Effect of Bi Substitution and Irradiation on and Magnetic properties Cobalt Ferrite Nanoparticles

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Introduction

Magnetic systems with spinel structure have garnered interest for its role in wide range of applications due to their large spin polarization and high magnetic critical temperatures, typically well above the room temperature. Ferrimegnetic and electrical properties of the spinel ferrites strongly influenced by the distribution of cations along with Fe^{3+}-Fe^{2+} between the tetrahedral and octahedral sites. Particularly, cobalt ferrite, inverse spinel at bulk and partial inversion in nano order. The inter play of cations in site occupation tune the electric and magnetic properties of the cobalt ferrite. In the present study we have tried to tune the magnetic properties of the cobalt ferrite by substituting the Cr^{3+} in place of iron.

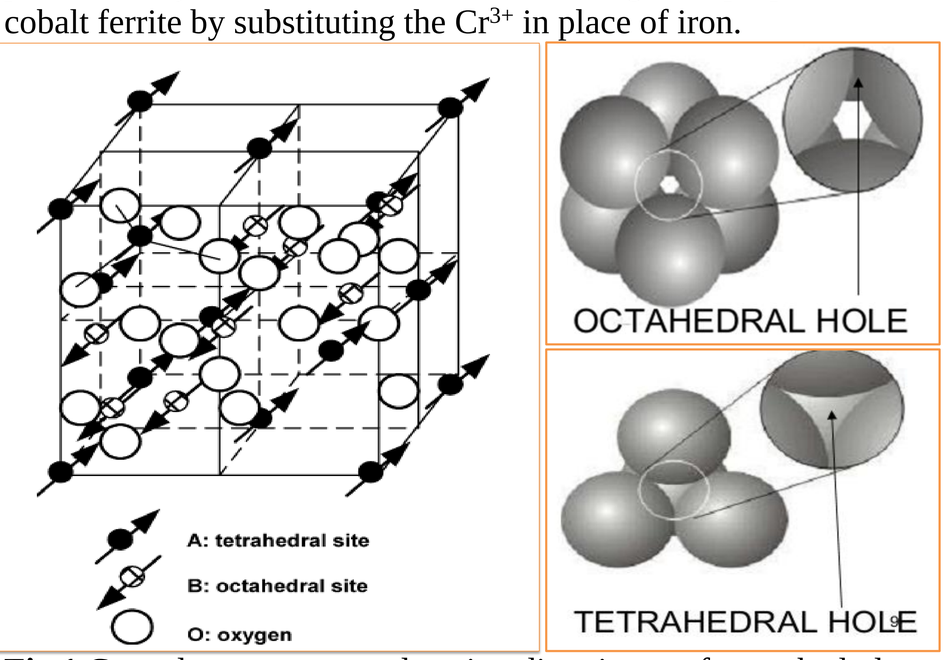


Fig.1. Crystal structure and spin directions of tetrahedral and octahedral sites.

$[Co_{1-x}Fe_x]_A [Co_xFe_{2-x}]_B O_4$ A and B represents tetragonal and octahedral sites. The net magnetization is $M_{A\sim}M_B$.

