PAA modified upconversion nanoparticles for highly selective and sensitive detection of Cu^{2+} ions

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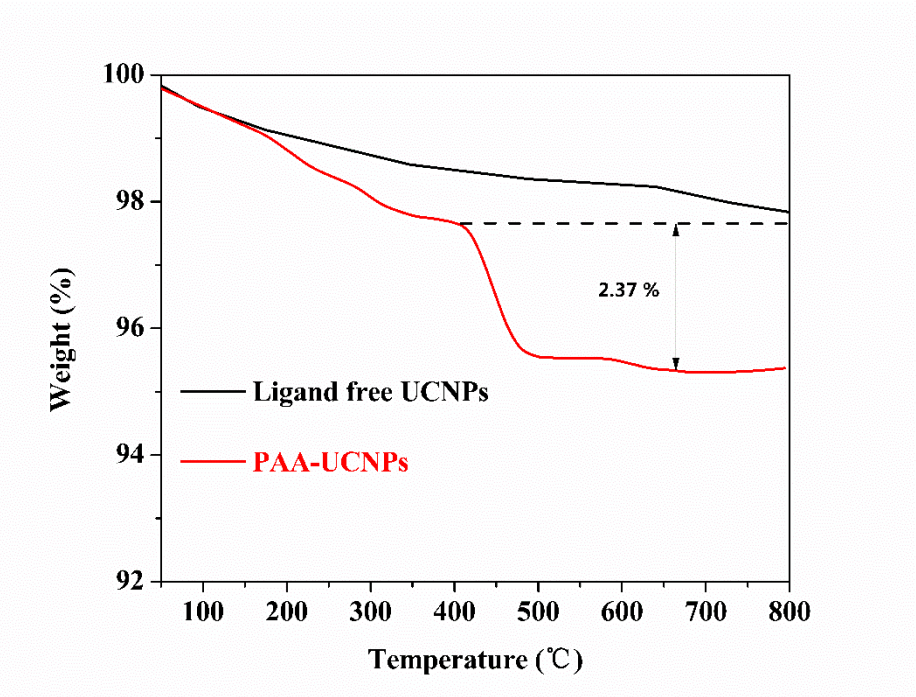

Fig. S1 TGA curves of ligand free $NaYb_{0.5}Nd_{0.5}F_4$@$NaYb_{0.5}Gd_{0.49}Tm_{0.01}F_4$@$NaGdF_4$ UCNPs and PAA coated $NaYb_{0.5}Nd_{0.5}F_4$@$NaYb_{0.5}Gd_{0.49}Tm_{0.01}F_4$@$NaGdF_4$ UCNPs, respectively.

