

Support Information

Sample Method for Simultaneously Achieving Red And Green Up-conversion Luminescence

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Experimental

Materials: All materials purchased were used as follows without further purification. 1-Octadecene (OM; 90%) and oleic acid (OA; 90%), $\text{Y}(\text{CH}_3\text{COO})_3 \cdot 4\text{H}_2\text{O}$, $\text{Yb}(\text{CH}_3\text{COO})_3$, and $\text{Er}(\text{CH}_3\text{COO})_3$ were purchased from Alfa Aesar. Ammonium fluoride (NH_4F), sodium hydroxide (NaOH), methanol, cyclo-hexane, and ethanol were purchased from Tianjinzhiyuan Chemical Reagent Co and used as received. All $\text{Re}(\text{CH}_3\text{COO})_3$ were dissolved in deionized water, NaOH and NH_4F dissolved in methanol solution in advance to reduce the experimental error.

Synthesis of $\text{NaYF}_4: x\text{Er}^{3+}$ ($x=5, 10, 25, 75$ mol%): 3 mL oleic acid and 7 mL octadecene were added to the two vials respectively, and 2 mL (0.4 mmol) $\text{Re}(\text{CH}_3\text{COO})_3$ (0.2 M) was added in proportion. The samples present pale yellow after heating to 150 °C and preservation for 45 min, a rare earth oleate precursor solution can be obtained while the sample was cooled to room temperature. 1 mL NaOH (1M) and 4 mL NH_4F (0.4 M) methanol mixture were added to the solution, insulated at 50 °C for 40 min. Vacuumed at 100 °C and argon was swap every 3 min to

balance bottle pressure. The solution was quickly heated (15 min) to 290 °C when bubbles no longer produced, kept warm for 1.5 h, and desired product can be obtained while cooled to room temperature. A certain amount of ethanol solution was added to the solution, centrifuged at 9000 rad/min for 6 min. The product was dissolved in 4 mL cyclohexane, 8 mL ethanol was added and centrifuged at 9000 rad/min for 6 min. Repeat the previous step with 4 mL ethanol and 4 mL methanol instead of 8 mL ethanol. The resulting sample was dissolved in 5 mL cyclohexane, sealed and stored in a glass vial at 4 °C.

Characterization

Size and morphology of samples were measured by JEM-2100F high-resolution transmission electron microscopy (HRTEM). The UV spectra were measured by Edinburgh FS5 fluorescence spectrometer, power-tunable 980 nm (maximum power: 800 mW) and 1550 nm (maximum power: 800 mW) laser diodes (LD) were used as excitation sources.

Table 1 Radiative decay time τ (μs) of $^4\text{S}_{3/2}$ (550 nm), $^4\text{F}_{9/2}$ (654 nm), $^4\text{I}_{9/2}$ (800 nm), $^4\text{I}_{11/2}$ (1000 nm), and $^4\text{I}_{13/2}$ (1535 nm) in phosphors $\text{NaYbF}_4:\text{Er}^{3+}$ samples under 980 and 1550 nm pulse LD

excitation.

	980 nm	1550 nm
$^4\text{S}_{3/2}$	9.75	6.54
$^4\text{F}_{9/2}$	200.35	164.57
$^4\text{I}_{9/2}$	69.61	103.29
$^4\text{I}_{11/2}$	115.09	
$^4\text{I}_{13/2}$	470.69	485.66

