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# Mössbauer Study of nano-sized $(Li_{0.5x}Fe_{0.5x}Zn_{1-x})Fe_2O_4$ particles

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## Introduction

The substituted lithium ferrites combine useful ferromagnetic properties with high Curie temperature ranging from 550℃ to 850 ℃,[1] high saturation magnetization,[2] and low microwave dielectric loss.[3] Saturation magnetization of $(Zn_{1-x}Fe_x)_A[Li_{0.5x}Fe_{2-0.5x}]_BO_4$ increased with zinc concentration, followed by a decrease at x = 0.7.[4] This is attributed to a dilution of the A-site with zinc which initially causes an increase in saturation magnetization due to the dominance of the B-site. Further increase in the zinc concentration causes to reduce the A-B interaction, resulting in a decrease in the saturation magnetization. High temperature annealing above 1150 ℃ causes the lithium to become volatile and consequently the magnetic properties are lost.[5] In this paper, we report a Mossbauer results of nano-sized lithium zinc ferrite particles and magnetic properties of zinc substituted lithium ferrite particles.

## Experimental

Lithium ferrite particles, (Li0.5xFe0.5xZn1-x)Fe2O4 ($0 \leq x \leq 1$), have been prepared by a high energetic ball milling process. The as-ball milled samples were annealed in air at various temperatures ranging from 600 to 1000 ℃ for 3 hours. X-ray diffraction measurements were preformed on all the powder samples with Cu K radiation. Magnetic properties were measured by a vibrating sample magnetometer with the maximum field of 10 kOe. The morphology and particles size of annealed samples were observed using TEM. The Mössbauer spectra were obtained in sinusoidal mode at room temperature and 77 K to understand changes in saturation magnetization and coercivity with the concentration of zinc.

## Results and Discussion

The lattice constant increases linearly with an increase in Zn content. This is generally explained by the volume differences of the cations. An increase in the lattice constant of the Zn ion is due to the ionic radius of $Zn^{2+}$, which is larger than other cations. For x = 0.7, the particle size is in the range from 20 to 50 nm, and the particle shape is maintained up to 700 oC where the saturation begins to plateau at 80 emu/g.

The saturation magnetization increases with increasing x and reaches the maximum (about 80 emu/g) at x = 0.7, followed by a decrease to 60 emu/g for x = 1 The coercivity increases with the value of x up to 0.7, then followed by a decrease. For x = 0.7, it was observed that the coercivity linearly decreases with increasing the annealing temperature.

In the Mössbauer parameters for x = 0.7 with different annealing temperature, the value of the hyperfine field has no significant variation with the annealing temperature, but the width of the outer line decreases with increasing annealing temperature. This is in consistent with the saturation magnetization variation with the annealing temperature. The line width for the outer line of Mössbauer spectrum decreases with increasing the annealing temperature, implying a decrease in the coercivity with the annealing temperature.[6]

The Mössbauer spectra for x = 0.7 and 0.9 all exhibit a well-defined Zeeman pattern consisting of two separate six line Zeeman patterns, one attributed to the $Fe^{3+}$ ions at the A site, tetrahedral, the other attributed to the $Fe^{3+}$ ions at the B site, octahedral. The x = 0.5 sample shows a ferromagnetic relaxation spectrum as shown in Figure 4 (a), and x = 0.1 and 0.3 show very similar paramagnetic spectra. Figure 4 (b) shows the clear sextet patterns superposed on a weak central doublet in 77 K Mössbauer spectra.

## Conclusion

A ball milling technique process reduces the annealing temperature down to 700 ℃ because of enlarged surface area. Loss of lithium was not observed in lithium zinc ferrite annealed at 1000 ℃ for 3 hours. The lithium zinc ferrite particles size was in the range of 20 to 50 nm. The lithium zinc ferrite at x = 0.7, posses the lowest coercivity (6 Oe) and the highest saturation magnetization (about 80 emu/g). The maximum magnetic saturation at x = 0.7 is due to the exchange interactions within the two magnetic sublattices, which are the tetrahedral and the octahedral sites. A decrease in the coercivity with annealing temperature is explained by a decrease in the line width of out line of Möossbauer spectrum.

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