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Supporting Information for

Controlled Synthesis and Upconversion Luminescence of Lanthanide Doped $BaYF_5$ Nanocrystals

Hailong Qiu,[a] Guanying Chen,[a,b] Liang Sun,[a] Shuwei Hao[a] Gang Han,[c]* and Chunhui Yang[a]*

[a]*School of Chemical Engineering and Technology, Harbin Institute of Technology, Harbin 150001, People's Republic of China. *E-mail:yangchh@hit.edu.cn*
[b]*Institute for Lasers, Photonics and Biophotonics, Department of Chemistry, University at Buffalo, The State University of New York, Buffalo, New York 14260.*
[c]*Department of Biochemistry and Molecular Pharmacology, University of Massachusetts Medical School, Worcester, Massachusetts 01605. *E-mail: gang.han@umassmed.edu.*

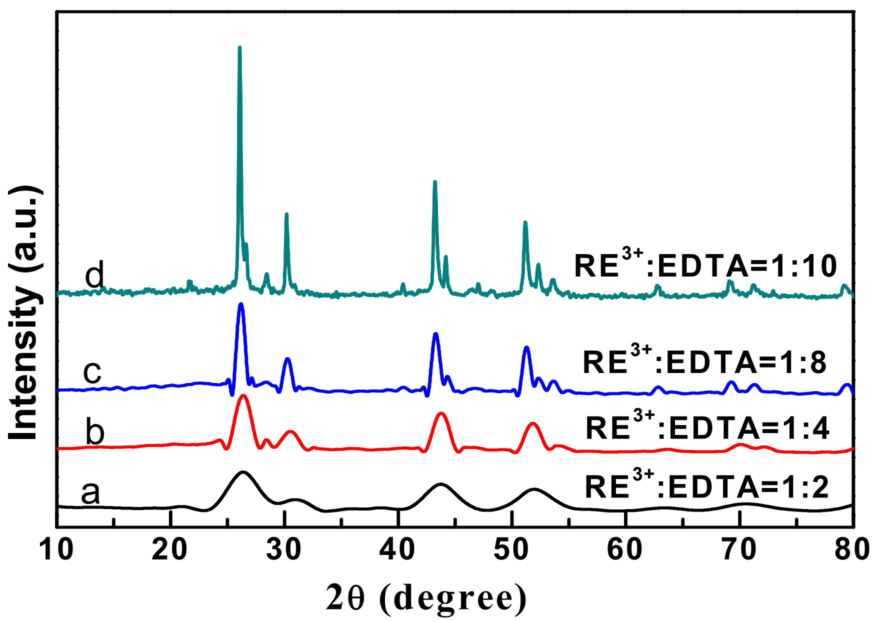

Figure S1. The typical XRD patterns of $BaYF_5$ with the RE^{3+}/EDTA of (a)1:2, (b)1:4, (c)1:8, and (d)1:10, respectively.

