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Synthesis, Structural and Magnetic Properties of Cobalt Ferrite ($CoFe_2O_4$) Nanoparticles by Simple Co-precipitation Technique

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Abstract

In the present work, phase pure Cobalt ferrite ($CoFe_2O_4$) nanoparticles are successfully synthesized by simple co-precipitation method. Structural and morphological properties of synthesized material are studied by X-ray diffraction (XRD) and Scanning electron microscopy (SEM) respectively. The results show that successfully formation of spherical nano particles with spinel crystalline structure. Strong peaks of Co, Fe and O are clearly observed in the EDX, which shows that the presence of these elements.

Keywords: Cobalt ferrite ($CoFe_2O_4$), nanoparticles, XRD, SEM, EDX

Introduction

Synthesis of magnetic nanomaterials research is particular to study optical, magnetic, electric properties [1,2] analyse to bulk materials. magnetic properties are built upon purity, shape and size of particles. Cobalt ferrite ($CoFe_2O_4$) nanoparticles are synthesised by Evaporation condensation [3], hot spraying, sol-gel [4], vapour phase reactions, thermal decomposition, hydrothermal Polly method [5], matrix isolation, co-precipitation method [6] etc. Co-precipitation method synthesised nanoparticles size of cobalt ferrite changes to variation of concentration, stirring speed, synthesis technique and temperature. [6-8]. Cobalt ferrite is widely used to sensors [9], solar cell [10], microwave absorber [11] and biomedical applications [12].

Spinel ferrite is mechanical hardness, moderate saturation, large coercivity, crystalline anisotropy and large cubic magnetisation at room temp [13]. In this paper we have synthesized cobalt ferrite nanoparticles by simple co-precipitation method at 80 ^{0}C. This method can be easily applied for bulk nanoparticle applications, such as for permanent magnets and biomedical applications.

Methodology

Synthesis of Cobalt ferrite ($CoFe_2O_4$) nanoparticles

The solution mixture of 50 ml of 1 M $FeCl_3.6H_2O$ and 50 ml of 0.5 M $CoCl_3.6H_2O$ and 7.5 M NaOH solution added by drop by drop up to pH 10-12. The solution is stirred for 45 minutes at 750 rpm at room temperature. The obtained precipitate of the solution is filtered out and washes five times with double distilled water. The obtained sample is dried in oven at 80 ˚C.

Characterisation:

Cobalt ferrite sample was characterised by X Ray Diffraction XRD (Bruker D8 Venture) to final material confirmed magnetic nanoparticle of $CoFe_2O_4$ with spinel Structured. Particle morphology is observed Scanning electron microscope SEM (FEI Nova Nano SEM 450).and composition of material identified by Energy Dispersive X-Ray Spectroscopy EDX (Bruker X Flash 6130). FTIR study confirmed that phase formation its characteristic bands.

Result and Discussion

XRD analysis

X-ray diffraction profile of samples can provide important information in qualitative phase analysis, quantitative phase analysis, determination of unit cell parameters, study of preferred orientation, and determination of particle size. Fig.1 shows the XRD pattern of $CoFe_2O_4$ characteristic peaks is matches to JCPDS file no -22-1086[14]. The XRD pattern of $CoFe_2O_4$ corresponding structure of lattice is cubic spinal and gooddetermine at (220),(311),(222),(400),(422),(511) and (500) reflections are XRD patterns in fig.1 No extra impurity is found.

From debye-scherror formula

$$d = 0.89\frac{\lambda}{\beta cos\theta}$$

where λ is a X ray wavelength and θ is a braggs angle. We have evaluated particle size from most intensity peak (311) full thickness half maximum. The mean size of particle is 15-25µm. Fig. 1 showed $CoFe_2O_4$ crystalline phase of nanoparticles by exactly similar peaks. The XRD result identified characteristic $CoFe_2O_4$ by major peak (311) sample almost 2θ=35.390 which is most important major peak of cubic spinal. The result shows that reaction temperature 353K is preferable for growth of cobalt ferrite crystallite. All the peaks recorded single phase spinal structure and no one more phase is observed.

