Magnetic Characteristics of Metal-doped Magnetite Nanoparticles Produced by *Thermoanaerobacter Ethanolicus*

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This work examined the magnetic properties of pure and metal-doped magnetite powders which were synthesized by a bacterially mediated process under anaerobic conditions. The iron(III)-reducing bacterial strain *Thermoanaerobacter ethanolicus* TOR-39, isolated from deep subsurface sediments, was incubated under anaerobic conditions at 65°C for 2 weeks in aqueous medium containing amorphous iron(III) oxyhydroxides (akaganeite). The microbial process produced several grams per liter of culture volume of uniformly sized single domain nanometer sized magnetite particles outside of bacterial cells. Particle size was verified using X-ray diffraction (XRD) and dynamic light scattering. Average crystallite size from XRD using the Scherrer method was 45 nm for the pure magnetite which agreed well with results from dynamic light scattering. The magnetic properties were characterized using a superconducting quantum interference device (SQUID) magnetometer. Zinc doped magnetite exhibited a saturation magnetization (at 5 K) of 100 emu/g while a value of 77 emu/g was observed for pure magnetite particles of roughly the same size. The low temperature biologically mediated production of metal-doped magnetite is also highly scalable allowing the production of large quantities within days. The process has shown its capability to produce metal (Zn, Mn, Ni, Co)- doped magnetites that may potentially exhibit utility in biogeoscience, magnetorheological materials, nanotechnology, or biomedical applications.