

NanoRem is a four year, €14 million research project funded through the European Commission FP7.

Introduction

- Iron nanocomposites have potential for remediation of heavy metals and organic compounds
- Conventional manufacturing methods are synthetic and involve harsh chemical regimes
- Nano-scale biogenic magnetite synthesized by the reduction of ferrihydrite by the anaerobic subsurface bacterium *Geobacter sulfurreducens* offers a benign alternative^{1, 2}
- Bionanomagnetite (bnm) is amenable to surface engineering to enhance its reactivity³
- Bnm offers a sustainable option for *in situ* remediation of heavy metals and organic compounds

Objectives

- Column studies to assess transport properties of biogenic magnetite
- Identify the stabilizers that could enhance its mobility in porous medium
- Assess the impact of stabilizers on the reactivity of biogenic magnetite
- Functionalization of bnm with palladium to enhance reactivity against metals and organics

Research methodology

- Microbiological methods to synthesize biogenic magnetite
- Analytical techniques including XRD and ICP-AES to characterize the magnetite for purity and total iron content
- Column studies involving fine quartz sand (0.3-0.8 mm diam.), as porous medium with an injection velocity of 100 m/d
- Stabilization studies using a variety of coatings to enhance mobility and transport in columns
- Reactivity studies using model organic (PCE) and metal (Cr(VI)) target compounds for remediation

Results

Reductive precipitation of palladium (II) onto the surface of bnm makes it an effective catalyst for the reduction of heavy metals and organic compounds in presence of external electron donor⁴

1. Functionalization of bionanomagnetite for remediation of chromium and organic solvents

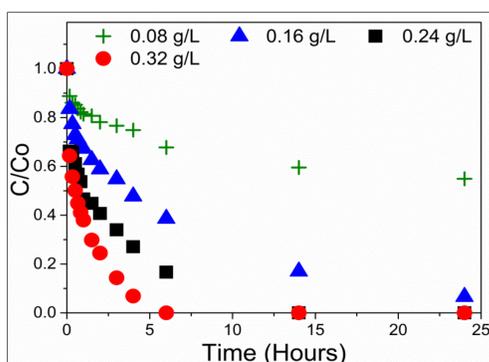


Fig. 1 C/Co of aqueous Cr(VI) concentration over time with Pd-Bnm / H₂ gas in a model Cr(VI) solution. Co denotes the starting Cr (VI) concentration, Cr (VI) level determined by dipheyl carbazide assay

The palladized bionanomagnetite promotes rapid decomposition of organic compounds nitrobenzene, perchloroethylene and trichloroethylene

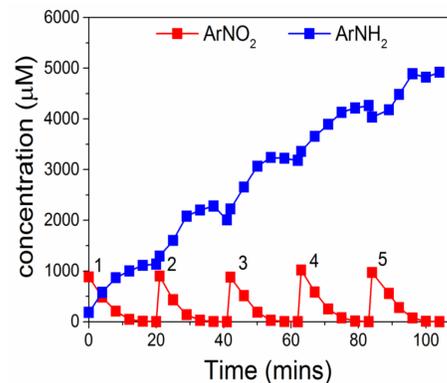


Fig.2 The concentration of the starting contaminant (ArNO₂) and accumulation of the reduced product ArNH₂ as a function of time, in the presence of Pd-Bnm/H₂. The number annotations refer to the repeated spiking of the batch experiment with 1000 μM ArNO₂

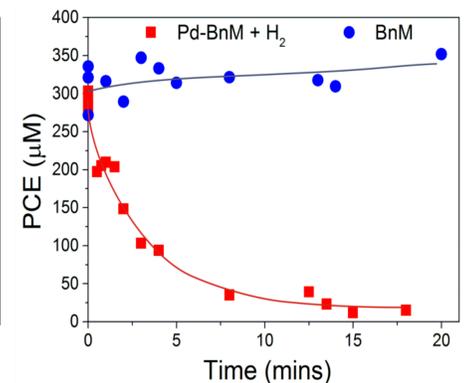


Fig.3 PCE concentration for synthetic groundwater treated with 1 g/L Fe Bnm (blue circles) and the 0.025 g/L Fe Pd-Bnm supplied with an excess of H₂ (red squares)

2. Mobility of biomagnetite through columns

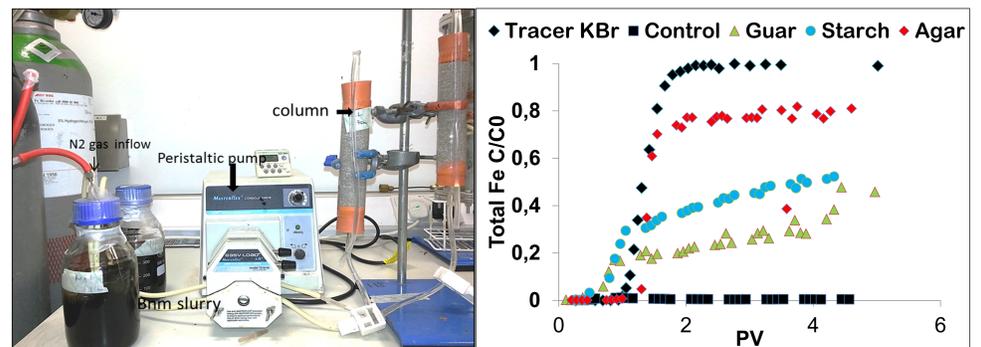


Fig. 4 (a): Columns set up for transport study Fig. 4 (b): Breakthrough curve for tracer (KBr), Control (uncoated) bnm and stabilized slurries with guar, agar and starch. Mobility was enhanced in the order agar>starch>guar>no coating.

3. Impact of the coatings on the reactivity of biomagnetite

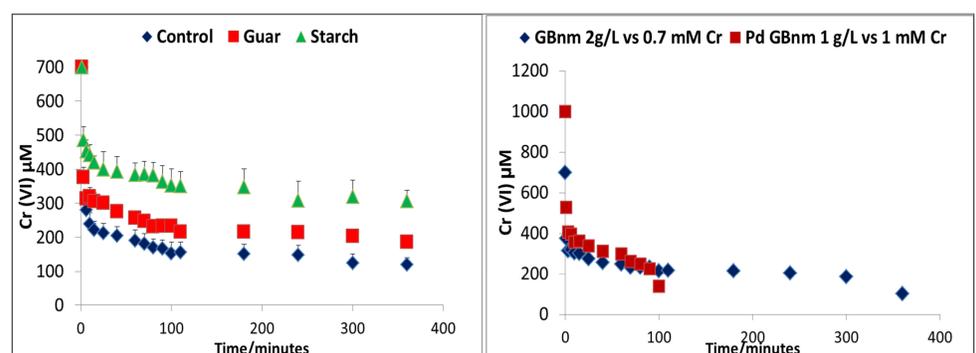


Fig. 5 Reactivity of bnm (control) and stabilized forms (guar and starch), reactivity was reduced, but remained significant, and could be enhanced with Pd additions. Fig.6 Bnm with guar (GBnm) and Pd bnm with guar (Pd GBnm).

Conclusion

- Pd bnm has significant potential for the remediation of pollutants
- Stabilization of bnm with guar (3g/L), agar (2g/L) and starch (2g/L) significantly improves its mobility in porous medium, while retaining activity
- The reactivity of coated bnm can be further improved by doping its surface with Pd (0)

