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Mössbauer studies of geometrical frustration spinel ZnCr$_{1.98}^{57}$Fe$_{0.02}$O$_4$

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In order to elucidate the role of Cr ions in ZnCr$_2$O$_4$ exhibiting geometrically frustration[1, 2], we have substituted a small amount of Fe ions for Cr sites and investigated the magnetic behavior of Fe ions, on nano scale, using Mössbauer measurement. The spinel ZnCr$_{1.98}^{57}$Fe$_{0.02}$O$_4$ powders were prepared by wet chemical solution process. Weighted amounts of zinc nitrate, chrome nitrate, and $^{57}$Fe isotope were dissolved in acetic acid, ethanol, nitric acid, and distilled water. The solution was refluxed at 80 °C for 12 hours to allow the gel formation and then dried at 120 °C in a dry oven for 24 hours. The dried powder was ground and annealed at 1000 °C for 3 hours in air. The crystal structure was found to be single-phase cubic spinel with space group of $Fd\overline{3}m$. The lattice constant $a_0$ and the internal structural parameter ($\alpha$) of the oxygen were determined to be 8.331 Å and 0.260, respectively. Mössbauer spectra of ZnCr$_{1.98}^{57}$Fe$_{0.02}$O$_4$ were taken from 4.2 to 295 K using a $^{57}$Co source in a rhodium matrix. At room temperature paramagnetic doublet is observed. Isomer shift values ($\delta$) of doublet is found to be 0.23 mm/s relative to the Fe metal, which are consistent with the high spin Fe$^{3+}$ charge state.

The absorption spectra at 4.2K show that the well developed two sextets are superposed with small difference of hyperfine field ($H_{hf1}= 463$ and $H_{hf2}= 453$ kOe). Isomer shift values ($\delta$) of the two sextets are found to be 0.33 and 0.34 mm/s relative to the Fe metal, respectively, which are consistent with the high spin Fe$^{3+}$ charge state.

References
