

Supplementary Information

Upconversion core/shell nanoparticles with lowered surface quenching for fluorescence detection of Hg²⁺ ion

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I. Quantum yield

For calculating the quantum yield, the fluorescent spectra of core and core/shell UCNPs with the same amount of nanoparticles were measured and shown in **Fig. S1**.

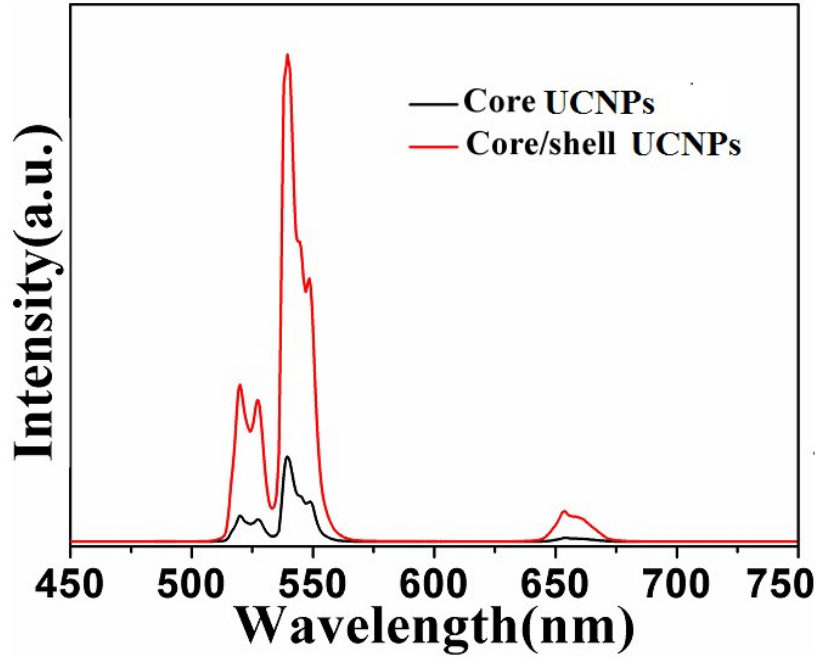


Fig. S1 Fluorescent spectra of core and core/shell UCNPs with the same amount of nanoparticles.

Based on the following Equation (1), the upconversion quantum yields (QY) for red and green emission are calculated and listed in **Table S1**.

Table S1. The quantum efficiency of the samples.

Sample	QY (green emission)	QY (red emission)
NaGdF ₄ :Yb ³⁺ ,Er ³⁺	0.152%	0.016%
NaGdF ₄ :Yb ³⁺ ,Er ³⁺ @NaYF ₄	0.833%	0.095%

The QY is defined as:

$$QY = \frac{\eta_{UE}}{\sum E_{\lambda} \times V_{IRST}} \quad (1)$$

where QY is the quantum yield, the energetic upconversion efficiency η_{UE} of NaGdF₄:Yb³⁺,Er³⁺@NaYF₄ core/shell nanoparticles is approximately calculated to be

0.833% according to QY of 0.3% from Frank C. J. M. van Veggel,s reporter in [Nanoscale, 2010, 2, 1417–1419] due to a fact that the upconversion efficiency of $\text{NaGdF}_4:\text{Yb}^{3+},\text{Er}^{3+}$ nanoparticles is close to that of $\text{NaYF}_4:\text{Yb}^{3+},\text{Er}^{3+}$. E_λ is the energy of defined wavelength, V_{IRST} is the Intensity Ratio of Single emission band to Total emissions.

