Supplementary Materials

Enhanced upconversion emission in $Yb^{3+}$and Er^{3+} codoped $NaGdF_4$ Nanocrystals by introducing Li^+ ions

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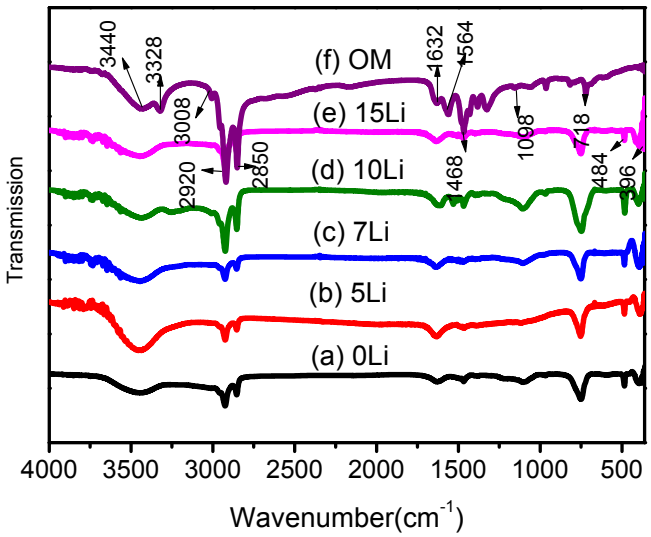

Figure S1 presents the measured Fourier transform infrared(FT-IR) transmission spectra of the prepared $NaGdF_4$ nanoparticles doped with 2 mol% Er^{3+},20 mol% Yb^{3+} ions, and further doped with Li^+ ions of 0-15mol%. The IR spectrum shows the bonding of the ligand molecules on the surface of nanoparticles. As shown in the Fig.S1, the spectra show a broad peak at 3440 cm^{-1}, which originates either from the υ (N-H) stretching of the NH_2 group of oleylamine or the υ (O-H) stretching mode of water which may be generated directly from the air. The intensities of broad peak at 3440 cm^{-1} in all samples are different and the intensity of broad peak at 3440 cm^{-1} in β-$NaGdF_4$:Yb^{3+}/Er^{3+} with 0 mol% Li^+ ions is weakest, which may be ascribed to the υ (O-H) stretching mode of water generating directly from the air during the measurements. The reason is that Fourier transform infrared (FT-IR) spectra were measured via the potassium bromide (KBr) pellet technique and bromide (KBr) pellet absorbed water easily. The absorption peaks at 2850 and 2920 cm^{-1} are due to the symmetric and asymmetric υ (CH_2) stretching modes. The peak at 1098cm^{-1} and 1564 cm^{-1} are assigned to C-N stretch and –NH_2 deformation vibration mode respectively,

indicating that the N-H bonds are intact. The peak at 1468 cm^{-1} is ascribed to -CH_3 asymmetric deformation vibration mode, whereas the peak at 3008 cm^{-1} is due to the characteristic =CH stretching vibration of the –HC=CH- group.[2] The above results indicate that oleylamine binds to the nanoparticles surface.[1] Such absorption peaks have similar intensities for all the samples of NPs, which were thereby expected to give similar effect on the UC efficiency.