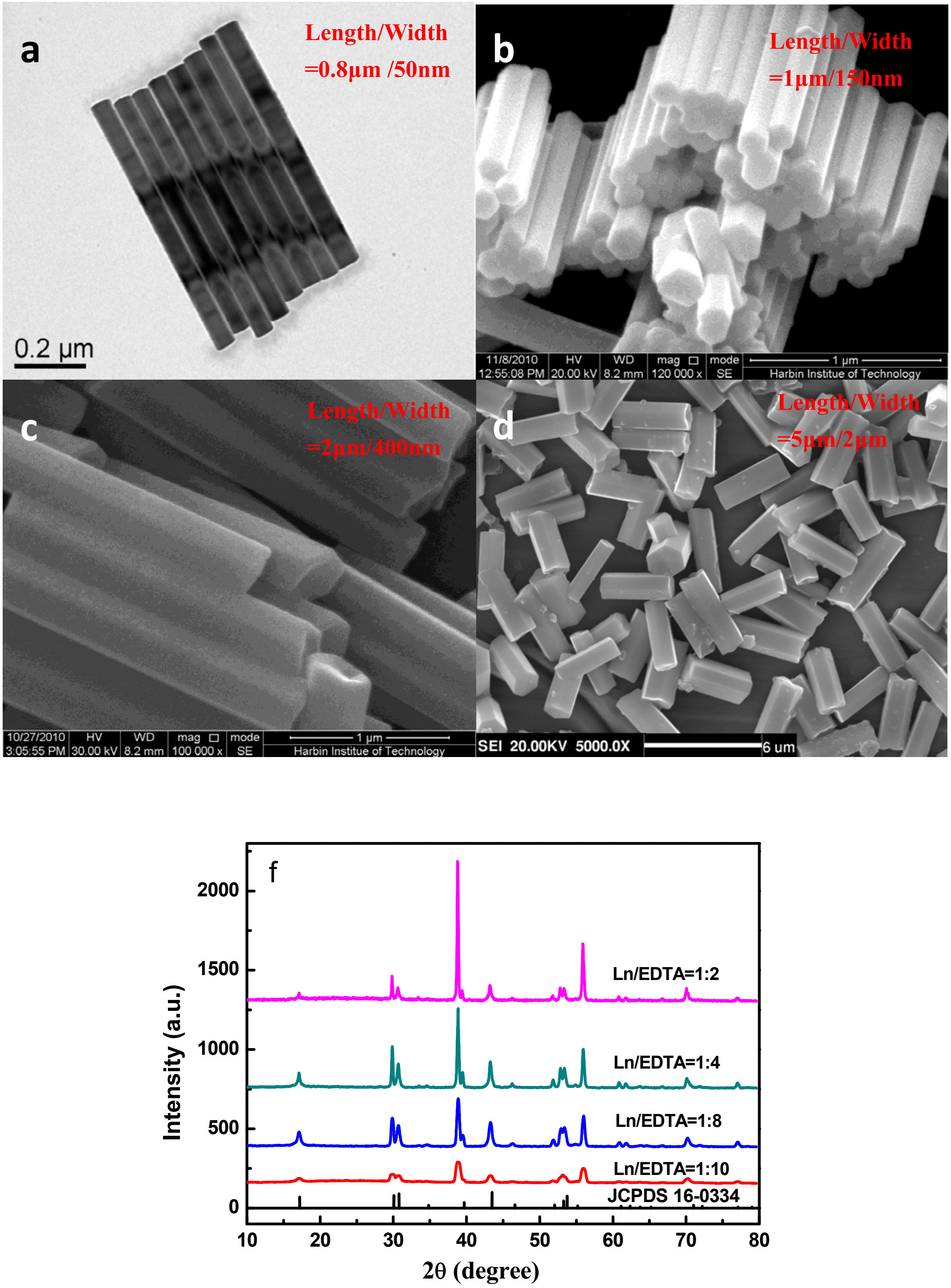

Figure S2. (a) TEM, (b, c and d) FESEM images of $NaYF_4$ with the RE^{3+}/EDTA of (a)1:10, (b)1:8, (c)1:4, and (d)1:2, respectively. (f) XRD patterns of $NaYF_4$ powders in Figure S2 (a-d). All the diffraction peaks of $NaYF_4$ powders with RE^{3+}/EDTA of (a)1:10, (b)1:8, (c)1:4, and (d)1:2 agree well with standard hexagonal structure of JCPDS 16-0334.

