Supporting Information

Detection of procalcitonin (PCT) using the double antibody sandwich method based on fluorescence resonant energy transfer between upconversion nanoparticles and quantum dots

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Figure S1 TEM images of NaYF₄:Yb, Er (a) before and (b) after hydrophilic functionalization.

Figure S2 TEM image of protein on the NaYF₄:Yb, Er after protein conjugation.

Figure S3 TEM image of CdTe QDs with MPA modification.
Figure S4 TEM image of QDs conjugated with antibody.

Figure S5 XRD pattern of NaYF$_4$:Yb, Er before PAA modification.

Figure S6 Infrared spectra of NaYF$_4$:Yb$^{3+}$, Er$^{3+}$ before (black line) and after (red line) PAA modification.
**Figure S7** Room-temperature fluorescence spectra of 5.0 mg/mL NaYF₄: Yb, Er nanoparticles in cyclohexane (b) and after PAA modification in water (a) with a 980-nm laser.

**Figure S8** The TEM photo of the FRET system between NaYF₄ (Yb, Er) upconversion nanoparticles (UCNPs) and CdTe quantum dots (QDs).
Figure S9 Schematic representation of the system for UCNPs quantum yield determination.

Figure S10 Response curve of the fluorescence spectrometer using a standard light source (iD2000 Deuterium halogen combo light source).

Figure S11 Fluorescence spectra of PAA (40μL, 5.0 mg/mL) functionalized NaYF₄: Yb, Er nanoparticles at 37 °C before (a) and after one hour (b) in serum samples (160μL of 0.02ng/mL negative sample) with a 980nm laser.
1. Calculation of the Förster distance $R_0$:

The Förster distance was defined by Eq. (3):

$$R_0 = 0.02108(\kappa^2 \varphi n^4 J)^{1/6} \text{ nm} \quad \text{Eq. (3)}$$

where $\varphi$ is the quantum yield of the donor, $\kappa^2 = 0.67$ (dynamic averaging) is the dipole orientation factor, $n = 1.35$ is the refractive index of the medium, and $J$ (in $\text{M}^{-1} \text{ cm}^{-1} \text{ nm}^4$) defines the spectral overlap between donor ($\text{Er}^{3+}$ in the UCNPs) PL and acceptor (QD) absorption as a function in Eq. (4). According to the literature,$^1$ the calculation of $J$ was $6.04 \times 10^{16} \text{ nm}^4 \text{ M}^{-1} \text{ cm}^{-1}$.

$$J = \int_{570\text{nm}}^{550\text{nm}} F(\text{Er}^{3+}) \epsilon_{\text{QD}} \lambda^4 d\lambda \quad \text{Eq. (4)}$$
References

1 FRET – Förster Resonance Energy Transfer, ed. I. L. Medintz and N. Hildebrandt, WileyVCH, Weinheim, Germany, 2014