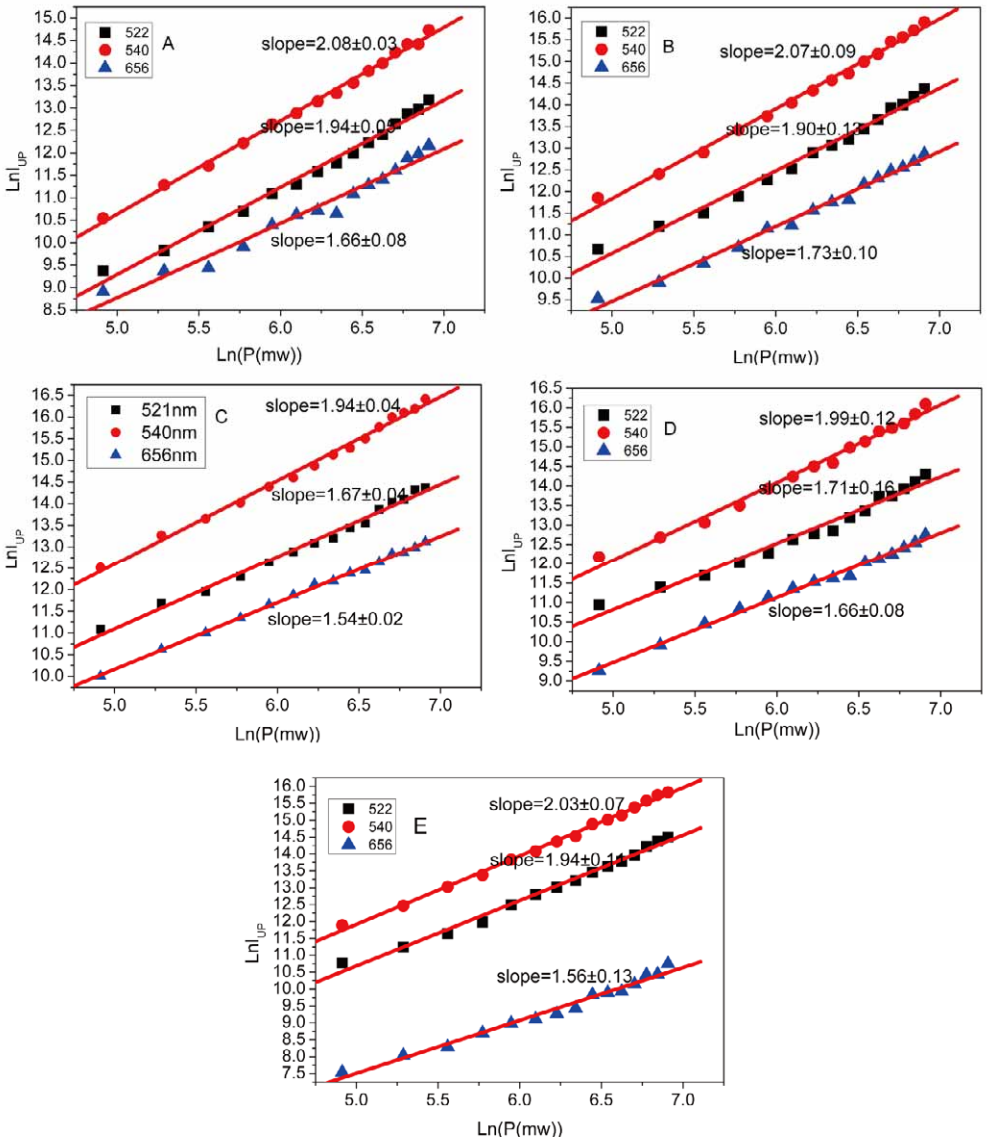

Figure S2 Pump power dependence of the green and red emission of $NaGdF_4$：Yb，Er with introducing Li^+ ions (A) 0mol% Li^+,(B) 5mol% Li^+,(C) 7mol% Li^+, (D)10mol% Li^+,(E) 15mol% Li^+

FigS2 shows the pump power dependence of the green and red emission of $NaGdF_4$: Yb/Er/ Li nanocrystals with introducing different concentration of Li^+ ions. As shown in the Fig.S2, the slops n values obtained in $NaGdF_4$:Yb,Er sample with introducing different Li^+ concentration are slightly smaller than that of $NaGdF_4$:Yb,Er NPs.

References

(1) W.B. Niu, S.L.Wu, S.F.Zhang and L.Li, *Chem. Commun.*, 2010, 46, 3908

(2) Q.B.Zhang, K.Song, J.W.Zhao, X.G. Kong, Y.J.Sun, X.M.Liu, Y.L Zhang, Q.H. Zeng and H.Zhang, *J.Colloid Interface Sci.* 2009,336,171