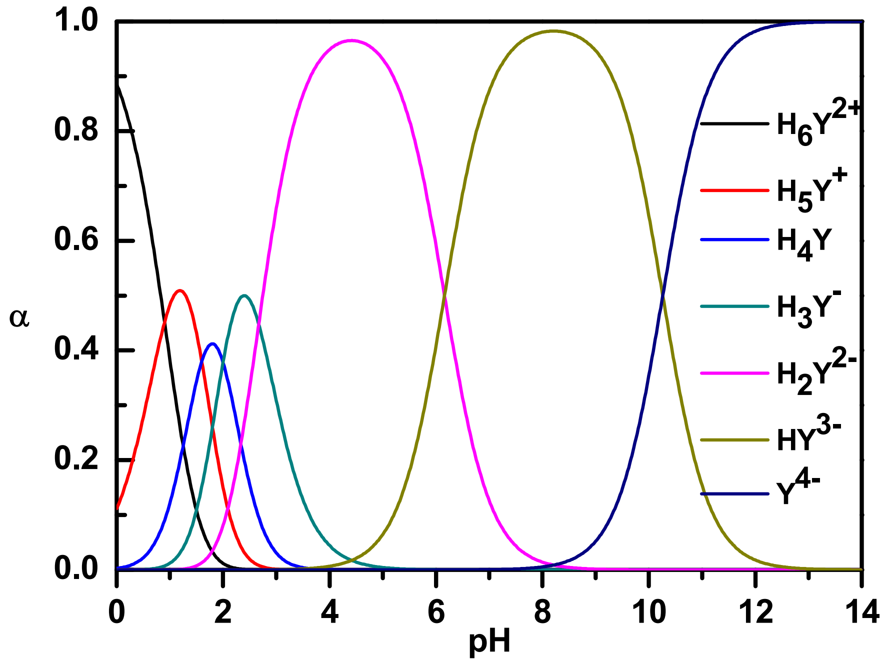

Figure S3. Relative distribution of species of EDTA versus the pH value.

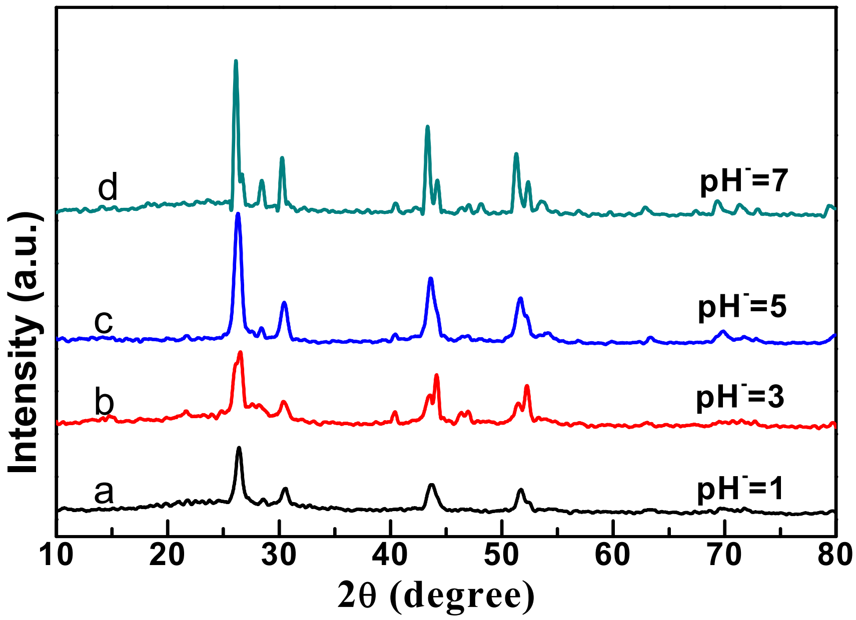

Figure S4. The typical XRD patterns of $BaYF_5$ at (a) pH=1, (b)pH=3, (c) pH=5, and (d) pH=7, respectively

