

Supporting information

Facile Synthesis of β -NaGdF₄:Yb/Er@CaF₂ Nanoparticles with Enhanced Upconversion Fluorescence and Stability via a Sequential Growth Process

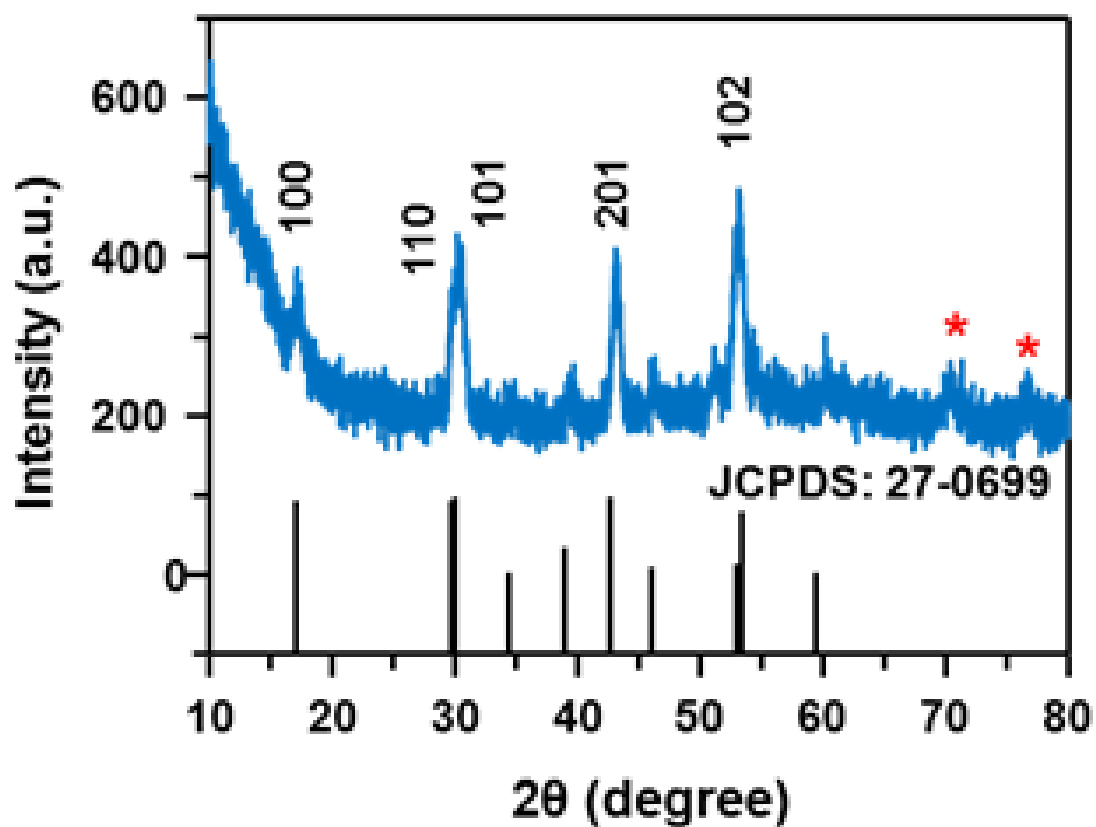


Fig. S1. X-ray diffraction (XRD) pattern of NaGdF₄:Yb/Er@CaF₂ NPs (blue) and standard pure hexagonal phase NaGdF₄ (JCPDS no. 27-0699) (black).

