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Structural Investigation of Cr^{3+}ions substituted Cu-ferrite nanoparticles

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ABSTRACT

A series of polycrystalline spinel ferrite having the chemical formula $CuCr_xFe_{2-x}O_4$ (x = 0.0, 0.2, 0.4, 0.6, 0.8, and 1.0) were synthesized by using sol-gel auto combustion method and studied by using X-ray diffraction (XRD) measurements. The XRD analysis reveals single phase cubic spinel structure of synthesized samples. The particle size was found by XRD and scanning electon microscopy (SEM) technique confirms the nanocrystalline nature of the samples. Bond length and Tetrahedral and octahedral bond edges also calculated from structural analysis.

Key words: Sol-gel, X-ray diffraction, Structural properties

INTRODUCTION

Ferrite materials are metal oxides have high electrical resistivity, low eddy current losses and useful in microwave applications such as circulators, isolators and phase shifters. Now a day nano sized ferrite materials have been widely used to prepare many electromagnetic devices such as inductors, converters, phase shifters and electromagnetic wave absorbers [1]. On the basis of crystal structure, spinel ferrites are represented by the formula AFe_2O_4, where A is a divalent metal ion. The crystal structure of ferrite consists of two interstitial sites, tetrahedral (A) and octahedral [B] sites, in which cations are occupied and nanoparticles from can shows different properties unlike those observed in bulk material. The fabrication of spinel ferrites nanoparticles has been the subject of intense research interest due to their excellent structural, magnetic, electrical and dielectric properties [2]. The properties of nanoparticles mostly depend on synthesis method. Therefore now a days different methods are being used for synthesis nanomaterials such as co-precipitation method, hydrothermal method, microemulsion method, sol-gel autocombustion method, so no chemical reaction method [3-7]. Among these methods sol-gel autocombustion method is used to synthesis of copper ferrite nanoparticles. In the present paper, we synthesized $CuCr_xFe_{2-x}O_4$ (x = 0.0, 0.2, 0.4, 0.6, 0.8, and 1.0) ferrite nanomaterial by using the sol-gel autocombustion method and investigated the consequent changes on structure of ferrite.

METHODOLOGY

$CuCr_xFe_{2-x}O_4$ (where x = 0.0 to 1.0 in the step of 0.2) synthesized by sol-gel auto combustion method. Calculated quantities of required metal nitrates were dissolved together in a 100ml of deionised distilled water to get clear solution. An aqueous solution of citric acid then added to the metal nitrate solution. The molar ratio was adjusted to 1:3. A small amount of liquid ammonia (NH_3) was added drop wise into the solution so as to maintain pH value. The process of mixing till continued to burn the material in the powder form. The final product is then grinded and subjected to further study.

RESULTS AND DISCUSSIONS

The X-ray diffraction (XRD) patterns of the samples (x=0.0 to 1.0 in the step of 0.2) of $CuCr_xFe_{2-x}O_4$ nanoferrite system shown in Fig.1.

The XRD patterns of all the Cr substituted copper ferrites shows the reflection such as (111), (220), (311), (222), (400), (422), (511), (440), (533) which belongs to cubic spinel ferrite. All the Braggs reflections peaks are allowed peaks have been indexed without any impurity peaks. The strongest reflection has come from (311) plane that indicates spinel phase.

