline and nanostructure, its lattice parameters, and the locations of atoms inside the cell were determined.
- Ultraviolet-visible radiation was used to evaluate the band gap and optical and electrical properties.
- The results of the studies were recorded in tables and presented graphically.

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Fig.1 PH Meter and Sensitive plans images

Fig. 2 image of furnace Vulcan

3. RESULTS

In this work, the results of an examination of ($Ag_x\ Cu_{(1-x)}\ Fe_2O_4$) (0.1,0.3,0.5,0.7 and 0.9) are exhibited. X-ray diffraction (XRD) data have been recorded and displayed graphically using the Rietveld method to study their crystal nanostructure and lattice parameters, the positions of atoms within the cell.
The UV-visible is used to evaluate the band gap and optical properties beside electrical and magnetic properties using absorption spectra beside a special computer program.

3.1 - Xray diffraction results ($Ag_x\ Cu_{(1-x)}\ Fe_2O_4$) (0.1 ,0.3,0.5 ,0.7 and 0.9)

XRD Data		**$Ag_{0.1}Cu_{0.9}Fe_2O_4$**	**$Ag_{0.3}Cu_{0.7}Fe_2O_4$**	**$Ag_{0.5}Cu_{0.5}Fe_2O_4$**	**$Ag_{0.7}Cu_{0.3}Fe_2O_4$**	**$Ag_{0.9}Cu_{0.1}Fe_2O_4$**
Space Group		P63 / mc (194)	P63 / mc(194)	P63 / mc (194)	P63 / mc (194)	P63 / mc (194)
Crystal System		Hexagonal	Hexagonal	Hexagonal	Hexagonal	Hexagonal
Cell Parameters 10^{-10} m	A	3.039	3.039	3.039	3.039	3.039
	B	3.039	3.039	3.039	3.039	3.039
	C	12.395	12.395	12.395	12.395	12.395
Density ($g.cm^{-3}$)		6.556	6.562	6.569	6.575	6.583
Volume $(10^{-10})^3$		99.1376	99.1383	99.139	99.1397	99.1401
d (10^{-10} m)		1.75171	1.75166	1.75159	1.75153	1.75147
Cell Angle	Alpha	90	90	90	90	90
	Beta	90	90	90	90	90
	Gamma	120	120	120	120	120

The crystal structure of all samples of the compound ($Ag_xCu_{1-x}\ Fe_2\ O_4$) for various concentrations when exposed to X-rays is shown in Table (1)

Table 1: lattice parameters of $ag_x cu_{1-x}\ fe_2\ o_4$ samples at different concentrations

3.2 UV-VIS Optical Results of (AgxCu1-x Fe2 O4) samples:

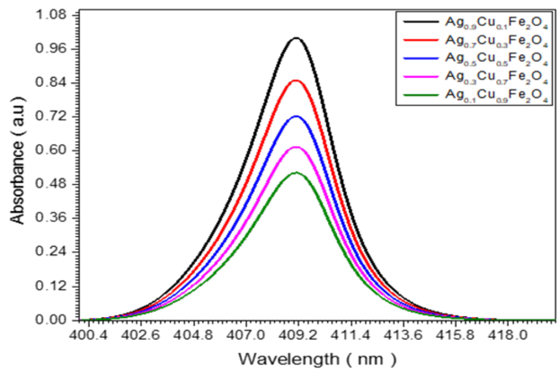

Fig. 3 Relation between Absorbance and wavelengths of five (AgxCu1-x Fe2 O4) samples (0.1,0.3,0.5,0.7 and 0.9).

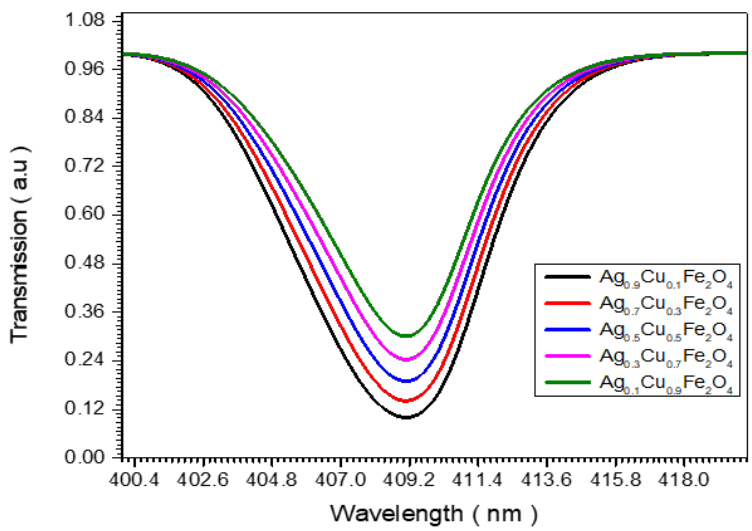

Fig. 4 Relation between transmission and wavelengths of five (AgxCu1-x Fe2 O4) samples (0.1,0.3,0.5,0.7 and 0.9)

