SERDP Strategic Environmental Research and Development Program
Conservation
CS-1267

Nano-Engineered Electrochemical Sensors for Monitoring of Toxic Metals in Groundwater

Background:

The present state-of-the-art for groundwater monitoring relies heavily on withdrawal of water samples for subsequent laboratory analysis. This process is time consuming and operator-intensive. The use of in situ sensors would obviate much of the sample manipulation and on-site labor required. However, the current generation of sensors for monitoring metal ion concentrations are fairly simple non-selective devices; the typical suite of sensors measure reducing potential, pH, temperature, water level, and conductivity. These sensors record the general chemical nature of the groundwater, but they are insufficient to determine concentrations of particular classes of metals of interest. Species-selective sensors are needed to detect and quantify concentrations of metal ions in aqueous media.

Objective:

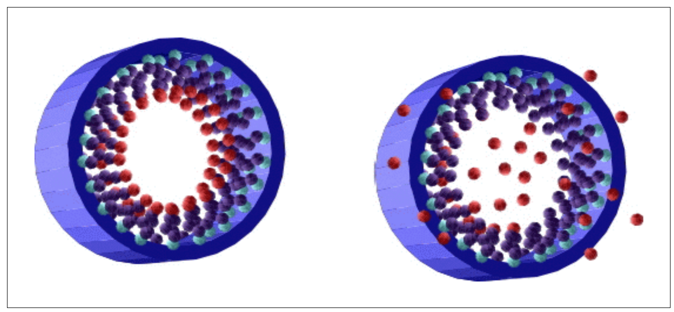
The overall objective of this research is to establish a proof of principle for a new class of sensors that utilize electrically conductive, high surface area sorbent material. The research aims (1) to develop the fabrication technology that combines the desired conductive matrices, mesoporous supports, and adsorptive coatings; (2) to test materials for uptake of aqueous lead (Pb) and mercury (Hg); and (3) to demonstrate the sensitivity of the Square Wave Anodic Stripping Voltammetry (SWASV) technique using the novel electrodes to measure aqueous Pb and Hg ion concentrations.

Summary of Process/Technology:

This project will develop a novel class of microscale electrochemical sensors for measurement of metal ion concentrations in aqueous streams. The sensors will be based on highly porous, functionally coated electrodes. These materials afford significant capacities for adsorption of metal ions to functional ligands embedded in the electrically conductive coating. Metal ion concentrations will be determined using preconcentration/voltammetry at electrodes impregnated with suitable ligands. Ion-specific chemistry at the modified electrodes can be exploited for the preferential accumulation of metal ions prior to the voltammetric quantification of the surface-bound metal ions. Following the accumulation step, the adsorbed metal ions are reduced by application of a negative-going potential. The reducing current is proportional to the metal ion concentration in solution.

Benefit:

The sensors to be developed are expected to have broad Department of Defense (DoD)/Department of Energy (DOE) applicability and increase data acquisition speed and precision. Moreover, the technology generated from this effort will lead to an entirely new class of sensors with applications across the process industries. The cost/benefit to DoD and DOE includes: (1) reduction in detector size and cost, (2) greatly enhanced data frequency and precision, (3) robust detector package capable of temperature and shock extremes, and (4) selective targeting of metals in groundwater or other aqueous media.



Self-Assembled Monolayers on Mesoporous Supports (SAMMS) embedded in a conductive medium concentrates metal ions of interest from aqueous media (left). Application of current releases the trapped species, allowing measurement of the metal ions by SWASV (right).

Accomplishments:

This SEED project began in FY 2002. Accomplishments will be noted upon completion of the project.

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