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Influence of Microbial Surfactants on Ligand Promoted Dissolution of Iron Oxides

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Iron is an essential element for most organisms. Because the solubility of Fe is exceedingly low under oxic conditions, many microorganisms actively modify their chemical environment in order to facilitate iron acquisition. For instance, molecules such as siderophores (Fe(III)-specific ligands) are produced by the biota in order to promote the dissolution of iron oxides and therefore enhance the bioavailability of iron. While it is well recognized that siderophores play an important role in ligand-promoted dissolution (Watteau and Berthelin, 1994; Kraemer, 2004), little is known about the possible interactions with other microbial exudates including microbial surfactants. At sufficiently high concentrations, surfactants form admicelles (bilayers of self-assembled molecules) at the surface of iron oxides and modify the physico-chemical surface properties. Therefore, ligand-promoted dissolution may be influenced by the presence of surfactants.

In this study, we investigated the influence of anionic surfactants on the ligand-promoted dissolution of goethite. Two anionic surfactants were considered: Rhamnolipids (RhL1 and RhL2) produced by *Pseudomonas aeruginosa* and the synthetic surfactant Sodium Dodecyl Sulphate (SDS). In a first step, we characterized the formation of admicelles on the goethite surface by conducting adsorption isotherm experiments. The effect of surfactant adsorption on the electrophoretic mobility of the goethite was measured in batch experiments. We then investigated the kinetics of ligand-promoted dissolution using the two siderophores desferrioxamine B (DFOB) and desferrioxamine D (DFOD) in batch experiments with varying surfactant concentrations.

Adsorption of the surfactants SDS and RhL to goethite at pH 6 caused a charge reversal, as was shown by electrophoretic mobility measurements. This indicates the formation of admicelles at the mineral surface. From the adsorption isotherm we can conclude that admicelle formation occurs at SDS concentrations $>$500 μM at pH 6.

The presence of SDS enhanced the ligand-promoted dissolution rates in the presence of DFOB and DFOD by a factor of 2 to 3. At a low SDS concentration (15 μM) the dissolution rate was constant over time. In contrast, at SDS concentrations above 300 μM a fast initial dissolution of goethite was observed, followed by a lower steady state dissolution rate. Furthermore, the admicelles supported the sorption of the iron-siderophore complex to the goethite surface. These observations indicate that even low surfactant concentrations can significantly enhance ligand-promoted dissolution. Bio-surfactants can therefore play an important role in biogeochemical processes such as iron acquisition and mineral weathering.

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