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ISSN 2411-3514 ONLINE
ISSN 1997-2490PRINTED

Al-Qadisiyah Journal Of Pure Science (QJPS)

Vol. xx, No. xx, pp. xx –xx, Month-Year

Preparation and investigation of structural and magnetic properties of cadmium-zinc compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$)

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Received: xxx / Accepted: xxx /Published: xxx ***DOI:*** ***CLC :***

ABSTRACT:

$CdFe_2O_4$ and $ZnFe_2O_4$ were prepared by Co-Precipitation method most frequently applied to prepare simultaneous precipitation of more than one component. Co-Precipitation used for achieving high homogeneity to the powder particles. Samples were investigated have phase cubic spinel structure according to the formula ($Cd_xZn_{1-x}Fe_2O_4$). Spinel ferrite of the form ($Cd_{0.3}$ $Zn_{0.7}Fe_2O_4$) has been prepared were sintered at room.The research studied structural, morphological and magnetic properties by X-ray diffractometer (XRD). (FE-SEM) field emission scanning electron microscope and (VSM) vibrating sample magnetometer. The element composition of cadmium-zinc ferrite shows increasing in lattice parameter (8.485887647) were calculated from XRD and crystalline size were determined. The results indicate increasing in volume of crystalline and distance between crystalline surfaces. The (FE-SEM) was used to determine the morphological variations and it's showed increasing in particle size (47.14 to 210 nm) with the increase of the ferrite concentration. The magnetic properties were measured using the Vibrating Sample Magnetometer showed a narrow hysteresis loop. This indicates that these materials lead to soft-ferrite and that the narrowing of the hysteresis loop shows the loss of magnetism.

KEYWORDS: Co-Precipitation Method, cadmium- zinc ferrites, VSM

1. Introduction

Nano ferrite spinel's are of great interest Addressing relationship between physical properties and their crystal structure. This has renewed interest to study different properties of pure and mixed spinel ferrite systems in Nano crystalline regime(Shinde & Laxman Appa Dhale, 2017) . Possess tremendous electrical and magnetic properties in wide technological applications such data storage system, ferrite fluid technology, medical diagnostics, magnetic sensors, targeted drug delivery, actuators (Hossain, Mohammad Sajjad.Md. Badiul Alamy, 2018). Ferrites are a crystalline mixture of different metal oxides and can generally be thought of as metal ions(Neelakanta, 1996). The ferrite is prepared in the form of powder and then pressed and molded to be the desired form (Pullar, Hajjaji, Amaral, Seabra, & Labrincha, 2014). It is one of the cheap materials, easy to manufacture, and the properties of the material on the granules and their size, as well as on the method of preparation and the temperature of the sintering and the type of elements and quantities of the component of the clay material. The hard ferrite, such as the barium ($BaFe_{12}O_{19}$) or centrontium with formula ($SrFe_{12}O_{19}$) (Version & Matter, 2003).Here, it is prepared in a ceramic way at a temperature of 1000 C°, which is suitable for use as a material (ram) (Makled et al., 2005).One of the most important benefits of frites which led to its widespread use as magnetic materials:

1. Work within a broad range of frequencies.
2. Low losses compared to their high magnetic potential.
3. High electrical resistance.
4. Thermal stability.
5. Cheap or low cost Low density.

Hard ferrites are a type of serpent that is permanent magnets[6,7]. One of the most important differences between strong materials and soft materials, Are magnetic properties where the soft materials do not retain magnetism after the magnetic field disappears but strong materials retain magnetism after the magnetic field disappears and have a wide hysteric ring (Park et al., 2014) (Ladislav Valko, 2003).

2. Experimental details of preparation

Co-Precipitation Method are done in the addition of alkali bases such as sodium hydroxide (OH) or the ammonium (NH_3) solution contains metals. The process is to mix these materials with special weight ratios and mix them with a few by adding distilled water to the ionic process of dissolving the chemicals and mixing with each other until the solution becomes one Temperature (50 C°) For a period of time, alkaline bases such as ammonia are added to the solution until the ph is between (8-12). Before using the pH mater, it must be calibrated by placing distilled water and a solution of a specific substance (ph) is fixed at a certain temperature to determine the readings the ph mater is correct and to reach the required base of the solution during the addition of ammonia, The metals begin deposition based on the ph value that affects the size and shape of the precipitated minutes and the sedimentation process is at a temperature of (50 C°). The precipitation can be performed in (30) minutes at (95 C°) Or without the process of filtration after pouring the solution with the mechanism of Buchner sedimentation after placing the filter paper for (24) hours and then put the candidate material inside the drying oven for a period (6-8) hours .at a temperature between (150 - 200 C°) dry thoroughly and leave it until the oven is cooled at room temperature and then grinded into a nanoparticle [8], and that the benefits of chemical deposition The homogeneous mixing of the reactive sediments reduces the temperature of the reaction, and then the first process of sintering begins by burning the materials formed into thermal art to a degree of (400-600 C°) for a period of (6) hours . The mixture is placed in the filter for a period of six hours at a temperature of (800-1100 C°) and therefore we have ferrite and begin the process of testing of the resulting ferrite material. The mixing of the resulting compounds (Zn Fe_2O_4) with (CdFe2O4) is performed according to the ratio (x=0.3) and the compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$).