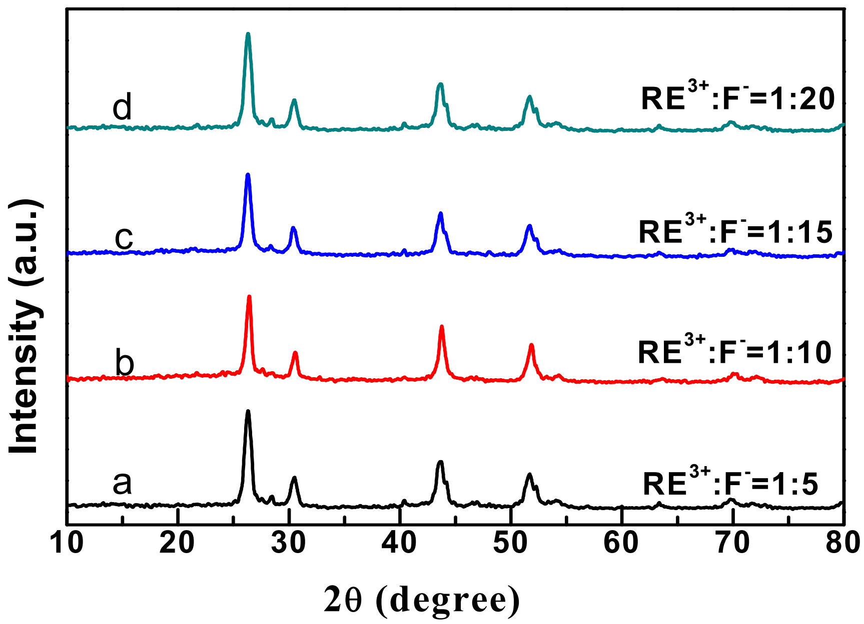

Figure S5. The typical XRD patterns of $BaYF_5$ with RE^{3+}/F^- ratio of (a) 1:5 (b) 1:10, (c) 1:15 and (d) 1:20, respectively.

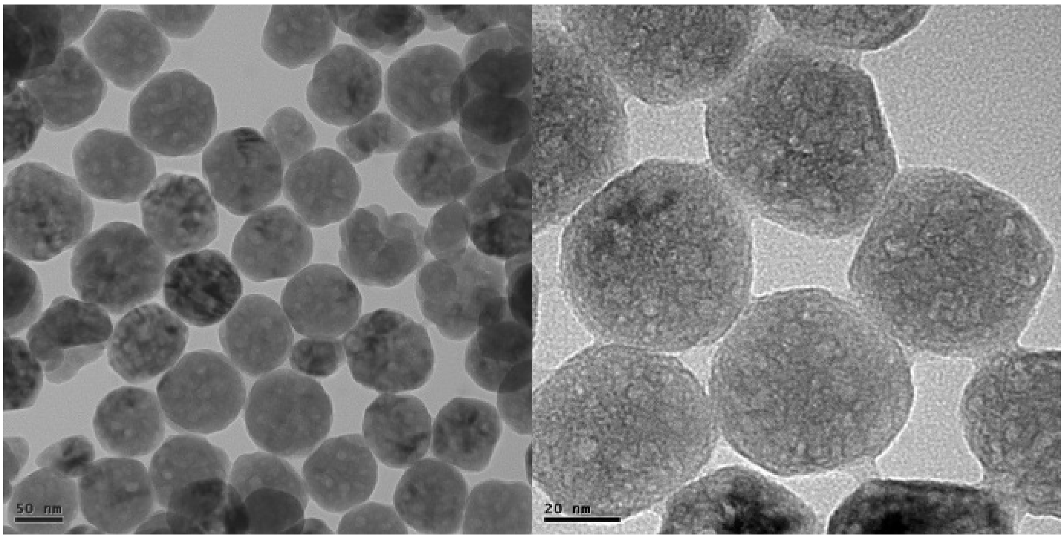

Figure S6. TEM images of $BaYF_5$ nanocrystals after ligand exchange.