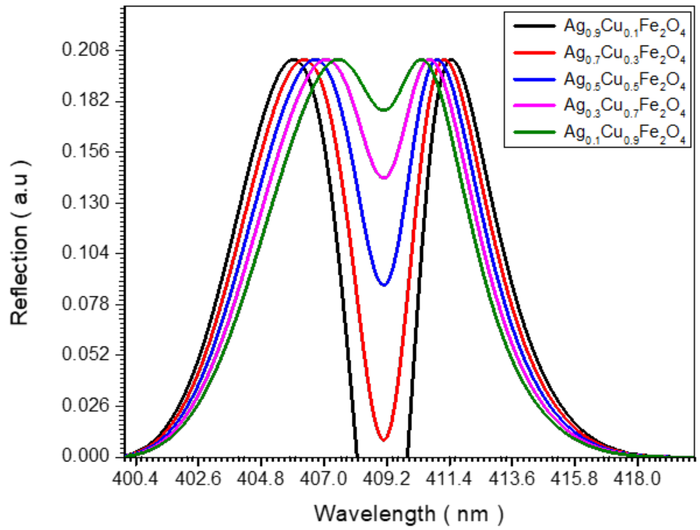

Fig. 5 Relation between reflection and wavelengths of five ($Ag_xCo_{1-x}Fe_2O_4$) samples (0.1 ,0.3,0.5 ,0.7, and 0.9) Molar concentrations

3. 3 FTIR Results of ($Ag_xCu_{1-x}Fe_2O_4$ (0.1 ,0.3,0.5 ,0.7 and 0.9)

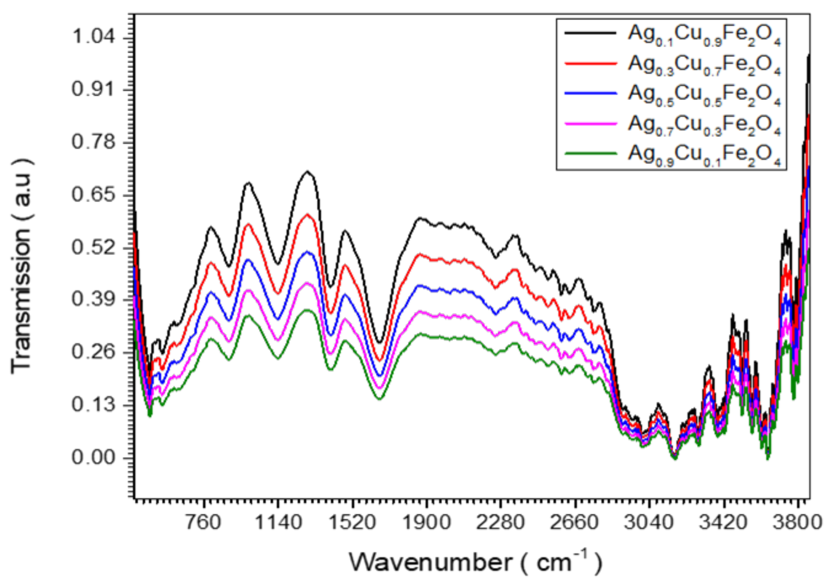

Fig. 6 IR spectrum of $Ag_xCu_{1-x}Fe_2O_4$ samples

Table 2: Data of IR spectrum for AgxCu1-x Fe2 O4 samples

No	Peaks (cm^{-1})	Bonds	Functional Groups
1	475	O^{+2}	Met Oxide
2	887	C–H "loop"	Aromatics
3	1140	C–N stretch	aliphatic amines
4	1410	C–C stretch (in–ring)	Aromatics
5	1670	N–H bend	1° amines
6	3015	C–H stretch	Aromatics
7	3160	O–H stretch	carboxylic acids
8	3390	N–H stretch	1°, 2° amines, amides
9	3640	O–H stretch, free hydroxyl	alcohols, phenols
10	3780	O–H stretch	Water

4. Discuss

The above results showed the optical properties of (Ag_x $Cu_{(1-x)}$ Fe_2O_4) for the molar concentrations x=0.1,0.3,0.5,0.7,0.9 are exhibited. The XRD technique shows that the crystal nano spacing d decreases upon increasing the molar concentration x.
Using a UV-VIS spectrometer figure (3) indicated that the absorbance increases upon increasing the concentration of Ag and decreasing the concentration of Cu. Figure (4) indicates that the transmission decreases as the Ag concentration rises. Figure (5) shows that the reflection in most cases for very long and very short wavelengths increases when the concentration of Ag increases as shown in Figure (5). The FTIR results in Figure (6) indicated that the transmission to infrared. radiation decreases as the Ag concentration increases. The results obtained are in good agreement with some previous studies. The observed change of absorbance with the wavelength is confirmed by the work of Schnaiter [18], Giorgio [19], and Karlsson [21] which indicated that the absorption coefficient thus absorbance changes with the wavelength The observed change of absorbance with the change of Ag and Cu concentration was confirmed by the work of Ernesto [22] which shows that increasing carbon concentration increases absorbance. Similarly Ahmed [24,26] showed in his work that changing Al concentration changes absorbance.

5. Conclusions

The results obtained for the optical properties of (Ag_x $Cu_{(1-x)}$ Fe_2O_4) samples showed that the crystal spacing, and transmission of infrared radiation decrease upon increasing the concentration of Ag and decreasing the concentration of Cu. In contrast, the absorbance and reflection increase when the Ag concentration is increased.

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