Supporting information for

Quenching of the upconversion luminescence of $NaYF_4$: Yb^{3+}, Er^{3+} and $NaYF_4$: Yb^{3+}, Tm^{3+} nanophosphors by water: the role of the sensitizer Yb^{3+} in non-radiative relaxation

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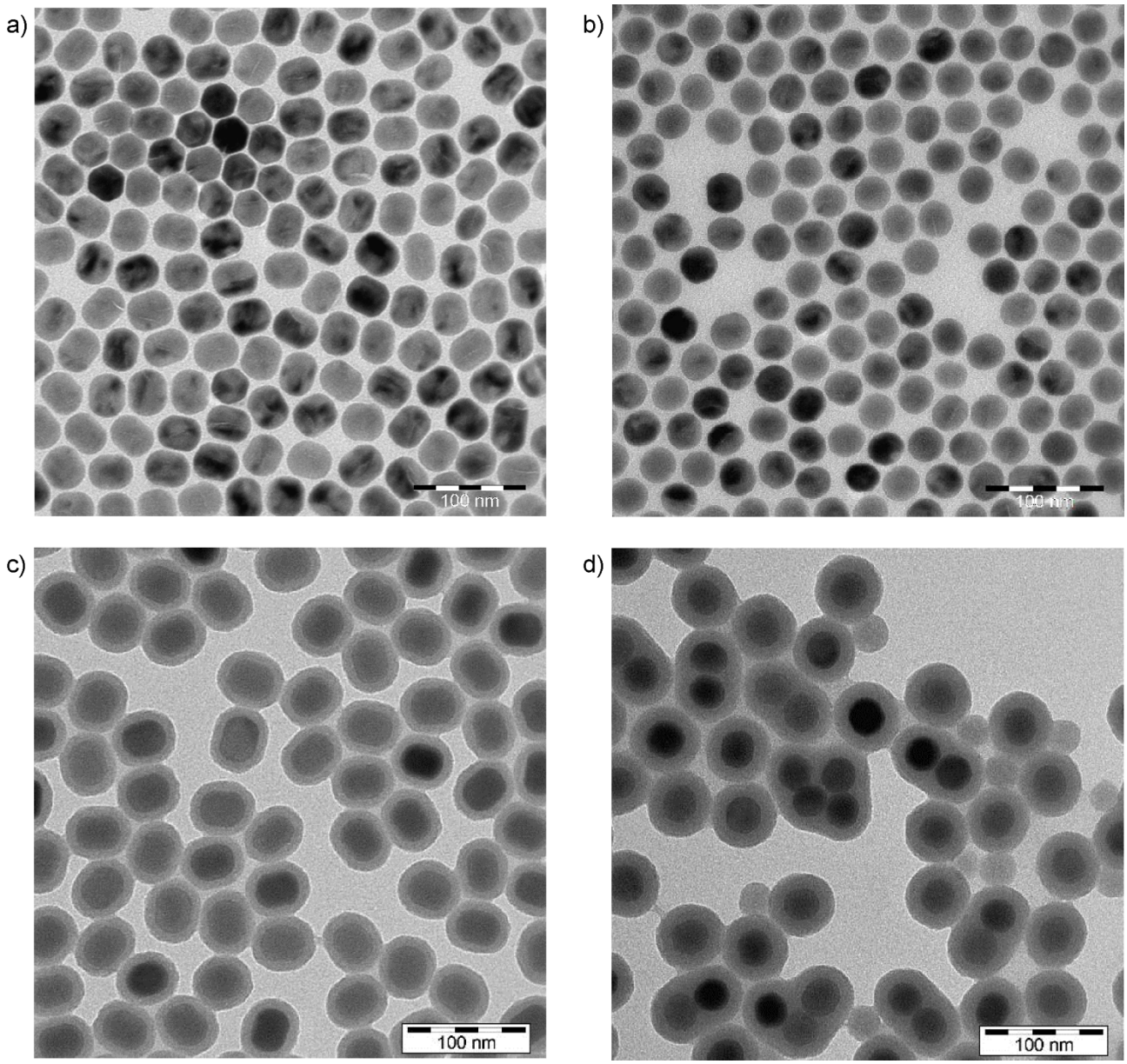

Figure S1. Transmission electron micrographs of a) bare and c) silanized $NaYF_4$: Yb^{3+}, Er^{3+} and b) bare and d) silanized $NaYF_4$: Yb^{3+}, Tm^{3+} nanophosphors (JEM-1400+ TEM, 80 kV, JEOL, Tokyo, Japan). Scale bar 100 nm.