3. Results and discussion

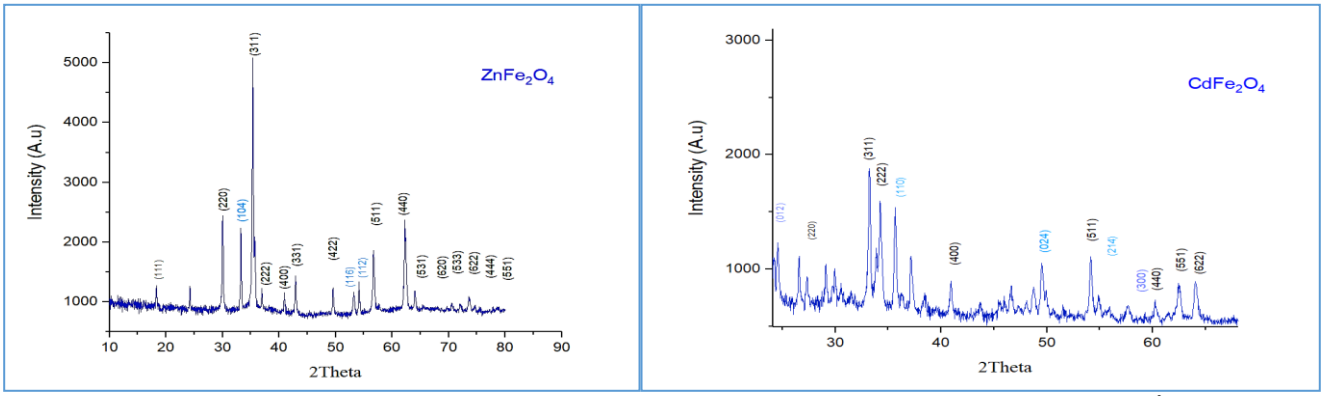
3.1. Structural analysis

Cadmium doped spinel Zinc ferrite with form ($Cd_xZn_{1-x}Fe_2O_4$) according to (x=0.3) were synthesized by Co-precipitation method. The figures (1), (2) appearance many diffraction peaks (111), (220) (311), (222), (400), (331), (422), (511), (440), and (531) planes in diffraction angle assures formation of spinel ferrite with cubic structure. The average crystalline size (*D*) were measured by using Debye–Scherrer formula ($D=K\lambda/\beta cos\theta$) for the samples were measured for the highest intensity at peak (311) the peaks for $ZnFe_2O_4$ is higher than and different $CdFe_2O_4$ peaks because the ionic diameter of cadmium is greater than the ionic diameter of the zinc, which is (0.83 A °) (W.H-Lawrence, 1970). Where λ is the X-rays wavelength, β is (FWHM) full width half maximum and θ is the Bragg's diffraction angle and K=0.9. The lattice constant (a) of all samples was determined by using miller indices values and using the inter planar spacing (d_{hkl}) by using the following formula $a = d\sqrt{h^2 + k^2 + l^2}$ Figures (3),(4) shows X-Ray diffraction for

