# STRUCTURAL AND MAGNETIC STUDY OF CHROMIUM FERRITE NANOPARTICLES

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**ABSTRACT**

Pure chromium nanoparticles with the general formula $CrFe_2O_4$ have been created using the conventional wet chemical co-precipitation process. For four hours, the prepared sample was annealed at 600 0C. For the prepared sample, room temperature X-ray diffraction patterns were obtained to verify the creation of a single-phase cubic spinel structure. On prepared samples, studies using a scanning electron microscope were performed to examine the surface morphology. The size of the particles as determined by XRD and SEM data is in the nanometer range. The range reported for the lattice constant was met. The pulse field hysteresis loop approach was used to study the magnetic characteristics. It was discovered that the coercivity and saturation magnetization values were higher than their bulk counterparts.

**Keywords:** chemical co-precipitation, nanoparticles, lattice constant, and X-ray diffraction

## Introduction

In the recent years ferrites having high electrical resistivity, low eddy current loss, structural stability, large permeability at high frequency, high coercivity, high cubic magneto crystalline anisotropy, good mechanical hardness, and chemical stability, nanosized spinel-type ferrites have emerged as an important class of nanomaterials.[1,2] As a result, research devoted to the development and characterization of such nanomaterials, the development of cost-effective, environmentally friendly synthesis processes, and the discovery of novel uses for existing materials has gained a great deal of interest. $MFe_2O_4$ type spinel ferrite attracts several researchers because of their twin property of magnetic conductor and electric insulator. These materials are widely used in the electronic and electrical industries for the fabrication of devices and components such as high-density magnetic core of read/ write for the high-speed tapes etc.[2,3]

In recent years there has been considerable interest in the study of the properties of nano-sized ferrite particles because of their importance in the fundamental understanding of the physical properties as well as to their proposed applications for many technological purposes.[4,5] The unique properties of nanoparticles are in general related to the adoption of materials, crystal structure to a small (nano size) and large surface to volume ratio.

Among the several spinel ferrites Chromium ferrite is an interesting ferrite because it crystallizes either in a tetragonal or cubic symmetry depending on the cation distribution among the interstitial site of a spinel structure.[6,7] The other interesting feature of Chromium ferrite is that it contains Jahn Teller ion which is responsible for interesting electrical and magnetic properties. In bulk form, Chromium ferrite is a magnetic compound useful in many technological applications.[8] They can also be prepared by techniques such as wet chemical co-precipitation,[9] sol-gel[10], hydrothermal synthesis[11] or microwave emulsion[12] at nanoscale, that can be employed in important applications such as ferro- fluid technology,[13] magnetically guided drug delivery.[14] The magnetic properties of spinel ferrite originate from the antiferromagnetic coupling between the octahedral and tetrahedral sub lattices. The magnetization results from the difference between the magnetization of tetrahedral (A) and octahedral [B] sites. The structural, electrical and magnetic properties of chromium substituted Chromium ferrite prepared in bulk form have been reported in the literature.[15,16] However, the structural and magnetic properties of Chromium ferrite prepared by wet chemical co-precipitation method are not reported in the literature.

In this study, we report our results on structural and magnetic properties of pure Chromium ferrite nanoparticles obtained by wet chemical co-precipitation method.

**Experimental**

The sample of $CrFe_2O_4$ spinel ferrite was prepared by wet chemical co-precipitation technique. The details of synthesis method have been discussed in our previous reports.[17] The structural characterization was made through X-ray diffraction technique in the 2θ range of $20^0$ - $80^0$. The XRD pattern was recorded at room temperature using Cr-Kα λ=1.521 $A^0$ radiation. Microstructural studies including evaluation of a particle size were conducted using a JEOL – JS scanning electron microscope. The magnetic measurements were carried out at room temperature using pulse field magnetic hysteresis loop tracer.

**Results and discussion**

**Structural Analysis**

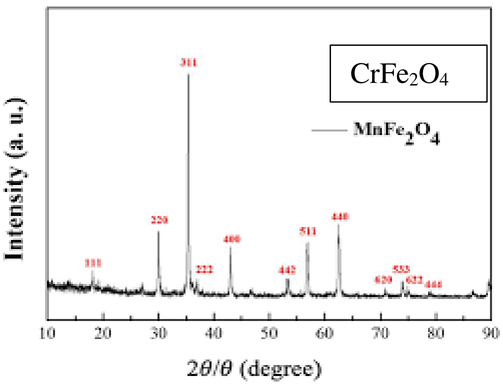


**Fig.1: X-ray Fig.1 shows the X-ray diffraction (XRD) pattern of $CrFe_2O_4$ nanoparticles.**

All the Bragg reflections have been indexed, which confirms the formation of cubic spinel structure in single phase. Bragg's reflections are found to be sharp and intense. The values of lattice parameter calculated from interplanar spacing (d) values and Miller indices are given in table 1. The value of lattice parameter is found to be 9.214 Å. The present value of lattice parameter of Chromium ferrite is in good agreement with the reported value.[18-21] The average crystallite size was determined from the measured width of the diffraction using Scherrer formula.[21] The particle size obtained from XRD data is found to be 36 nm.

