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Electrocatalytic Nanoparticles

Inorganic enzymes

Overview

The majority of biosensors in use and reported in the literature require labels or reagents for bioagent detection. Although these devices are specific and sensitive, the use of environmentally sensitive labels and large volumes of reagents is a significant hurdle in producing robust field deployable and autonomous biological sensors. Electrocatalytic nanoparticles have drawn much interest for biological detection as they effectively serve as inorganic enzymes, generating a signal analogous to that obtained from enzymatic turnover with significant advantages over enzymes including increased thermal and environmental stability. We have developed a reagent-less immunoassay using nanoparticle modified antibodies and are developing a reagent-less and label-free biosensors using electrocatalytic nanoparticles.

Approach

We have developed new approach for electrochemical immunoassay sensing in which Pd NPs can be loaded onto an anti-TNF-α antibody to create an electrocatalytic antibody [1]. Gold particles are first covalently linked to the antibody (step A right). These gold nanoparticles then act as a seed for growth of a palladium shell (step B right).

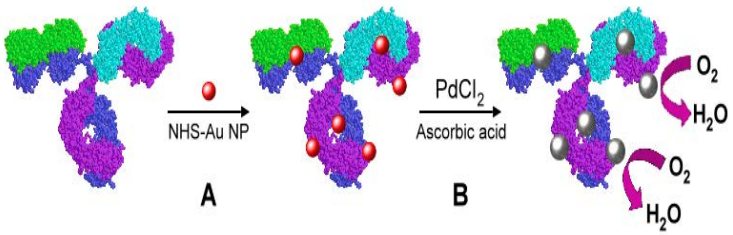

Figure 1. Au-Pd NP.

Pd nanoparticles have proven to be sensitive to the oxygen reduction reaction. As oxygen is present in all buffer or aqueous samples, no additional reagents are required for detection. Linear sweep voltammetric analysis shows excellent catalytic activity for the Au/Pd modified antibody towards oxygen reduction. A complete sandwich immunoassay consisting of diazonium-antibody probe immobilization, exposure to target, and capture of nanoparticle-antibody label is shown below.

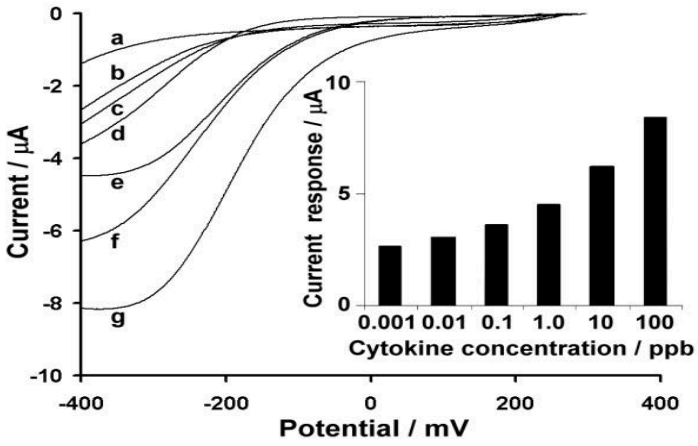

Figure 2. Reagent-less protein detection.

Upon increasing concentration of TNF-α target a cathodic current appears due to the reduction of oxygen in the buffer. A strong signal dependence upon concentration is observed from 1 ppt to 100 ppb TNF-α. The corresponding analytical signals taken from the current at -400 mV (inset) show that the technique is highly suitable for quantitative work with a detection limit of 1 ppt.

We are now pursuing methods to selectively deposit nanoparticles onto electrode surfaces to allow for reagent-less and label-free detection. The figure below shows deposition of Au nanoparticles onto a gold electrode array. The control electrodes (left) showed minimal non-specific absorption which the target electrodes (right) showed a much higher density of nanoparticle coverage.

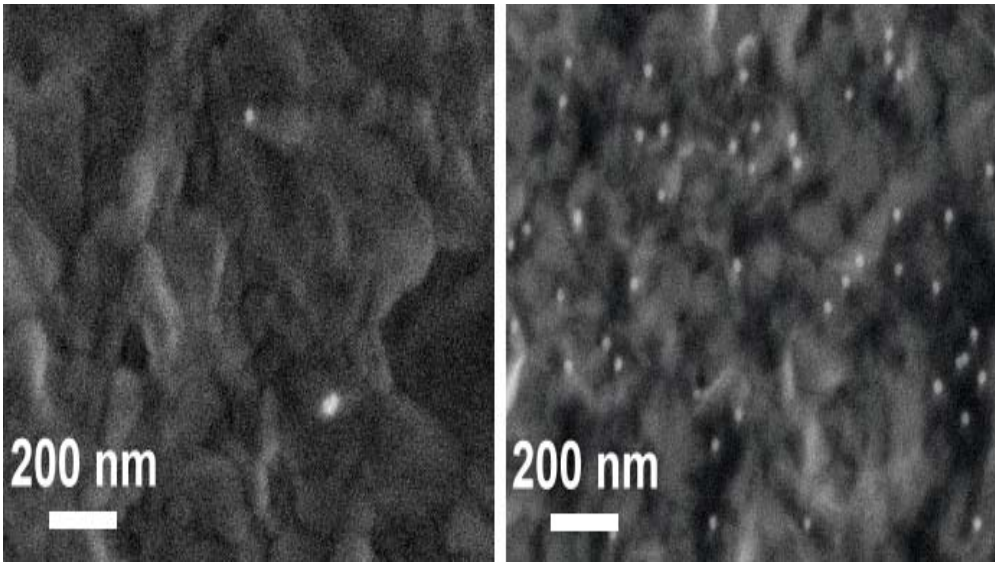

Figure 3. NP control and modified electrodes.

For additional information or questions, please email us at BioNano@sandia.gov.

U.S. DEPARTMENT OF ENERGY NNSA National Nuclear Security Administration

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