

Scaling up production of biogenic magnetite for industrial use

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Magnetite nanoparticles have a high surface to volume ratio and magnetic properties that can be exploited for a wide range of applications including targeted cancer therapies [1], magnetic data storage devices [2] and bioremediation [3-4]. Fe(III)-reducing bacteria produce nanoscale magnetite through the reductive transformation of low crystallinity Fe(III)-bearing oxides [5]. However, the commercial applicability of biogenic nanoparticles depends critically upon the ability to generate kg to tonne quantities of the nanoparticles. Therefore this technology relies upon the upscaling of laboratory biotransformation experiments which are commonly performed at 10 to 100 ml volumes. The goal of this study was to develop a batch fermentation of *Geobacter sulfurreducens* which could then be used to generate large quantities of biogenic magnetite that match the performance of the biomaterials made at small scale in the laboratory.

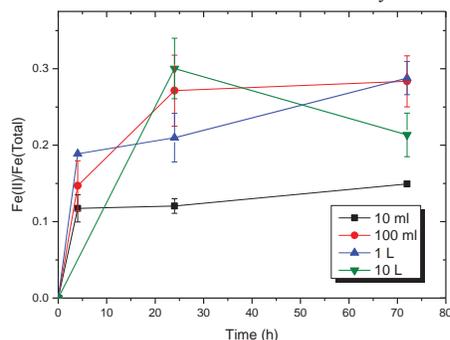


Figure 1: Fe(III) reduction (monitored by Fe(II) measurements by ferrozine) for bioreduction of Fe(III)oxyhydroxides during scale up of biomagnetite production.

Fermentation was carried out at 50 L scale and this led to production of biogenic magnetite via the reduction of Fe(III) oxyhydroxide in vessels from 10 ml to 10 L in size, containing 50 mmoles/L of Fe (Fig. 1). Spectroscopy (XAS/XMCD), microscopy (ESEM/TEM) and testing of the material against model contaminants, such as Cr(VI), was carried out to determine the quality and performance of the materials produced from the industrial scale fermentation.

[1] Goya et al. (2008) *Current Nanoscience* **4**, 1-16. [2] Zeng et al. (2006) *Phys Rev B* **73**, 4. [3] Hencl et al. (1995) *Water Res* **29**, 383-385. [4] Cutting et al. (2010) *Environ Sci Technol* **44**, 2577-2584 [5] Lovley et al. (1987) *Nature* **330**, 252-254.

Isotopic composition of volcanic sulfate aerosols

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Volcanic sulfur dioxide is oxidized in the atmosphere to sulfate aerosols. Volcanic aerosols present in the stratosphere, by altering the atmospheric albedo and energy balance, can impact the global climate significantly. Records of past volcanic eruptions are needed to determine the role of volcanism in climate change.

Polar ice cores provide some of the most valuable volcanic records constructed from time series of sulfate in snow. The time coverage of such records can be as long as tens of thousands of years. However, many of the sulfate signals in these records may be from relatively small tropospheric eruptions with no significant climatic impact and therefore should be excluded from consideration when investigating the volcano-climate connection.

We have found that the sulfate converted from volcanic sulfur dioxide in the stratosphere contains unique isotopic signatures [1,2]. Mass independent fractionation (MIF) of sulfur isotopes in sulfate indicate photolysis-based conversion reactions in the stratosphere and therefore can be used to identify climate-impacting stratospheric eruptions in the ice core records [3,4]. We present here sulfur isotope measurement of volcanic sulfate in Greenland and Antarctica ice cores. In addition to sulfur-33 data discussed in previous work, we present data of sulfur-36 MIF excess in the sulfate of several volcanic eruptions in the last 1,000 years and discuss the possible interpretation of the new data in terms of the reaction mechanism of the oxidation of sulfur dioxide to sulfate.

[1] Savarino et al. (2003) *Geophys. Res. Lett.* **30**, 2131. [2] Baroni et al. (2008) *J. Geophys. Res.-Atmos.* **113**, D20112. [3] Cole-Dai et al. (2009) *Geophys. Res. Lett.* **36**, L22703. [4] Lanciki et al. (2011) *Geophys. Res. Lett.* **39**, L01806.