Atomic resolution STEM imaging of organic surfactant molecules on CeO_2 nanocrystals

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Nanocrystals (NCs), under the title of building block for modern science and technology, are promising candidates in the field of environmentally friendly catalysts, energy storage materials, and biological applications. Usually, NCs are synthesized by chemical approaches with the aid of some specific organic molecules, known as surfactant, surface ligand or capping agent, whose coverage is an indispensable component for NCs surface chemistry. Regarding of crucial role of surfactant ligand on NCs surface chemistry, it is necessary to deeply investigate such kinds of interfacial interaction between the NCs core and surfactant molecules shell, which might require an intricate mix of concepts and techniques borrowed from surface science and coordination chemistry, and material science.

In order to reveal the surfactant-related NCs chemistry, versatile characteristic approaches, have been tried to probe the surfactant molecule on NC surface. Scanning transmission electron microscopy (STEM), with updated imaging mode by introducing annular bright field (ABF) detector, makes it possible to resolve light and heavy elements in the same time.[1, 2] Besides, another advantage of STEM is its flexibility for adjusting beam probe and collection angular regions of the detectors, offering us versatile and robust image conditions for specific scientific purposes. Moreover, electron energy loss spectra (EELS) is readily for acquiring elemental mapping spectra in a STEM mode.

In this regard, STEM imaging and EELS spectra techniques are combined in our work, to investigate the characterization solutions for direct imaging of surfactant molecule on the surface of NCs. A chemical synthesized surfactant-modified cubic CeO_2 NC is chosen for a model system, since its outstanding role as environmental catalysts.[3, 4] The EELS elemental mapping spectra offer us explicit evidence for the existence and distribution of organic surfactant on CeO_2 NCs surface, and optimized STEM imaging condition provides enhanced contrast for its direct imaging. In principle, our results pave the way for interpretation of the surfactant related NC surface chemistry, and, in future, interfacial investigation of inorganic and organic materials.

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