Electronic Supplementary Material (ESI) for Journal of Materials Chemistry B.

Supporting Information for

In vivo analysis of size- and time-dependent uptake of $NaYF_4$:Yb,Er upconversion nanocrystals by pumpkin seedlings

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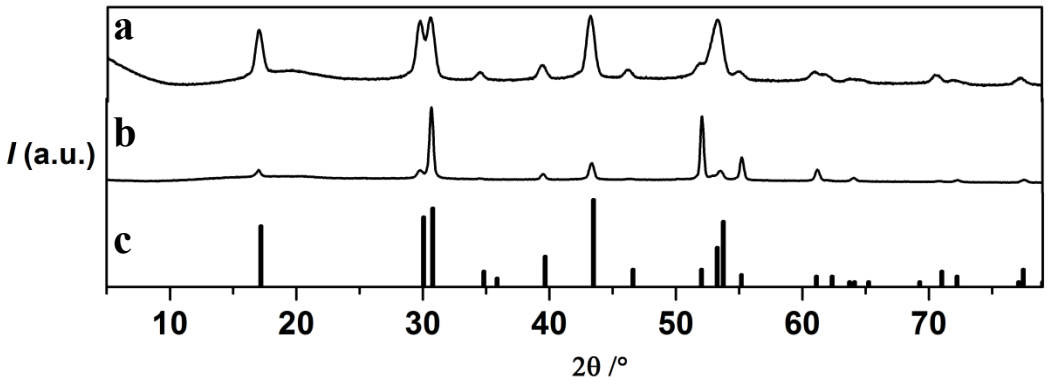

Figure S1. XRD data of 14 nm β-$NaYF_4$:Yb,Er/$NaGdF_4$ core/shell particles (a), of β-$NaYF_4$:Yb,Er nanorods having a width of 22 nm and a length of 41 nm (22 * 41 nm) (b) and reference data (PDF-number: 00-028-1192) of hexagonal phase (β) $NaYF_4$ (c).

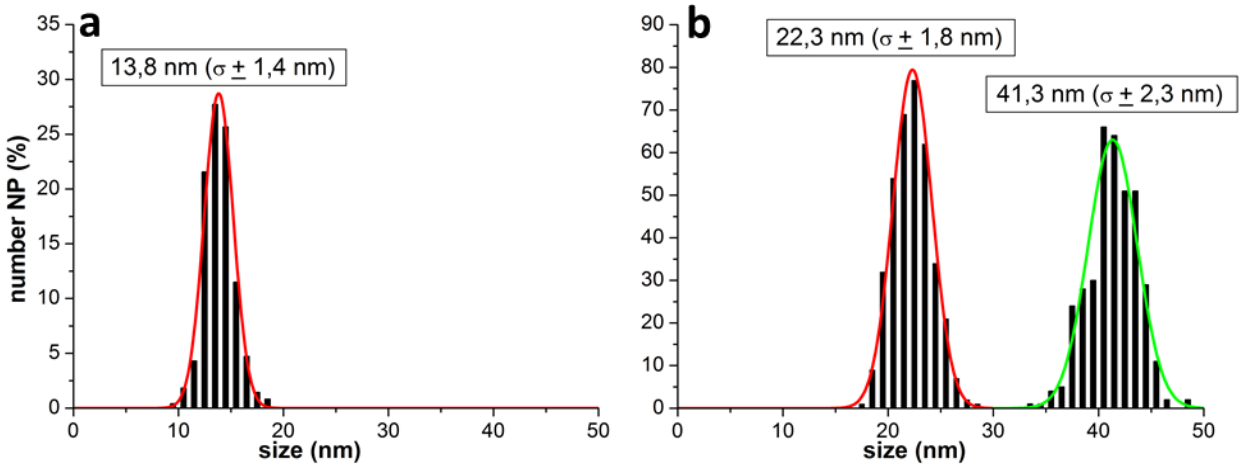

Figure S2. Histogram of small (a) β-$NaYF_4$:Yb,Er/$NaGdF_4$ core/shell particles (n = 487 particles) and (b) big β-$NaYF_4$:Yb,Er nanorods having a width of 22 nm and a length of 41 nm (n = 369 particles)

