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Doping of Nano Zinc Ferrites by Chromium: Structural and Magnetic Properties Studies

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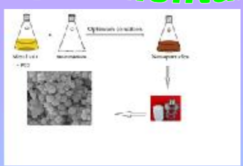
Abstract

A series of Chromium-substituted Zinc ferrites ($Cr_xZn\ Fe_{2-x}O_4$ with = 0.00, 0.10, 0.20, 0.30, 0.40) were synthesized via hydrothermal method. The structural characterizations of all the prepared samples were done using XRD, FTIR and EDAX, TEM, HR-TEM and TGA measurements . These studies confirmed the formation of single-phase inverse spinel structure in all the compositions. From HR-TEM measurments, crystallinity are observed to increase with increase of the concentration of Chromium. The surface morphology and particle size of a typical sample were determined using SEM and TEM respectively. The substitution of Chromium strongly influences the magnetic characteristics, and this is confirmed from the magnetization measurements at different temperatures.

INTRODUCTION

The nanoferrites are interesting materials owing to their wide range of applications in modern science and technology. They have recently attracted considerable research interest on their structural, magnetic and electrical properties. These structures are attractive for microwave applications, magnetic sensors and catalytic materials owing to their great magnetic permeability and dielectric constant, low dielectric loss, high Curie temperature as well as mechanical strength and chemical stability at low frequencies. The properties of ferrite nanoparticles are influenced by composition and microstructure. The addition of impurities induces changes in the defect structure and texture of the crystal, creating significant modifications in the magnetic and electrical properties of these materials. A spinel structure, as spinel ferrite, prompts two types of interstitial sites, tetrahedral and octahedral. These sites are surrounded by four and six oxygen atoms, respectively. Among different spinel ferrites, the zinc ferrite is of special interest. It has a wide range of applications such as photo-conductive materials, information storage and sensors, electronic devices and high frequency application.

Experimental



Results and Discussion

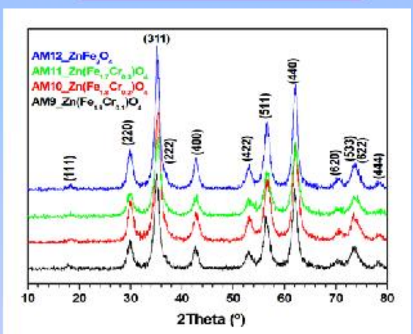


Fig 1. XRD patterns of $ZnFe_2O_4$ nanoparticles and their doping with Chromium.

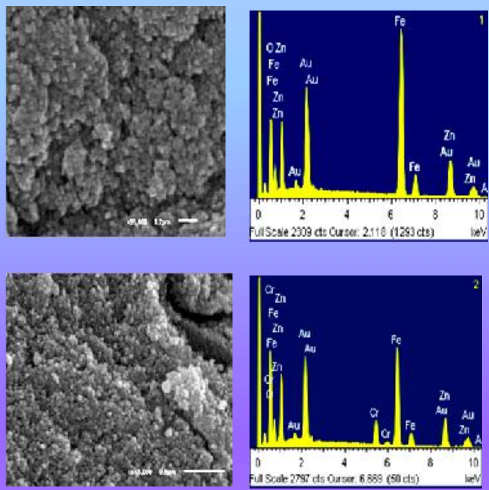


Fig. 2. SEM images and EDS for AM11, 12 samples.