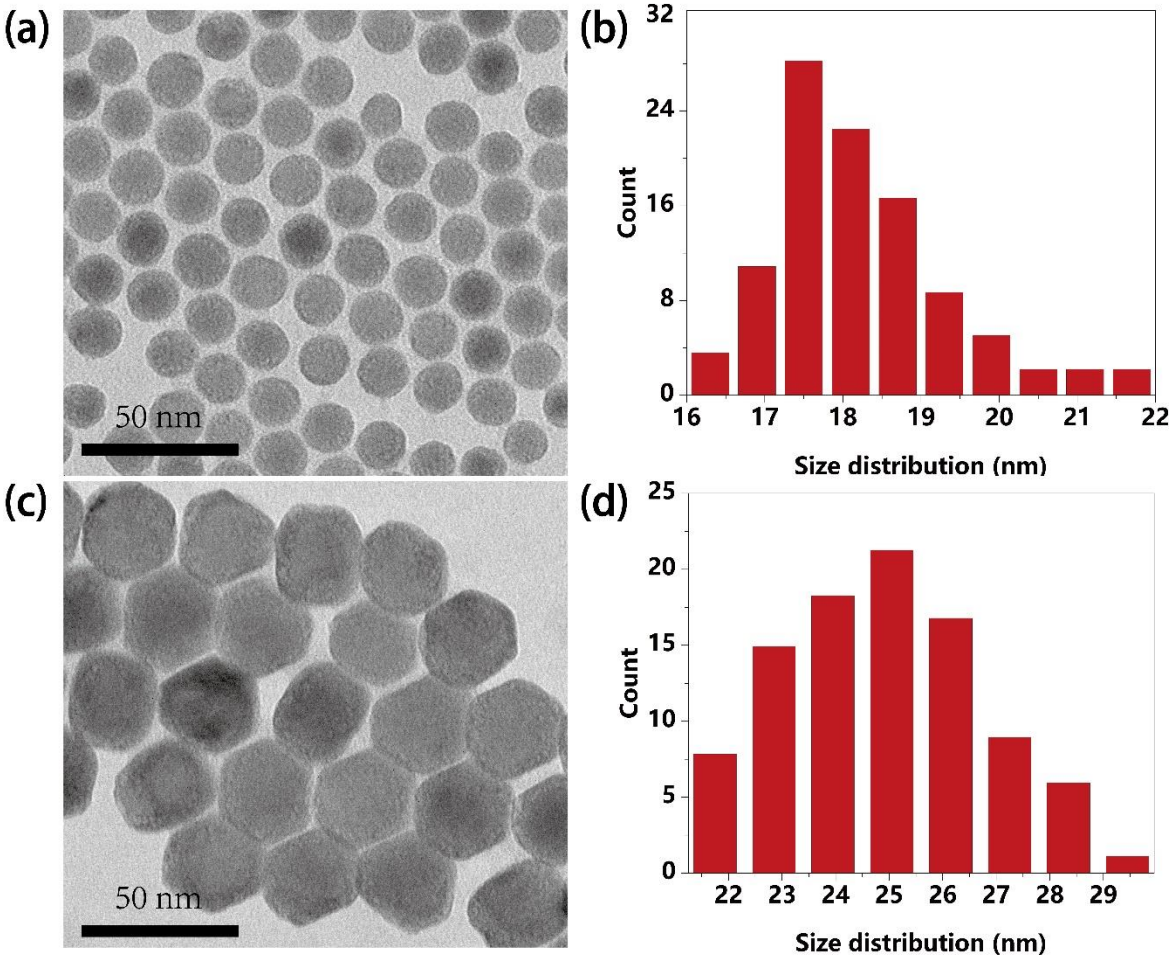

Fig. S2 TEM images (a and c) and size distribution (b and d) of the as-prepared core of $NaYb_{0.5}Nd_{0.5}F_4$ and core-shell structure with composition of $NaYb_{0.5}Nd_{0.5}F_4@NaYb_{0.5}Gd_{0.49}Tm_{0.01}F_4$ nanoparticles, respectively.

