A comparison between Curie temperature of nano and bulk Al doped nickel ferrite

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Abstract: Nanocrystalline Al-doped nickel ferrite NiAl0.5Fe1.5O4 has been synthesized by sol-gel method. The X-ray diffraction (XRD) revealed that the powder obtained is single phase with spinel structure. Average crystallite size has been calculated by Scherrer's formula. Magnetic hysteresis loop was measured at room temperature with a maximum applied field of 8000 Oe. The Curie temperature (Tc) obtained by Faraday balance. The results show that magnetization decreases whit decreasing of particle size and Curie temperature increases.
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Keywords: Sol-gel; Ni-Al ferrite; Nanocrystalline; Magnetic properties; Curie temperature.

1. Introduction

There are many methods for preparation of fineparticle ferrites[1]. The preparation technique plays an important role in surface properties and the Curie temperature (Tc) can also be varied by substitution of non-magnetic cations[2]. In the present investigation, we have employed sol-gel method to synthesize Al-doped nickel ferrite nanoparticles. This method offers a significant saving in time and energy consumption over the traditional methods, and requires less sintering temperature. This method is employed to obtain improved powder characteristics, more homogeneity and narrow particle size distribution, thereby influencing structural, electrical and magnetic properties of spinel ferrites. In this work, NiAl0.5Fe1.5O4 fine powder was prepared by sol-gel method. It has been shown that single-phase Ni-Al ferrite fine particles can be prepared by this method, at a temperature much lower than is associated with the conventional ceramic method.

information to measure the effect of climate change and anthropogenic changes on vegetation.

The forest herbs, which play important role for rural communities for example, the livestock totally dependent on them for fodder and as traditional medicines, have been hardly studied from diversity standpoint (Singh and Singh 1987). Quantitative information on the forest floor species of the Central Himalaya region is generally lacking except for studies done by Rawat and Singh (1989), and Singh and Singh (1992). Interestingly, most of the recent major field experiments addressed questions relating to species diversity which has been carried out in grasslands. But forest herbs of the Himalayan region remain poorly studied.

In the present study we investigate herb species richness (spermatophyte) in terms of taxonomical diversity and species composition in relation to oak and pine forests in Central Himalayan forests.

2. Experimental procedure

2.1. Synthesis technique

Nanocrystalline powder of NiAl0.5Fe1.5O4 was prepared by sol-gel method. The citric acid (C6H8O7.H2O), nickel nitrate (Ni(NO3)2.6H2O), ferric nitrate (Fe(NO3)3.9H2O), and aluminum chloride(AlCl3.6H2O) were used as starting materials. The metal nitrates were dissolved together in a minimum amount of de-ionized water to get a clear solution. A clear solution of citric acid was mixed with metal nitrates solution, then ammonia solution was slowly added to adjust the pH at 7. The mixed solution was heated on a hot plate with continuous stirring at 90-100◦C. During heating the solution became viscous and finally formed a very viscous green gel and began to bubble, after 1h a hard black mass was remained. The as-prepared powder was heat treated at 500◦C for 2h to get the final product.

2.2. X-ray diffraction (XRD) studies

The structural characterization of the as prepared ferrite powder was carried out, using Bruker D8 XRD system with CuKα radiation (wavelength, λ=1.5406Å). The average particle size D was calculated using XRD data, employing the Scherrer's formula:

$$D=0.9\lambda/\beta\cos\theta$$

Where β is the angular line width at half maximum intensity and θ is the Bragg angle of the peaks.

2.3. Magnetic measurements

Magnetic measurements were performed using the AGFM. Magnetic hysteresis loop was measured at

room temperature with maximal applied magnetic fields up to 8000 Oe.

The Curie temperature of the sample was measured by Faraday balance.