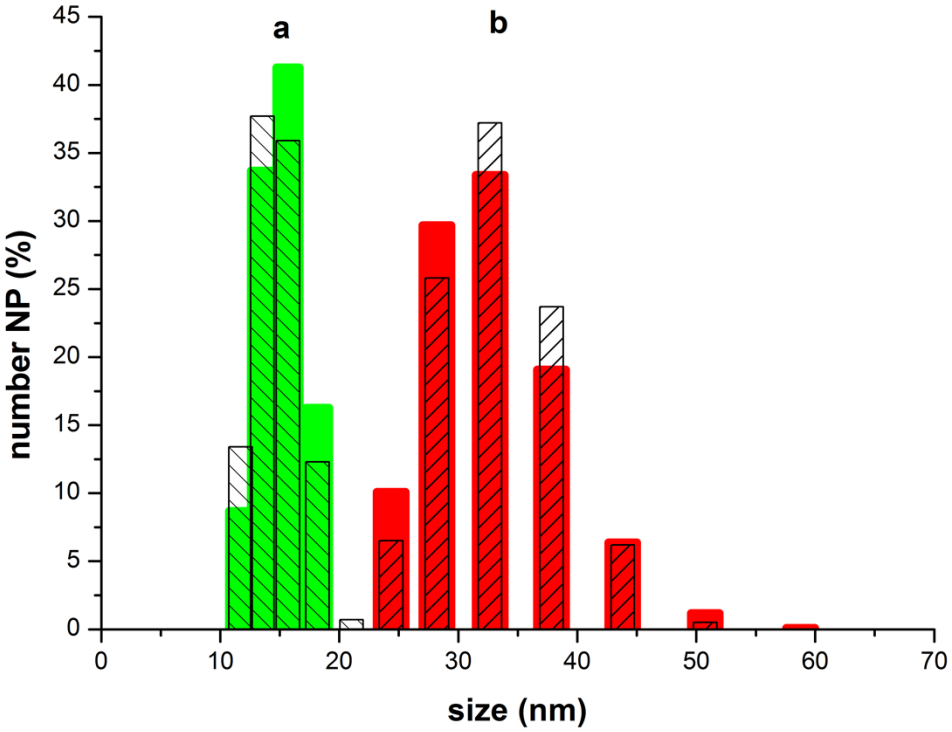

Figure S3. Dynamic light scattering (DLS) data of (a) 14 nm β-$NaYF_4$:Yb,Er/$NaGdF_4$ core/shell particles (green: before HEDP functionalization; black: after HEDP functionalization) and of (b) 22 * 41 nm β-$NaYF_4$:Yb,Er nanorods (red: before HEDP functionalization; black after HEDP functionalization).