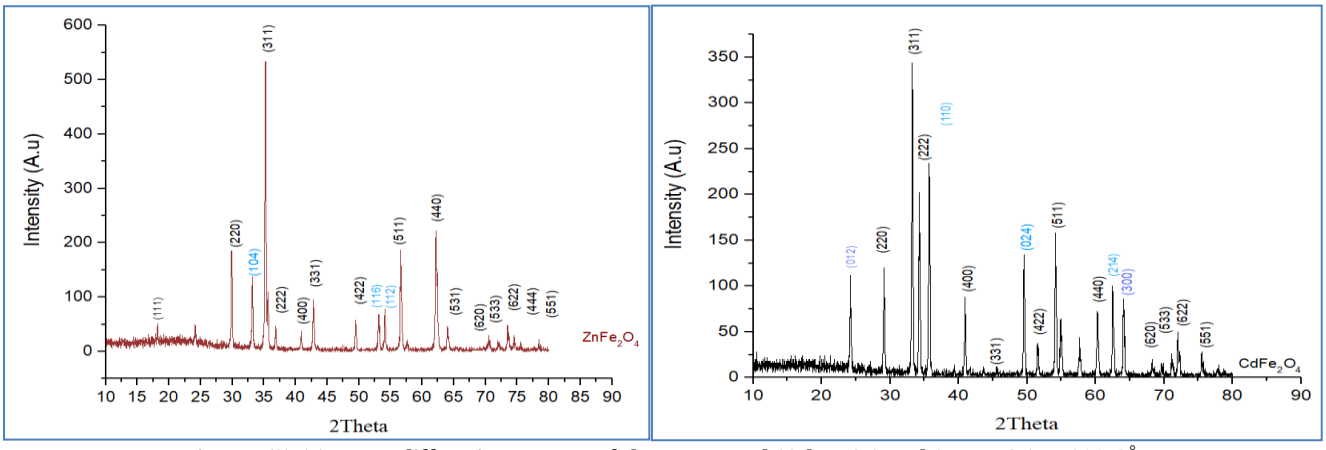
compound ferrite $CdFe_2O_4$ and $ZnFe_2O_4$ respectively and it's revealed the highest values at peak (311) the values of lattice parameter for ($Cd_{0.0}Zn_{1.0}Fe_2O_4$=8.425887647) and ($Cd_{1.0}Zn_{0.}0Fe_2O_4$=8.916407702) for compound materials. The table (1) shows variation of lattice constant and crystallite size of ($Cd_xZn_{1-x}Fe_2O_4$) ferrite samples. We investigate that when increasing the cadmium ferrite to the ratio (0.3) the lattice parameter will be at value (8.485887647).The difference in values is due to ionic diameter for cadmium and zinc as shown in figures (5) and (6).

Table 1: shows the information extracted from the XRD examination

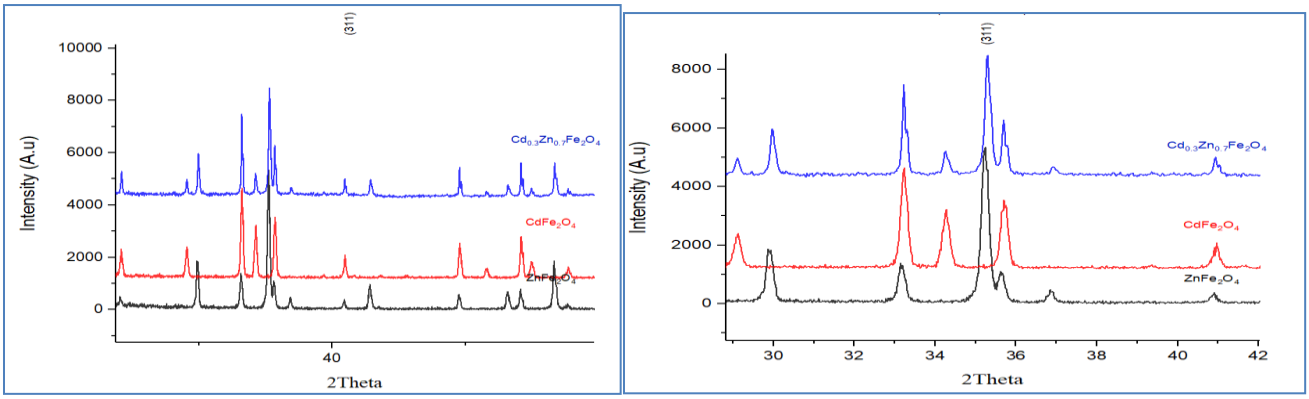
X	$Cd_xZn_{1-x}Fe_2O_4$	d(A°)	a(A°)	D=K.λ/Bcosθ	ε =BcosΘ/4	S (A°)
0.0	$Cd_{0.0}Zn_{1.0}Fe_2O_4$	2.540501319	8.425887647	364.2269352	0.000951676	7.538E-06
1.0	$Cd_{1.0}Zn_{0.0}Fe_2O_4$	2.688398716	8.916407702	453.8272308	0.000763784	4.85533E-06
0.3	$Cd_{0.3}Zn_{0.7}Fe_2O_4$	2.540501319	8.485887647	456.1078433	0.000775263	4.60237E-06



Figures (1,2) Shows X-ray diffraction pattern of the compound ($CdFe_2O_4$) and ($ZnFe_2O_4$) at 600 C°.



Figures (3),(4) X-ray diffraction pattern of the compound ($CdFe_2O_4$) and ($ZnFe_2O_4$) at 900 C°.



