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Neutron diffraction and magnetic structure studies on Co-Al ferrite
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Al substituted CoAl\textsubscript{x}Fe\textsubscript{1-x}O\textsubscript{4} (x = 0.1, 0.3, 0.5) samples were fabricated using the sol-gel method, and their magnetic and structural properties have been studied with x-ray and neutron diffraction, Mössbauer spectroscopy and magnetization measurements. The crystals of the samples x = 0.1, 0.3, and 0.5, fired at 1000 °C, were found to have a cubic spinel structure with lattice constants of \( a_0 = 8.3864 \), 8.3670, and 8.3392 Å, respectively.

Mössbauer data were collected in the temperature range of 14-850 K. The temperature dependence of the magnetic hyperfine field in \( ^{57}Fe \) nuclei at the tetrahedral (A) and octahedral (B) sites was analyzed based on the Néel theory of magnetism. For the sample CoAl\textsubscript{0.1}Fe\textsubscript{1.9}O\textsubscript{4}, the intersublattice A-B interaction and intrasublattice A-A superexchange interaction were antiferromagnetic with strengths of \( J_{A-B} = -23.3 \, k_B \) and \( J_{A-A} = -18.0 \, k_B \), respectively, while the intrasublattice B-B superexchange interaction was found to be ferromagnetic with a strength of \( J_{B-B} = 5.6 \, k_B \). While for the sample CoAl\textsubscript{0.5}Fe\textsubscript{1.5}O\textsubscript{4}, the strengths of the A-B, A-A and B-B interaction were \( J_{A-B} = -21.4 \), \( J_{A-A} = -13.6 \), and \( J_{B-B} = 4.1 \, k_B \), respectively.

Neutron diffraction patterns on CoAl\textsubscript{0.1}Fe\textsubscript{1.9}O\textsubscript{4} and CoAl\textsubscript{0.5}Fe\textsubscript{1.5}O\textsubscript{4} were obtained at various temperature ranges from 10 K to Néel temperature, and all cation distributions and atomic distances were determined by Rietveld refinements. Neutron diffraction at 10 K for CoAl\textsubscript{0.1}Fe\textsubscript{1.9}O\textsubscript{4} revealed a cubic spinel structure of ferrimagnetic long range ordering, with magnetic moments of Fe\textsuperscript{3+}(A)(-4.18 \( \mu_B \)), Fe\textsuperscript{3+}(B)(4.81 \( \mu_B \)), Co\textsuperscript{2+}(B)(2.98 \( \mu_B \)), respectively. The changes of exchange interactions with Al substitution are interpreted on the basis of cation distributions and bond lengths. It is interpreted that a noticeable strength of the A-A interaction and the unusual reduction of magnetic moment are closely related to the covalency effects.