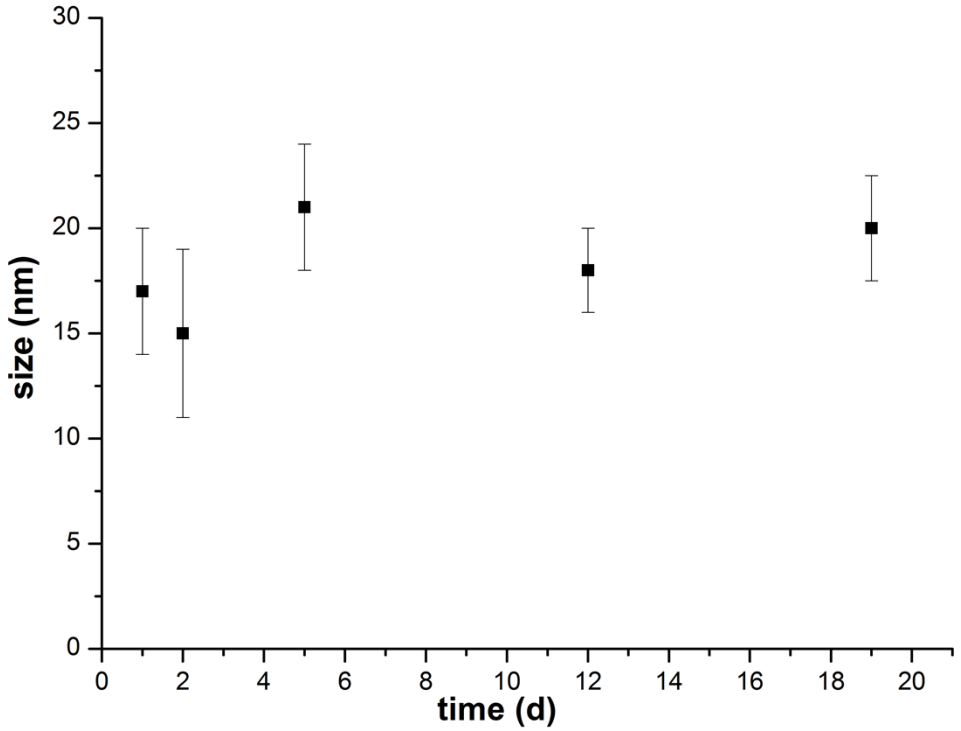

Figure S4. Particle size of HEDP functionalized 14 nm β-$NaYF_4$:Yb,Er/$NaGdF_4$ core/shell particles in aqueous colloidal solution as determined by dynamic light scattering (DLS). The particle size remains constant during 20 days indicating high colloidal stability.

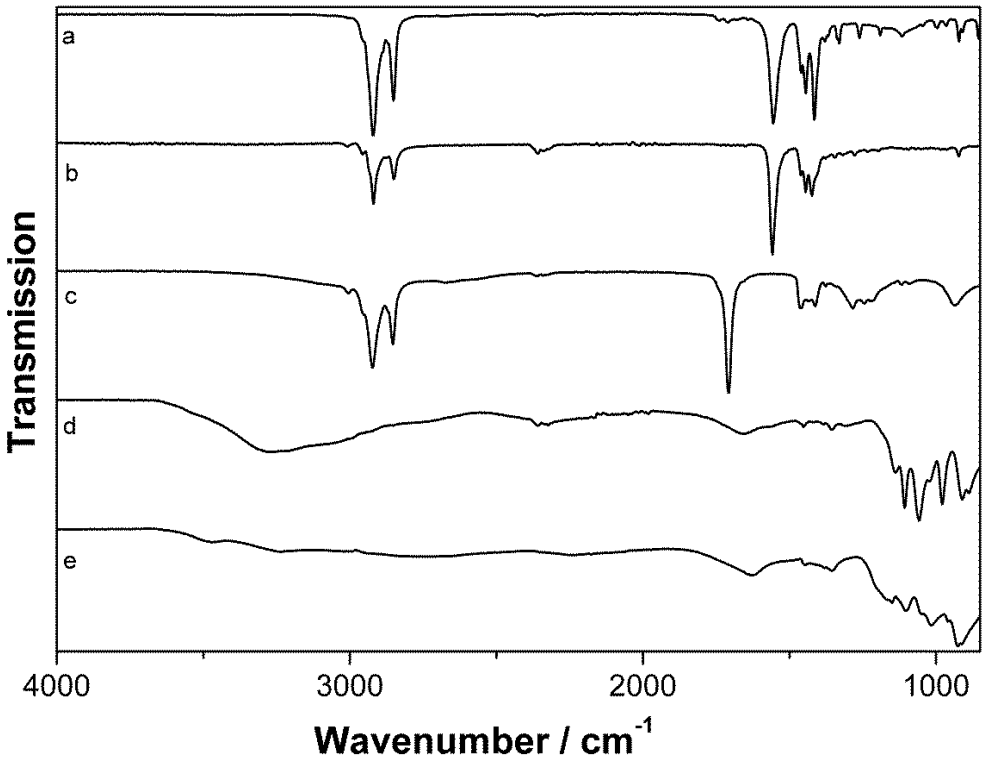

Figure S5. IR spectrum of hexagonal phase $NaYF_4$:Yb,Er UCNPs directly after the synthesis in oleic acid/octadecene (a). IR spectra of sodium oleate (b) and oleic acid (c) for comparison. IR spectrum of the same $NaYF_4$:Yb,Er UCNPs after ligand exchange with HEDP (d) and IR spectrum of HEDP for comparison (e).