If x=0 Normal spinal
x=1 Inverse spinel
0<x<1 Partial inversion

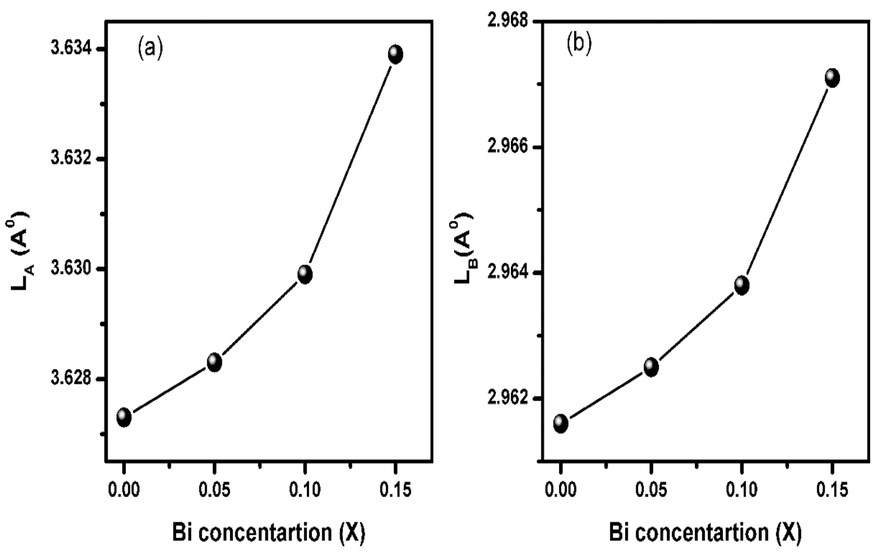


Fig.5. Variation of hoping length (a) tetrahedral (L_A) and (b) octahedral (L_B) sites as a function of Bi concentration

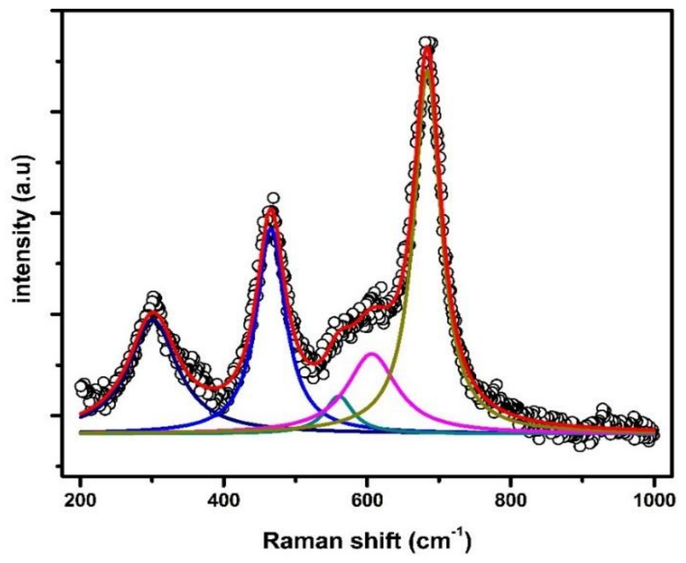
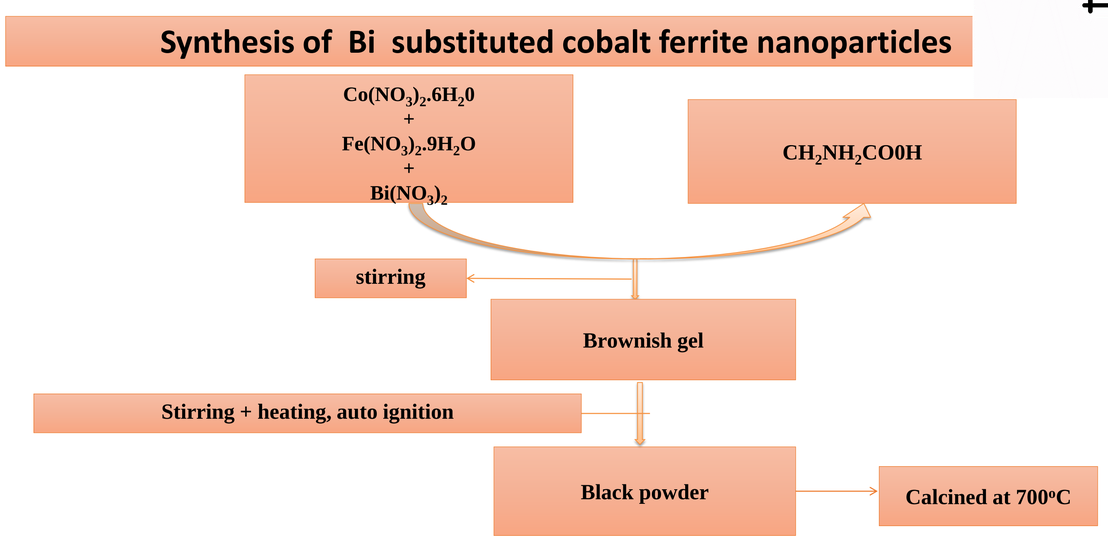


Fig.6. Raman spectra of 0.1 Bi substituted cobalt ferrite nanoparticles.