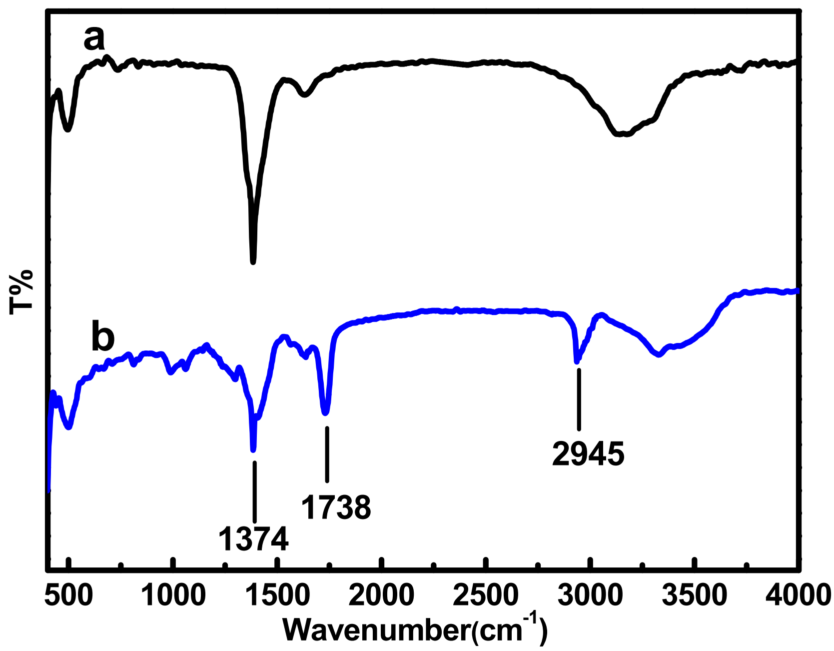

Figure S7. Fourier transform infrared (FT-IR) spectra of $BaYF_5$ nanocrystals before (a) and after (b) ligand exchange using PAA. Photographs of colloidal solutions of the $BaYF_5$ nanocrystals (50-60nm) dispersed in cyclohexane and water before (c) and after (d) PAA modification. The FT-IR spectra were used to characterize the functional groups present on the surface of nanocrystals. The band at 1374 cm^{-1} characterizing the mode of the C=O (N-CO-OH) stretching vibration in the EDTA molecule became weaker after ligand exchange (Figure S7b), suggesting the decreased EDTA molecule on the surface of $BaYF_5$ nanoparticles. Moreover, the bands at 1738 cm^{-1} and 2945 cm^{-1} newly appeared in Figure S7b characterize the –COOH group and the stretching vibration of methylene (CH_2) in the long alkyl chain, respectively, illustrating the presence of the PAA molecule on the on the surface of $BaYF_5$ nanoparticles. These observations give a strong evidence of the successful exchange of EDTA by the ligand of PAA. The broad band between 2800 cm^{-1} and 3600 cm^{-1} arises from the O-H stretching vibration (COO-H).

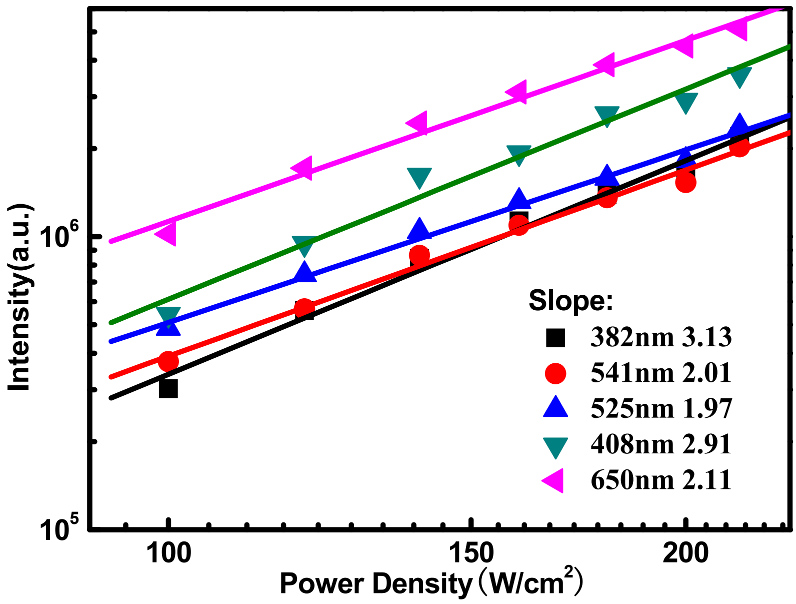

Figure S8. The dependence of the intensities of upconversion emissions bands on the power of excitation at 980 nm in the $BaYF_5$: 18%Yb^{3+}/2%Er^{3+}system.