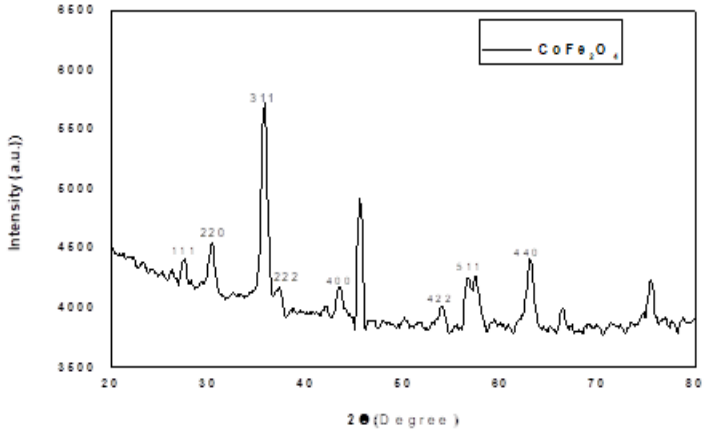

Fig.1: XRD pattern of the prepared ($CoFe_2O_4$) cobalt ferrite particles.

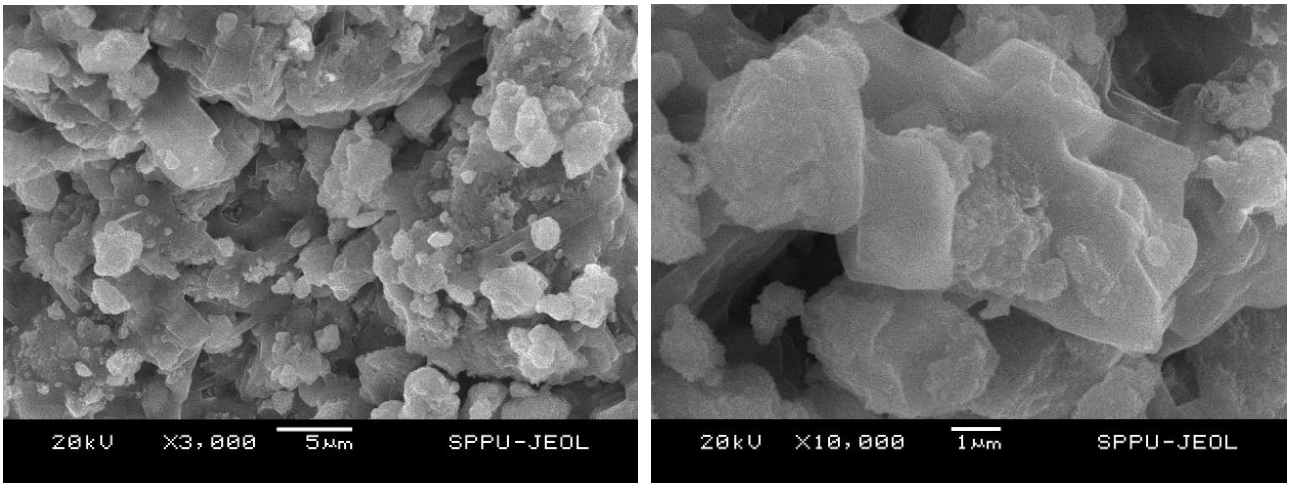

Fig 2: SEM images of Cobalt Ferrite and ($CoFe_2O_4$) nanoparticles.

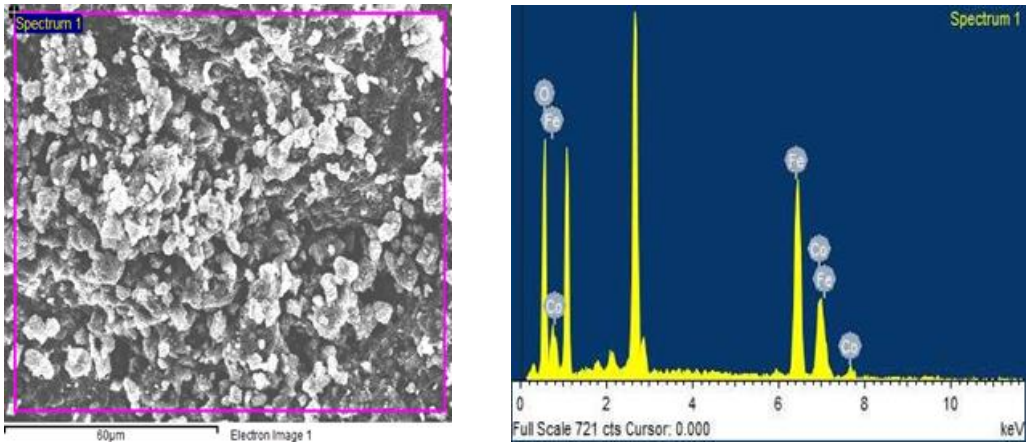

Fig 3: EDS image of prepared cobalt ferrite nanoparticles.