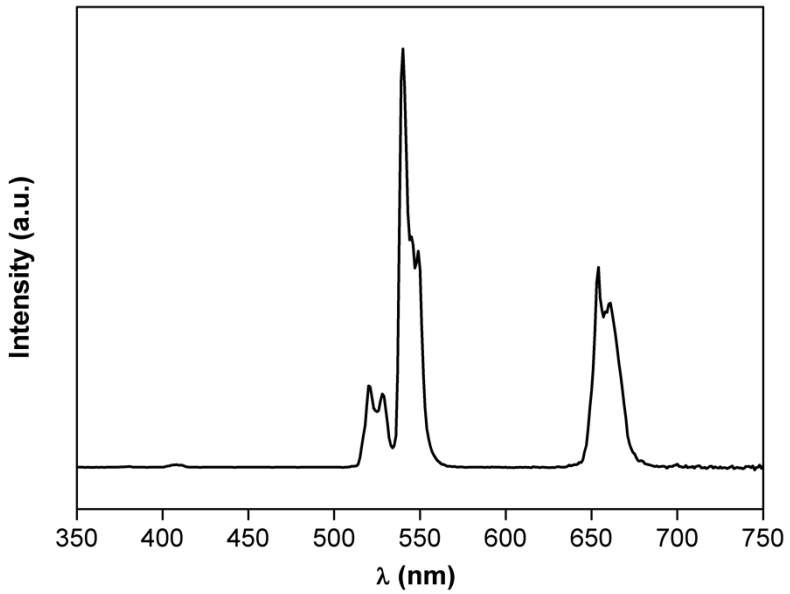

Figure S6. Upconversion emission spectrum of β-$NaYF_4$:Yb,Er UCNPs ($\lambda_{exc.}$ = 978nm).

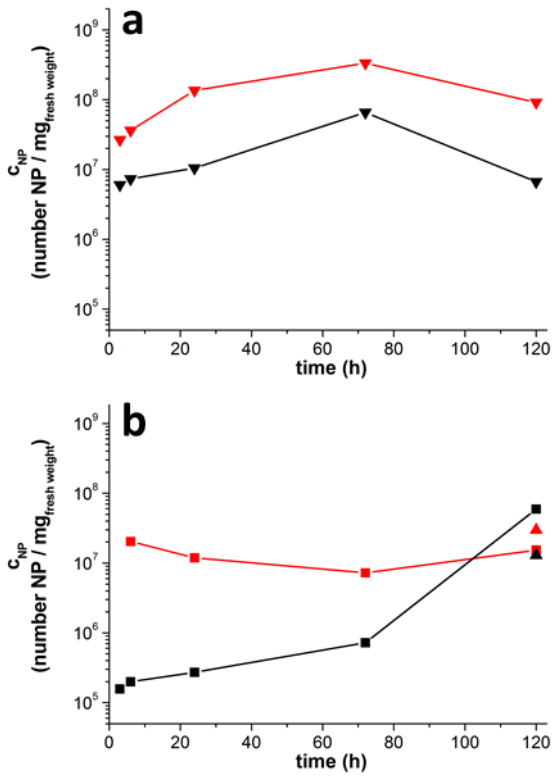

Figure S7. Number of 14 nm particles (**red**) and 22 * 41 nm nanorods (**black**) per milligram fresh weight at different times after incubation. UCNPs in root collar = lower hypocotyl (▼) (a) and in different leaves (■ primary leaves; ▲ foliage leaves) (b). The number of UCNPs was determined by X-ray fluorescence spectroscopy (XRF).

Table S1. Number of 14 nm β-$NaYF_4$:Yb,Er/$NaGdF_4$ core-shell particles per milligram fresh weight at different times after incubation (x: value below the detection limit of XRF).

Incubation times (h)	root	root collar	Upper hypocotyl	cotyledon	cotyledon leaf base	cotyledon leaf margin	primary leaves	foliage leaves
3	2,7E8	2,7E7	5,2E6	6,8E6	6,83E6	x	x	x
6	3,5E8	3,6E7	7,4E6	6,7E6	5,72E6	7,7E6	2,0E+07	x
24	9,4E8	1,4E8	1,8E7	4,4E6	4,65E6	3,9E6	1,2E+07	x
72	1,6E9	3,3E8	1,5E7	9,3E6	4,02E6	1,3E7	7,1E+06	x
120	6,3E8	9,2E7	8,1E6	7,9E6	1,24E6	1,1E7	1,5E+07	2,9E+07

Table S2. Number of 22 * 41 nm β-$NaYF_4$:Yb,Er nanorods per milligram fresh weight at different times after incubation (x: value below the detection limit of XRF).