Synthesis of Bi substituted cobalt ferrite nanoparticles



Surface morphology of Bi substituted cobalt ferrite nanoparticles

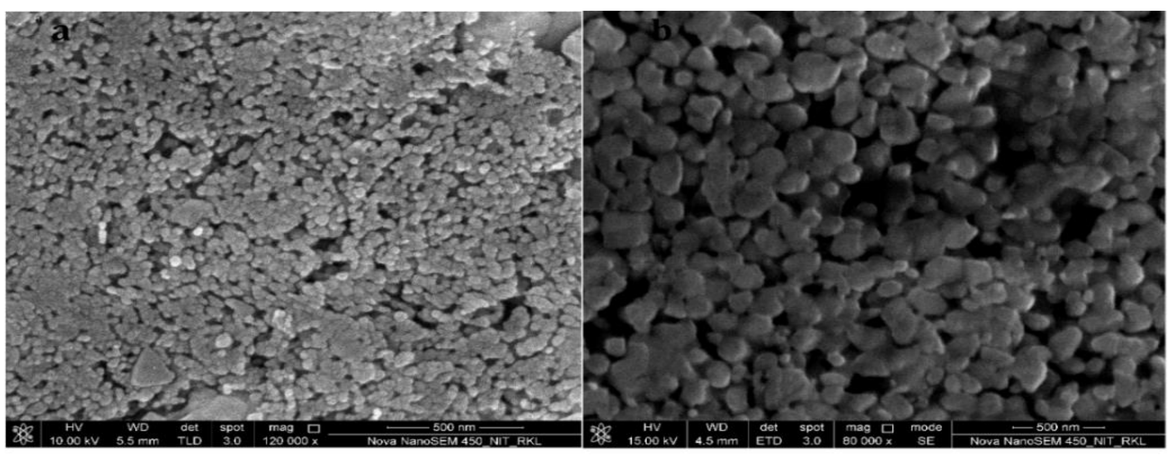


Fig.2 FESEM image of the $CoFe_{2-x}Bi_xO_4$

Structural analysis of Bi substituted cobalt ferrite nanoparticles

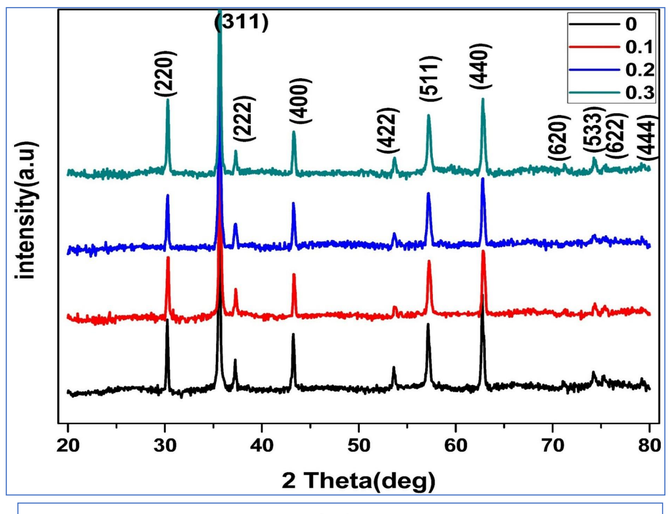


