CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

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Project Number

S0605

Project Title

Simple and Cost-Effective Detection of Cadmium Using an Electrochemical Sensor Made with Gold Nanoparticles

Abstract

Objectives/Goals

The main objectives of my project are (1) to develop a simple and cost-effective detection method using an electrochemical sensor made with gold nanoparticles and (2) to evaluate its sensing potential.

Methods/Materials

Gold nanoparticles of ~1.6 nm diameter were synthesized by Brust¡#s method. Briefly gold salts (HAuCl4) reacted with various hexanethiols to form gold-thiolate polymers which were further reduced to gold nanoparticles. The surface of gold nanoparticles was functionalized with marcaptoundecanoic acid (MUA) and 18-crown-6-undecanethiol (CW) by ligand exchange reactions. After purification, gold nanoparticle films were prepared on interdigitated array electrodes by drop cast. Then conductance of a gold nanoparticle film was measured in various standard solutions of cadmium ions. To evaluate sensing potential, figures of merit (e.g. detection limit, sensitivity, selectivity) were determined.

Results

Three different prototypes of electrochemical sensors were prepared and tested for the detection of metal ions (sodium, magnesium, and cadmium). The sensor made with CW-functionalized gold nanoparticles showed best performance for cadmium detection (lowest 0.43 nM detection limit, highest 0.029 S/M sensitivity, and highest selectivity), whereas non-functionalized gold nanoparticle sensor displayed worst performance. It was possible to prepare at least 15 drop cast films with 10 mg of gold nanoparticles.

Conclusions/Discussion

Conductance of a gold nanoparticle film was significantly affected by metal ions bound on the film and correlated to the concentration of metal ions (sensitivity & detection limit). Selectivity was controlled by regulating the binding of metal ions on functionalized gold nanoparticles. My prototype sensors are simple, portable, and convenient to measure cadmium ions. They can be operated with a small 1.5 V battery (low power consumption) and prepared with a cost less than $5.

Summary Statement

My project describes a simple, cost effective method to detect cadmium ions in contaminated water and has a possibility to detect cadmium ions in contaminated soil samples.

Help Received

Chemistry department at Fresno State University allowed me to conduct all experimental works (synthesis of gold nanoparticles, and measurement of conductance)