SUPPORTING INFORMATION

Comprehensive Studies of Li^+ Effect on $NaYF_4$:Yb/Er Nanocrystals: Morphology, Structure, and Upconversion Luminescence†

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Experimentation

Preparation of lithium oleate (LiOA: 0.5 mol/L). In a typical synthesis, LiOH (12.5 mmol) and oleic acid (25 mL) were added to a 100 mL flask, then the solution was heated to 150 ^{o}C for 1 h under argon atmosphere with vigorous stirring.

Preparation of $Li_xNa_{1-x}YF_4$:Yb/Er nanocrystals (LiOA as Li^+ source). In a typical synthesis, $RECl_3$ (RE = Y, Yb, Er) were added by a molar ratio of 80:18:2 (in total 1 mmol) to a 100 mL flask containing oleic acid (7.5 mL) and 1-octadecence (17.5 mL). The solution was then heated to 150 ^{o}C for 30 min under argon atmosphere with vigorous stirring. After cooling to 40 ^{o}C, the methanol solution (10 mL) containing NH_4F (4 mmol) and NaOH (2.5(1-x) mmol), and LiOA (2.5x mmol) were added into the mixture quickly and maintained for 30 min, after which the temperature was raised to 80 ^{o}C to remove the methanol. The reaction mixture was then heated to 300 ^{o}C for 1.5 h. Finally, the as-prepared nanoparticles were separated by centrifugation, washed by ethanol and deionized water, and stored in cyclohexane for testing.