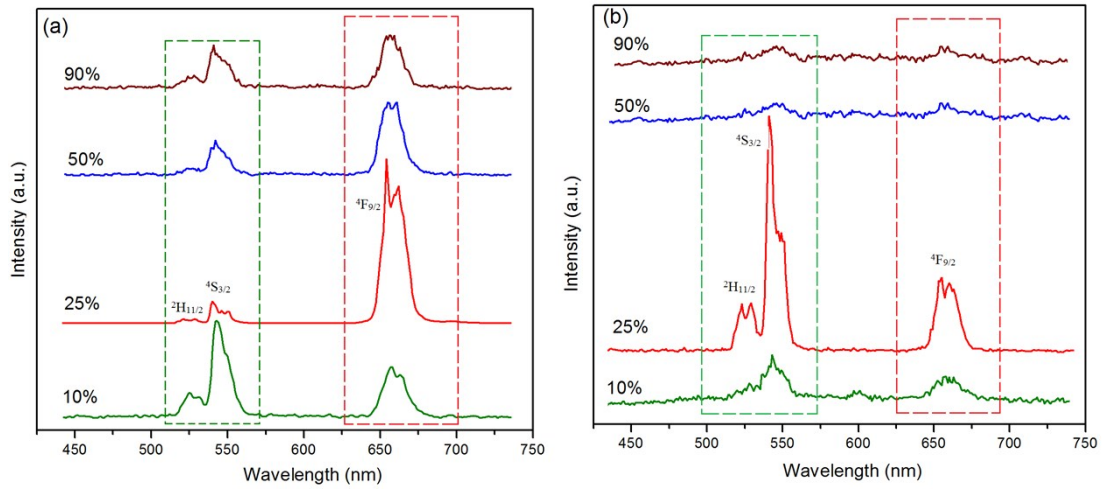


Fig. S1 UCL spectra of $\text{NaYbF}_4: x\text{Er}^{3+}$ ($x=10, 25, 50, 90$ mol%) under 980 and 1550 nm

excitation.

