Mercury toxicity and mercury resistance in a bacterial model system

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The toxic heavy metal mercury (Hg) occurs naturally as the ore cinnabar (HgS) in many places on Earth. Given its protean chemical and physical properties and despite its toxicity, Hg has been used in many ways by humans for millenia, leading to its dispersal well beyond its natural deposits.

Hg toxicity

Since the rise of oxygen in the atmosphere, many aerobes have relied upon thiol homeostasis to maintain a low cytosolic redox poise. Hg is a thiol homeostasis poison. We use global proteomics system to dissect the toxicity mechanisms of various chemical forms of mercury and to identify the most vulnerable metabolic subsystems as biomarkers for Hg exposure.

Hg resistance

With increased atmospheric oxygen, key redox enzymes and metalloregulators in bacteria and archaea evolved into a defense system allowing cells to recover from Hg exposure. This suite of enzymes, transporters, and regulatory genes, known as the mercury resistance *(mer)* operon, is one of the most widely found genetic loci in aerobic and facultative bacteria and archaea. We are connecting the biophysical and biochemical properties of these *mer* proteins to other cellular proteins and metabolic processes upon which the *mer* locus depends for resources while detoxifying reactive mercury compounds.

A simplified quantitative and conceptual model of Np sorption to natural sediments

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Safe disposal of actinide bearing wastes requires an in depth analysis of countless variables that determine the type of controls required to minimize the risk to the public, workers, and the environment. Conceptual and quantitative models describing the subsurface transport of actinides, such as Np, can be developed considering the rates and extent of sorption to sediments, ligand complexation reactions, and redox transformations. However, this can be a long and tedious process and sometimes is unable to accurately depict macro scale heterogeneities present at field scale conditions. This ability to use a simplified model that still captures the inherent complexity of actinide interfacial reactions will greatly reduce model complexity while still maintaining accuracy. The aim of this work was to examine Np sorption to Savannah River Site end member subsurface sediments and to quantify the influence of reduction of Np (V) to Np (IV), ligand complexation, and sorption hysteresis. Experiments have shown that neither various reductants at environmentally relevant concentrations nor anaerobic, reducing conditions were able to reduce Np (V) to Np (IV). The addition of NOM also did not result in an increase or decrease in sorption. Np desorption experiments indicated that sorption was a reversible process indicating little to no sorption hysteresis. Ultimately, sorption of Np to both end member soils could be described by assuming a single reaction: Np sorption to iron oxide as a bidentate mononuclear surface complex. FITEQL was used to fit experimental sorption data at Np concentrations ranging from 10^{-7} to 10^{-10} M using surface complexation constants for Np (V)-goethite interactions [1, 2]. For each of the end member soils, the concentration of iron sites involved in Np sorption were between 3.5-4.1% of the total extractable iron determined by the citrate-dithionite-bicarbonate method. This simple model is based upon a conceptual understanding of Np interfacial reactions and can be used to predict Np sorption behavior under varying geochemical conditions.

[1] Turner (1995) CNWRA Rept. 95-001. [2] Nakayama and Sakamoto (1991) *Radiochim. Acta*. **52/53**, 153-157.