Supporting Information

Synthesis of upconversion $NaYF_4:Yb^{3+},Er^{3+}$ particles with enhanced luminescent intensity through control of morphology and phase

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Effect of F^-/Ln^{3+} ratio

NaF was used as the F^- source for the preparation of $NaYF_4$ crystals. Different F^-/Ln^{3+} (Ln^{3+}=Y^{3+}, Yb^{3+}, Er^{3+}) ratios of 8:1, 16:1 and 24:1 were selected to study the effect of F^-/Ln^{3+} ratio on the phase, morphology and luminescent intensity of the obtained products. The pH value and the reaction time were fixed at 2.0 and 14 h. The XRD patterns of the as-prepared products were shown in Fig. S1. It can be seen that the F^-/Ln^{3+} ratio does not affect the crystal structure, and all the products are pure β-$NaYF_4$

(JCPDS No. 16-0334). The morphology of the as-prepared samples is presented in Fig. S2. The morphology changes dramatically with varying F^-/Ln^{3+} ratio. For the sample prepared at F^-/Ln^{3+} ratio of 8:1, the microstructure is much less uniform with microrod-like structure (Fig. S2(a)). While, when F^-/Ln^{3+} ratio was changed to 16:1, hexagonal $NaYF_4:Yb^{3+},Er^{3+}$ microtubes with cracked ends were obtained (Fig. S2(b)). The morphology of the sample synthesized at F^-/Ln^{3+} ratio of 24:1 is shown in Fig. S2(c). As can be seen from the image, the products were all irregular microrods. To compare the upconversion luminescent intensity, we plotted the fluorescent spectra of the as-prepared products against different F^-/Ln^{3+} ratios (Fig. S3). The results indicate that hexagonal $NaYF_4:Yb^{3+},Er^{3+}$ microtubes generate higher luminescent intensity than hexagonal $NaYF_4:Yb^{3+},Er^{3+}$ microrod-like structure. While the irregular hexagonal $NaYF_4:Yb^{3+},Er^{3+}$ microrods prepared under F^-/Ln^{3+} ratio of 24:1 possess the lowest luminescent intensity.

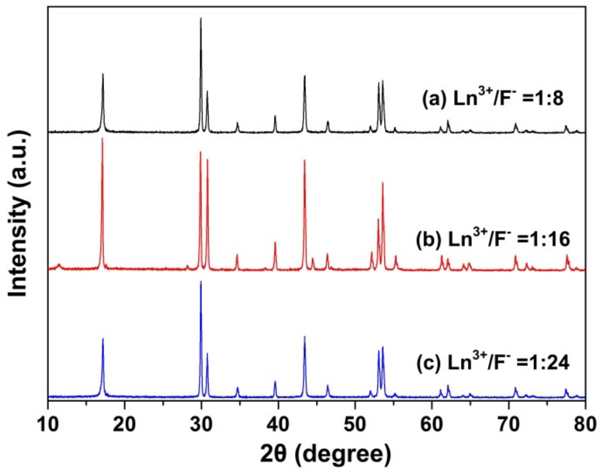

Fig. S1 XRD patterns of the as-prepared products with different F^-/Ln^{3+} ($Ln^{3+}=Y^{3+}$, Yb^{3+}, Er^{3+}) ratios: (a) F^-/Ln^{3+} = 8:1; (b) F^-/Ln^{3+}=16:1; (c) F^-/Ln^{3+}=24:1.

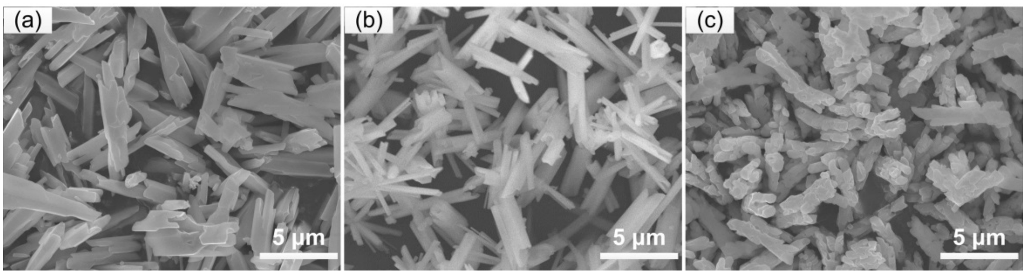

Fig. S2 SEM images of the as-prepared products with different F^-/Ln^{3+} ($Ln^{3+}=Y^{3+}$, Yb^{3+}, Er^{3+}) ratios: (a) F^-/Ln^{3+}= 8:1; (b) F^-/Ln^{3+}=16:1; (c) F^-/Ln^{3+}=24:1.

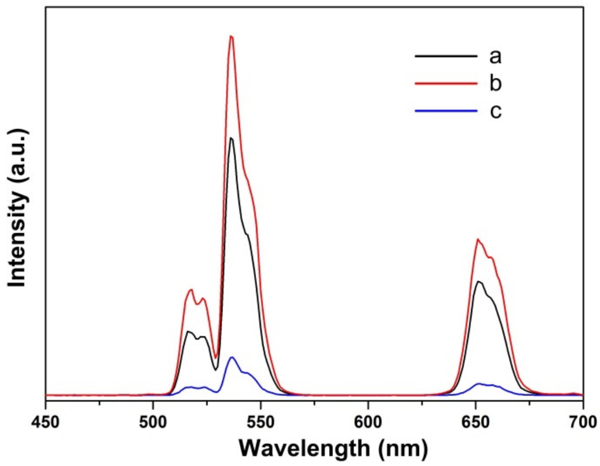

Fig. S3 Fluorescence spectra of the as-prepared products with different F^-/Ln^{3+} (Ln^{3+}=Y^{3+}, Yb^{3+}, Er^{3+}) ratios: (a) F^-/Ln^{3+} = 8:1; (b) F^-/Ln^{3+}=16:1; (c) F^-/Ln^{3+}=24:1.