3. Results

Fig. 1 shows XRD pattern of NiAl0.5Fe1.5O4 sample. The XRD pattern clearly indicates that the prepared sample contains cubic spinel structure only Average crystallite size has been calculated by Scherrer's formula. The results are as showen in table 1. Al3+ ion has strong preference to occupy octahedral sites [3]. The removal of magnetic Fe3+ ion from magnetic sublattice and substitution of the nonmagnetic Al3+ ion in its place weakens the superexchange interactions, which tends to align the neighboring dipoles antiparallelly. This substitution decreases the magnetization of the sample, compared to nickel ferrite nanoparticles as was reported in other works [4].

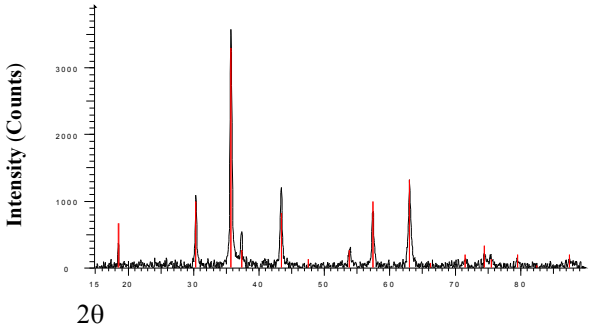

Figure 1. X-ray diffraction pattern of NiAl0.5Fe1.5O4 nanoparticles.

Table 1: Structural and Magnetic properties of NiAl0.5Fe1.5O4 nanoparticles.			
NiAl0.5Fe1.5O4			
D(nm)	a(Å)	M(8000 Oe)(emu/gr)	Tc(◦c)
21.42	8.31	14.9	720

Magnetic hysteresis loop of Al-doped nickel ferrite NiAl0.5Fe1.5O4 nanoparticles measured at room temperature using AGFM are shown in Fig. 2. At maximal applied field of 8000 Oe, the saturation was not achived.

The value of magnetization at applied magnetic field of 8000 Oe for NiAl0.5Fe1.5O4 nanoparticles was measured to be 14.9 emu/gr. Which is approximately lower than the value of the bulk sample at room temperature [5].

Perhaps most noteworthy of our results is that the Curie temperature measured for NiAl0.5Fe1.5O4 nanoparticles, approximately 720◦C, is nearly of twice the measured bulk value of 390◦C [6]. Because the sample is in nano size maybe the increase in Curie temperature is due to the decrease in particle size that also has been reported in other work [7].

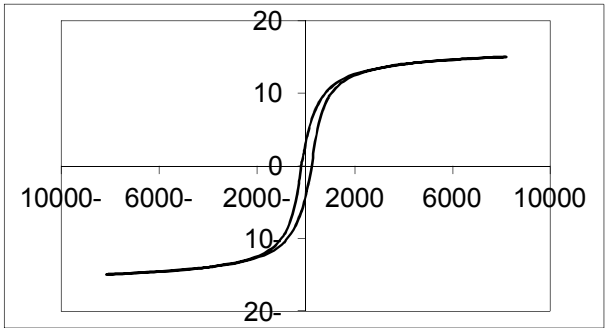

Figure 2. Magnetic hysteresis loop of NiAl0.5Fe1.5O4 nanoparticles.

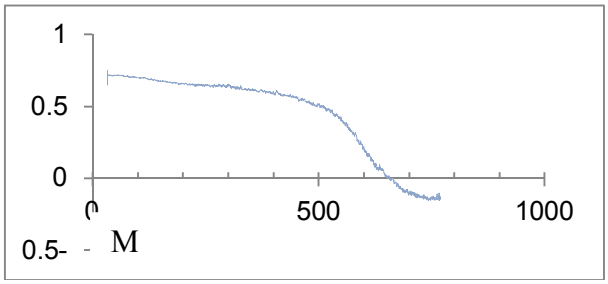

Figure 3. Curie temperature of NiAl0.5Fe1.5O4 nanoparticles.

4. Conclusion

This research work shows that by substitution of Al 3+ for Fe3+ in nickel ferrite, the value of magnetization is decreased and by decreasing the particle size a further decrease is observed, also a noticeable increased in Curie temperature was observed.

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