IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, March 2025
Impact Factor: 7.67

Study of Magnetic Properties of Lithium-Cadmium Ferrite Nanoparticles Prepared by Sol-Gel Method

AltafIsuf Fakir[1], Suvaiba Tajammul Hussain Dalvi[2], Solkar Ayesha Nazim[2]
Anjuman Islam Janjira Degree College of Science, Murud Janjira[1,2]

Abstract: *Lithium-Cadmium ferrite (Li□- ₓCdₓFe₂ O₄ , where x = 0, 0.1, 0.2) nanoparticles were synthesized using a simple, cost-effective sol-gel auto-combustion method at low temperature. Lithium-Cadmium ferrite belongs to the category of soft ferrites and has potential applications, particularly in gas sensors. The present study focuses on analyzing the structural and magnetic properties of the synthesized Lithium-Cadmium nanoferrite samples. The magnetization behavior of the nanoparticles was investigated, and key parameters such as saturation magnetization (Ms), remanence (Mr), and coercivity (Hc) were derived from the hysteresis loops. Vibrating Sample Magnetometry (VSM) results indicate that as Cd^{2+} substitution increases in Lithium ferrite, both remanence (Mr) and saturation magnetization (Ms) increase. However, coercivity (Hc) initially increases up to x = 0.1 and then decreases at x = 0.2. These magnetic property variations suggest that the synthesized materials transition from hard ferrite to soft ferrite behavior.*

Keywords: Nanoparticles, Lithium-Cadmium ferrite, Sol-Gel Method, Magnetic Properties

I. INTRODUCTION

Nano ferrites have grown significant attention in both industrial and research domains due to their versatile applications. These materials are particularly valued for their roles in Ferro fluids, magnetic drug delivery, gas sensors, electromagnetic devices, high-frequency applications and hyperthermia for cancer treatment [1][2][3]. Among the various ferrites, lithium ferrite ($LiFe_2O_4$) stands out as a soft magnetic material with high saturation magnetization (Ms) and low coercivity (Hc), making it a prime candidate for numerous technical applications. As Lithium-Cadmium ferrite ($Li_{1-x}Cd_xFe_2O_4$) belongs to the soft ferrite category it also exhibits tunable magnetic properties depending on Cd^{2+}substitution. The incorporation of Cd^{2+} ions into the lithium ferrite structure influences the cation distribution within the spinel lattice, thereby varying the material's magnetic behavior. Various synthesis techniques, including hydrothermal, co-precipitation, and sol-gel methods, have been engaged to prepare ferrite nanoparticles [4]. Among these, the sol-gel auto-combustion method offers advantages such as short treating time at a very low temperature, high compositional homogeneity, and controlled particle size distribution [5]. Understanding the magnetic properties, including saturation magnetization (Ms), remanence (Mr), and coercivity (Hc), is crucial for optimizing the material for potential applications. The present study focuses on the synthesis of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2) nanoparticles via the sol-gel auto-combustion method and investigates their structural and magnetic properties using Vibrating Sample Magnetometry (VSM).

II. SYNTHESIS METHOD

Lithium-Cadmium ferrite ($Li_{1-x}Cd_xFe_2O_4$) nanoparticles were prepared using the sol-gel auto-combustion method. The stoichiometric amounts of Lithium nitrate ($Li(NO_3)_2$, 68.95 g/mol), Cadmium nitrate ($Cd(NO_3)_2$, 308.48 g/mol), and Ferric nitrate ($Fe(NO_3)_2$, 404.00 g/mol) were dissolved in distilled water to prepare a homogeneous precursor solution. The solution was stirred using a magnetic stirrer for 20 minutes to ensure complete dissolution. Citric acid ($C_5H_8O_7.H_2O$) was then added as a complexing agent, and the solution was maintained at 30°Cfor 60 minutes. To regulate the pH, ammonia water (NH_4OH) was added gradually until the pH reached 7. The solution was then heated to 100 °C under continuous stirring till gel formation occurred. The obtained gel underwent auto-combustion, leading to the formation of fine ferrite powder. The resulting powder was further sintered at 600°Cto enhance crystallinity.