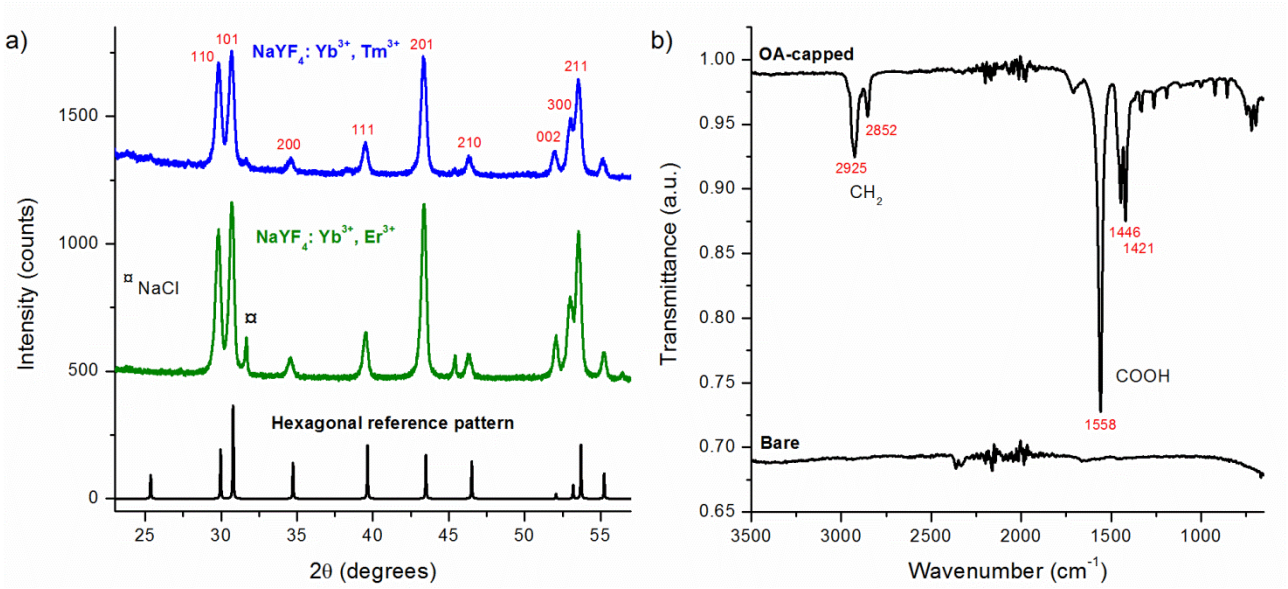

Figure S2. a) X-ray powder diffraction spectra of the $NaYF_4$: Yb^{3+}, Er^{3+} and $NaYF_4$: Yb^{3+}, Tm^{3+} nanophosphors, and the reference pattern of hexagonal $NaYF_4$: Yb^{3+}, Er^{3+} (Huber G670, Huber Diffraktionstechnik GmbH & Co. KG, Rimsting, Germany). b) FT-IR spectra of oleic acid (OA) – capped and bare a UCNPs (Vertex 70, Bruker Optics, Billerica, MA). The spectrum of OA-capped UCNPs shows CH_2 and COOH stretches, which are absent in the spectra of bare UCNPs.

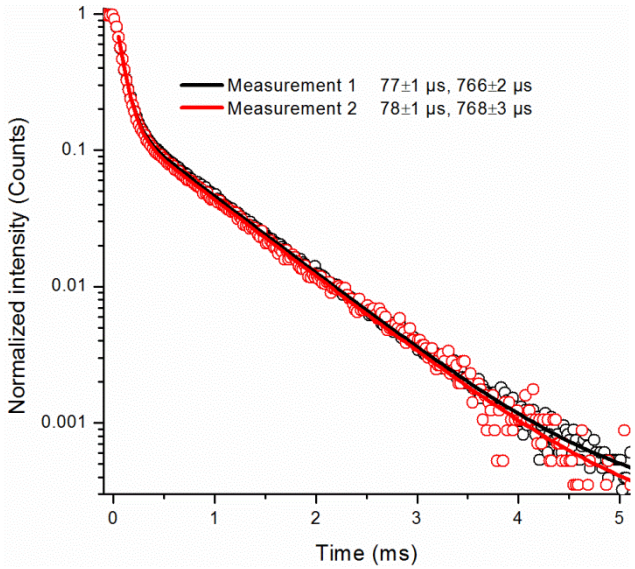

Figure S3. The repetitiveness of the luminescence lifetime measurement of bare $NaYF_4$: Yb^{3+}, Er^{3+} nanophosphors in water at 544 nm upon excitation at 980 nm with 20 ms pulse width. The two measurements were performed on the same sample eight days apart.

