Supporting Information

Enhanced red upconversion luminescence by codoping Ce³⁺ in β-NaY(Gd_{0.4})F_{4:} Yb³⁺/Ho³⁺ nanocrystals

Wei Gao, Hairong Zheng*, Qingyan Han, Enjie He, Fangqi Gao, Ruibo Wang

School of Physics and Information Technology, Shaanxi Normal University, Xi'an 710062, China E-mail: hrzheng@snnu.edu.cn

1.1. Synthesis of the β-NaYF₄:Yb³⁺/Ho³⁺/Ce³⁺ microplates and microprisms

β-NaYF₄:Yb³⁺/Ho³⁺/Ce³⁺microplates and microprisms are hydrothermally prepared by with trisodium citrate as a chelator in the reference ^[1]. Firstly, 3.0g NaNO₃ and 4.0 ml NaF (1.0 M) are added into 10.0 ml deionized water under vigorous stirring to form solution A. Second, the mixture 1.2 ml of RE(NO₃)₃ (0.5 M, RE=Y, Yb, Ho and Ce) and 6 ml solution of trisodium citrate (0.1 M) were slowly added into the solution A. Then one need to stir it for about 20 min until it completely becomes white liquid. Finally, the mixture slowly are transferred into a 40.0 ml Teflon-lined autoclave and heated at 180°C for 24 hours. The β-NaYF₄:Yb³⁺/Ho³⁺/Ce³⁺ microcrystals were collected by centrifuging, wash with deionized water and ethanol several times. The collected samples were dried at 60°C for several hours. The β-NaYF₄ microplates were obtained by tuning the pH value is 7, and the β-NaYF₄ microprisms were obtained by tuning the pH value is 3.

2.2. Figure



Fig. S1 XRD patterns of β-NaYF₄: 20%Yb/2%Ho³⁺/*x*Ce³⁺ microplates (a) and microprisms (b) (x=0%, 4%, 8% and 12%).



Fig. S2 SEM images of β-NaYF₄: 20%Yb³⁺/2%Ho³⁺/xCe³⁺ microplates (a-d) and microprisms (e-h) (x=0%, 4%, 6%, 8% and 12%). The EDS spectra of β-NaYF₄: 20%Yb³⁺/2%Ho³⁺ microplates (i-j) and microprisms (k-l) with codoping x%Ce³⁺ (x=0% and 12%).

Table S1 The calculated CIE chromaticity coordinate (x, y) of β -NaYF4: $20\% Yb^{3+}/2\% Ho^{3+}$ samples with different Ce³⁺ concentration.CIE chromaticity coordinate (x, y)

	CIE chromaticity coordinate (x, y)	
Samples	microplates	microprisms
β-NaYF ₄ : 20%Yb ³⁺ /2%Ho ³⁺	(0.4987 0.4734)	(0.2602 0.6514)
β -NaYF ₄ : 20%Yb ³⁺ /2%Ho ³⁺ / 4%Ce ³⁺	(0.5508 0.4113)	(0.3521 0.5432)
β -NaYF ₄ : 20%Yb ³⁺ /2%Ho ³⁺ / 6%Ce ³⁺	(0.5917 0.3721)	(0.4745 0.4368)
β -NaYF ₄ : 20%Yb ³⁺ /2%Ho ³⁺ / 8%Ce ³⁺	(0.6312 0.3334)	(0.5201 0.3764)
β -NaYF ₄ : 20%Yb ³⁺ /2%Ho ³⁺ / 12%Ce ³⁺	(0.6498 0.3037)	(0.5546 0.3519)



Fig. S3 Schematic drawing of the experimental setup.

References

[1] N. Liu, W. P. Qin, G. S. Qin, T. Jiang and D. Zhao, *Chem. Commun.*, 2011, 47, 7671.