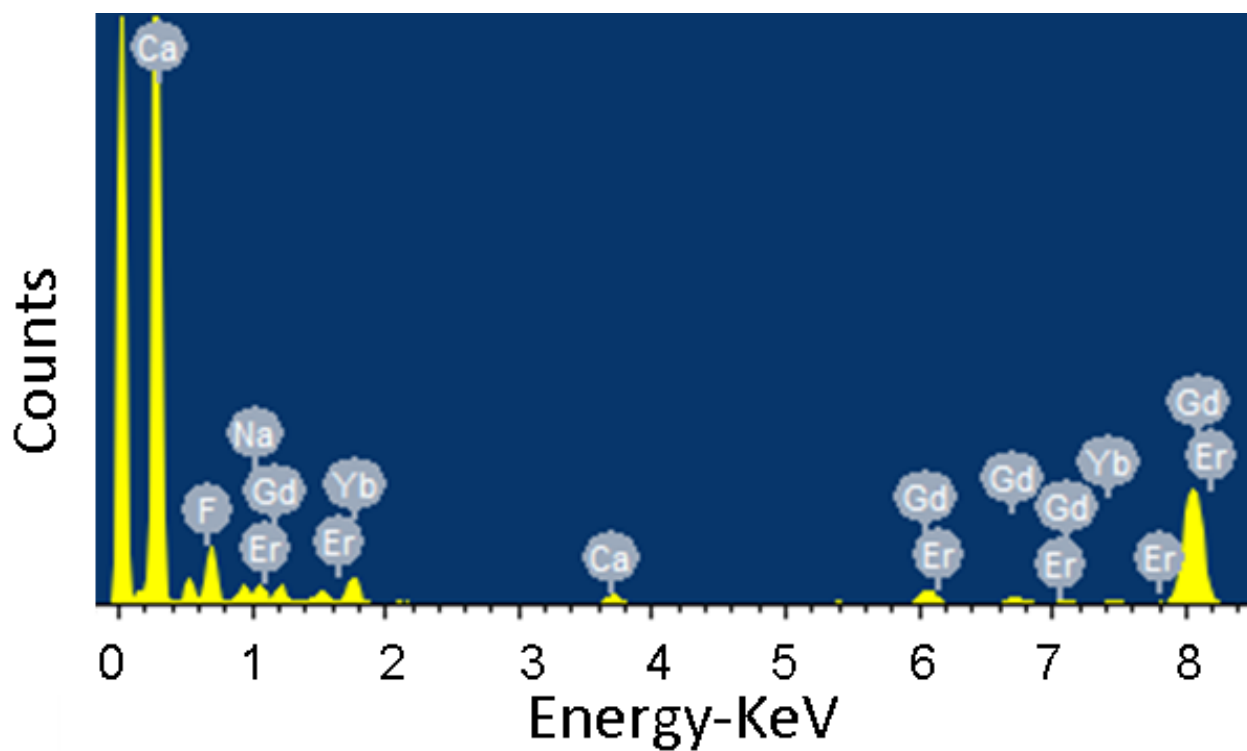


Fig. S2. The energy-dispersive X-ray spectroscopy analyses of (a) $\text{NaGdF}_4:\text{Yb,Er}@CaF_2$ core/shell NPs, revealing the presence of F, Na, Gd, Yb, Er and Ca, illustrating the formation of $\text{NaGdF}_4:\text{Yb/Er}@CaF_2$ core/shell nanoparticles.

