Electronic Supplementary Information

Magnetic and optical properties of multifunctional core-shell radioluminescence nanoparticles

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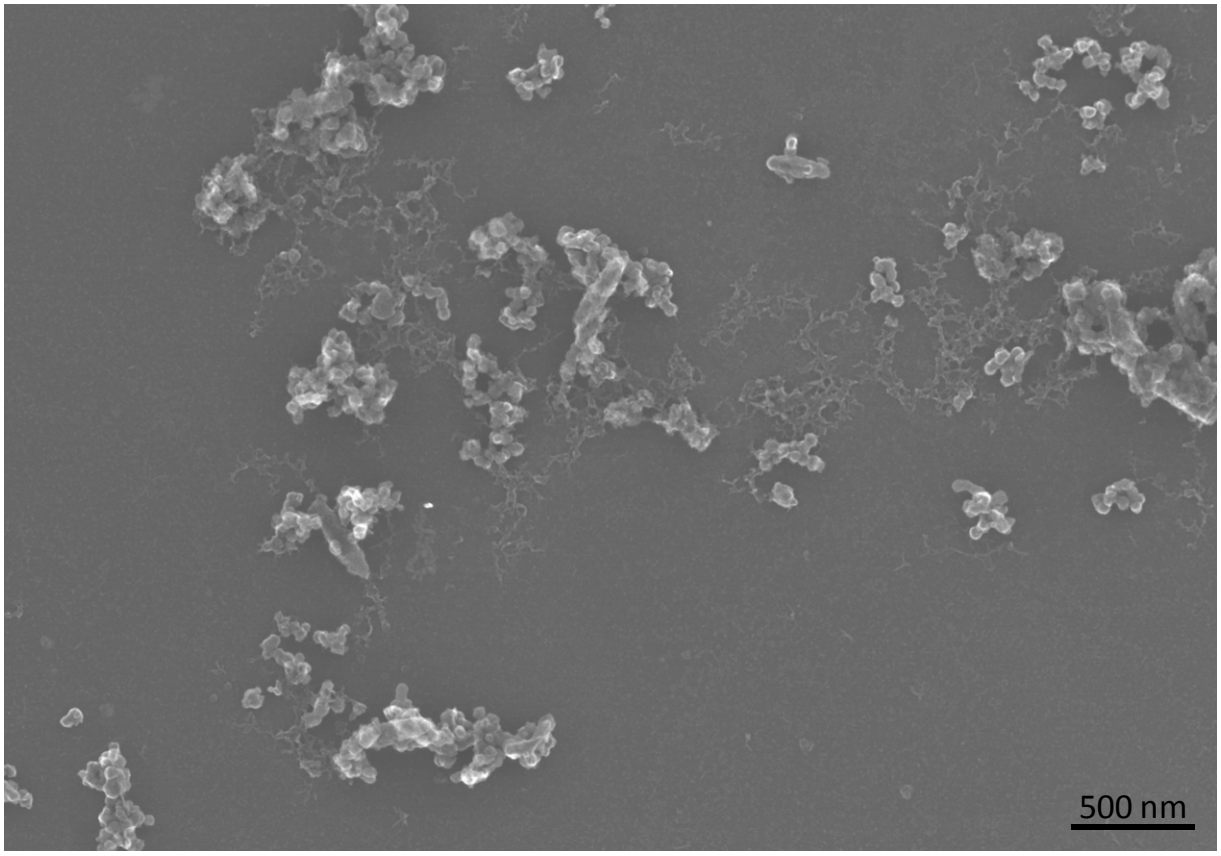

Fig. S1. SEM images of growth of $Gd(OH)CO_3$:Eu on spindle-shaped hematite nanoparticles without using an intermediate silica shell.

