AU NANOPARTICLE LIQUIDS, PROTO-ASSEMBLIES AND DISPERSIONS: SAXS STUDY OF GROWTH

Rich Vaia, Steve Diamanti, Rob MacCuspie, Kyoungweon Park,
Hilmar Koerner, Rajesh Naik
Air Force Research Laboratory, Materials and Manufacturing Directorate, WPAFB, OH

Gold (Au) nanoparticles are a mainstay of current nanoscience and technology, and their occurrence can be traced back to ancient Roman glasswork (Lycurgus Cup) and medieval stain glass windows. With such a diversity of applications, developing a better understanding of the impact of macromolecular additives on single-phase fabrication routes, and ultimately on the resultant interfacial composition and structure, is critical to optimize performance and lower production cost. For example, by minimizing the volume fraction of organic corona necessary to generate a net long-range repulsive pair-potential (and thus maximizing inorganic volume fraction), neat Au nanoparticle assembles may exhibit liquid-like behavior, which affords intriguing possibilities for numerous applications including conductive lubricants and contacts, solvent-less inks for micro-fabrication, and compliant electrodes. Also, bio-macromolecules, such as peptides identified by phage display techniques, are providing alternative room-temperature aqueous-based routes to nanoparticles with narrow polydispersity, unique shapes and biologically active surface functionality. For many of these reactions, small-angle x-ray scattering (SAXS) is uniquely situated to directly monitor the morphological evolution of the nanoparticles in real-time. This presentation will discuss the nanoparticle characteristics during incubation, nucleation and growth phases of Au(I) reduction by tert-butylamine-borane in benzene. In contrast to alternative reaction monitoring techniques, such as optical absorption spectroscopy that only provides a measure of Au(0) concentration, deconvolution of the SAXS profile provides direct information of nanoparticle size, polydispersity and relative number density, as well as the on-set of clustering and superstructure formation. In general, this approach provides new insights on the impact of peptides and other additives on the various stages of nanoparticle formation and the ability to quantify particle-pair potentials and ascertain impact on assembly – de-assembly process of nanoparticle superstructures.