Fig. 3. XRD pattern of the $CoFe_{2-x}Bi_xO_4$

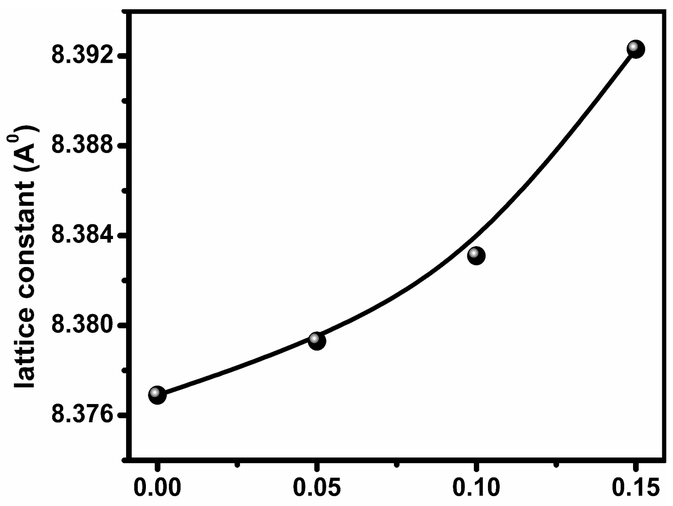
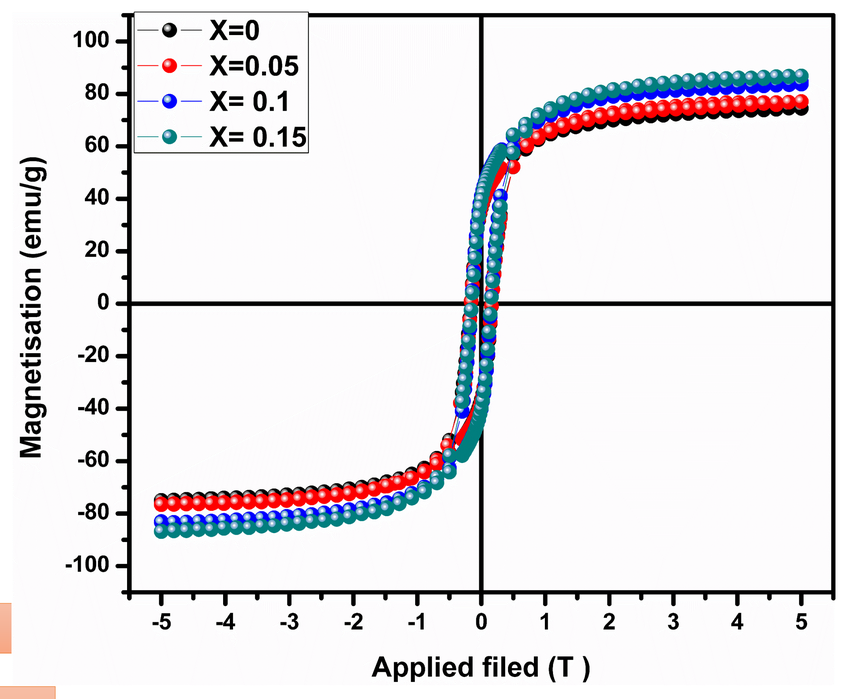


Fig. 4. XRD pattern of the $CoFe_{2-x}Bi_xO_4$

Magnetic properties



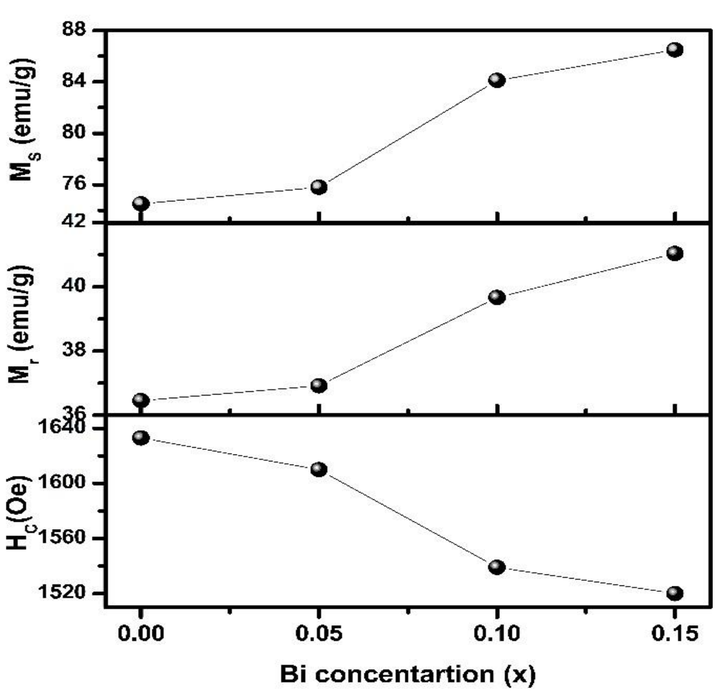
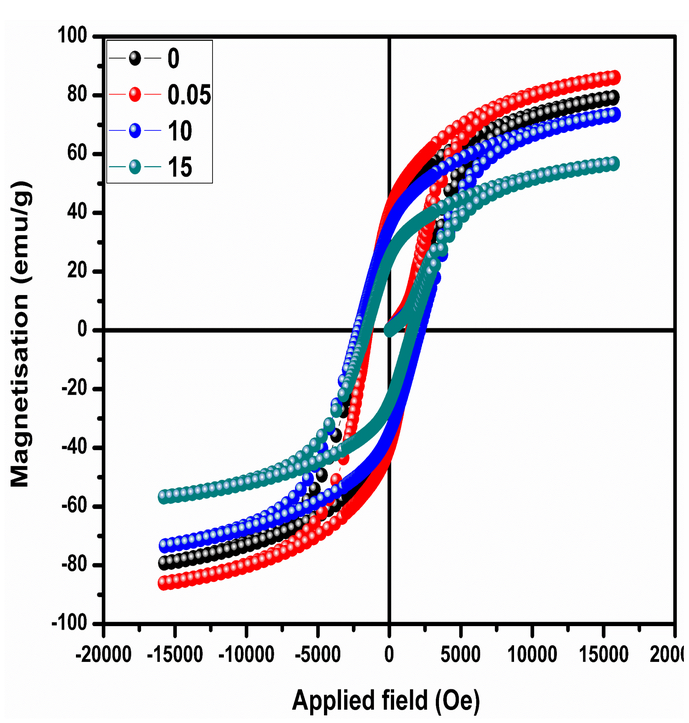


