

Effects of Coating Iron Phases with Polyacrylic Acids on the Ammonium Oxidation/PFAS Defluorination by *Acidimicrobium* sp. A6

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Background/Objectives. We have previously shown that per- and polyfluoroalkyl substances (PFAS) can be defluorinated by the Feammox bacterium *Acidimicrobium* sp. Strain A6 (A6). A6 is an autotroph often found in acidic, iron-rich sediments and uses ammonium as an electron donor and solid Fe(?) as an electron acceptor. While for a potential A6-based PFAS bioremediation scheme supplying ammonium is relatively easy, supplying and spatially distributing a solid iron oxide phase into a groundwater system is much more challenging. Iron oxides are typically positively charged and readily sorb onto the negatively charged sediments in the subsurface. To overcome this challenge, the aim of this research is to develop transportable ferrihydrite and/or goethite particles by changing their zeta potential from positive to negative, coating them with polyacrylic acid (PAA) while not decreasing the bioavailability of the treated ferric iron phase to A6 and therefore negatively affecting PFOA defluorination by this bacterium.

Approach/Activities. PAAs were selected for this purpose because they are widely used in consumer products and are not considered toxic. Four types of PAAs, spanning a wide range of molecular weights (i.e., 2.1K, 6K, 240K, and 450K), were selected and used to coat ferrihydrite and goethite in the A6 growth medium. Dynamic light scattering (DLS) and electrophoretic light scattering (ELS) measurements were performed to determine the particle size and stability of the PAA-coated iron phases. Zeta potential values were determined as a function of the pH and PAA loading. To test the bioavailability of PAA-coated ferrihydrite/goethite to A6, Feammox incubations were conducted using A6 enrichment cultures in the absence and presence of PAA-coated ferrihydrite/goethite, adding 1 mg/L of PFOA.

Results/Lessons Learned. Focusing first on ferrihydrite, the lowest negative zeta potential was achieved for a PAA/ferrihydrite ratio of 1/5 (w/w) or higher, at a pH of 5.5. While ammonium had little if any effect on particle stability of PAA-treated ferrihydrite, calcium affected particle aggregation and decreased the absolute value of the negative zeta potential, hence the calcium concentration in the growth medium was reduced, without affecting the growth of A6. Higher amounts of ammonium oxidation and fluoride production were observed in all PAA-treated samples over 50 days of incubation versus the untreated controls. Of the PAA-treated samples, the 6K-treated sample resulted in significantly more decrease in PFOA than the control during the incubation period, and the 450K-treated sample had the highest PFOA degradation rate up to Day 40 of the incubations. Although less PFOA degradation was detected in the 240K-treated sample compared to the other treatments, here too the PFOA removal at the end of the incubations was significantly higher than that of the control. These results show that PAA-coated ferrihydrite not only improves the particle stability in suspension but also has a positive impact on the Feammox process and PFOA degradation. The presence of PAA coatings resulted in significantly less buildup of ferrous ion in solution, which we hypothesize is a reason why PAA has this positive effect on the Feammox process. Based on these results, PAA 6K and 450K were selected to assess their transport in column studies. The use of goethite vs. ferrihydrite is currently being investigated, with initial results very similar for either Fe(III) phase. Although in lab incubations, we have more experience using ferrihydrite as the Fe(III) source,

goethite will be easier to obtain in quantities that might be required for a field bioremediation scheme.