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Discovery enabled by in-situ synchrotron X-ray techniques

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ABSTRACT

Understanding the complex mechanism of nanocrystal formation and transformation in solutions represents a challenge in materials science. For example, formation of colloidal noble metal nanocrystals from homogeneous liquid solutions involves many complicated processes that are poorly understood. The absence of enough knowledge of nanoparticle formation in liquid media is due to the difficulty in developing effective tools to “see through” solvents and probe chemical and physical events in the liquids. This situation also leads to challenging barriers that prevent the synthesis of functional nanoparticles with precisely tailored properties and better understanding of the dependence of nanoparticles’ performance on their physical parameters including shape and crystalline phase. The exceptional penetration power of the high-flux, high-energy X-ray beams in liquid solutions and reaction vessels (e.g., glass flasks) enables the direct probing of nanophase evolution in large-volume reactors that are usually used in conventional wet chemistry laboratories. The weak absorption of the high-energy X-ray beams in reactants and solvent molecules eliminates the possible side reactions during nanoparticle growth and transformation. As a result, time-resolved, high-energy synchrotron X-ray techniques represent one class of ideal methods for noninvasive probing of growth/transformation mechanism of colloidal nanocrystals in conventional reactors. In this presentation, the time-resolved high-energy synchrotron X-ray diffraction is demonstrated to monitor the nanophase evolution involved in the synthesis of colloidal Ag nanocubes and the physical/chemical transformation of colloidal Ag nanowires to nanoparticles/nanotubes.

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