Figures (5),(6) Illustrated the effect of the increase of cadmium for the ferrite compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$).

3-2 Microstructural analysis

The results of the (FE-SEM) morphologies of ($Cd_XZn_{1-X}Fe_2O_4$) analysis with ratio (x=0.0,1.0) comparing with the compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$) at (x=0.3).The pictures of morphology for preparing samples showed in figures (7),(8) and (9) and it's revealed the crystal size of cadmium ferrite of compound ($Cd_{1.0}Zn_{0.0}Fe_2O_4$) with value between (210-108.8 nm). As for the crystal size of zinc ferrite of compound ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) it's ranged between (79.2-47.14 nm) this difference in values is due to the crystal size of the cadmium nanoparticles is greater than zinc nanoparticles because of the ionic diameter size of cadmium is more than greater the ionic diameter of zinc (0.83 A°) and the ionic diameter of cd (0. 99 A°) after addition of (0.3) ratio of ferrite of cadmium ($Cd_{0.3}Zn_{0.7}Fe_2O_4$) noticed increasing in crystalline particle size of nanoparticles in crystalline lattice. The results of the X-ray diffraction technique (EDS), which provides the knowledge of the structures and the chemical elements, showed that the ratio of (X = 0.0) of the compound ($Cd_{0.0}Zn_{1.0}Fe_2O_4$) were spectra showed many elements like (iron, zinc, carbon and oxygen) as shown in figures (10),(11) and (12). The (EDS) spectra of the compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$) revealed the the following elements only (iron, cadmium, carbon, oxygen, and zinc) and table (2) showed the atomic ratio of oxygen and it varies between (16.5 to 18.9), iron ranged between (62.9 to 65.5)and carbon (4.8-2.7) while zinc decreased and cadmium increased by replacing cadmium with zinc.

Table 2 : Shows Percentage of constituent elements of rheumatic compounds.

X	$Cd_XZn_{1-X}Fe_2O_4$	O	σ	Fe	σ	Zn	σ	Cd	σ	C	σ	Total
0.0	$Cd_{0.0}Zn_{1.0}Fe_2O_4$	16.4	0.1	62.9	0.3	15.8	0.2	-	-	4.8	0.2	100
1.0	$Cd_{1.0}Zn_{0.0}Fe_2O_4$	17.1	0.1	74.6	0.2	-	-	4.6	0.1	2.6	0.2	100
0.3	$Cd_{0.3}Zn_{0.7}Fe_2O_4$	18.7	0.2	65.5	0.3	12.0	0.2	1.2	0.1	2.7	0.1	100

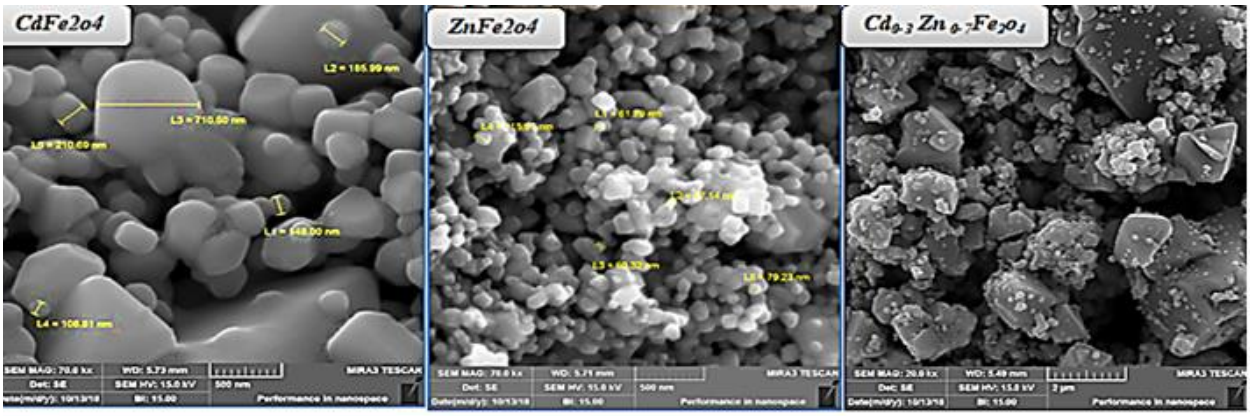


Figure (7),(8)and(9) Shows FE-SEM images of the $CdFe_2O_4$,$ZnFe_2O_4$ and for compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$).