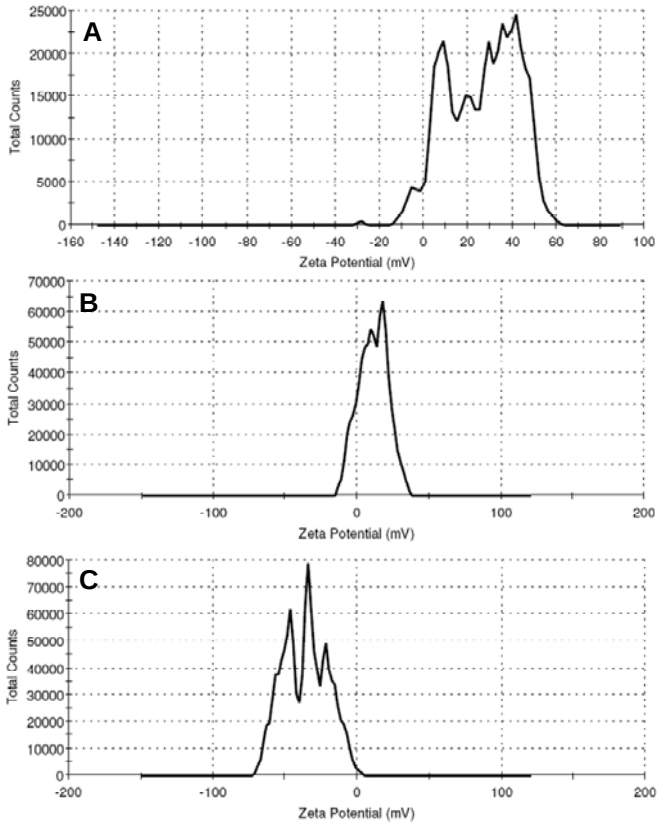

Fig. S2. Zeta potential of (A) hematite nanorice (+26.1 mV), (B) $Gd(OH)CO_3$:Eu (+11.1 mV), (C) silica coated hematite (-35.9 mV).