**Table.1: Lattice constant, X-ray density and crystallite size from XRD data**

| Structural parameters | Values |
|---|---|
| Lattice constant (a) | 9.214 AU |
| X-Ray density ( ? x) | 5.241 g/cm$^3$ |
| Crystallite Size (t) | 36 nm |

Scanning electron micrograph (SEM) of the prepared sample is shown in above Fig. 2. It can be observed that the grains are in nano-meter range. The micrograph reveals dense microstructure with developed grains along with few pores.

**Magnetic Properties Study**

**Fig. 3 shows the magnetization versus field image plot of $CrFe_2O_4$ nanoparticles.**

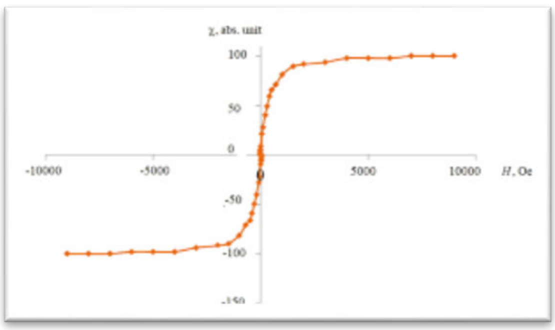


**Fig. 3: Hysteresis loop for $CrFe_2O_4$ nanoparticles**

**Fig.2: SEM image of $CrFe_2O_4$ nanoparticles**

These plots are used to evaluate saturation magnetization (Ms), remanence magnetization (Mr) and coercivity (Hc). The values of these magnetic parameters are given in table 4. The saturation magnetization values (Ms) are used to calculate magneton number nB are given in table 4. The observed variation in magneton number was also studied by Neel's theory.[22-26] According to Neel's theory the magneton number is the difference of magnetic moment of B sub lattice and A sub lattice respectively, The calculated value of magneton number is also given in table

2. $n_B = M_B - M_A$

**Table 2: Magnetic parameters of CrFe2O4**

| Magnetization parameters | | | Magneton number '? B'(? B) | |
|---|---|---|---|---|
| Mr (emu/gm) | Ms (emu/gm) | Hc (Oe) | Cal. | Obs. |
| 20.14 | 45.21 | 221.35 | 1.2 | 0.98 |

## Conclusions

The wet chemical co-precipitation process was effectively used to produce chromium ferrite ($CrFe_2O_4$) nanoparticles. X-ray diffraction was used to confirm that the chromium spinel ferrite system formed in a single phase. The range reported for the lattice constant was met. Saturation, remanence magnetization, and coercivity values are elevated and exhibit ferrimagnetic nature.

## REFERENCES


1. Dippong T. Characterization and Applications of Metal Ferrite Nanocomposites. Nanomaterials (Basel). 2021 Dec 30;12(1):107. doi: 10.3390/nano12010107. PMID: 35010057; PMCID: PMC8746313.
2. B. Jeyadevan, K. Tohji and K. Nakatsuka, J. Appl.Phys. 76 (1994) 6325.
3. G. F. Goya, H. R. Rechenbury, J. L. Jiang J. Appl. Phys. 84 (1998) 1101.
4. S. Marup, J. Z. Jiang, F. Bodker, A Harsewell, Euro physlett. 56 (2001) 441.
5. Ch. Venkateshwarlu, D. Ravinder,J. Alloy. Compd. 397 (2005) 5.
6. S. J. Stewart, M. Tueros, G. Gerlhicchiarao, R. B. Scrorzelli, Solid. State. Com. 129 (2004) 347.
7. A. Kasak, D. Makovec, A. Zhidarsic, M. Profinik, J. Eur. Ceram. Soc. 24 (2004) 959.
8. A. K. Giri, K. Pellerin, W. Pongsakswad, M. Sorescu, S. Majetich, IEEE Trans. Magn. 36 (2000) 3029.
9. Masaru Tada, Takashi Kanemaru, Takeshi Hara, Takashi Nakagawa, Hiroshi Handa and Masanori Abe, J.
10. Magn. Magn. Mater. 321 (2009) 1414.
11. J. L. Darmann, D. Fiarani Magnetic properties of fine particles North Holland, Amsterdam, 1992.
12. B. D. Cullity, Moments of X-ray diffraction Adison- Wesley publ. co. Landon (1967).
13. L. Néel (1932). Ann. de Phys., 17, 5-105.
14. Dippong T., Deac I.G., Cadar O., Levei E.A. Effect of silica embedding on the structure, morphology and magnetic behavior of $(Zn_{0.6}Mn_{0.4}Fe_2O_4)_\delta/(SiO_2)_{(100-\delta)}$ nanoparticles. Nanomaterials. 2021;11:23332.
15. Jonssan. P. Hanson M. F., Nordblad P. Phys. Rev. B 2050, 61, 1261.