

# Microbial reduction of synthetic Biogenic Iron Oxides containing various amounts of Organic Carbon and Silica

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## Abstract

Iron oxides formed in close association with bacteria are referred to as biogenic minerals (BIOS). Both the organic part of BIOS and the iron oxide particles affect the net surface charge of those iron-organic carbon aggregates and offer reactive sites that can immobilize many soluble contaminants (Warren and Haack 2001) making BIOS a contender in bioremediation technologies. However, before using BIOS in bioremediation, it is essential to understand the interactions of impurities such as organic matter and other minor components (including silica) (Dyer et al. 2010). This project involves the synthesis of Biogenic Iron Oxides (BIOS) using various silica contents and different soluble alginate concentrations (as an analogue for bacterial exopolysaccharides) close to natural environmental conditions. The mineralogical, chemical and physical composition of the synthesized samples was determined by X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Field Emission Scanning Electron Microscopy (FESEM), Fourier-transform Infrared Spectroscopy (FTIR), and with a Malvern Zetasizer Nano instrument. The various samples (mainly ferrihydrite) were then reduced in the presence of *Shewanella putrefaciens* CN32, a well-known iron reducing bacterium. All microbial reduction experiments (see Table 1) with different types of BIOS were performed under anoxic conditions.

Results indicate that the ratio of organic matter and silica to Fe (III) in BIOS affects the reduction rate. It is proposed that alginate binds to iron oxide particles and protects them from reduction. However, samples in presence of high concentration of silica (i.e., > 0.05) showed structural disorder which likely prevented nucleation of well ordered ferrihydrite, which in return increased their rate of reduction. In addition, higher reduction rates of ferrihydrite were reported at higher concentrations of silica in BIOS, even in the presence of alginate.

## Keywords

Ferrihydrite, Alginate, Silicate, coprecipitation, Reduction, *Shewanella* CN32

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## Conflicts of interest

The authors have declared that no competing interests exist.

## References

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Table 1.

Percentage of the reduced Fe and linear reduction rates for BIOS containing different molar ratios of organic matter and silica to Fe(III) in hydrous Fe oxides (HFO).

| Sample                          | Maximum Fe Reduced (%) /day | Reduction Rate (day <sup>-1</sup> ) | R <sup>2</sup> |
|---------------------------------|-----------------------------|-------------------------------------|----------------|
| HFO                             | 1.9                         | 0.026±0.005                         | 0.998          |
| Alginate HFO 0.03               | 2.29                        | 0.027±0.001                         | 0.953          |
| Alginate HFO 0.04               | <b>4.18</b>                 | <b>0.037 ±0.005</b>                 | <b>0.953</b>   |
| Alginate HFO 0.05               | 2.14                        | 0.016±0.001                         | 0.970          |
| Alginate HFO 0.06               | 1.26                        | 0.016±0.002                         | 0.967          |
| Silicate HFO 0.001              | 2.2                         | 0.028±0.003                         | 0.963          |
| Silicate HFO 0.005              | 2.9                         | 0.021±0.002                         | 0.950          |
| Silicate HFO 0.01               | 1.2                         | 0.014±0.001                         | 0.985          |
| Silicate HFO 0.05               | <b>2.8</b>                  | <b>0.047±0.006</b>                  | <b>0.949</b>   |
| Silicate HFO 0.1                | <b>4.5</b>                  | <b>0.026±0.003</b>                  | <b>0.946</b>   |
| Alginate 0.03 + Silica 0.05 HFO | <b>3.95</b>                 | <b>0.048 ±0.005</b>                 | <b>0.977</b>   |
| Alginate 0.03+ Silica 0.001 HFO | 3.8                         | 0.030±0.002                         | 0.982          |
| Alginate 0.03+ Silica 0.005 HFO | <b>4.5</b>                  | <b>0.028 ± 0.003</b>                | <b>0.951</b>   |
| Alginate 0.03+ Silica 0.1 HFO   | <b>4.7</b>                  | <b>0.047±0.001</b>                  | <b>0.998</b>   |