Organofullerene Nano- and Microspheres Containing Inorganic and Biological Nanoparticles: Self-Assembly and Electron Tomography

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Organofullerene amphiphiles show diverse behaviors in water, forming vesicles, micelles, Langmuir-Blodgett film, and anisotropic nanostructures. We found that gradual in situ protonation of an organic solution of (4-heptylphenyl)$_5C_{60}^-K^+$ (**C7K**, Figure a) by water or buffer generates the corresponding protonated molecule, (4-heptylphenyl)$_5C_{60}H$ (**C7H**), which self-assembles to form a nano- and microsphere of organofullerene. The diameter is controlled by the preparation or pH of the buffer in range between 30 nm to 2.5 μm. By using an aqueous solution of organic dye, or aqueous dispersion of inorganic nanoparticle, protein, and virus, we encapsulated these entities in the fullersphere. This approach through self-assembly is distinct from other preparations of organic core-shell particles that generally require polymerization for construction of a robust shell. We found that the rigid spherical shape is suitable for electron tomography (ET), which is an analytical method to reconstruct three-dimensional (3D) structures of target nanomaterials. The spheres sticked out to vacuum (Figure b) enable us to collect the transmission electron microscope (TEM) images from various angles in a constant contrast, and 3D structures and coordinate can be reconstructed on the incorporated specimens (Figure c).

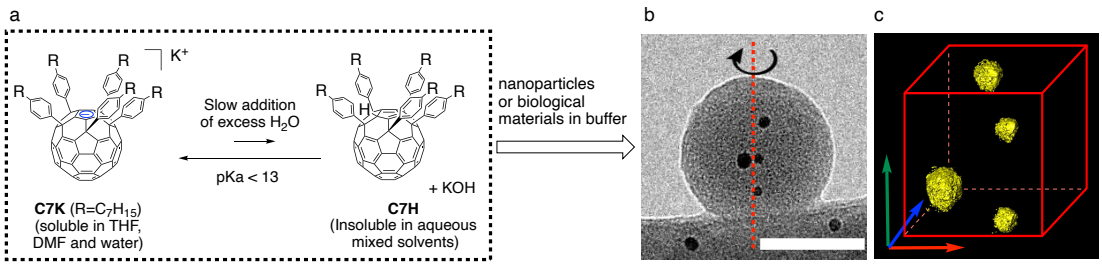

Figure. Preparation of self-assembled multiple-component nanospheres by utilizing an equilibrium of organofullerenes in water and structural analysis of incorporated specimens with ET. (a) An equilibrium between **CnH** and **CnK**. (b) TEM image of gold nanoparticles (AuNPs) in an organofullerene nanosphere. Scale bar: 50 nm. (c) The reconstructed volume data of incorporated AuNPs.