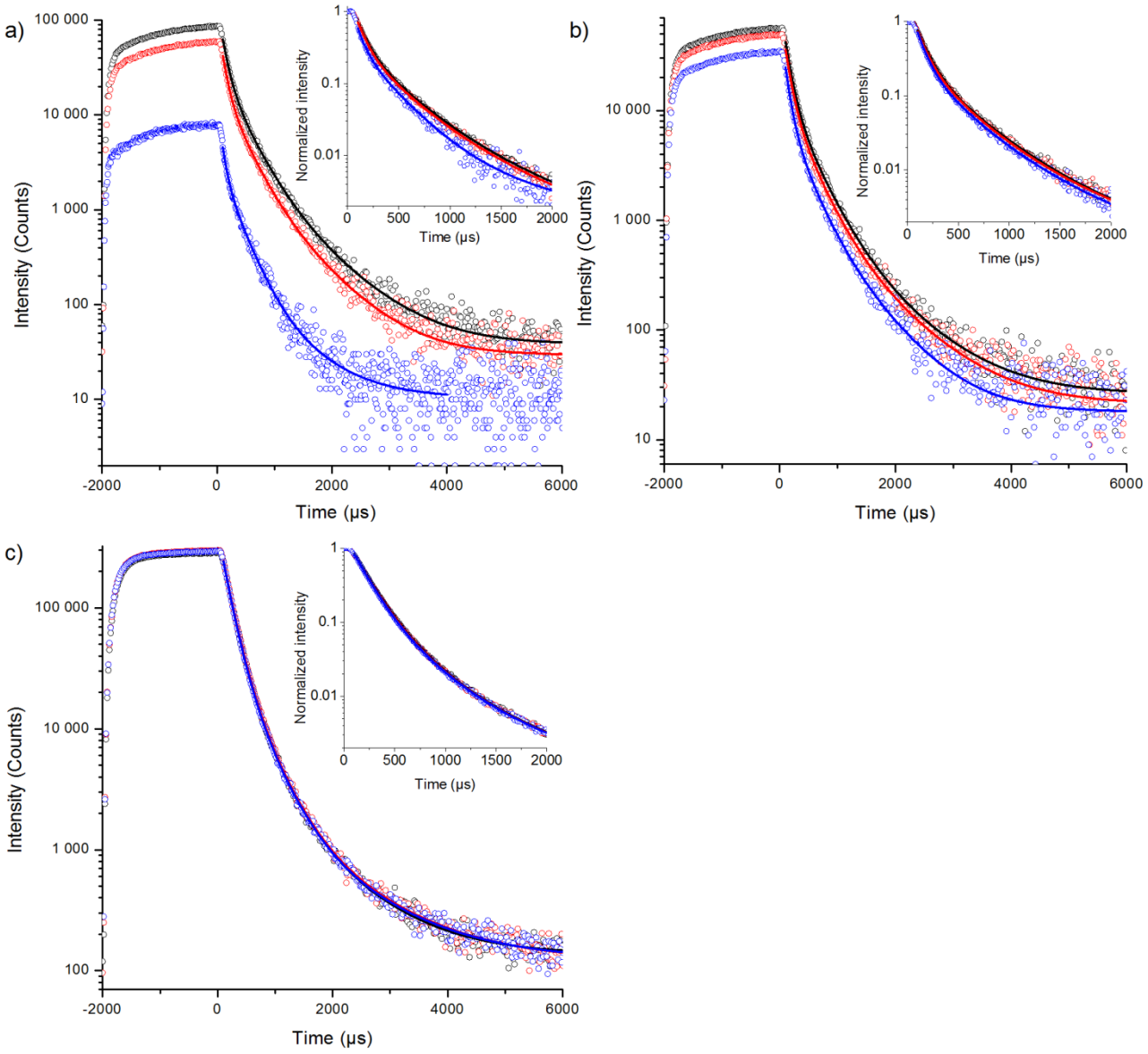

Figure S4. Decay curves of upconversion emission of bare $NaYF_4$: Yb^{3+}, Er^{3+} at 535 nm at time point 1–6 min (black), 10–16 min (red) and 25–31 min (blue) after diluting from D_2O to a) 99 vol% H_2O and b) 75 vol% H_2O in D_2O, or c) 100 vol% D_2O using 20 ms excitation pulse width. Insert: Normalized decay curves.