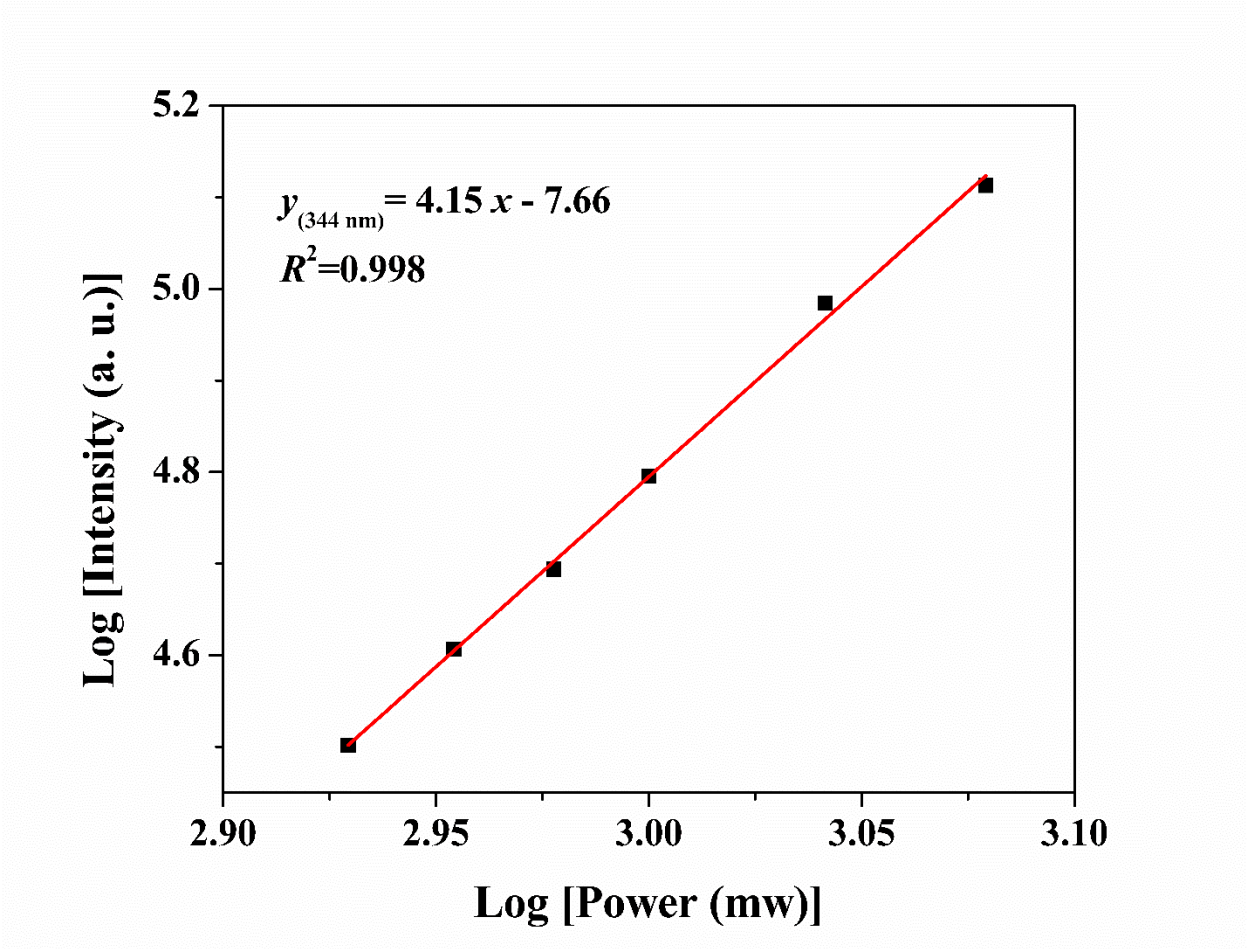

Fig. S3 Double-logarithmic plots of the pump-power dependent upconversion emission intensity from Tm^{3+} emission at 344 nm recorded under 980 nm excitation.

Table S1. Comparison of the PAA-UCNPs nanoplatform with the other reported platforms for the Cu^{2+} detection.

Probes	Analytes/excitation wavelength	LOD	Linear range	reference
PAA-$NaYb_{0.5}Nd_{0.5}F_4$@$NaYb_{0.5}Gd_{0.49}Tm_{0.01}F_4$@$NaGdF_4$	Cu^{2+}/ 980 nm	0.1 μM	0.125–3.125 μM	This work
TPEA-Carbon quantum dots	Cu^{2+}/ 405 nm	10 nM	10^{-6} –10^{-4} M	1
Rhodamine B-SiO_2 coated $NaYF_4$:Yb,Er@$NaYF_4$	Cu^{2+}/ 520 nm	0.82 μM	-	2
Carboxyl-modified CdTe QDs	Cu^{2+}/ 340 nm	0.36 nM	0 to 100 nM	3
PEI-capped $NaGdF_4$:Yb/Tm	Cu^{2+}/ 980 nm	57.8 nM	0.1-2 μM	4
TSPP-$NaYF_4$:Yb,Er,Gd@SiO_2	Cu^{2+}/ 980 nm	2.16 μM	5 μM–0.16 mM	5
Rd-NH_2-β-$NaYF_4$:Yb^{3+}/Er^{3+}	Cu^{2+}/ 980 nm	-	2–14 μM	6
RB-hydrazide-$NaYF_4$:Yb^{3+}/Er^{3+}	Cu^{2+}/ 980 nm	10^{-6} M	10^{-5} to 10^{-6} M	7

*TPEA = ([N-(2- aminoethyl)-N,N,N’ -tris(pyridin-2-ylmethyl)
TSPP = meso-tetra(4-sulfonatophenyl)porphine dihydrochloride
Rd-NH_2 = 2-amino-3′,6′-bis(ethylamino)-2′,7′-dimethyl-3′,9a′-dihydrospiro[isoindoline-1,9′-xanthen]-3-one

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