Fig.7. M-H loop and variation of magnetic properties of Bi substituted cobalt ferrite nanoparticles



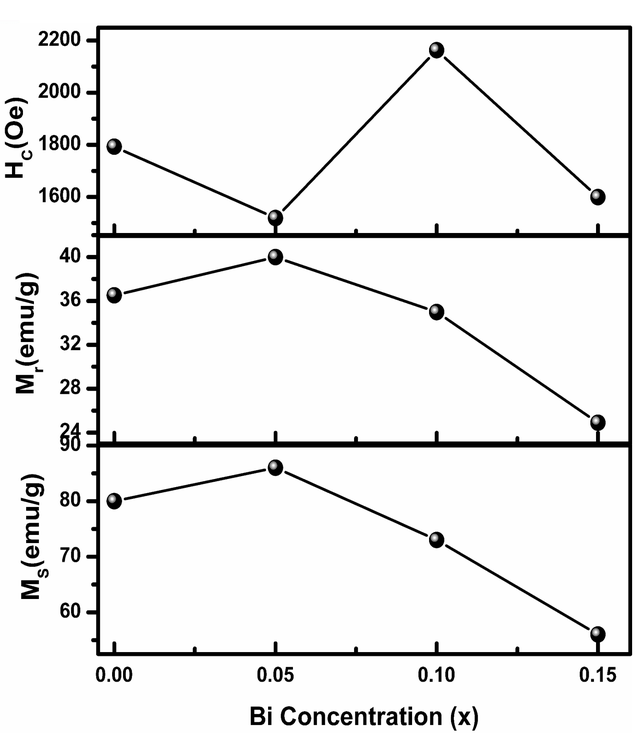


Fig.8. M-H loop and variation of magnetic properties of Bi substituted and gamma ray irradiated cobalt ferrite nanoparticles

Conclusion: Bi^{3+} substituted spinel cobalt ferrite nanoparticles prepared by auto combustion method. Phase was confirmed by the XRD analysis and the particle size was estimated from the surface morphology (which is in nano range) study of FESEM image. Particle size and hoping length were increased with the substitution of Bi^{3+} due to the large size of bismuth compared to the iron. The magnetic properties of Bi substituted cobalt ferrite nanoparticles analyzed before and after gamma irradiation. Before gamma radiation saturation magnetization and remnant magnetization increased with Bi substitution while coercivity decreased. In case of irradiated samples there is irregular variation of magnetic properties with bismuth substitution. In this case saturation magnetization and remnant increased form parent to 5% substitution after that decreased. Coercivity showed higher value in 10% substitution and remaining samples showed lower than the parent cobalt ferrite.