Incubation times (h)	root	root collar	Upper hypocotyl	cotyledon	cotyledon leaf base	cotyledon leaf margin	primary leaves	foliage leaves
3	1,1E8	6,0E6	5,6E5	4,3E5	3,3E5	5,0E5	1,6E5	x
6	1,7E8	7,3E6	7,8E5	4,5E5	1,7E5	6,3E5	2,0E5	x
24	3,6E8	1,1E7	9,1E5	8,0E5	7,0E5	8,6E5	2,7E5	x
72	1,8E9	6,6E7	8,1E5	2,8E6	1,1E6	3,9E6	7,2E5	x
120	1,8E9	6,7E6	1,8E6	1,0E7	2,3E6	1,5E7	5,9E7	1,3E7

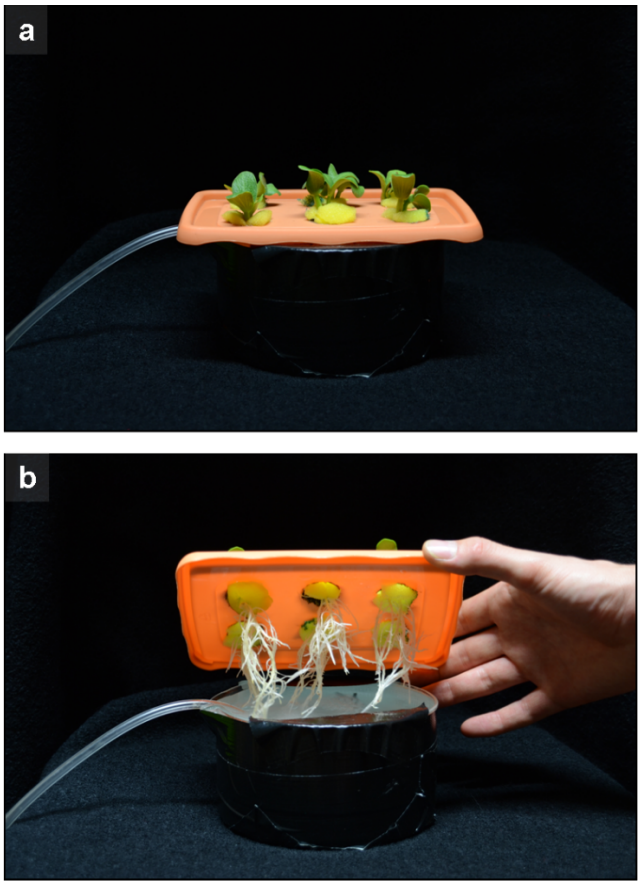

Figure S8. Experimental setup used for the hydroponic cultivation of *Cucurbita maxima* seedlings. The image displays the roots of the plants and the vessel (black) with the aqueous nutrient solution containing the UCNPs. See text for details.

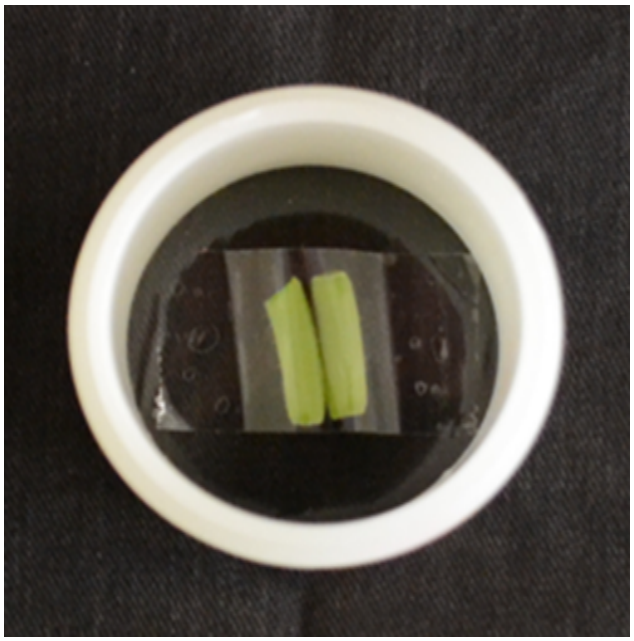

Figure S9. Sample preparation used for the determination of Yttrium by X-ray fluorescence aspectroscopy (XRF). Parts of the hypocotyl are fixed on a thin polypropylene film by adhesive tape. For details of the analysis see text.