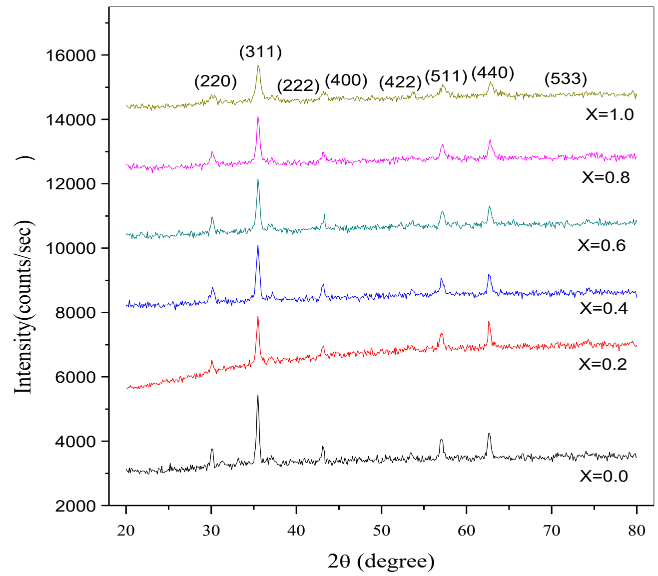

Fig.1. X-ray diffraction patterns of the $CuCr_xFe_{2-x}O_4$ (x = 0.0, 0.2, 0.4, 0.6, 0.8, 1.0) nanoparticles

1. Lattice constant

Lattice constant (a) of all composition was calculated by using the formula,

$$a = d\sqrt{N} \quad Å$$

where $N = h^2 + k^2 + l^2$, d is the interplanar spacing. The variation of lattice parameter with Cr^{+3} compositions lies in between 8.3886 Å to 8.3057 Å is listed in **Table 1**.

2. Particle size

The average particle size (t) of all sample compositions has been calculted from full width at half maximum (FWHM) of broadening of the most intense peaks (311) using Debye-Scherrer formula [10].The values of particle size obtained from XRD data and SEM (Table 1) are close to the results obtained from SEM images.

3. Bond length

The bond length R_A (is the shortest distance between A site cations and oxygen ion) and R_B (is the shortest distance between B site cations and oxygen ions) have been calculated by the equation [11] and listed in Table 2.

Table 1: Variation in Lattice constant and Particle size of $CuCr_xFe_{2-x}O_4$ nanoferrite

Ferrite composition	Lattice constant 'a' (Å)	Particle size 't' (nm)	
		XRD	SEM
$CuFe_2O_4$	8.3886	28.80	37
$CuCr_{0.2}Fe_{1.8}O_4$	8.3582	26.58	30
$CuCr_{0.4}Fe_{1.6}O_4$	8.3345	25.68	27
$CuCr_{0.6}Fe_{1.4}O_4$	8.3211	23.56	25
$CuCr_{0.8}Fe_{1.2}O_4$	8.3109	21.43	22
$CuCr_{1.0}Fe_{1.0}O_4$	8.3057	19.90	18

Table 2: Bond length, tetrahedral and octahedral edge of $CuCr_xFe_{2-x}O_4$ nanoferrite

Cr Content x	**Bond length (Å)**		**Tetrahedral and octahedral edges (Å)**				
	R_A	R_B	d_{AX}	d_{BX}	d_{AXE}	d_{BXE}	d_{BXEU}
0.0	1.903	2.048	1.282	1.865	1.995	3.077	2.797
0.2	1.896	2.041	1.276	1.878	1.988	3.067	2.785
0.4	1.891	2.035	1.250	1.872	1.982	3.057	2.777
0.6	1.888	2.032	1.221	1.865	1.975	3.046	2.767
0.8	1.886	2.029	1.195	1.859	1.969	3.037	2.758
1.0	1.884	2.028	1.174	1.855	1.963	3.029	2.751

It is evident from **Table 2.** that the bond length R_A and R_B decreases with Cr^{3+} ions content x. The decrease in bond length can be attributed to the decrease in lattice constant 'a' with Cr^{3+} ions content x.

4. Tetrahedral and octahedral bond edges

The bond length of tetrahedral (A) site 'd_{Ax}' and octahedral [B] site 'd_{Bx}', tetrahedral edge d_{AXE}, shared octahedral edge 'd_{BXE}' and unshared octahedral edge 'd_{BXEU}' of $CuCr_xFe_{2-x}O_4$ nanoferrite system were calculated by using the values of lattice constant 'a' and oxygen positional parameter 'u', in the standard equations and values are depicted in **Table 2**.