Element	Weight%	Atomic%
O K	42.00	72.00
FeK	39.06	19.18
Co k	18.94	8.82
Totals	100.00	

SEM and EDX

The morphology and particle size of as-prepared$CoFe_2O_4$ particle synthesized by chemical co-precipitation method investigated by using SEM micrograph as shown in fig 2. The SEM images reveal the morphology and microscopic structure of ferrite nanoparticles which are in agreement with the XRD results. The images imply considerable degree of agglomeration of ferrite particles due to its magnetic nature and the combination of primary particles held together by weak surface interaction such as the vander Waals forces.

From SEM images it also ovserved that particles are distributed non uniformly.

The elemental analysis of the $CoFe_2O_4$ nano ferrite samples was done by Energy dispersive spectrometer

(EDS). The product of $CoFe_2O_4$ of all the compositions has been determined by the EDS and the patterns obtained are shown in Fig.3 shows the presence of Co, O, Fe. A quantitative EDS analysis is used to calculate the composition of $CoFe_2O_4$ particle. The result shown in molar ratio of $CoFe_2O_4$ is about 1:2.1:3.8 which ostensible composition.

Conclusion

Cobalt ferrite nanoparticle have been successfully synthesised using simple co-precipitation technique at 80^0 C. XRD pattern and SEM micrographs shows crystallinity and spinal structure of sample. The average particle size estimated by XRD is 20 nm. The XRD and EDS result shows the quantitative sample analysis and sample is in pure phase.

Conflicts of interest: The authors stated that no conflicts of interest.

References

1. R.Illa, R.Jeskoa,c , R.Silbera,c , O.Zivotskyd , K. M.Kutlakovaa , L.Matejovaa, , M.Kolencíkf , J.Pistoraa,c .J.Hamrleg. Materials Research Bulletin 117(2019)96-102
2. D.M. Jnaneshwara, D.N. Avadhani ,Daruka Prasad , B.M. Nagabhushana, H. Nagabhushana , S.C. Sharma , C. Shivakumara , J.L. Rao , N.O. Gopal , S.Ke , R.P.S. Chakradhar.(339)2013.
3. K. Maaz, A, Mumtaza,, S.K. Hasanaina , A.Ceylan mag.mate.308 (2007) 289–295
4. N Karthigayan, P Manimuthu , M Priya , and Suresh Sagadevan. Nanomaterial and nanotechnology 2017.
5. L. J. Cote, A. S. Teja, A. P. Wilkinson, Z. J. Zhang. Fluid Phase Equilibria 210 (2003) 307–317
6. Y.Il Kim, D. Kim, C. Lee. Physica B 337 (2003) 42–51
7. M. Vadivel, R. Ramesh Babu, K. Ramamurthi , M. Arivanandhan. Nano.stru.and nano.obj.11(2017)112-123
8. K. L. Routray, B.Sahoo, D.Behera. MRX-108359.R1
9. C.Xiangfeng, J.Dongli, G. Yu, Z.Chenmou. Sensors and Actuators B 120 (2006) 177–181
10. N. Labchir, N. Labchir , A. Hannour , A. Ait Hssi , D. Vincent, K. Abouabassi, A. Ihlal , M. Sajieddine.mate.sci.in.semi.pro.111(2020)104992
11. N. Gandhi, K.Singh, A.Ohlan , D.P. Singh , S.K. Dhawan . com.sci.amd technology.71(2011)1754-1760
12. S.Munjal, N.Khare , C.Nehate , V.Koul .jon.ofmag.and mag.mater.404(2016)166-169
13. V. Blaskov , V. Petkov , V. Rusanov , Ll.M. Martinez , B. Martinez , J.S. Mufioz M. Mikhov . Journal of Magnetism and Magnetic Materials 162 (1996) 331-337.
14. JCPDS data base 22-1086.