Bacterial interactions with solid substrates: Applications for microbial fuel cells, carbonate surfaces and metal oxide reduction

O. BRETSCHGER[1], A. OBRAZTSOVA[1], C. STURM[2], L. ZHANG[2], Y. GORBY[3], I-S. CHANG[4,5], B-H. KIM[4], F. MANSFELD[1], K. H. NEALSON[1] AND A. LUTTGE[2]

[1]University of Southern California, Los Angeles, CA
[2]Rice University, Houston, TX
[3]The J. Craig Venter Institute, La Jolla, CA
[4]Korea Institute of Science and Technology, Seoul, Korea
[5]Gwangju Institute of Science and Technology, Gwangju, South Korea

Shewanella oneidensis MR-1 is a flexible microorgansim that can use a broad range of electron acceptors, including several solid substrates. MR-1 reduces Mn(IV), Fe(III) oxides, impacts the surface morphology of carbonates, and produces power in microbial fuel cells. A microbial fuel cell (MFC) utilizes the catalytic action of bacteria to convert the chemical energy of organic or inorganic compounds into electrical energy. MR-1 catalyzed power generation and metal oxide reduction appears to be strongly dependent on how these bacteria are grown, and their ability to produce and employ specialized cytochromes for extra-cellular electrons transfer. These cytochromes are hypothesized to directly pass electrons to substrates via the cell membrane and extra-cellular appendages i.e. nanowires. MR-1's ability to change the chemistry of its local environment may also play a role in changing the surface characteristics of carbonate and other substrates during attachment. We study interactions between MR-1 and substrates with a multifaceted combination of experimental and theoretical methods. Different MR-1 deletion mutants were generated to explore the role of cytochromes in power production and metal-oxide reduction. The results show that a few key cytochromes play a role in all of the processes explored, but that their degree of participation in each process is very different.

Characterisation of Mo and V interactions with ferrihydrite as an analogue for deep-sea hydrothermal plumes processes

L. BRINZA[1], L.G. BENNING[1] AND P.J. STATHAM[2]

[1]School of Earth and Environment, University of Leeds, LS2 9JT, United Kingdom (l.brinza@earth.leeds.ac.uk, l.benning@earth.leeds.ac.uk)
[2]National Oceanography Centre, Southampton, SO14 3ZH, United Kingdom (pjs1@noc.soton.ac.uk)

In deep-ocean hydrothermal plumes molybdenum and vanadium are known to be readily scavenged by freshly formed iron oxihydroxides nanoparticles (i.e., ferrihydrite, FH) forming during the oxidation of hydrothermal vent fluids via mixing with seawater. These scavenging processes have important implications for the cycling and budget of Mo and V in the ocean, yet, no quantitative information about the mechanisms that govern the interaction between FH and Mo or V are available.

In order to study the mechanisms involved, poorly ordered ferrihydrite nanoparticles were characterised for their particle size, crystallinity and surface charge (point of zero charge = 7.96). Furthermore, the influences of sorbed inorganic carbon species, of co-precipitated Mo or V, and of ionic strength (0 - 1 M) on the ferrihydrite surface charge were studied.

The comparison between adsorption and co-precipitation for ferrihydrite and Mo or V will be discusses based on differences in the maximum uptake capacities from kinetic and thermodynamic approaches. For the first time, maximum sorption capacities of 1.32 mmol Mo/g FH and 1.79 mmol V/g FH were derived, indicating that both metals have a high binding affinity for the FH surface. Interestingly, Mo-edge X-ray absorption spectroscopic measurements of the bonding environment of Mo sorbed on- or co-precipitated with FH showed no difference in Mo speciation between the adsorbed or the co-precipitated system (tetra coordinated Mo with Mo-O first shell bond distances of 1.76 Å in both cases).

These results provide evidence that in deep-sea hydrothermal plumes the chemistry of molybdate and vanadate is strongly controlled by the presence of and interactions with neoformed FH nanoparticles.