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Thermodynamic stability of the size distribution of charged metal nanoparticles

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Ligand-stabilized metal nanoparticles (NPs) have become essential in many active areas of research. A narrow size distribution is essential for controlling their physicochemical properties and for increasing the degree of ordering in NP superlattices. During NP synthesis, coalescence and Ostwald ripening induce polydispersity. Digestive ripening (DR) is a widely-used, post-synthetic step that reduces the dispersity and produces narrow size distributions of ligand-stabilized NPs of noble metals, transition metals, metal sulfides and halides, II-VI semiconductors, lanthanide oxides, as well as alloys and core-shell bimetallic NPs. DR involves heating the as-prepared, polydisperse colloidal solution in the presence of excess strong capping ligand at or near the boiling point of the solvent under reflux. A ligand-exchange reaction induces the redistribution of atoms among NPs and leads to a narrow size distribution. In spite of the experimental efforts to provide insights, the mechanisms of DR are not yet known. We present a DR theory that clarifies the factors that determine the size distribution of charged NPs.

Primary author(s) : Prof. MANZANARES, Jose A. (Universidad de Valencia)

Co-author(s) : Prof. GIRAUT, Hubert H. (EPFL); Prof. CERVERA, Javier (Universidad de Valencia); Dr. PELJO, Pekka (EPFL); Prof. MAFÉ, Salvador (Universidad de Valencia)

Presenter(s) : Prof. MANZANARES, Jose A. (Universidad de Valencia)

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