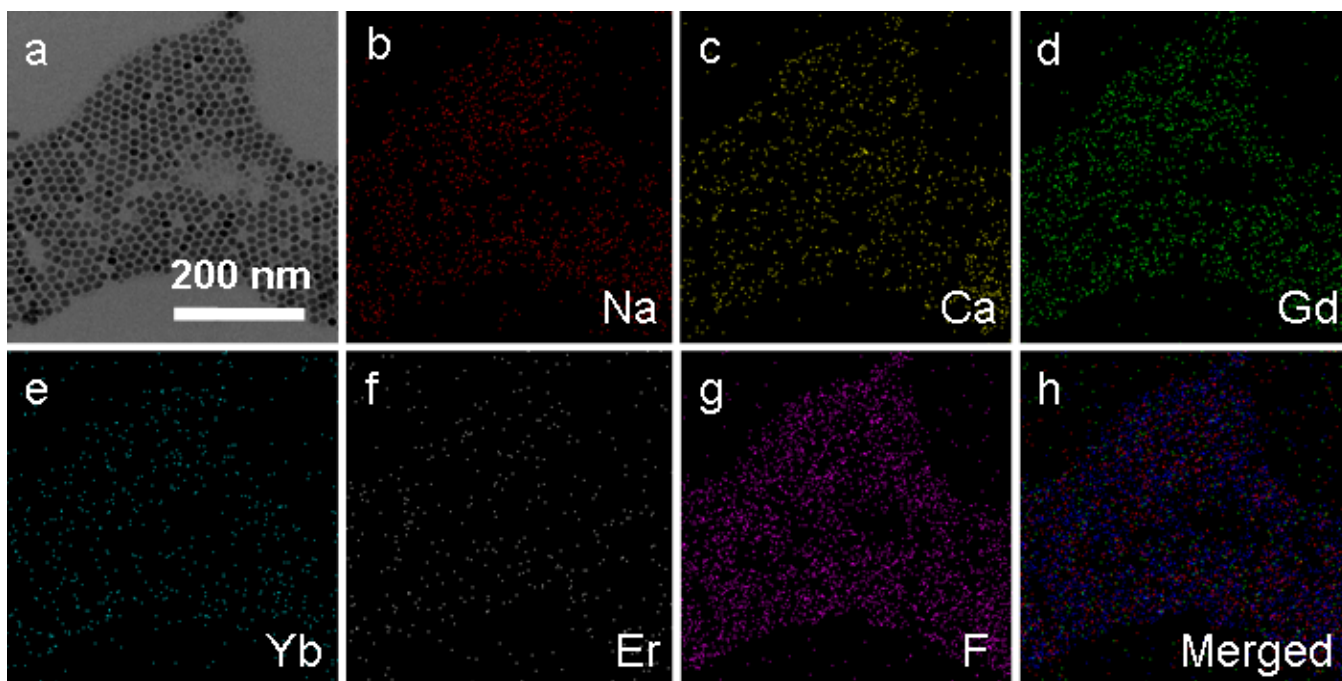


Fig. S3. (a) STEM image of $\text{NaGdF}_4:\text{Yb,Er}@CaF_2$ core-shell NPs; (b -g) Element maps: (b) Na; (c) Ca; (d) Gd; (e) Yb; (f) Er; (g) F and merged images of the all the elements (h).

Fig. S4. (a) TEM image of the core NaGdF₄:Yb/Er NPs; (b-c) TEM images of the core-shell NaGdF₄:Yb/Er@CaF₂ NPs with different shell thickness obtained from 0.25 mmol RE-OA, 0.125 mmol Ca-OA, 0.0741 g NH₄F, 0.05 g NaOH at 280 °C (named core-shell-1), and 0.25 mmol RE-OA, 0.25 mmol Ca-OA, 0.0741 g NH₄F, 0.05 g NaOH at 280 °C (named core-shell-2); (a-c) TEM images of the as-prepared samples demonstrate the different core-shell thickness: (d) 12.16 nm; (e) 12.63 nm; (f) 13.29 nm. (g) HRTEM image and (h-i) dark-field scanning transmission electron microscopy images of the core-shell-1 NaGdF₄:Yb/Er@CaF₂ nanoparticles.

Fig. S5. TEM images of the as-prepared product obtained from different amount of NaOH and other synthetic parameters were kept at same as synthesis of the core-shell-2 NPs : (a) 0.02g; (b) 0.16 g.

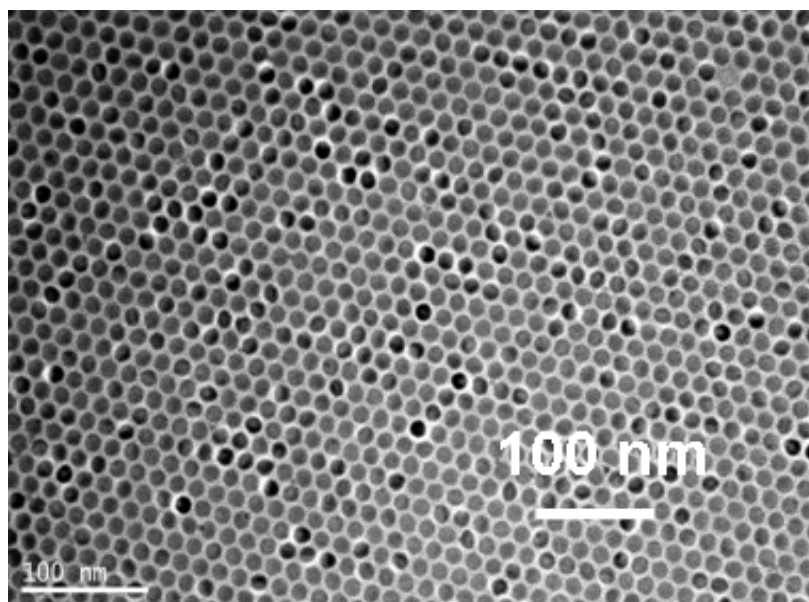


Fig. S6. TEM image of the NaGdF₄:Yb/Er NPs.

Table S1. Element composition of the as-prepared NaGdF₄:Yb,Er@CaF₂ core-shell nanoparticles from EDX analyses.

Element	Weight%	Atomic%
F	35.13	70.27
Na	6.90	11.41
Ca	6.51	6.18
Gd	38.24	9.24
Er	0.00	0.00
Yb	13.21	2.90
Totals	100.00	