Electronic Supplementary Material (ESI) for RSC Advances.

SUPPORTING INFORMATION

Upconversion luminescence in sub-10 nm β-$NaGdF_4$: Yb^{3+}, Er^{3+} nanoparticles: An improved synthesis in anhydrous ionic liquids

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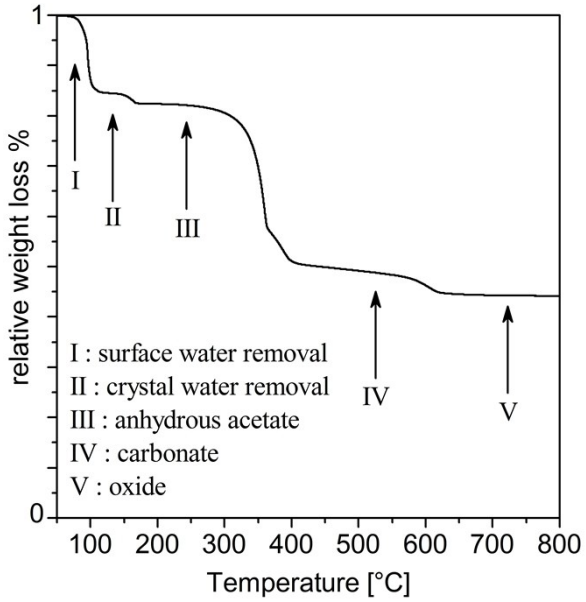


Fig. S1: Thermogravimetric analysis of the rare earth acetate hydrate precursor $RE(OAc)_3 \cdot aq.$ with RE = $Gd_{0.8}$, $Er_{0.02}$, $Yb_{0.18}$. The sample was heated by 5 K/min in a N_2 flow of 20 ml/min.

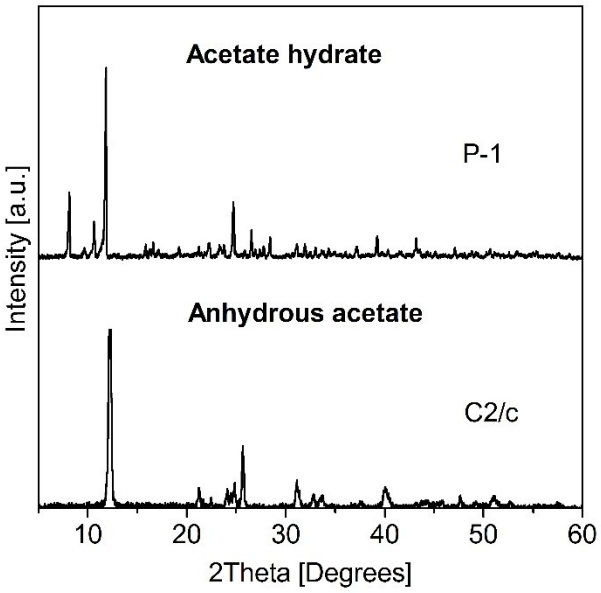


Fig. S2: Powder X-ray diffraction (XRD) patterns of the rare earth acetate hydrate $RE(OAc)_3 \cdot aq.$ (top) and the anhydrous rare earth acetate $RE(OAc)_3$ (bottom) with RE = $Gd_{0.8}$, $Er_{0.02}$, $Yb_{0.18}$. The space groups are specified in the figure and structures discused in Ref. S1.

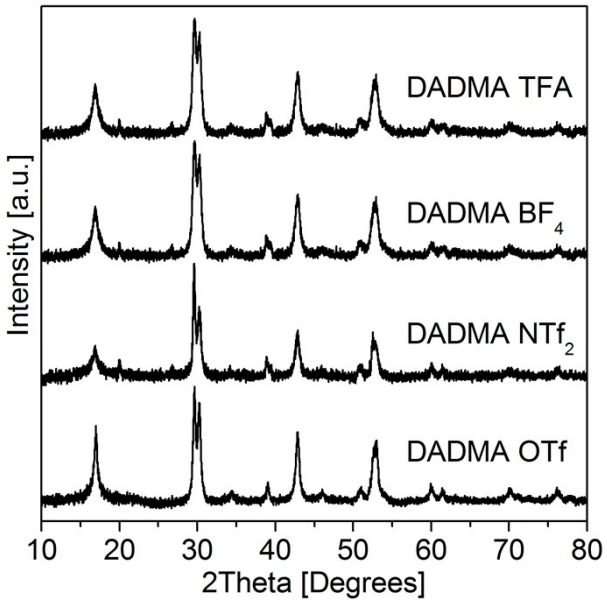


Fig. S3: Powder XRD patterns of nanocrystalline β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} samples synthesized in 0.5:1.5 vol. ethylene glycol (EG) / ionic liquid (IL) solutions with IL = diallyldimethylammonium (DADMA) trifluoroacetate (TFA), DADMA BF_4, DADMA bis(trifluoromethanesulfonyl)amide (NTf_2), and DADMA trifluoromethanesulfonate (OTf). Samples were synthesised from 60 mg $RE(AcO)_3$, 20 mg NaCl, and 80 mg NH_4F at 120°C for 30 min.

