Supporting Information

Synthesis of Nd^{3+}/Yb^{3+} Sensitized Upconversion Core-shell Nanocrystals with Optimized Hosts and Doping Concentrations

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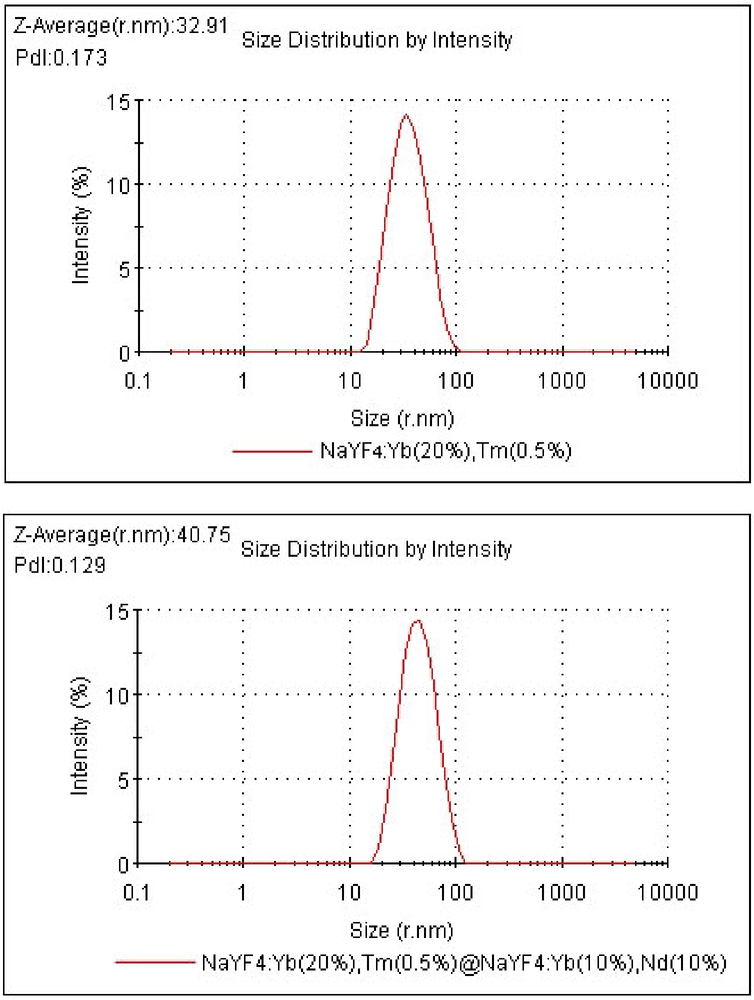

Figure S1. Size distributions of the $NaYF_4$ NCs (seeds) and the core-shell $NaYF_4$@$NaGdF_4$ NCs. Average diameters of the $NaYF_4$ NCs and $NaYF_4$@$NaGdF_4$ NCs are about 32.9nm and 42.7nm, respectively. This data confirms the uniformity of these core-shell NCs and the increase in diameter after the shell growth.

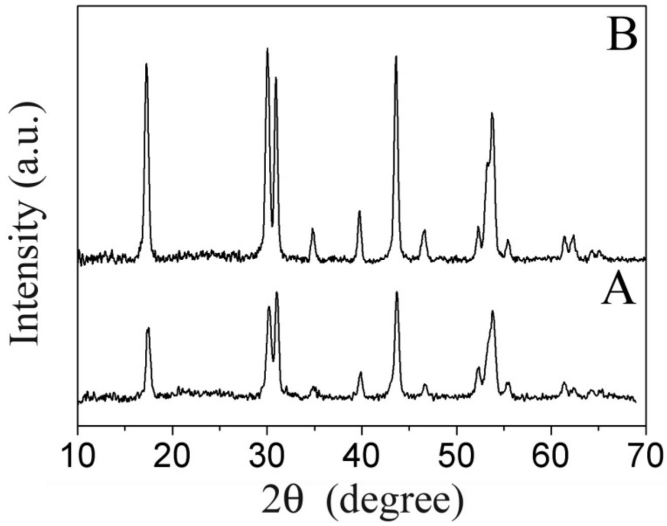

Figure S2. XRD patterns of (A) the $NaYF_4$:Yb,Tm seeds and (B) the prepared $NaYF_4$:Yb,Tm@$NaGdF_4$:Yb,Nd NCs. All diffraction peaks of the $NaYF_4$:Yb,Tm NCs can be clearly indexed to the pure hexagonal $NaYF_4$ crystal (JCPDS No. 28-1192). XRD patterns of the $NaYF_4$:Yb,Tm@$NaGdF_4$:Yb,Nd NCs were much similar to those of the core NCs, albeit a little stronger in intensity. The increased intensity could have resulted from the size increase of the NCs and the similar crystal structure between $NaYF_4$ and $NaGdF_4$ (JCPDS No. 27-0699).

Element	Gd (3d)	Y (4d)	Yb (4d)	Nd (4d)	Tm (4d)	Na (1s)	F (1s)	C (1s)	O (1s)
Content (at.%)	18.13	8.37	3.93	2.12	0.01	13.47	37.35	12.83	3.79

Table S1. Element contents of the surface of $NaYF_4$:Yb(20%),Tm(0.5%)@$NaGdF_4$:Yb(10%),Nd(10%) determined by XPS analysis.