DOI: 10.48175/IJARSCT-24701

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, March 2025
Impact Factor: 7.67

Finally, the sintered sample was ground thoroughly to obtain Lithium-Cadmium ferrite nanoparticles suitable for further characterization.

III. RESULTS AND DISCUSSION

X-Ray Diffraction

Figure 1 presents the XRD patterns of $Li_{1-x}Cd_xFe_2O_4$ samples (x = 0, 0.1, 0.2), confirming phase purity due to the absence of additional peaks. The average grain size, calculated using the Debye-Scherrer formula, ranged from 32.65to 39.28nm (Table 1), though variations in lattice parameter were observed with increasing Cd^{2+} content.The lattice parameter increases linearly with cadmium content. The increase in lattice parameter is expected due to higher ionic radii of Cd^{2+} than other[6]. The peaks at (2 2 0), (3 1 1), (4 0 0), (4 2 2) and (4 4 0) confirmed the spinel structure of the samples[7]. This also demonstrates the homogeneityof the prepared samples.The XRD patterns shows sharp peaks indicate good crystallinity, and the differences in peak intensity between the samples suggest variations in crystal growth.

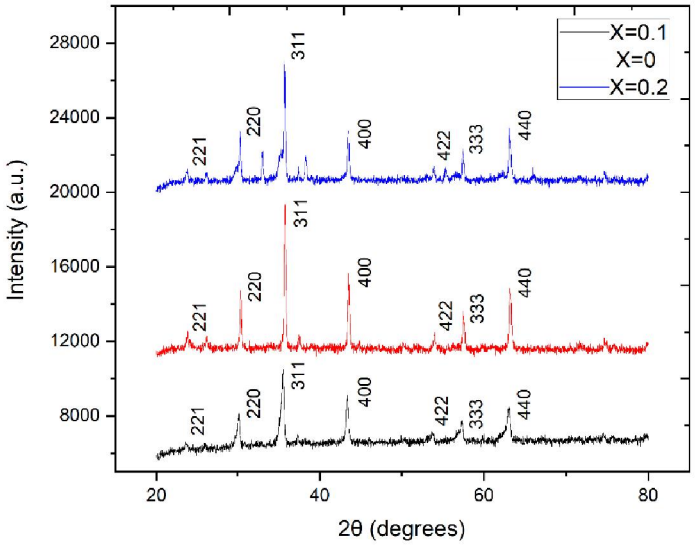

Figure 1 stacked XRD patterns of $Li_{1-x}Cd_xFe_2O_4$ samples (x = 0, 0.1, 0.2)

Table 1

Sr. No	Concentration	$t = \frac{0.9\lambda}{\beta cos\theta}$ (nm)	Lattice parameter (Å)	Interplanar spacing (d)
1	$Li_1Cd_0Fe_2O_4$	23.69	32.65	2.19
2	$Li_{0.9}Cd_{0.1}Fe_2O_4$	19.10	33.26	1.74
3	$Li_{0.8}Cd_{0.2}Fe_2O_4$	23.00	39.28	2.11

Magnetic Property (VSM)

Typical hysteresis loops of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2), samples as obtained from VSM characterization are shown in Figure 2.The saturation magnetization (Ms) for all the ferrites after sintering is listed in Table 2.It is clear that for the samples the saturation magnetization increases from 47.28 to 55.20 emu/gm and remanence magnetization (Mr) increases from 16.32 to 21.79 emu/gm. This could be due to Cd^{2+} replace ion on the tetrahedral A–sites, causing the decrease of magnetic moment in the sub lattice M_A, resulting in the increase magnetic moment which increases saturation magnetization[8]. It is also found that with increasing concentration of Cd^{2+},coercivity (Hc) first increasesup

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, March 2025
Impact Factor: 7.67

to x = 0.1 concentration then decreases for x = 0.2 concentration.This could be due to further increase in the concentration of Cd^{2+} (more than 0.1), the exchange interaction between A and B sites gets lowered resulting in strengthening of B-B interaction and weakening of A-B interaction, which leads to decrease of coercivity (Hc).the decreasing in coercivity (Hc) can be utilized to change magnetic properties of Lithium ferriteand hard magnetic material can be converted to soft magnetic material.