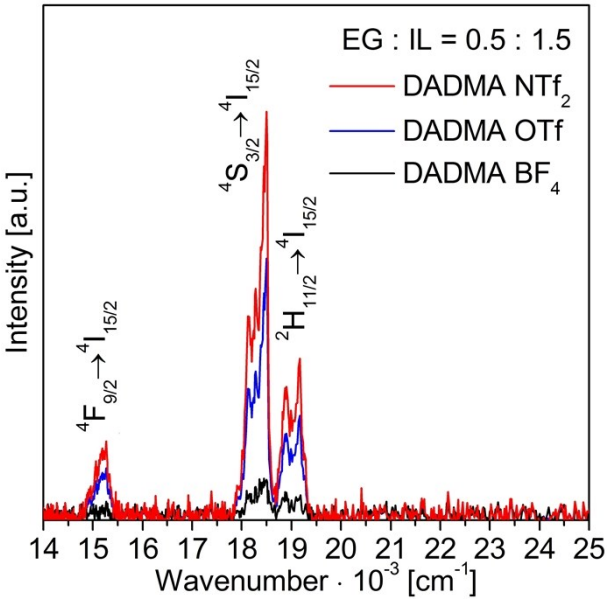


Fig. S4: UC luminescence of β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} nanoparticles from 0.5:1.5 vol. EG/IL solutions with IL = DADMA BF_4 (black trace), DADMA OTf (blue trace), and DADMA NTf_2 (red trace). Nanoparticles from the EG/DADMA TFA synthesis are not shown due to their very weak emission intensity. The UC luminescence was excited at 970 nm with 580 mW (unfocused) laser power.

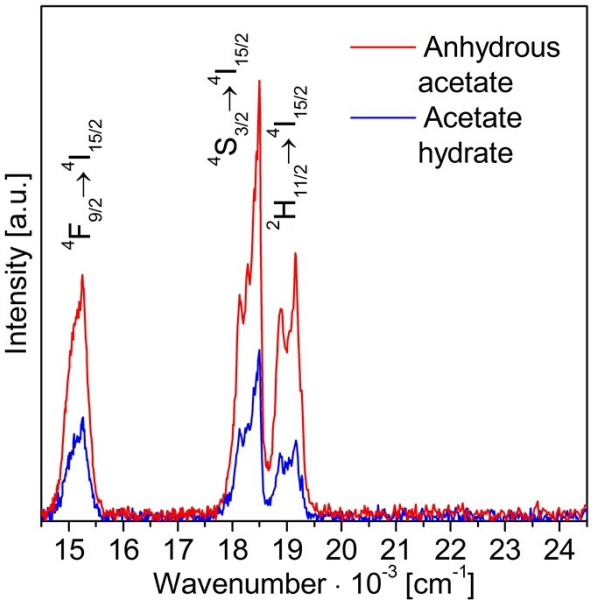


Fig. S5: Upconversion luminescence of β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} nanoparticles from a 0.5:1.5 vol. EG/IL synthesis with IL = DADMA NTf_2 and the rare earth acetate hydrate (blue trace) or the anhydrous rare earth acetate (red trace). Samples were synthesised from 30 mg $RE(AcO)_3$, 10 mg NaCl, and 120 mg NH_4F at 200°C for 30 min. The UC luminescence was excited at 970 nm with 580 mW (unfocused) laser power.

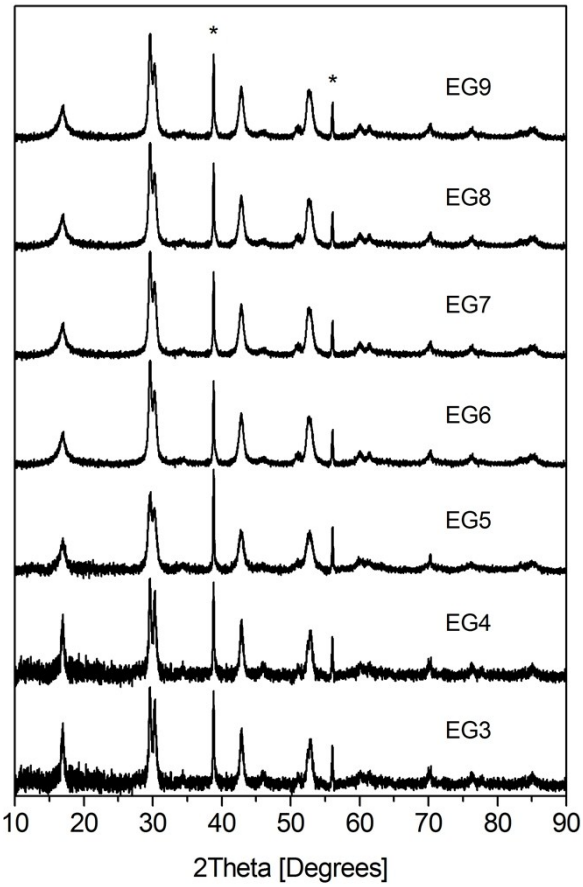


Fig. S6: Powder XRD patterns of β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} nanoparticles from EG/DADMA OTf syntheses. Sample names refer to Tab. 1. NaF peaks are marked by asterisks for the top trace.