The XPS analysis was also employed to investigate the surface information of the core-shell Y@Gd NCs. Though all the lanthanide elements could be detected in the fine-scan mode, it should be noted that the Gd element is predominant on the surface (18.13 at.%) of the core-shell NCs, which is significantly higher than the element Y (8.37 at.%). These XPS results imply that the surface of the core-shell nanocrystals mainly consists of $NaGdF_4$ shell. The signals from C and O are from the surface-adsorbed oleic acids (OA) on the core-shell NCs during synthesis.

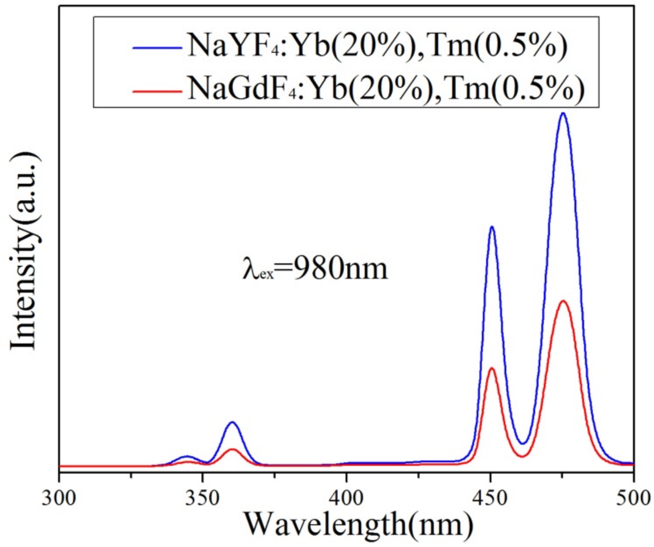

Figure S3. UC emission spectra of $NaYF_4$:Yb(20%),Tm(0.5%) and $NaGdF_4$:Yb(20%),Tm(0.5%) under 980nm excitation. This data shows that $NaYF_4$ is a better host for UC fluorescence than $NaGdF_4$ for Yb^{3+}/Tm^{3+} codoping when they have a similar size, doping level and the same hexagonal phases.

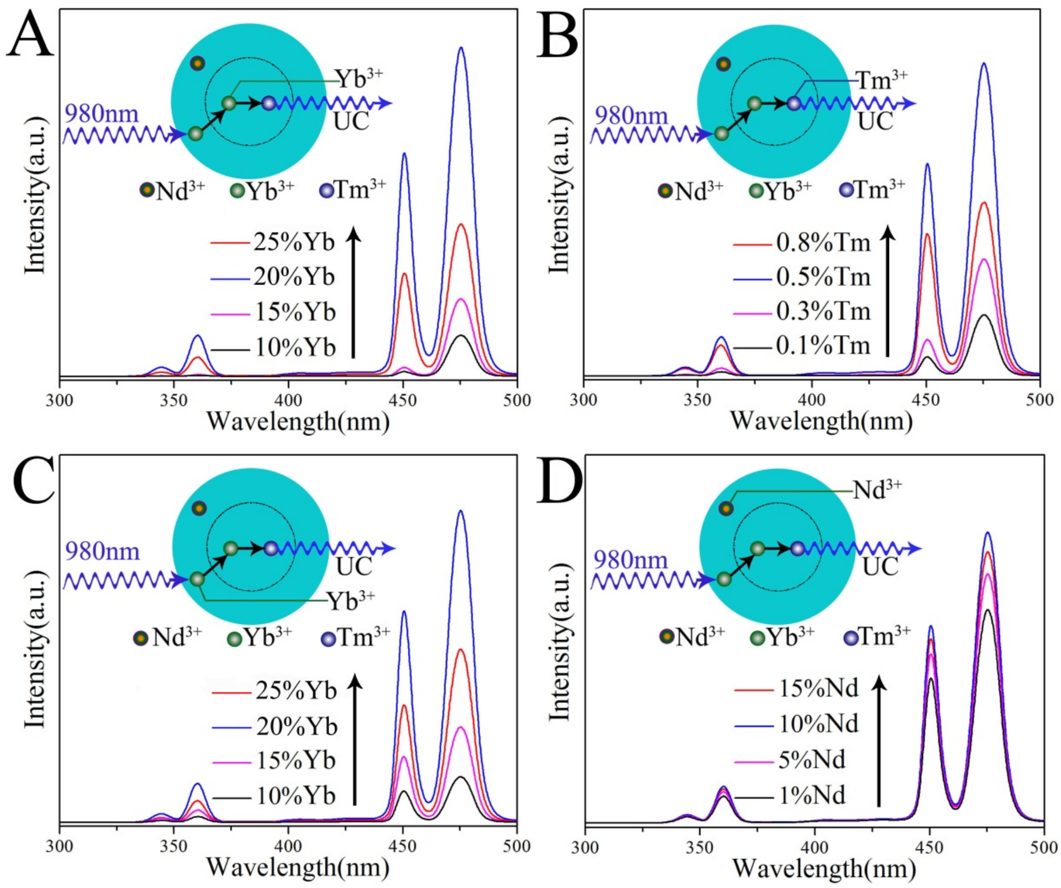

Figure S4. Comparison of UC emission intensities of $NaYF_4$:Yb,Tm@$NaYF_4$:Yb,Nd UCNs under 980nm excitation by changing the doping concentration of different ions: (A) Yb^{3+} in the core; (B) Tm^{3+} in the core; (C) Yb^{3+} in the shell; (D) Nd^{3+} in the shell.