Materials Science and Engineering Department

Fall Seminar Series

Manipulating Optical Absorption of Ultrafine Metal Nanoparticles

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Ultrafine metal nanoparticles with sizes less than 10 nm are widely used as catalysts in many important reactions. Photocatalysis relies on the absorption of photoenergy in the catalyst nanoparticles to activate specific chemical bonds (or electron pairs in molecule orbits) and thus trigger the desirable chemical reactions with appropriate selectivity. The sizes of ultrafine metal nanoparticles are small enough to induce quantum phenomena on the nanoparticle surfaces while maintaining metallic properties inside the nanoparticles. This class of nanoparticles is presented as "quantum-sized metal nanoparticles" (or QSMNPs). In this presentation, the QSMNPs made of platinum group metals supported on spherical silica nanoparticles, which serve as dielectric light antennae to enhance light absorption in the QSMNPs, are shown as a new class of photocatalysts for selectively driving chemical reactions. In a typical photocatalytic reaction, light absorption in the QSMNPs excites free electrons in the nanoparticles. The small size of the QSMNPs reduces the travel distance of photoexcited electrons (or hot electrons) to reach the QSMNP surface, thus improving the quantum yield of converting the adsorbed photoenergy to the energetic electrons available for chemical transformations on the QSMNP surface. The "inverse" Coulomb blockade effect (i.e., one classic quantum effect on electron transfer) on the surface of the QSMNPs promotes the injection of hot electrons into specific chemical bonds of the surface adsorbates. Releasing energy of hot electrons activates these specific chemical bonds, favoring the improvement of product selectivity in many important reactions. e.g., oxidation of alcohol to aldehyde, hydrogenation of nitrobenzene, and CO_2 reduction.

Dr. Yugang Sun obtained his B.S and Ph.D degree from the University of Science and Technology of China (USTC) in 1996 and 2001, respectively. He then worked as a postdoctoral fellow with Prof. Younan Xia at the University of Washington and Prof. John A. Rogers at the University of Illinois at Urbana-Champaign. In 2006, Dr. Sun joined the Center for Nanoscale Materials at Argonne National Laboratory (ANL) to start his independent research career. He moved to the Chemistry Department of Temple University in January 2016. He received the Presidential Early Career Award for Scientists and Engineers (PECASE) in 2007 and DOE's Office of Science Early Career Scientist and Engineering Award in 2008. His research focuses on the design/synthesis of hybrid nanostructures as well as the investigation of novel properties of the synthesized nanostructures in the context of nanophotonics, photocatalysis, sensing, and energy storage/conversion. His group also works on developing in situ techniques for tracking nanomaterials formation and transformation as well as big data processing.

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