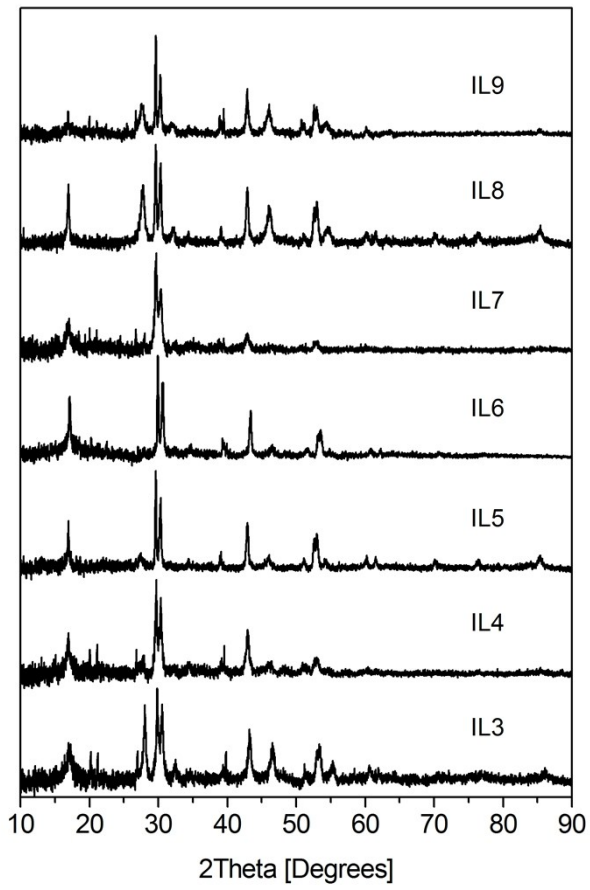


Fig. S7: Powder XRD patterns of β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} nanoparticles from IL syntheses. Sample names refer to Tab. 1.

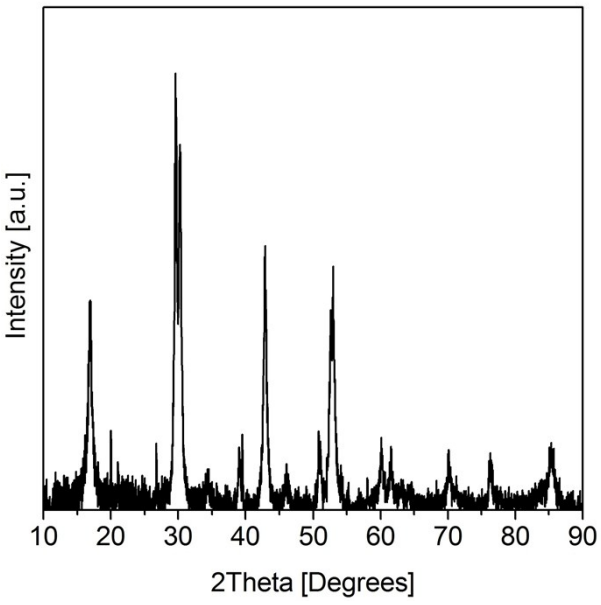
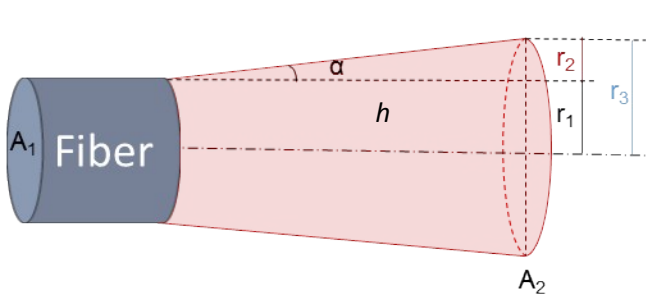


Fig. S8: Powder XRD pattern of β-$NaGdF_4$: 18% Yb^{3+}, 2% Er^{3+} / β-$NaGdF_4$ core-shell nanoparticles from sample CS_IL4.



r_1 = 200 µm

h = 2 mm

α = 20°

$r_2 = h/\tan\alpha$ = 0.73 mm

r_3 = 0.93 mm

$A_2 = \pi r_3^2$ = 2.7 mm² = 0.027 cm²

Power density = P/A_2

Fig. S9: Evaluation of the power density from the fiber geometry. The divergence angle α = 20° and the fiber radius r_1 = 200 µm determine the illuminated area A_2. The resulting power densities are reported in Tab. S1.

Table S1: Evaluated power density for the measured laser power used in this work.

Power [mW]	Power density [W/cm²]
70	2.6
330	12.2
580	21.5

Reference

S1 C. Heinrichs, PhD thesis, Universität zu Köln, Synthese und Charakterisierung wasserfreier Selterdmetall-Nitrate, -Acetate und -Oxyacetate, 2013.