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Superexchange interactions in inverse spinel lithium ferrites

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Spinel ferrites, MFe_2O_4 (M = Ni, Mg, Co, Li) samples were prepared by sol-gel method. It has been studied by X-ray diffraction, Mössbauer spectroscopy. X-ray diffraction patterns were analyzed by the Rietveld refinement. The samples have been cubic spinel structure with the lattice constant (a_0) is 8.326 ~ 8.390 Å. The temperature dependence of the magnetic hyperfine field is analyzed by the Néel theory of ferrimagnetism. The intersublattice A-O-B and intrasublattice A-O-A superexchange interactions are found to be antiferromagnetic while the intrasublattice B-O-B superexchange interaction is ferromagnetic for the MFe_2O_4 (M = Ni, Mg, Co) samples as shown in Table 1. On the other hand, the intersublattice superexchange interaction is found to be antiferromagnetic while the intrasublattice superexchange interactions are ferromagnetic for the lithium ferrite sample.

1 Introduction

Spinel ferrites, MFe_2O_4 (M = Ni, Mg, Co, Li) are well known ferrimagnetic materials with an inverse spinel structure [1–3]. Cobalt ferrite is hard magnetic material with high coercivity (5400 Oe), but the others MFe_2O_4 (M = Ni, Mg, Li) are soft magnetic materials. Studies on the superexchange interaction of ferrite have been reported by a number of authors [4, 5]. Specially, lithium ferrites have been studied for cathode materials in rechargeable lithium batteries as well as low-cost substitutes to garnet materials $Y_3Fe_5O_{12}$ in microwave frequency applications [6–8]. It has been reported that $Li_{0.5}Fe_{2.5}O_4$ prepared by solid state reaction has ordered structure below 735 °C and disordered structure around 1000 °C [9, 10]. Disordered structure is generally inverse spinel structure with space group $Fd3m$ and ordered structure corresponds to space group $P4_332$.

In this work, we have tried to study the difference of exchange interaction between disordered $Fd3m$ and ordered $P4_332$ with ordered cation distribution on the octahedral site in lithium ferrite. The temperature dependences of the magnetic hyperfine fields for ^{57}Fe nuclei at the tetrahedral (A) sites and the octahedral (B) sites are analyzed by using the Néel theory of ferrimagnetism.