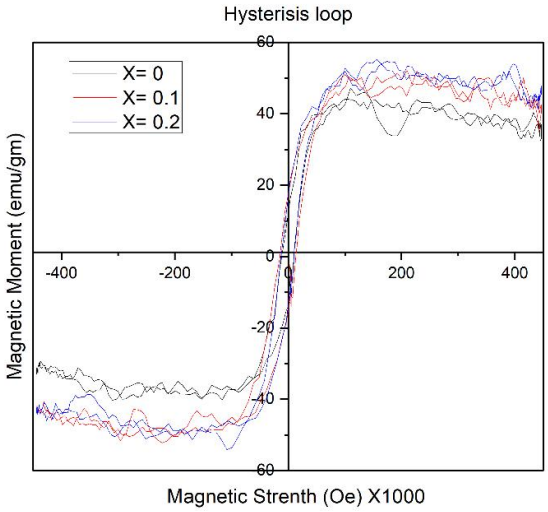

Figure 2. Hysterisis loop of $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2)samples.

Table 2

Sr. No	Concentration	Hc Oe X 1000	Mr emu/gm	Ms emu/gm
1	X=0	5714.07	016.320	047.280
2	X=0.1	8302.62	020.680	052.200
3	X=0.2	4848.75	021.790	055.200

IV. CONCLUSION

Lithium-Cadmium ferrite nanoparticles $Li_{1-x}Cd_xFe_2O_4$ (x = 0, 0.1, 0.2), were prepared via sol-gel auto combustion route. From XRD Patternconfirmed the spinel structure of the samples with good crystallinity. it is also clear that the lattice parameter increases linearly with cadmium content.From VSM it is clear that the saturation magnetization (Ms)andremanence magnetization (Mr) increases with cadmium content while first increases up to x = 0.1 concentration then decreases for x = 0.2 concentration.The change in magnetic property with cadmium content can be utilized to change magnetic properties of Lithium ferrite and hard magnetic material can be converted to soft magnetic material.

REFERENCES

[1] Sharma RK *et al.* Synthesis of Chromium Substituted Nano Particles of Cobalt Zinc Ferrites by Coprecipitation. *Materials Letters*, 2005; **59**, 3402-3405. http://dx.doi.org/10.1016/j.matlet.2005.06.004

[2] Mathew DS and Juang RS. An Overview of the Structure and Magnetism of Spinel Ferrite Nanoparticles and Their Synthesis in Microemulsions. *Chemical Engineering Journal*, 2007; **129**, 51-65.

[3] Salih, S. J., & Mahmood, W. M. (2023). Review on magnetic spinel ferrite (MFe2O4) nanoparticles: From synthesis to application. Heliyon, 9(6), e16601. https://doi.org/10.1016/J.HELIYON.2023.E16601

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 10, March 2025
Impact Factor: 7.67

[4] Yang, H., Yang, X., Lin, J., Yang, F., He, Y., & Lin, Q. (2023). Effect of Cd2+ Substitution on Structural–Magnetic and Dielectric Properties of Ni–Cu–Zn Spinel Ferrite Nanomaterials by Sol–Gel. Molecules, 28(16), 6110. https://doi.org/10.3390/MOLECULES28166110

[5] Shirsath, S. E., Wang, D., Jadhav, S. S., Mane, M. L., & Li, S. (2018). Ferrites Obtained by Sol-Gel Method. Handbook of Sol-Gel Science and Technology: Processing, Characterization and Applications, 695–735. https://doi.org/10.1007/978-3-319-32101-1_125

[6]Bellad, S. S., Watawe, S. C., Shaikh, A. M., &Chougule, B. K. (2000). Cadmium substituted high permeability lithium ferrite. Bulletin of Materials Science, 23(2), 83–85. https://doi.org/10.1007/BF02706546

[7]Akhter, S., & Hakim, M. A. (2010). Magnetic properties of cadmium substituted lithium ferrites. Materials Chemistry and Physics, 120(2–3), 399–403. https://doi.org/10.1016/j.matchemphys.2009.11.023

[8]Fakir, A. I., Gk, M., Bs, M., & Sm, R. (2018). Effect of Pb^{2+} Doped in Co Nanoferrite on Magnetic Properties Synthesized by Sol-gel Technique. 63628, 256–259.