Recent progresses in the mineral encapsulation of cells

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The encapsulation of cells within mineral hosts is of interest for both fundamental aspects related to geomicrobiology and cell-material interactions and for applications in the design of biosensors and bioreactors [1].

For a long time, the long-term viability of immobilized bacteria within inorganic matrices was only achieved in silica-based materials [2]. Recently, we have evaluated novel nanostructured gels based on aluminium-, iron- and zirconium-oxyhydroxide colloids as hosts for *Escherichia coli* immobilization [3, 4]. In all cases, the viability rates after encapsulation were lower than for silica. However, in the presence of an organic additive, the preservation of biological activity over one month in the absence of nutrients was possible.

Attempts to correlate the properties of the inorganic colloids and resuting gels with observed viability rates suggest that two main factors, *i.e.* mineralisation kinetics and particle/cell membrane interactions, may be responsible for observed difference between the mineral gels. The possible effect of the rheological properties of the gels should also be considered.

Based on these data, the immobilization of bacterial cells can now be envisioned in a wide range of inorganic materials of geological, biotechnological and medical interest.

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The influence of humic acids on microbial Fe(III) reduction rates and iron mineral formation

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Microorganisms change the mineralogy of iron minerals in the environment by catalyzing Fe(II) oxidation or Fe(III) reduction. Mineral transformation influences magnetic properties of soils, porosity of aquifers, availability of nutrients or toxic elements and the reactivity of iron minerals. Humic substances can influence electron transfer between bacteria and Fe(III) minerals by either shuttling electrons between cells and the mineral surface, by complexing and thus solubilizing Fe(III) or by sorption to the mineral surface.

In this study 2-line ferrihydrite, a poorly crystalline Fe(III) hydroxide, was microbiologically transformed in the presence of different humic acid concentrations by the iron reducing strain *Shewanella oneidensis* MR-1. Depending on the humic acid concentration, these redox-active organic molecules were shown to either sorb to the iron mineral and hinder electron transfer by limiting the bioavailable mineral surface via aggregate formation or to function as dissolved electron mediators between cells and the mineral surface thus stimulating iron mineral reduction. The amount of adsorbed and dissolved humic acids was shown to play a key role for the competition between inhibiting or accelerating effects. Additionally, the identity of the formed mineral precipitates was determined using sequential extraction, μ-XRD and Moessbauer spectroscopy. In the presence of humic acids the formation of less crystalline iron mineral phases was observed compared to minerals formed in the absence of humic acids. This change in crystallinity potentially affects the reactivity of the minerals and the bioavailability of iron in anoxic environments.

Overall it can be concluded that a better understanding of microbially catalyzed mineral transformations, specifically in the presence of natural concentrations of humic substances, helps to evaluate and predict the reactivity of iron minerals in natural environments.