Microbial reduction of hematite: effects of particle size and exopolysaccharides

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In this study we have investigated the effect of hematite particle size on the growth rate and extent of dissimilatory iron reduction by *Shewanella oneidensis* strain MR-1 and a mutant strain (Δ4179) of *S. oneidensis*, which is deficient in exopolysaccharide (EPS) production. Under anaerobic conditions at pH = 7.4, three types of electron acceptors were utilized: (1) hematite nanoparticles (avg. diameter = 10nm, surface area (SA) = 230 m^2/g), (2) hematite macroparticles (avg. diameter = 800 nm, SA = 19 m^2/g), and (3) soluble ferric citrate. Increases in cell density were observed, with nanoparticles resulting in the lowest cell growth, macroparticles an intermediate growth, and soluble ferric citrate the highest cell growth up to 68 hours for both wild type and the Δ4179 mutant strain. The wild type resulted in more pronounced differences in cell productivity between the nanoparticle and macroparticle systems. Regardless of the electron acceptor types, the Δ4179 strain showed greater cell productivity than the wild type after 24 hours of incubation. A comparison of hematite nanoparticle, macroparticle, and soluble ferric citrate reduction by the wild type showed the same trend as the cell growth data. Scanning Transmission X-ray Microscopy (STXM) was utilized to identify ferrous iron associated with the cell membrane of wild type grown with hematite nanoparticles. SEM and TEM images showed a strong association between the particles and cells for both the wild type and Δ4179 strains. The results of this study suggest that differences in hematite particle size influence cell activity and iron reduction rate. We infer that when nanoparticles adhere to cells, active sites on cell membrane may have become saturated by particles and hence cell growth and iron reduction were retarded. It is also possible that ferrous iron precipitation on the cell membranes causes an inhibitory effect similar to that of the nanoparticles. The potential role of EPS in the nucleation of ferrous iron precipitates and of suspended hematite particles in the vicinity of the cells, resulting in occlusion of active sites on cell membranes, is also considered.