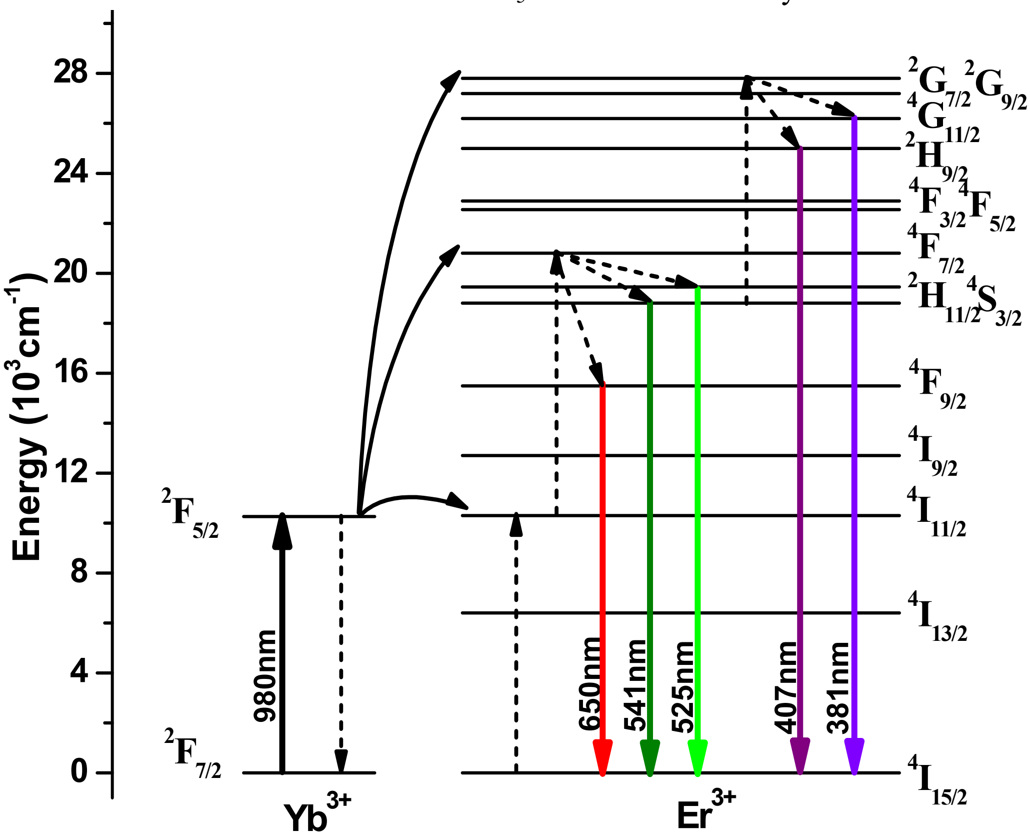

Figure S9. Schematic energy-level diagrams, upconversion excitation, and visible emission schemes for the $BaYF_5$: Yb^{3+}/Er^{3+} system.

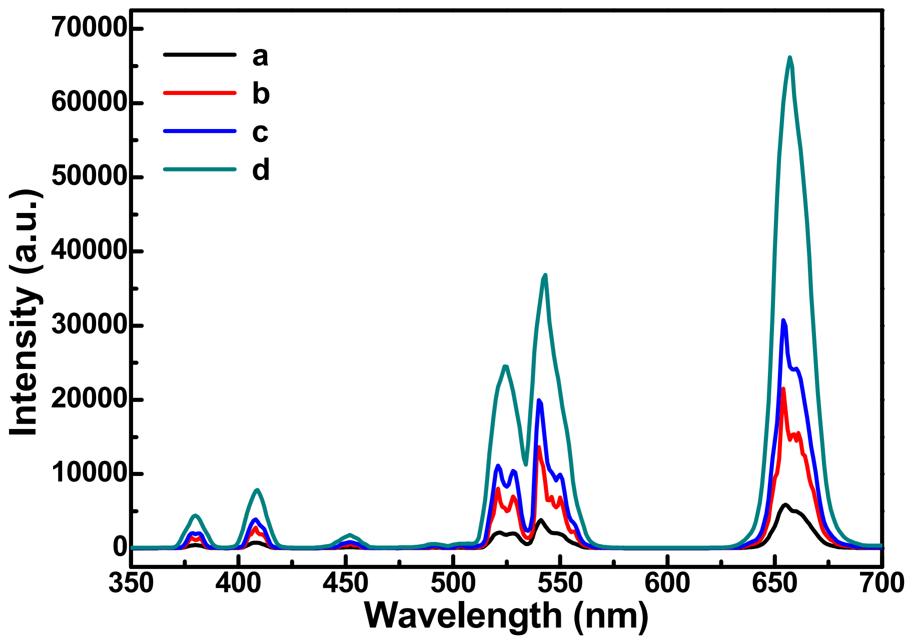

Figure S10. Upconversion emission spectra in the wavelength range of 350-700 nm of $BaYF_5$:18%Yb^{3+}/2%Er^{3+} powders with size of (a) 10-20 nm, (b) 50-70 nm, (c) 100 nm, and (d) 1μm microcrystals. The corresponding TEM images of $BaYF_5$:18%Yb^{3+}/2%Er^{3+} powders with size of (a) 10-20 nm, (b) 50-70 nm, (c) 100 nm, and (d) 1μm was shown in Figure 2.

