Opportunities for undergraduate researchers

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Synthesis and fabrication of nanomaterials

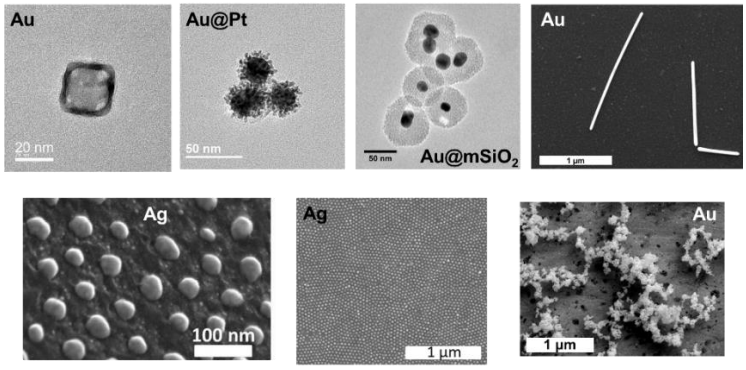

Figure 1. Electron microscopy images of metal nanostructures of varying size, shape, structure, and composition.

Many metals exhibit interesting and new electrical, magnetic, optical, and mechanical properties when their size has nanometer dimensions (1 nm = 1 x 10^{-9} m). These emergent properties have enabled metal nanomaterials to be useful agents in biological applications such as drug delivery and medical imaging as well as in chemical applications such as molecular sensing and catalysis. One of our team's research interests is in the synthesis and fabrication of metal nanomaterials. We make metal nanomaterials of different sizes, shapes, structures, compositions, and surface chemistries (Figure 1) to tune their properties for use in chemical and biological applications. A range of methods are used including reduction and oxidation reactions, photochemistry, and lithography (printing with templates) to create dispersions and arrays of uniform nanomaterials. The tools we use to characterize the properties of nanomaterials include UV-visible spectroscopy, optical microscopy, electron microscopy, and electrochemistry.

Ultramicroelectrodes and nanoelectrochemistry

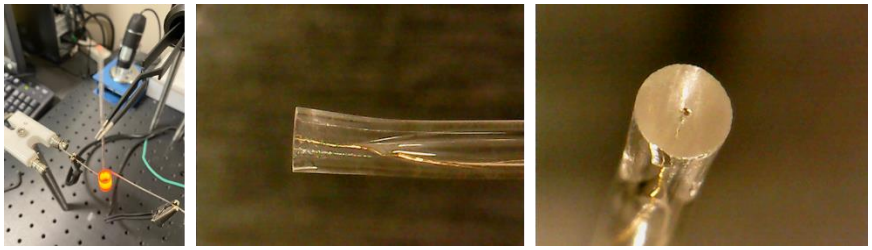

Figure 2. Fabrication apparatus and polished Au ultramicroelectrode.

Electrodes with small diameters (< 100 µm) minimize Ohmic losses and double layer capacitances in electrochemical systems which allow their use in novel applications such as performing electrosynthesis in organic solvents without the use of electrolytes. We fabricate, characterize, and utilize ultramicroelectrodes to study new reaction pathways at fast timescales.

Computational chemistry and data analytics

Often measurements made in experiments provide complex and large amounts of data. To help interpret and understand our experiments, we frequently use computer programs that allow us to simulate experimental results and to process large sets of data. For example, we use computational tools such as density functional theory to calculate Raman spectra to compare to our experimentally measured Raman spectra to help us understand the structures and reactions of molecules (Figure 3). In another application, we write and use computer code (in MATLAB or Python) to reveal trends in large sets of data acquired during chemical reactions. Both computational chemistry and computer programming are useful in studying chemistry, but also are technical skills that many companies are seeking for big data analytics.

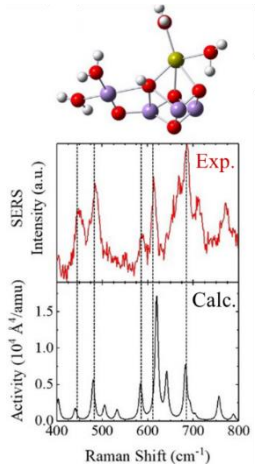

Figure 3. Experimental and calculated Raman spectra of $CaMn_4O_5 \cdot 4H_2O$. JACS, **2018,** *140,* 5853.