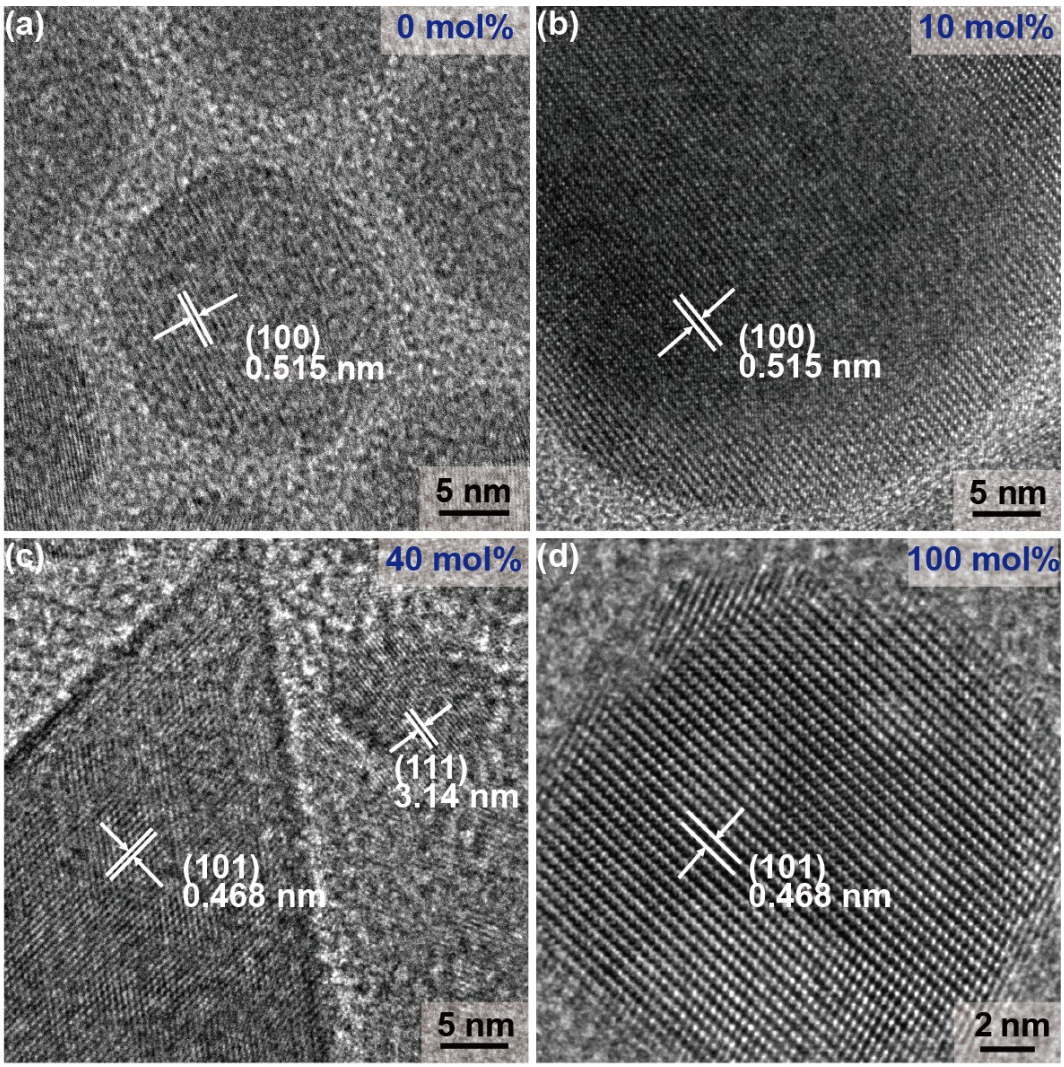

Fig. S1 HRTEM images of $NaYF_4$:Yb/Er nanocrystals doped with different concentrations of Li^+: (a) 0 mol%, (b) 10 mol%, (c) 40 mol%, (d) 100 mol%.

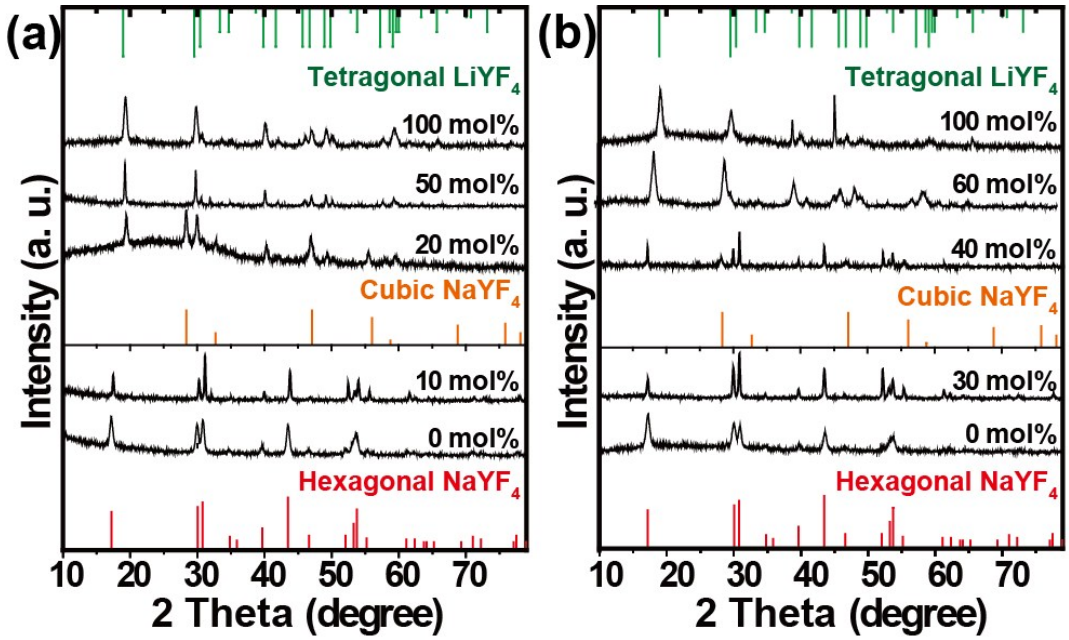

Fig. S2 XRD signals of as-synthesized $Li_xNa_{1-x}YF_4$:Yb/Er nanocrystals using (a) LiOA and (b) LiOH as Li^+ sources, respectively. The standard diffraction patterns are: hexagonal $NaYF_4$ (red): JCPDS no. 16-0334, cubic $NaYF_4$ (yellow): JCPDS no. 06-0342, and tetragonal $LiYF_4$ (green): JCPDS no. 17-0874, respectively.