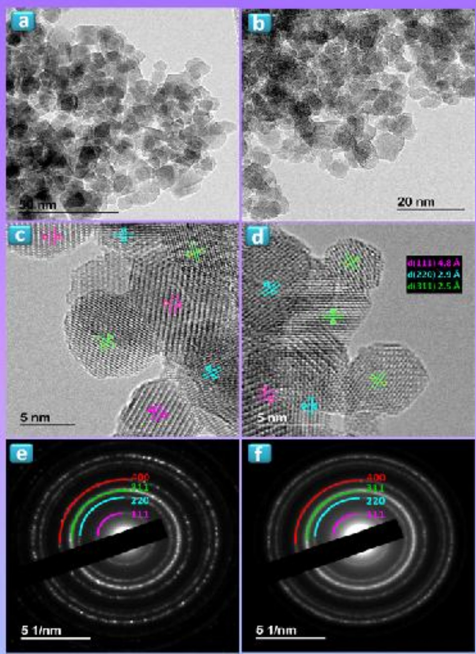


Figure 3. (a,b) TEM images, (c,d) HRTEM images, and (e,f) selected area electron diffraction (SAED) patterns for AM12 (left) and AM11 (right) samples.

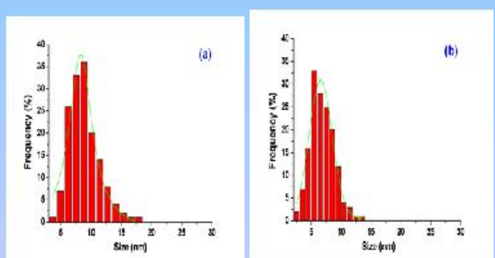


Fig.4. Histograms of particle-size distribution for **AM12** (a) and **AM11** (b).

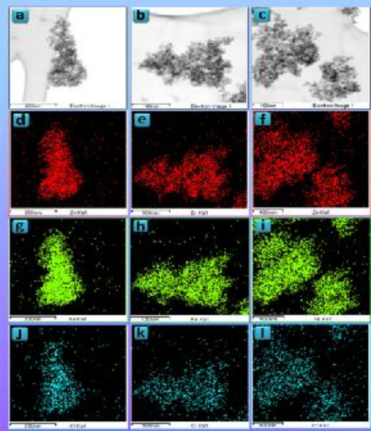


Figure 6. Elemental mapping for AM11 (a,d,g,j), AM10 (b,e,h,k) and AM9 (c.f.i,l) samples: (a-c) BF-STEM images, (d-f) Zn Kα$_1$ maps, (g-i) Fe Kα$_1$ maps and (j-l) Cr Kα$_1$ maps.

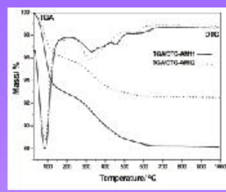


Fig.7. TGA/DTG curves of as-prepared AM11(solid) and AM12 (dotted).

Magnetic Characterization

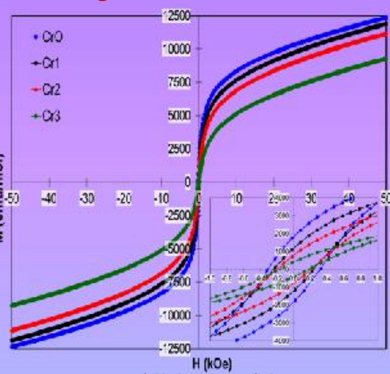


Figure 8. Magnetic field dependence of the magnetization measured at 5 K (M-H loops) of Cr doped $ZnFe_2O_4$ samples. Inset magnifies the central area of the hysteresis loops.

Conclusion

In summary, we have demonstrate that hydrothermal technique is a feasible and effective processing route for synthesize pure Cr doped Zn-ferrites. X-ray powder diffraction and electron microscopy confirm the single-phase nature for all compositions being partially inverse spinel structures with similar cubic cell parameters. On this sense, superparamagnetic state is observed over an extended range below room temperature whereas ferrimagnetic ordering is established at low temperature 5 K. In addition, surface spin canting is considered as the main cause of the large forced susceptibility.

References

[1] N. Kumari, V. Kumar, S.K. Singh J. Alloys and Comp. 622 (2015) 628.

[2] M. A. A. Ali El-Remaily, A. M. Abu-Dief, Tetrahedron, 71, 2579-2584, (2015)