THE INFLUENCE OF Zn DOPING ON THE CATION DISTRIBUTION AND STRUCTURAL PROPERTY IN FERRITE SPINEL $CoFe_2O_4$

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Spinel ferrite MFe_2O_4 (M = Co, Fe, Mn, Zn...) has a face-centered cubic crystal structure and belongs to the $Fd\bar{3}m$ space group [1].

Based on the distribution of M and Fe cations on the tetrahedral and octahedral sites, the structural formula of MFe_2O_4 is defined as $\left(M_{\delta}^{2+}Fe_{1-\delta}^{3+}\right)\left[M_{1-\delta}^{2+}Fe_{1+\delta}^{3+}\right]O_4^{2-}$, where the round brackets and square brackets represent the tetrahedral and octahedral sites, respectively, $0 < \delta < 1$ is the inversion factor, there are 3 types: normal ($\delta = 1$), inverse ($\delta = 0$) and mixed spinel ($0 < \delta < 1$) [1].

Cobalt ferrite $CoFe_2O_4$ (CFO) has attracted great research interest due to its potential applications in many fields such as high-density data storage, lithium batteries, sensors, magnetic fluids, electronic generators, environmental, biomedical, etc., as well as its attractive physical properties [2, 3]. The replacement of magnetic Co^{2+} by non-magnetic cations Zn^{2+} in the spinel ferrite phase can cause significant changes in their structural, optical, magnetic, and other properties, due to the distribution of cation ions between the available A and B sites. A recent study showed a similar effect when $CoFe_2O_4$ nanoparticles synthesized by the sucrose-assisted combustion route were doped with Zn, both saturation magnetization (Ms) and remanent magnetization (Mr) decreased with increasing Zn concentration, which was also related to the occupancy of octahedra and tetrahedra [4].

In this paper, we present a systematic study of the structural and magnetic properties of Zn-doped CFO prepared by the solid-state reaction method and using a combination of X-ray diffraction, neutron diffraction, Raman scattering, X-ray photoelectron spectroscopy (XPS), and magnetic measurements. The X-ray diffraction and neutron diffraction results demonstrate that the Zn-doped CFO have a cubic spinel structure belonging to the $Fd\bar{3}m$ space group. The XPS spectrum shows that the presence of Zn^{2+} ions causes the change of Fe^{3+} cations from tetrahedral sites to octahedral sites and the opposite for Zn^{2+} cations. The saturation magnetization decreases significantly with increasing Zn doping concentration. The results obtained show that the magnetic moment of site A decreases as non-magnetic Zn ions increase at site A, leading to paramagnetism, while the magnetic moment of site B increases as Fe^{3+} ions increase at site B.

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