SUPPORTING INFORMATION

Upconversion luminescence in sub-10 nm β-NaGdF₄: Yb³⁺, Er³⁺ nanoparticles: An improved synthesis in anhydrous ionic liquids

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**Fig. S1:** Thermogravimetric analysis of the rare earth acetate hydrate precursor $\text{RE(OAc)}_3\cdot\text{aq.}$ with $\text{RE} = \text{Gd}_{0.8}, \text{Er}_{0.02}, \text{Yb}_{0.18}$. The sample was heated by 5 K/min in a $\text{N}_2$ flow of 20 ml/min.

**Fig. S2:** Powder X-ray diffraction (XRD) patterns of the rare earth acetate hydrate $\text{RE(OAc)}_3\cdot\text{aq.}$ (top) and the anhydrous rare earth acetate $\text{RE(OAc)}_3$ (bottom) with $\text{RE} = \text{Gd}_{0.8}, \text{Er}_{0.02}, \text{Yb}_{0.18}$. The space groups are specified in the figure and structures discussed in Ref. S1.
Fig. S3: Powder XRD patterns of nanocrystalline $\beta$-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$_4$F at 120°C for 30 min.

Fig. S4: UC luminescence of $\beta$-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-NaGdF₄: 18% Yb³⁺, 2% Er³⁺ nanoparticles from a 0.5:1.5 vol. EG/IL synthesis with IL = DADMA NTf₂ 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 NH₄F 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-NaGdF₄: 18% Yb³⁺, 2% Er³⁺ 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 $\beta$-NaGdF$_4$: 18% Yb$^{3+}$, 2% Er$^{3+}$ nanoparticles from IL syntheses. Sample names refer to Tab. 1.

**Fig. S8:** Powder XRD pattern of $\beta$-NaGdF$_4$: 18% Yb$^{3+}$, 2% Er$^{3+}$ / $\beta$-NaGdF$_4$ core-shell nanoparticles from sample CS_IL4.
Fig. S9: Evaluation of the power density from the fiber geometry. The divergence angle $\alpha = 20^\circ$ and the fiber radius $r_1 = 200 \ \mu m$ 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/cm$^2$] |
|------------|---------------------------|
| 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.