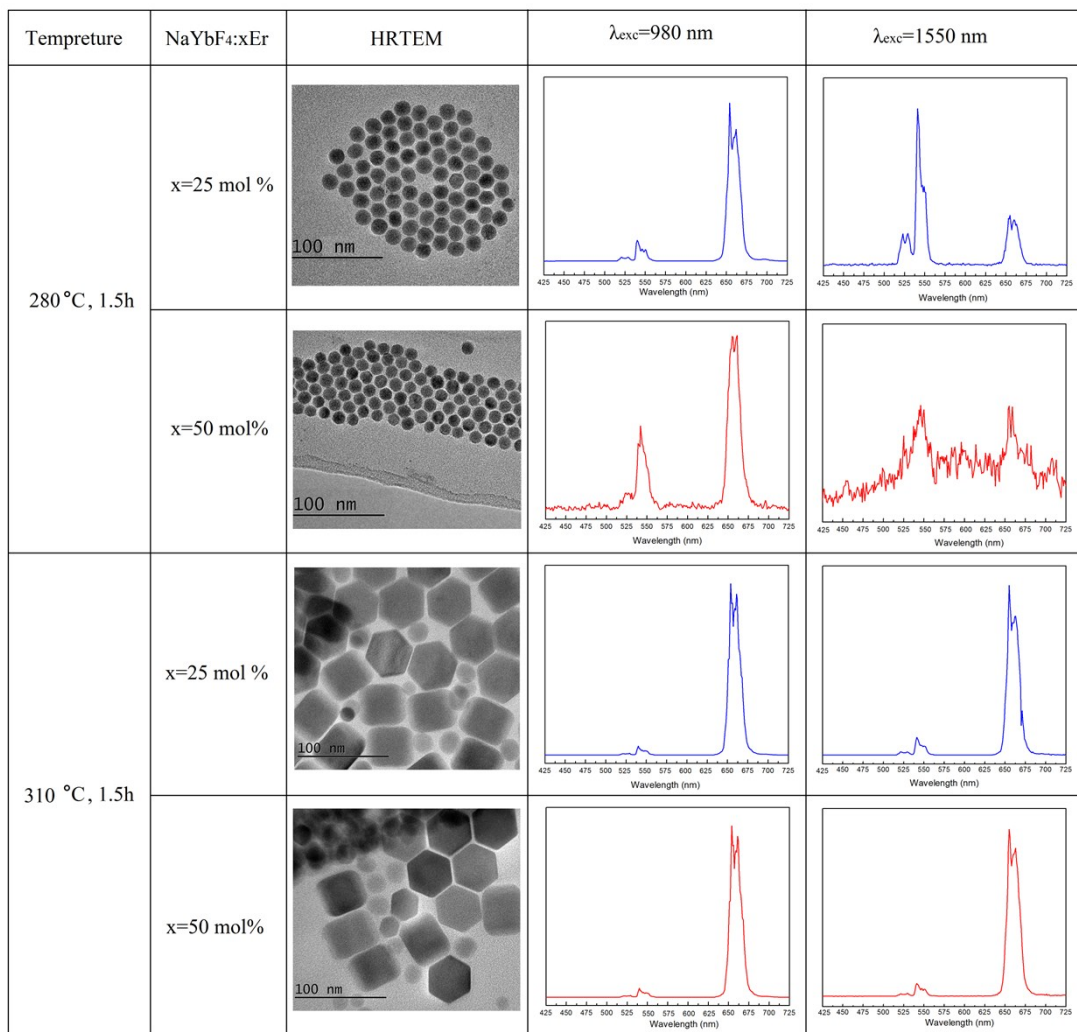


Fig. S2 UCL spectra of NaYbF₄:xEr³⁺ (x=25, 50 mol%) prepared in differ condition (280, 310 °C for 1.5 h) under 980 and 1550 nm excitation.

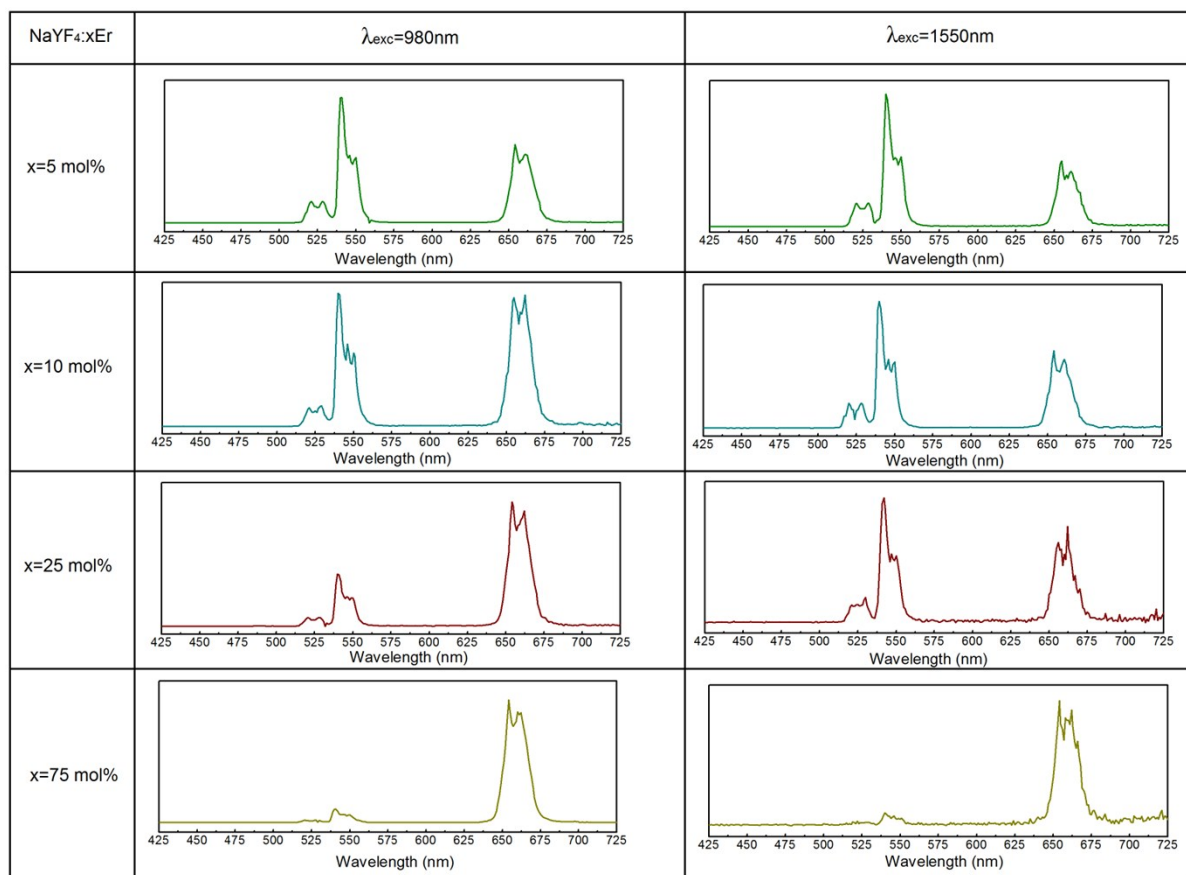


Fig. S3 UCL spectra of NaYF₄:xEr³⁺ (x=5, 10, 25,75 mol%) under 980 and 1550 nm excitation.