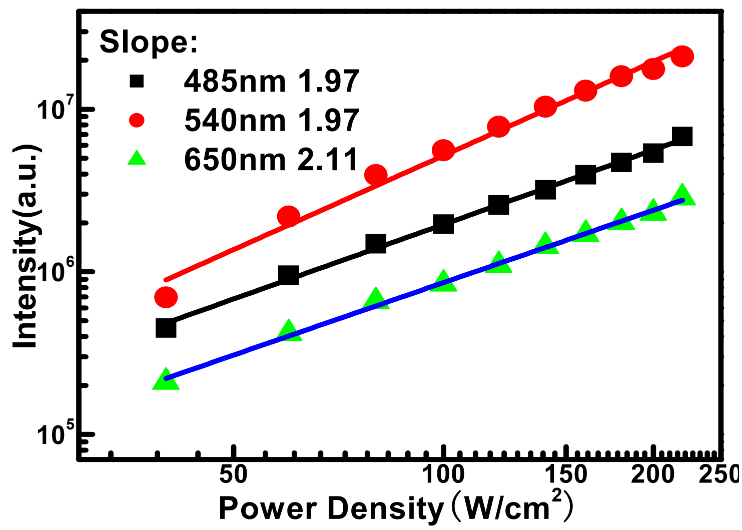

Figure S11. The dependence of the intensities of upconversion emissions bands on the power of excitation at 980 nm in the $BaYF_5$: 18%Yb^{3+}/2%Ho^{3+}system.

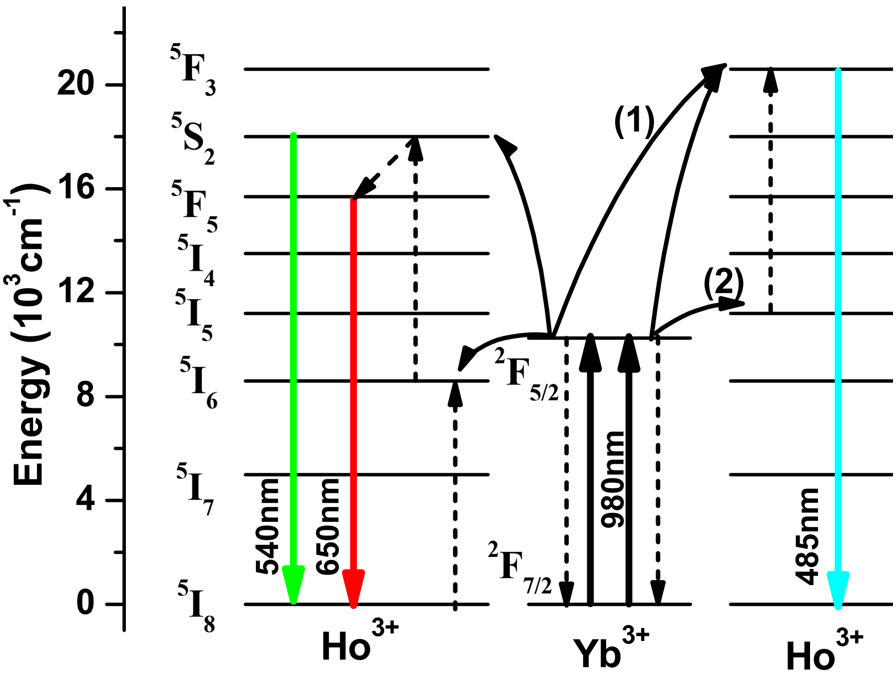

Figure S12. Schematic energy-level diagrams, upconversion excitation, and visible emission schemes for the $BaYF_5$: Yb^{3+}/Ho^{3+} system.

