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Site Determination of Mn Doping in Protein Encapsulated $\gamma$-Fe$_2$O$_3$ Nanoparticles

V. POOL, Dept of Physics, Montana State University, M. KLEM, C. JOLLEY, T. DOUGLAS, Dept. of Chem. and Biochem, Montana State University, M. YOUNG, Dept. of Plant Sciences and Pathology, Montana State University, E. ARENAHOLZ, Advanced Light Source, Berkeley National Labs, Y.U. IDZERDA, Dept of Physics, Montana State University — In this study, Mn has been doped (0-33%) into 6 nm, $\gamma$-Fe$_2$O$_3$ nanoparticles grown inside the horse-spleen ferritin (HSF) protein and compared to similarly protein encapsulated pure $\gamma$-Fe$_2$O$_3$ and Mn-oxide nanoparticles to determine the Mn doping site. By using soft-X-ray absorption spectroscopy (XAS), soft-X-ray magnetic circular dichroism (XMCD), and frequency dependent Alternating Current Magnetic Susceptibility (ACMS), we have ascertained that the Mn dopant is substituting preferentially as Mn$^{2+}$ and prefers the octahedral site in the $\gamma$-phase Fe$_2$O$_3$ spinel structure. The measured Mn L$_{23}$ XAS spectra are compared to measured reference powders and molecular-orbital calculations supporting this conclusion of the Mn dopant substitution site. We find that the Mn L$_{23}$ XAS multiplet structure for the nanoparticles is simpler than for our bulk standards, complicating this identification but suggesting that the nanoparticle lattices are relaxed from the distortions present in the bulk.

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