Fig. S4 Multi-color photos of NaYbF₄:25%Er³⁺, the excitation power density of 1550 nm is fixed at 38.03 mW/mm² while that of 980 nm are 0, 15.47, 19.92, 24.22, 28.41, 32.67, 37.06, 40.82, 44.52, and 52.08 mW/mm², specific measurement methods is shown as below. (Canon EOS 5D

Mark III, Tv=1:320, Len: EF24-70mm f/2.8L II USM, Av= 2.8, ISO=12800)



Fig. S5 specific measurement methods of Fig. S4. (Canon EOS 5D Mark III, Tv=1:10, Len: EF24-70mm f/2.8L II USM, Av= 2.8, ISO=12800)

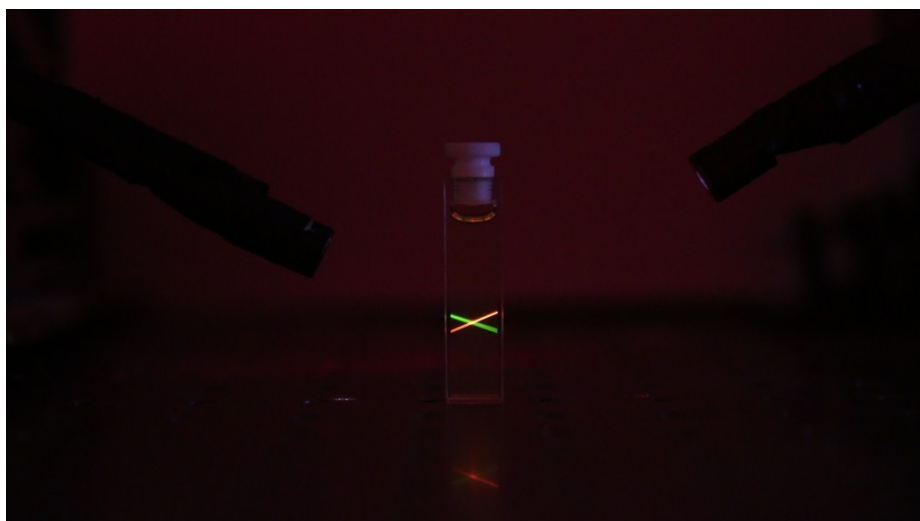
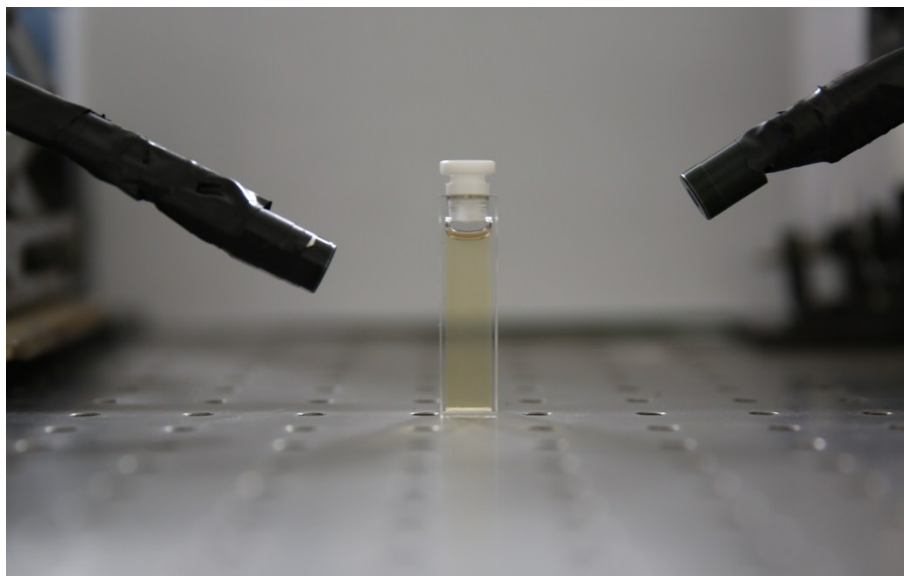


Fig. S6 Specific measurement methods of Fig. 2b in the manuscript. (Canon EOS 5D Mark III,

Tv=1:10, Len: EF24-70mm f/2.8L II USM, Av= 2.8, ISO=12800)