Table S1. Decay times and amplitude fractions of upconversion emission of bare $NaYF_4$: Yb^{3+}, Er^{3+} at 535 nm at different time points after diluting to different proportions of H_2O in D_2O. Fitting range 100 µs – 6 ms.

	1 – 6 min	**10 – 16 min**	**25 – 31 min**
99 vol% Water			
τ_1 (µs)	94 ± 2.5 (76.5 %)	83 ± 2.9 (76.7 %)	67 ± 4.0 (76.0 %)
τ_2 (µs)	316 ± 11.9 (20.9 %)	288 ± 13.2 (20.4 %)	261 ± 36.6 (22.4 %)
τ_3 (µs)	778 ± 4.8 (2.6 %)	706 ± 35.5 (2.9 %)	728 ± 508 (1.6 %)
75 vol% Water			
τ_1 (µs)	104 ± 2.7 (80.7 %)	97 ± 3.0 (79.3 %)	83 ± 3.4 (81.0 %)
τ_2 (µs)	344 ± 17.1 (17.6 %)	319 ± 15.8 (18.8 %)	284 ± 20.6 (16.4 %)
τ_3 (µs)	873 ± 75.5 (1.7 %)	846 ± 60.5 (1.9 %)	690 ± 48.0 (2.6 %)
D_2O			
τ_1 (µs)	159 ± 2.1 (83.1 %)	158 ± 1.8 (84.3 %)	154 ± 1.6 (84.6 %)
τ_2 (µs)	353 ± 15.5 (15.9 %)	369 ± 13.1 (15.0 %)	369 ± 11.6 (14.7 %)
τ_3 (µs)	994 ± 67.6 (1.0 %)	1175 ± 89.8 (0.7 %)	1174 ± 85.2 (0.7 %)

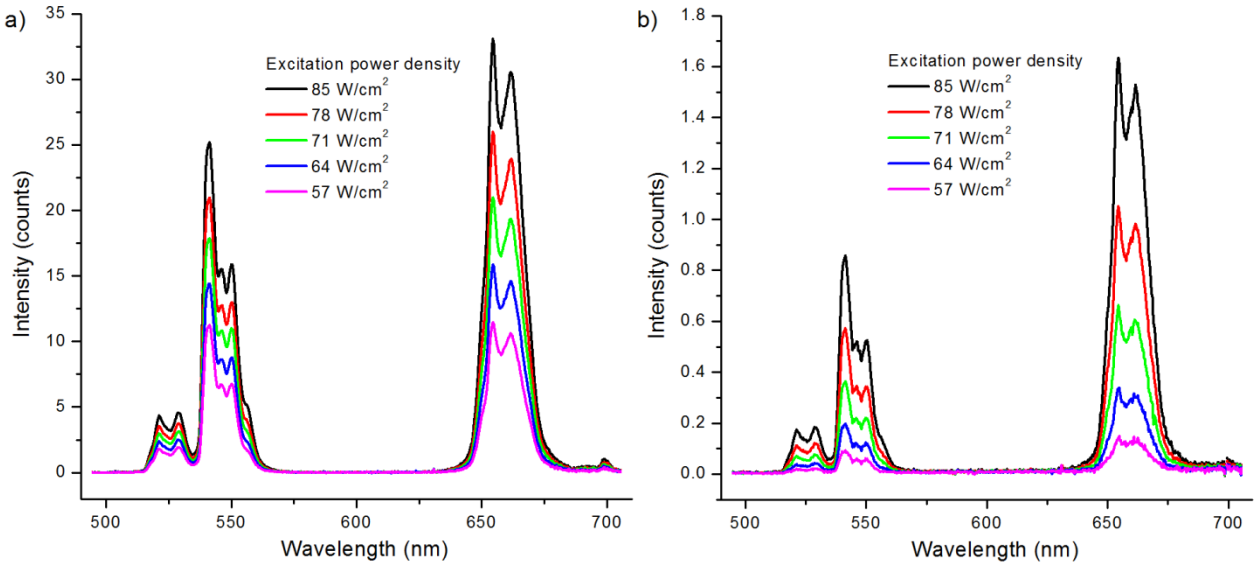

Figure S5. Upconversion luminescence spectra of bare $NaYF_4$: Yb^{3+}, Er^{3+} nanophosphors a) in D_2O and b) in H_2O at increasing excitation power densities.