Bacterially-Produced Uraninite – Ultrastructural Characterization by High Resolution Imaging and Analyses

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Uranium (U) in contaminated aquifers poses a serious environmental threat for soils and groundwater at present and in the future. One of the strategies for U(VI) immobilization in soils is microbially-mediated reduction of soluble U(VI) to a relatively insoluble uraninite, UO_2(s).

The reduction of U(VI) by *Shewanella oneidensis* MR-1 was studied in experiments to examine bioreduction kinetics. Biogenic U(IV) nanoparticles were observed to specifically precipitate in the periplasm, the exterior face of the cell outer membrane and with extracellular polymeric substances [1]. The uraninite structure was characterized by correlated methods of electron microscopy, including chemical and nanodiffraction analyses by energy-dispersive spectroscopy and selected-area electron diffraction coupled with transmission electron microscopy (TEM) and additionally by high-resolution, aberration corrected, scanning-transmission electron microscopy (STEM).

The aberration corrected STEM enabled the unparalleled atomic-level imaging of newly formed biominerals and could be correlated with absorption spectroscopy analyses of the insoluble uranium species material by x-ray absorption near edge structure (XANES) and extended x-ray absorption fine structure (EXAFS), that were performed earlier [2, 3].

This new methodology of direct imaging with atomic resolution will allow for the investigation of hypotheses studying electron transfer-driven uranium reduction mechanism(s). Direct visualizations of nascent nanoparticulate U(IV) and particle aggregation state will have important implications for predicting the transport and fate of heavy metals and radionuclides in the environment.

[1] Marshall *et al PLoS Biol*. (2006), **4**:1324 –1333 [2] Burgos *et al Geochim. Cosmochim Acta* **72** (2008), 4901-4915 [3] Boyanov *et al* (2011) *Environ. Sci. Technol*. 2011, **45**, 8336–8344