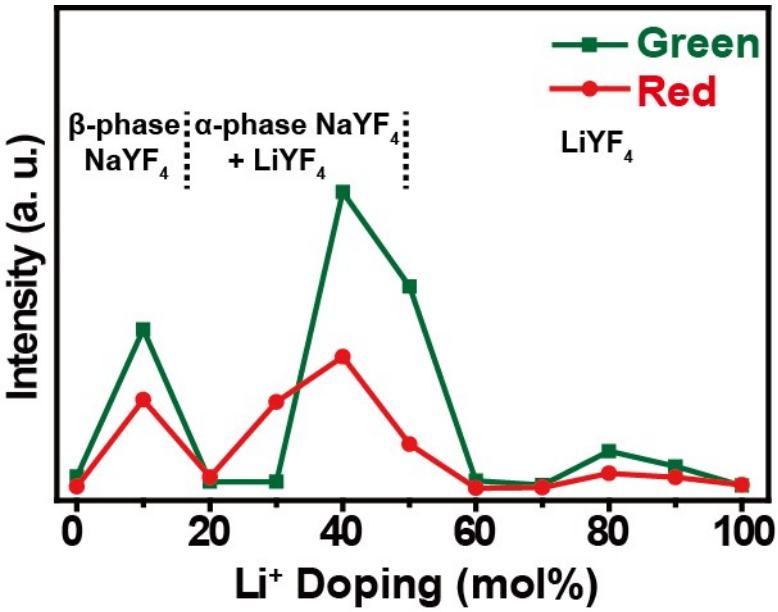

Fig. S3 Intensity variation of the upconversion luminescence of $Li_xNa_{1-x}YF_4$:Yb/Er (x = 0-100 mol%) nanocrystals, after excluding the large size contribution The green line and red line represent the intensity in green region and red region, respectively.

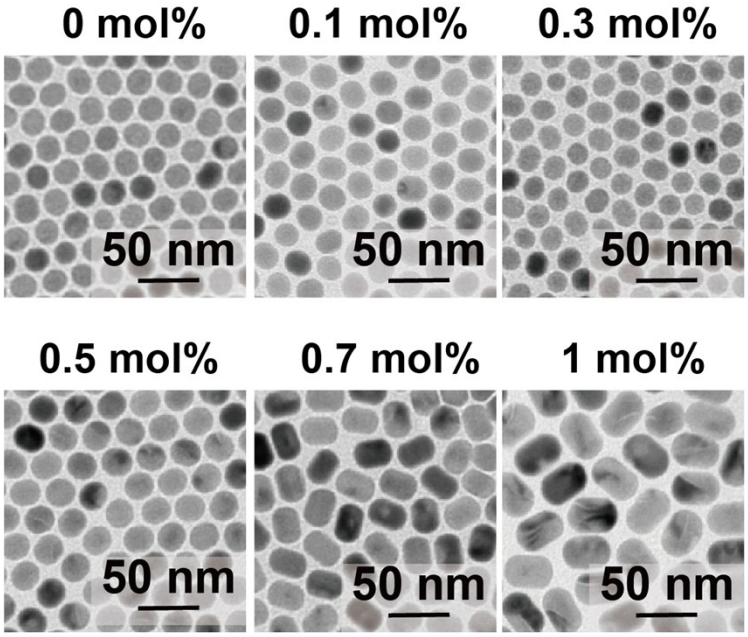

Fig. S4 TEM images of $Li_xNa_{1-x}YF_4$:Yb/Er (x = 0-1 mol%) nanocrystals synthesized at extremely low Li^+ doping concentrations.

