Nanoparticle-Based Materials for Microanalysis

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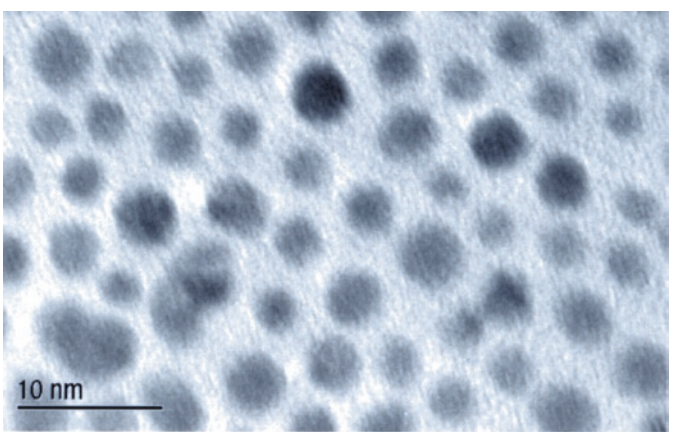
FY 2003 Cost: $132.0K

◆ Nanoparticles and nanoparticle-based materials have many unique properties that can be exploited to develop new chemical sensors with greatly enhanced chemical sensitivity and lower detection limits. Advanced sensors for trace detection have applications in national security, homeland security, environmental monitoring, and energy conversion systems. ◆

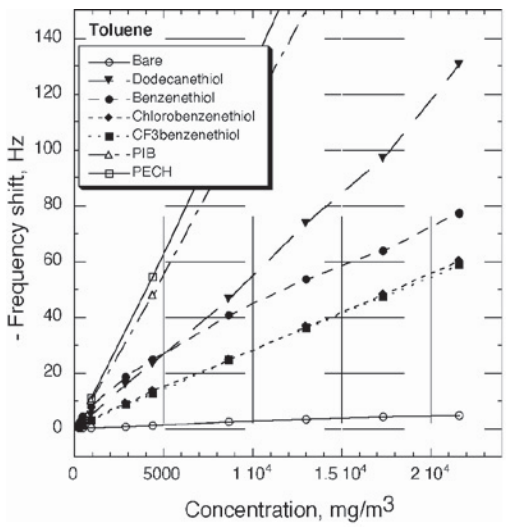
In this project, we synthesized and characterized new nanoparticle-based films with tunable surface properties as interactive sensor materials for use on chemical vapor sensors. Tunable surface properties were achieved by synthesizing gold nanoparticles protected by organic thiol molecules containing various functional groups for analyte interaction. The derivatized nanoparticles were then coated as thin films onto sensor surfaces for the evaluation of vapor uptake and chemical selectivity. The vapor uptake properties of these materials were determined by measurements using the quartz crystal microbalance, and these results provide the basis for understanding sensor responses and rational use in sensor applications.



Transmission electron microscopy image of a monolayer of chlorobenzenethiol-protected gold nanoparticles.

Our measurements indicate that the nanoparticle-based materials examined sorb vapors with partition coefficients that are of the same order of magnitude as the organic polymers used for comparison. Transduction is also important in sensor performance, and these materials can be used as conducting films on chemiresistor sensors that measure the resistance of the film. It has been reported that chemiresistor sensors coated with such nanoparticle films can offer lower detection limits than polymer-coated vapor sensors. Given our vapor sorption results, it can be concluded that the reported better detection limits must be due to more signal-to-noise per sorbed vapor molecule.

The implications are that nanostructure matters and suitable nanostructures can lead to improved signal-to-noise per sorbed molecular unit. Tailoring nanostructure for more sensitive transduction represents an area of opportunity for nanoscience in chemical detection.



Calibration curves comparing the sensitivities of the nanoparticle-coated thickness shear mode sensors with polymer-coated thickness shear mode sensors, plotting the magnitudes of the responses against the vapor concentrations in mg/m³.