5. Scanning electron micrographs (SEM) analysis

The micrograph of the recorded typical sample (x= 0.6) is as shown in **Fig. 3.** From the SEM images, it is observed that uniform grains are progressively increased with increasing Cr^{3+} content x and the ferrite sample exhibit an aggregated continuous grain growth. It can be also observed that the prepared samples are amorphous and porous in nature. The particle size determined from SEM images by linear intercept method [12] and the values are given in **Table 1.**

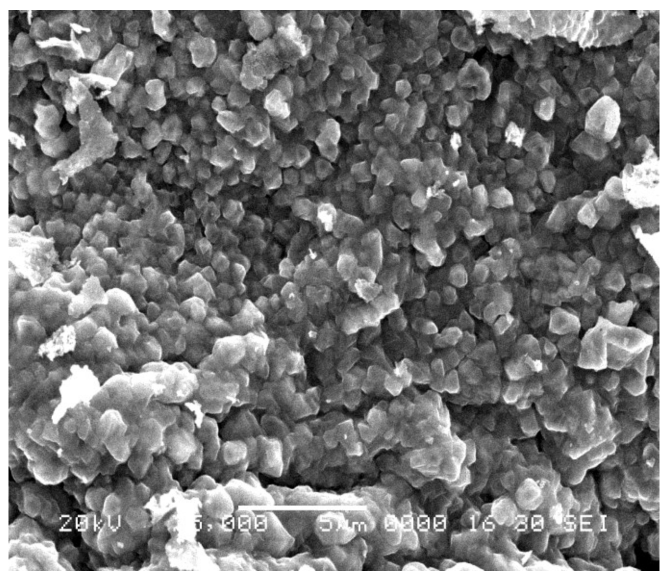

Fig. 3: Typical SEM image (x=0.6) of $CuCr_xFe_{2-x}O_4$ nanoferrite system

CONCLUSION

In conclusion, the substitution of Cr^{3+} ions in Cu-ferrite has been successfully investigated by sol-gel autocombustion technique. Powder XRD, SEM data indicate clearly the information of ultrafine single phase cubic spinel structure of syntheszed Cu-Cr ferrite material. The particle size obtains in between 19.90 to 28.80 nm. Bond length, tetrahedral and octahedral bond edges are directly depends on lattice constant.

REFERENCES

1. Harris VG, Geiler A, Chen YJ, Yoon SD, Wu MZ, Yang A, Chen ZH, He P, Parimi PV, Zuo X, Patton CE, Abe M, Acher O and Vittoria C. J. Magn. Magn. Mater., 321, 2009, 2035 .
2. Fu YP, Hu SH. Ceram. Int., 36, 2010, 1311.
3. Yue Zhang, Zhi Yang, Di Yan, Yong Liu. J. Magn. Magn. Mater., 322, 2010, 3470 .
4. Cabanas A and Poliakoof M. J. Mater. Chem., 11, 2011,1408.
5. Ahn Y, Choi EJ, Kim S, and Ok HN. Mater. Lett., 50, 2001,47.
6. Lee JG, Park JY and Kim CS. J. Mater. Sci., 33, 1998, 3965.
7. Shafi KVPM, Gedanken A, Prozorov R and Balogh J. Chem. Mater., 10, 1998, 103445.
8. Shinde BL, Suryavanshi VS and Lohar KS. Int. J. Mater. Sci., 12, 3, 2017, 433-442.
9. Imran S, Amin N, Arshad MI, Islam MU, Anwar H, Azam A, Ahmad M, Fakhar- E-Alam M, Murtaza G, Mustafa G. Digest J. Nanomaterials and Biostructures., 11, 4, 2016,1197-1204.
10. Cullity BD , Stock SR. Elements of X-ray diffraction (New York, Prentice Hall) P-154, 2001.
11. Standly KJ. Oxide Magn. Mater. Oxford U. K. Clarendon (1972)
12. Wurst JC, Nelson JA. Am. Ceram. Soc. Bull, 55, 1972 ,109