

Title: MODELING THE KINETICS OF REMOVAL FOR URANIUM(VI) AND SULFATE FROM AQUEOUS SOLUTIONS IN THE PRESENCE OF SULFATE-REDUCING BACTERIA (DESULFOVIBRIO, CLOSTRIDIUM, BIOMINERALIZATION)

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Abstract: The objective of these studies is to describe and characterize the reactions involved in the reduction and precipitation of heavy metal ions by both a mixed culture of sulfate-reducing bacteria (SRB), as well as a pure culture of *Desulfovibrio desulfuricans* (ATCC 7757). The enzymatic reduction of soluble hexavalent U(VI) to insoluble tetravalent U(IV) by *Desulfovibrio desulfuricans* has been reported. Further studies have shown that the electron transport enzyme cytochrome c_3 in *Desulfovibrio vulgaris* could reduce U(VI) to U(IV). The hypothesis of this current study is that enzymatic bioreduction is the dominant mechanism in the removal of soluble U(VI) from an aqueous solution containing a mixed culture of sulfate-reducing bacteria in the presence of an electron donor.

A mixed culture of sulfate-reducing bacteria was isolated from an acid mine drainage treatment column with subsequent development of a simple growth medium utilizing lactate as both the carbon source and electron donor. Analysis of the 16s rRNA genes present in this culture indicate that both a *Desulfovibrio vulgaris* and a non-SRB *Clostridium sp.* are present. Gram stains of the culture indicate that the G+ *Clostridium sp.* composed approximately 10–20% of the culture, and the remaining is represented by the G-SRB. Two cultures were examined for the enzyme kinetics of U(VI) and sulfate reduction: the *D. vulgaris* dominated mixed culture and a pure culture of *Desulfovibrio desulfuricans* (ATCC 7757). Reduction with U(VI) alone, sulfate alone, and U(VI) in conjunction with sulfate, for both cultures, was monitored utilizing a developed method with ^{233}U and/or ^{35}S as tracers, by scintillation counting, for U(VI) and sulfate reduction.

Models were fit to the experimentally obtained U(VI) and sulfate reduction data. A modified non-growth Monod model using five variables describes the U(VI) only reduction for both cultures, while a standard zero order model, with respect to sulfate, best fits the sulfate alone data. A first order model best describes the removal of U(VI) from solution in the presence of sulfate which is still best described by a zero order model. A significant lag time to U(VI) and sulfate reduction was observed at low cell concentrations with both cultures and was inversely correlated to cell concentration.

Transmission electron microscopy (TEM) provided the visualization of the mixed culture cells, *Desulfovibrio vulgaris* with a *Clostridium sp.*, both from uranium free growth culture and after a uranium reduction experiment. An electron dense, cell produced biomineralized mass was visible and appeared to emanate from the cells periplasmic space. (Abstract shortened by UMI.)