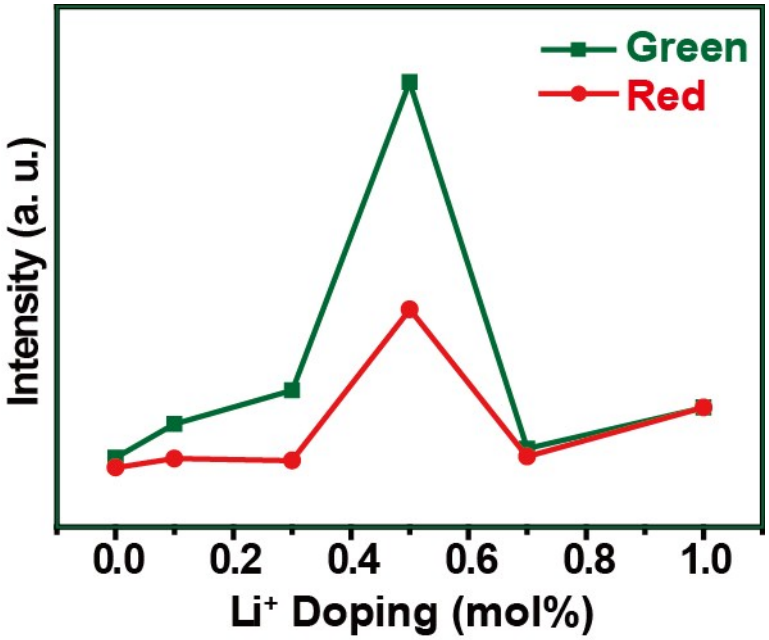

Fig. S5 Intensity variation of the upconversion luminescence of $Li_xNa_{1-x}YF_4$:Yb/Er (x = 0-1 mol%) nanocrystals, after excluding the large size contribution. The green and red lines represent the luminescence intensities in green and red regions, respectively.