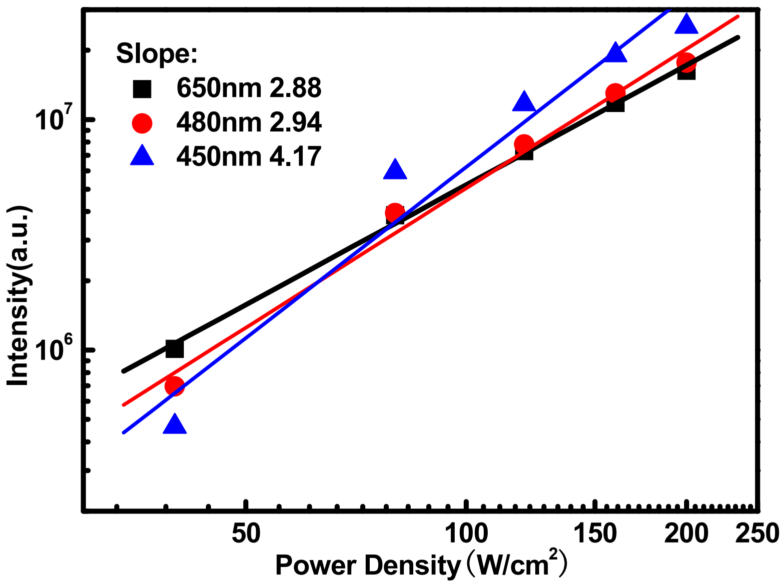

Figure S13. The dependence of the intensities of upconversion emissions bands on the power of excitation at 980 nm in the $BaYF_5$: 18%Yb^{3+}/2%Tm^{3+}system.

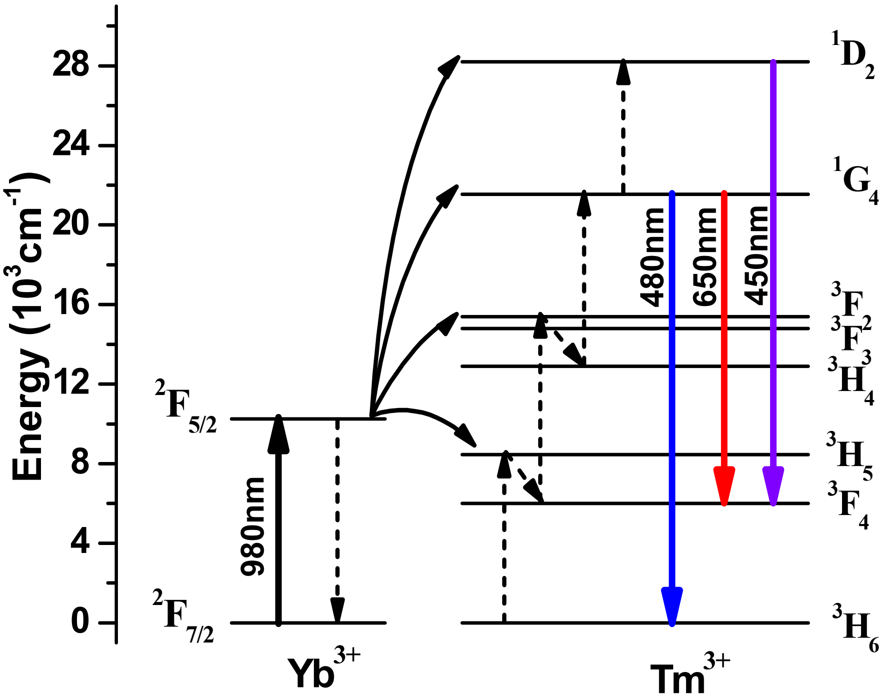

Figure S14. Schematic energy-level diagrams, upconversion excitation, and visible emission schemes for the $BaYF_5$: Yb^{3+}/Tm^{3+} system.

Table S1. The effect of reaction conditions

Reaction conditions	Size and shape
RE^{3+}:EDTA	
1:2	10-20nm nanoparticles
1:4	50-70 nm nanoparticles
1:8	100 nm nanoparticles
1:10	1μm cubic microcrystal
pH	
1	5-10nm nanoparticles
3	5-10nm nanoparticles
5	30-40nm nanoparticles
7	250-300nm nanoparticles
RE^{3+}:F^-	
1:5	10-20nm nanoparticles
1:10	10-20nm nanoparticles
1:15	10-20nm nanoparticles
1:20	10-20nm nanoparticles