Size-Controlled Electrodeposition of Gold Nanoparticles and Nanoclusters

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Abstract

Controlling the size of metal nanoparticles (NPs) on conductive electrode supports is important for applications in catalysis, sensing, optoelectronics, and plasmonics because the size dictates the properties of the NPs. Researchers have developed various solution-based methods to synthesize metal nanostructures with controlled size and shape, which can then be purified and assembled on electrode supports for electrochemical applications. This involves many steps, including electrode functionalization to make the NPs stick and cleaning of the NPs to remove stabilizers that are typically employed in the synthesis. In our lab, metal NPs are typically chemically-synthesized and attached electrostatically to aminopropyltriethoxysilane (APTES)-modified indium-tin-oxide-coated glass (glass/ITO) electrodes, chemically-attached to mercaptopropyltrimethoxysilane (MPTMS)-modified glass/ITO, attached directly to glass/ITO by electrophoretic deposition (EPD), or directly attached by electrodeposition. Our group previously reported the size-controlled electrodeposition of Au NPs on glass/ITO from an acidic electrolyte solution of $AuCl_4^-$, where the size decreased as the deposition potential decreased. The smallest size of the Au NPs was 3-4 nm in diameter. Here we describe electrodepositon of Au NPs on glass/ITO from $HAuCl4.3H_2O$ in basic electrolyte with and without phosphine-based stabilizers at potentials of -0.2 to -1.2 V versus Ag/AgCl using chronocoulometry to keep the amount of Au deposited constant. The peak potential (E_p) for oxidation in anodic stripping voltammetry (ASV) from -0.2 V to 1.2 V in 0.1 M $KClO_4$ and 0.01 M KBr electrolyte solution provides the size of the deposited Au NPs. The oxidation potential of the Au NPs shifts negative with decreasing NP size**.** In absence of phosphine stabilizers, the majority of the Au NPs have a size of 3-4 nm at a potential less than -0.8 V, but there is also evidence of 1-2 nm Au nanoclusters (NCs) in the ASV at -1.2 V. With phosphine stabilizers, the presence of small 1-2 nm Au NCs is much more prevalent and becomes the dominant size. This simple method of depositing 1-2 nm sized metal clusters directly on electrode supports could have many potential applications, especially in electrocatalysis relevant to energy storage devices.

Biography:

Binu Thapa is a 2nd year graduate Chemistry student from Department of Chemistry, University of Louisville. She is currently working on electrochemical studies of managanese dioxide nanoparticles and size-controlled electrodeposition of gold nanoparticles and nanoclusters.