Preparation of highly luminescent perovskite nanoparticles and novel upconversion-perovskite nanohybrids

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Hybrid organic–inorganic lead halide perovskites are of great interest in photovoltaic devices and as luminescent materials for light-emitting devices.[1] Crystalline colloidal $CH_3NH_3PbBr_3$ nanoparticles have been prepared with good luminescence quantum yield (20 %) using long ammonium salts as capping ligands. Fine-tuning of the molar ratios of all the components, which either form part of the framework or act as the organic capping, produces an enhancement of their luminescence up to 83%.[2-3] We have recently demonstrated that the use of a quasi-spherical shaped 2-adamantyl ammonium bromide (AD), as the only capping ligand, gives rise to the highest luminescent quantum yield (~100 %) of $CH_3NH_3PbBr_3$ perovskite nanoparticles (PK@AD), Figure 1a,b. Formation of host-guest complexes on the nanoparticle surface by using cucurbit[7]uril (CB[7]) produces photostable nanoparticles (PK@AD-CB), which preserve the perovskite luminescence and exhibit enhanced stability under wet conditions. These structures can be very promising materials for the preparation of luminescent devices. [4]

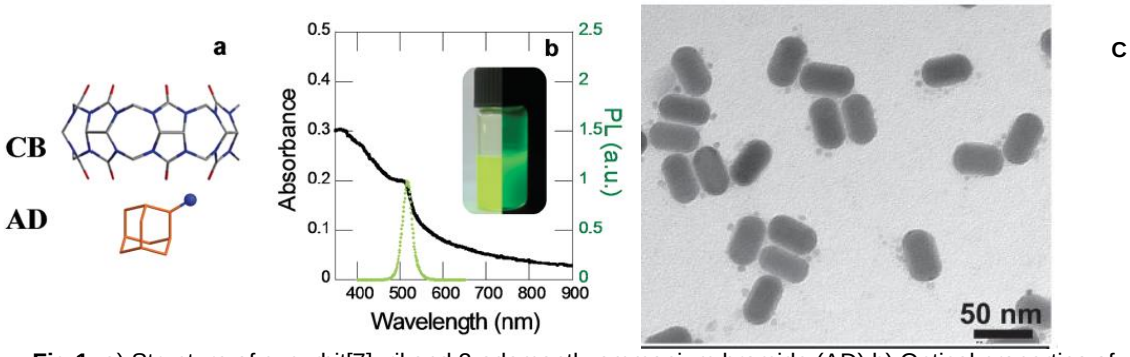

Fig.1: a) Structure of cucurbit[7]uril and 2-adamantly ammonium bromide (AD) b) Optical properties of PK@AD nanoparticles; b) TEM images of $UC_n@PK_{CB}$ nanohybrid.

Combination of different nanomaterials to make new nanohybrids with novel properties is an interesting and difficult task that requires exceptional control at the nanoscale. Upconversion-perovskite nanohybrids have been prepared by assembling naked $NaYF_4$:Yb^{3+},Tm^{3+} nanoparticles (UCn) to perosvkite nanoparticles. A rigid macromolecule, specifically CB[7], was used to anchor the perovskite nanoparticles firmly to the upconversion nanoparticles, thus leading to $UC_n@PK_{CB}$ nanohybrids (Figure 1c). Interesting, a comercial multiphoton laser scanning confocal microscope was used to demonstrate the successful assembly as well as to evaluate the upconversion luminescence lifetime (in the range of several tens of μs), thus allowing the visualization of the extraordinarily efficient nontrivial resonance energy transfer from the upconversion nanoparticle to the perovskite after near-infrared (NIR) excitation of the nanohybrid. The novel nanohybrids have demonstrated good photostability under prolonged irradiation with UV-light as well as NIR light. [5]

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