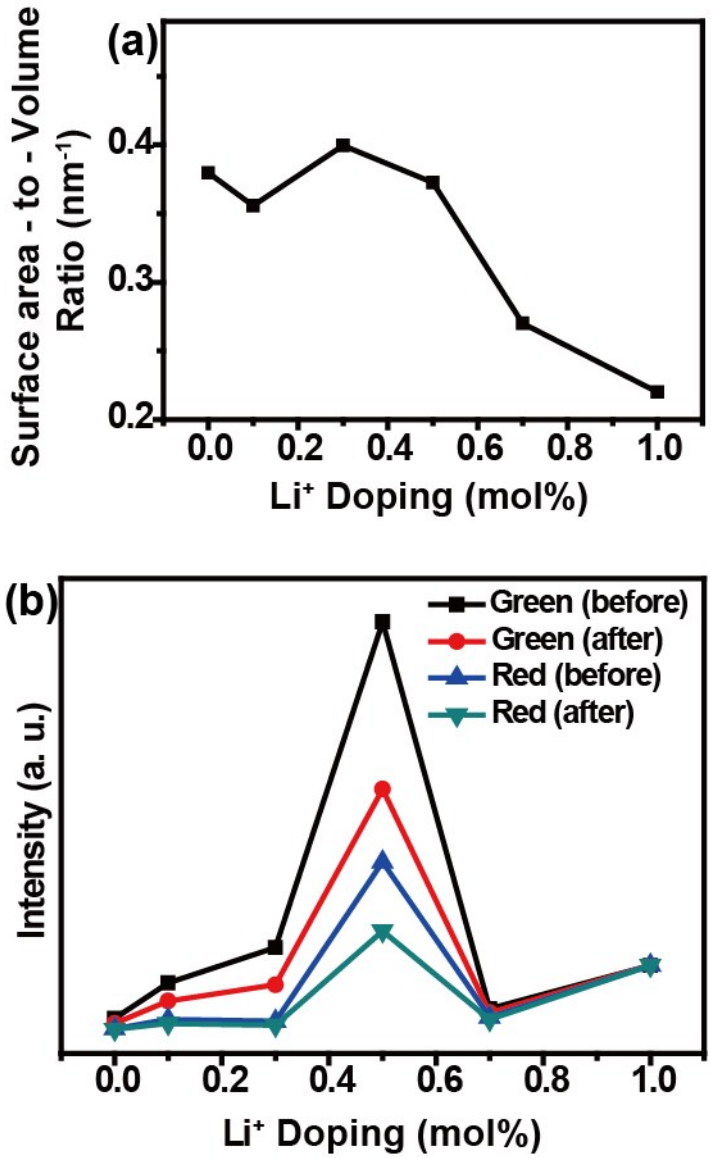

Fig. S6 (a) Surface area to volume ratio at different Li^+ doping concentrations. (b) Intensity variation of the upconversion luminescence of $Li_xNa_{1-x}YF_4$:Yb/Er (x = 0-1 mol%) nanocrystals before and after excluding the size contribution.

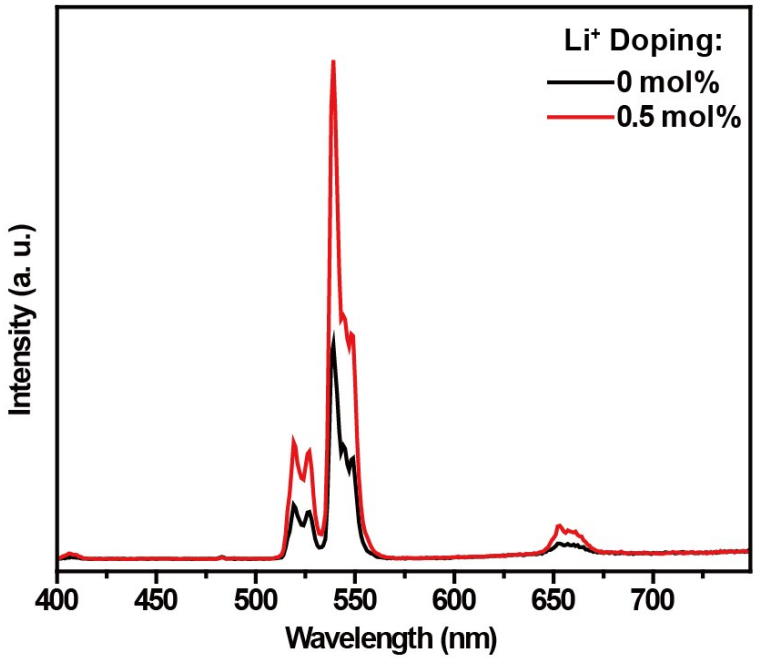

Fig. S7 Upconversion luminescence spectra of $Li_xGd_{1-x}YF_4$:Yb/Er (x = 0, 0.5 mol%) nanocrystals using continuous wave 980 nm diode laser as the excitation source.

