Microbial Sorption of Plutonium and the Role of Extracellular Polymeric Substances

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Decades of nuclear weapons testing and production have left a legacy of radionuclide contamination at many sites around the world. One of the most pressing concerns is the eventual fate of the radionuclides released into the environment. Plutonium (Pu) is of particular concern as over 2000 metric tons have been deposited in the subsurface worldwide. Its long half-life (239Pu - 2.4 x104 yr) coupled with high toxicity makes it of concern for long-term risk assessments. Complications in predicting environmental behavior of Pu arise from its ability to exist in different oxidation states (III, IV, V, and VI) and the resulting differences in geochemical behavior. Additional complexities in Pu behavior occur in the presence of microbes and microbial exudates.

We examined the sorption of Pu (IV) and Pu(V) to an aerobic bacterium Pseudomonous sp, isolated from Pu-contaminated groundwater collected at the Nevada National Security Site (Nevada, USA). To quantify the contribution of extracellular polymeric substances (EPS) to Pu sorption, we compared Pu sorption using cells with and without bound-EPS. Our results showed that while bound-EPS contributes significantly to Pu(V) sorption across a wide concentration range, cells with and without EPS showed the same sorption capacity towards Pu(IV). Oxidation state analysis of Pu in the supernatant indicates near complete reduction of Pu(V) in the presence of cells containing bound-EPS, but not with EPS-free cells, suggesting that bound-EPS promotes Pu(V) reduction. Bound-EPS extracted from Pseudomonous sp. also promoted rapid reduction of Pu(V). With 13C labeled glucose as the carbon source, we extracted 13C enriched bound-EPS and examined its composition using Nuclear Magnetic Resonance spectroscopy (NMR). The bound-EPS is primarily comprised of polysaccharides, a number of low molecular weight compounds, and aromatic functional groups, phosphorous functional groups were identified. The potential roles of these functional groups in Pu complexation and reduction will be discussed. Prepared by LLNL under Contract DE-AC52-07NA27344.