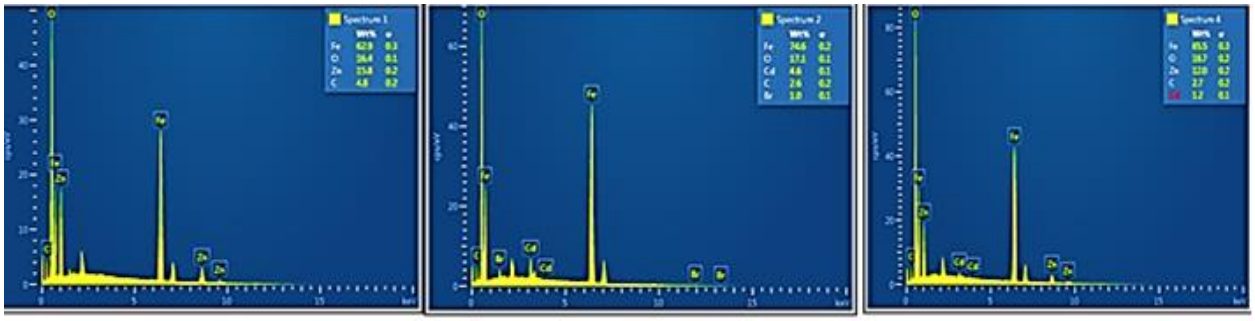


Figure (10),(11)and(12) Shows EDS examination of the $CdFe_2O_4$,$ZnFe_2O_4$ and for compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$).

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3-3 Magnetic properties - VSM

The field depending hysteresis loop diagram for prepared samples with ratio (x=0.3) is shown in figure (13). The magnetic properties were achieved by using (VSM) vibrating sample magnetometer. The relation between applied magnetic field and magnetization was plotted. The magnetic parameters like remnant magnetization (M_r) and saturation magnetization (M_s) and coercivity (H_c) were investigated. The compound of ($Cd_{0.3}Zn_{0.7}Fe_2O_4$) were examined and found with the range of applied field have a narrow hysteresis ring. This indicates that these materials are soft-type and that the narrow-ring hysterically shows the loss of magnetism and these changes is lead to redistribution between ions of cadmium and zinc and that might be the cadmium ion have a priority site in lattice (Iqbal & Ashiq, 2008). The values were indicated for magnetization (MS) showed (2.7709 emu/gm) and coercivity (Hc) showed (47.901) and the ratio between Mr / Ms (0.0659) and magnetism (Mr) will be (0.1828 emu/gm) when adding (0.3) of cadmium ferrite. The difference in crystallization and the shape and size of nanoparticles and as well as the distribution of positive ions in the lattice .The cadmium constituent compound ferrite as Neel's model that describe ferromagnetic structure have two sub-lattice tetrahedral and octahedral site which they are antiparallel to each other causing decreasing in magnetic moment thus the occupying of cadmium by octahedral site that change the magnetization values and the cadmium will be no magnetic material.

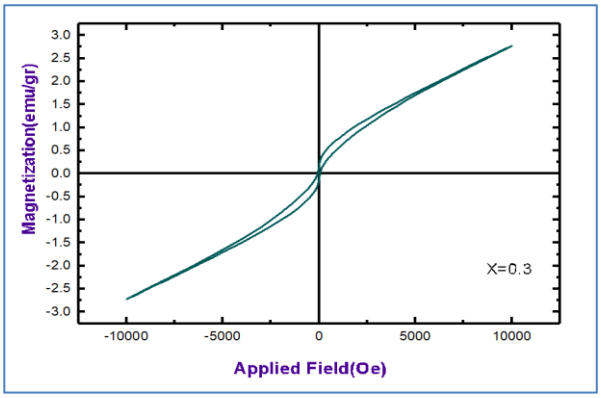

Figure (13) shows the hysteresis loop of the compound ($Cd_{0.3}Zn_{0.7}Fe_2O_4$).

4 Conclusion

Preparation of Cadmium - Zinc ferrite, the mixture by (x = 0.3) and the increase of the fraction of ferrite cadmium to zinc increases the crystal size and the interstitial distance of crystalline surfaces (d). Because, the increase to the difference of ionic diameters of both cadmium and zinc .Where zinc (0.83 A°) and cadmium (0.99 A°) of the compound ($Cd_0.3Zn_{0.7}Fe_2O_4$) and found that the compound ring narrow hysterics and this indicates that these materials are soft-type and the narrow ring hysterical shows the loss of magnetism, these are the characteristics of the ferrite.

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Available online at http://qu.edu.iq/journalsc/index.php/JOPS

ISSN 2411-3514 ONLINE
ISSN 1997-2490PRINTED

Al-Qadisiyah Journal Of Pure Science (QJPS)

Vol. xx, No. xx, pp. xx –xx, Month-Year

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