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Relation between Mössbauer Spectroscopy and Geometrical Frustration Factors in $\text{MCr}_{1.98}^{57}\text{Fe}_{0.02}\text{O}_4$ (M = Co, Zn)

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In order to elucidate the role of Cr ions in MCr_2O_4 (M = Co, Zn) exhibiting geometrically frustration and multiferroic property [1, 2], we have substituted a small amount of Fe ions for Cr sites and investigated the magnetic behavior of Fe ions using by Mössbauer measurement. The spinel $\text{MCr}_{1.98}^{57}\text{Fe}_{0.02}\text{O}_4$ powders were prepared by wet chemical solution process. The crystal structure was found to be single-phase cubic spinel with space group of $Fd\bar{3}m$. The lattice constants a_0 and the internal structural parameter (x) of the oxygen were determined to be 8.340, 8.331 Å and 0.261 and 0.260, respectively. Mössbauer spectra of $\text{MCr}_{1.98}^{57}\text{Fe}_{0.02}\text{O}_4$ were taken from 4.2 to 295 K using a ^{57}Co source in a rhodium matrix. The Mössbauer absorption spectra at 4.2K show that the well developed two sextets are superposed with small difference of hyperfine fields (H_{hf}). The hyperfine fields of $\text{CoCr}_{1.98}^{57}\text{Fe}_{0.02}\text{O}_4$ and $\text{ZnCr}_{1.98}^{57}\text{Fe}_{0.02}\text{O}_4$ were determined to be 490–480 kOe and 460–450 kOe, respectively. Isomer shift values (δ) of the two sextets are found to be 0.33–0.35 mm/s relative to the Fe metal, which are consistent with the high spin Fe^{3+} charge state. From the results of Mössbauer measurement, it is suggested that Cr^{3+} ions have two different magnetic sites, and is correlated between hyperfine fields and degree of magnetic geometrical frustration.

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