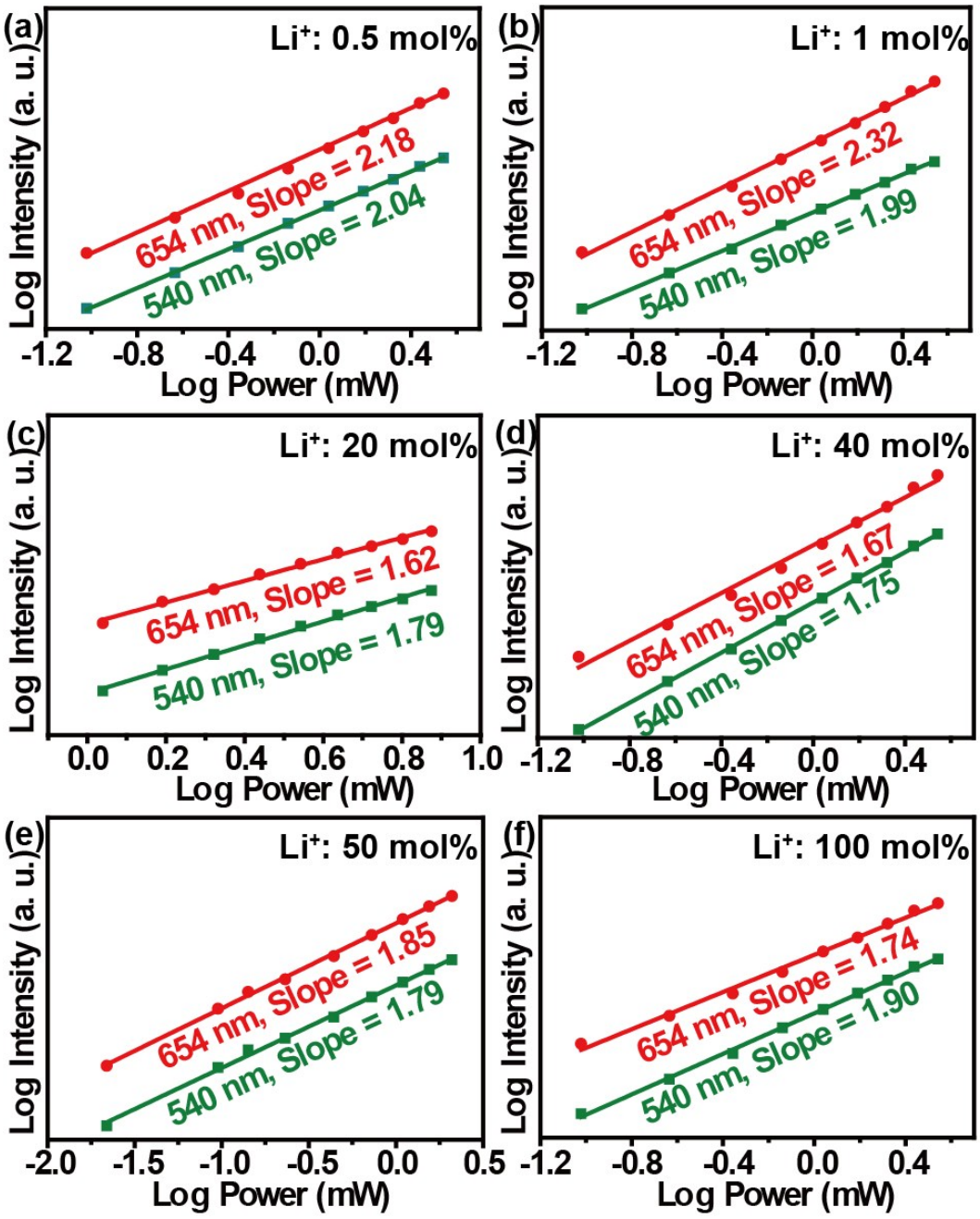

Fig. S8 Log-Log plots of the upconversion intensities of $Li_xNa_{1-x}YF_4$:Yb/Er ((18/2 mol%) nanocrystals at (a) x = 0.5, (b) 1, (c) 20, (d) 40, (e) 50, and (f) 100 mol%, respectively.