II. FRET efficiency

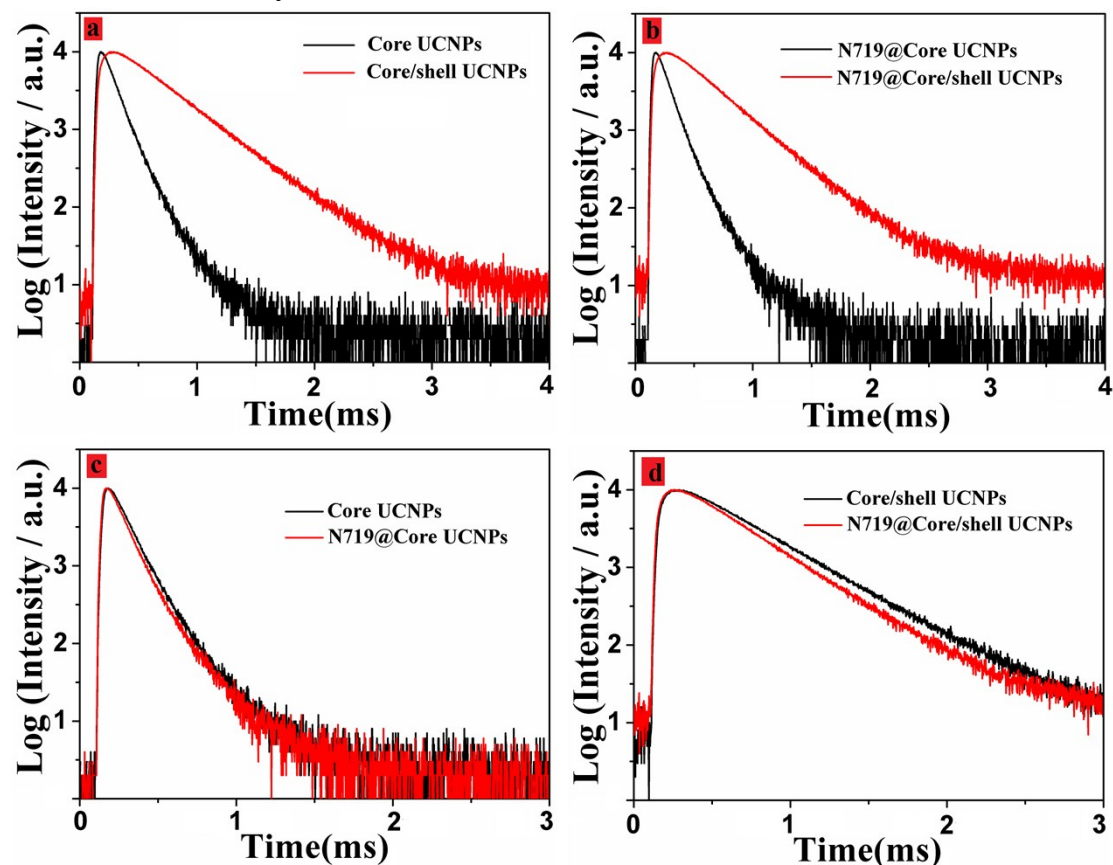


Fig. S2 Fluorescence decay of 540 nm green emission of core UCNP, core UCNP@N719, Core/shell UCNP and core/shell UCNP@ N719.

The decay time of UCNP has been measured before and after it reacts with N719 and is presented in **Fig. S2**. The lifetime of 540 nm green emission of core UCNP and N719@core UCNP is addressed to be 0.134 ms and 0.12 ms, respectively, according to the decay curves, while those of core/shell UCNP and N719@core/shell UCNP are addressed to be 0.484 ms and 0.41 ms, respectively. The FRET efficiency can be calculated by the following equation [J. Phys. Chem. B 2006, 110, 26068-26074]:

$$E = 1 - \quad (2)$$

where τ_{da} and τ_d are the fluorescence lifetimes of a donor in the presence and absence of an acceptor. The calculated FRET efficiency of N719@core UCNPs ($\tau_{da}=0.12$ ms, $\tau_d=0.134$ ms) and N719@core/shell UCNPs ($\tau_{da}=0.41$ ms, $\tau_d=0.484$ ms) is equal to 10.4% and 15.3%, respectively, according to the fluorescence lifetimes.