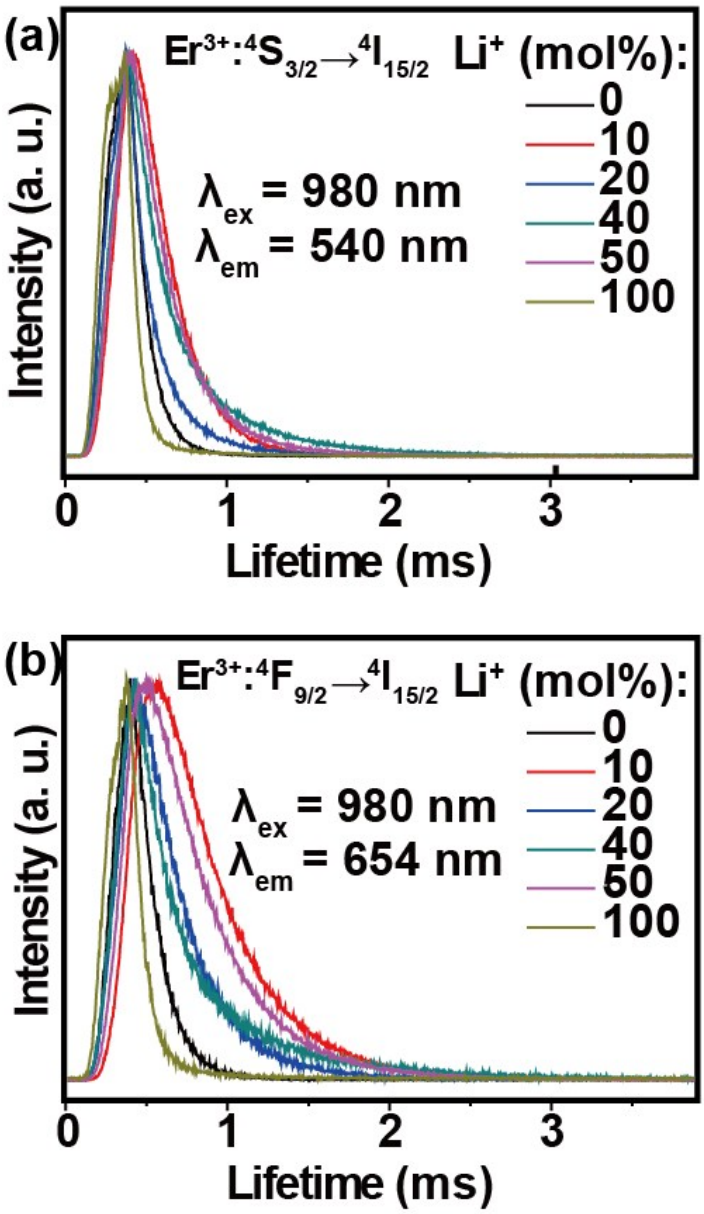

Fig. S9 Upconversion luminescence decay curves of Er^{3+} at (a) 540 nm, and (b) 654 nm.

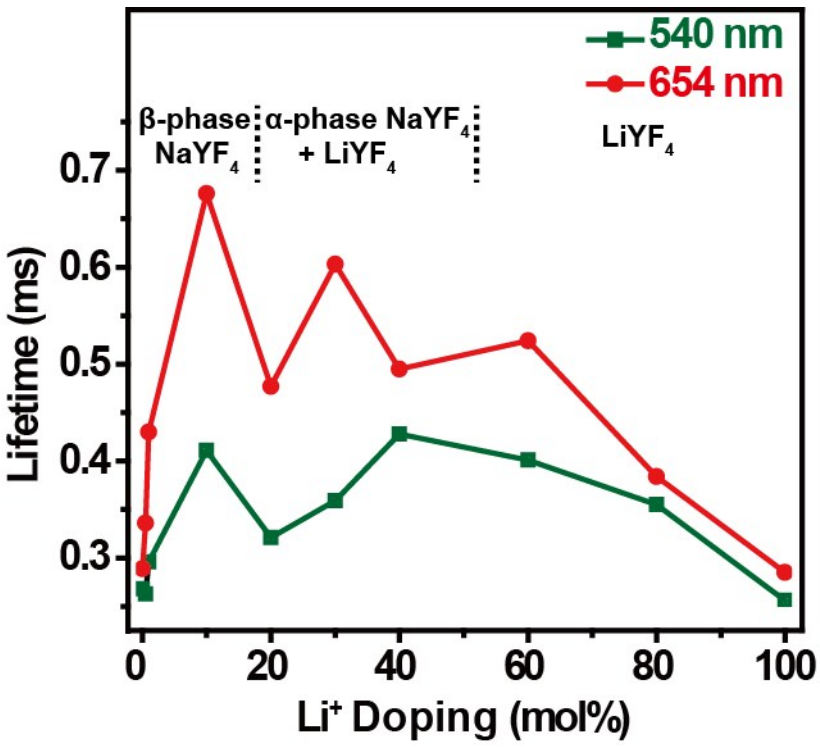

Fig. S10 Lifetime variation of $Li_xNa_{1-x}YF_4$:Yb/Er (x = 0-100 mol%) nanocrystals at different Li^+ doping concentrations.