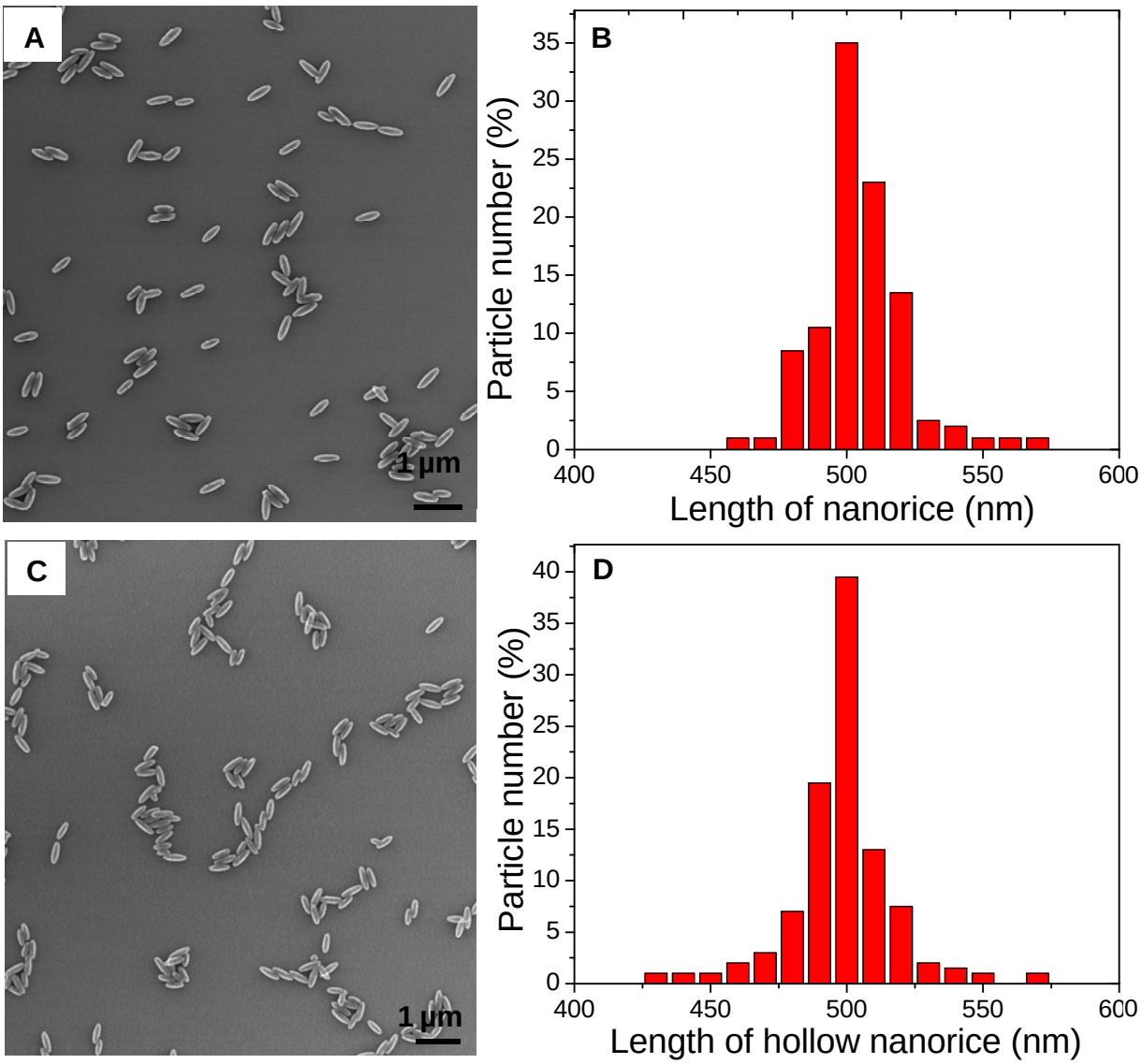

Fig. S3. SEM images of nanorice (γ-Fe_2O_3@SiO_2@Gd_2O_3:Eu, solid structure) (A) and corresponding size distribution (B). SEM images of hollow nanorice (SiO_2@Gd_2O_3:Eu) (C), and corresponding size distribution (D).

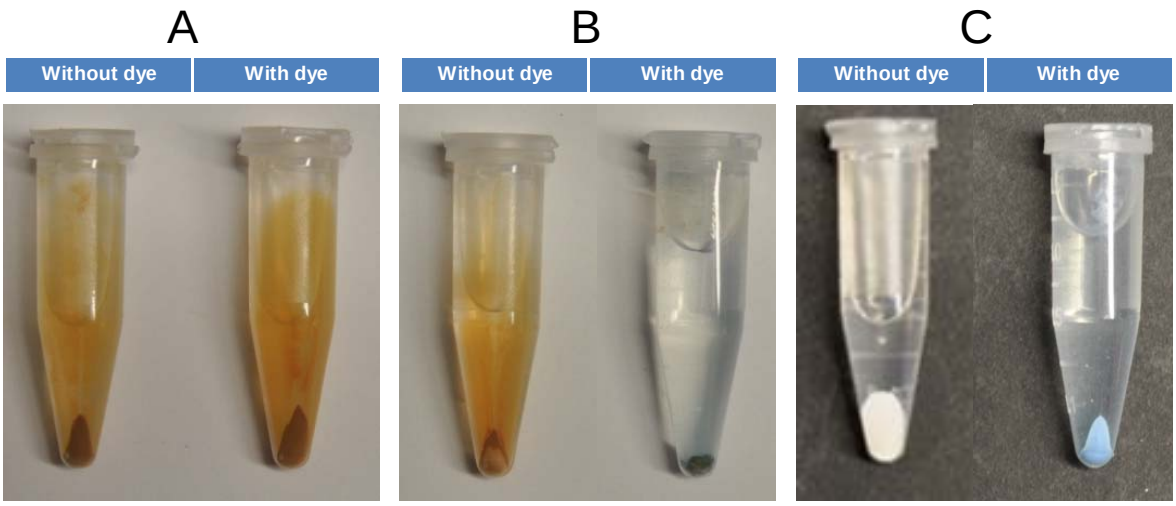

Fig. S4 Photography of nanorice (A), nanoeyes (B), and hollow nanorice (C) without and with bromocresol green dye encapsulated by a ~10 nm silica coating. Samples were obtained after centrifuged for 15 min at 4000 rpm.

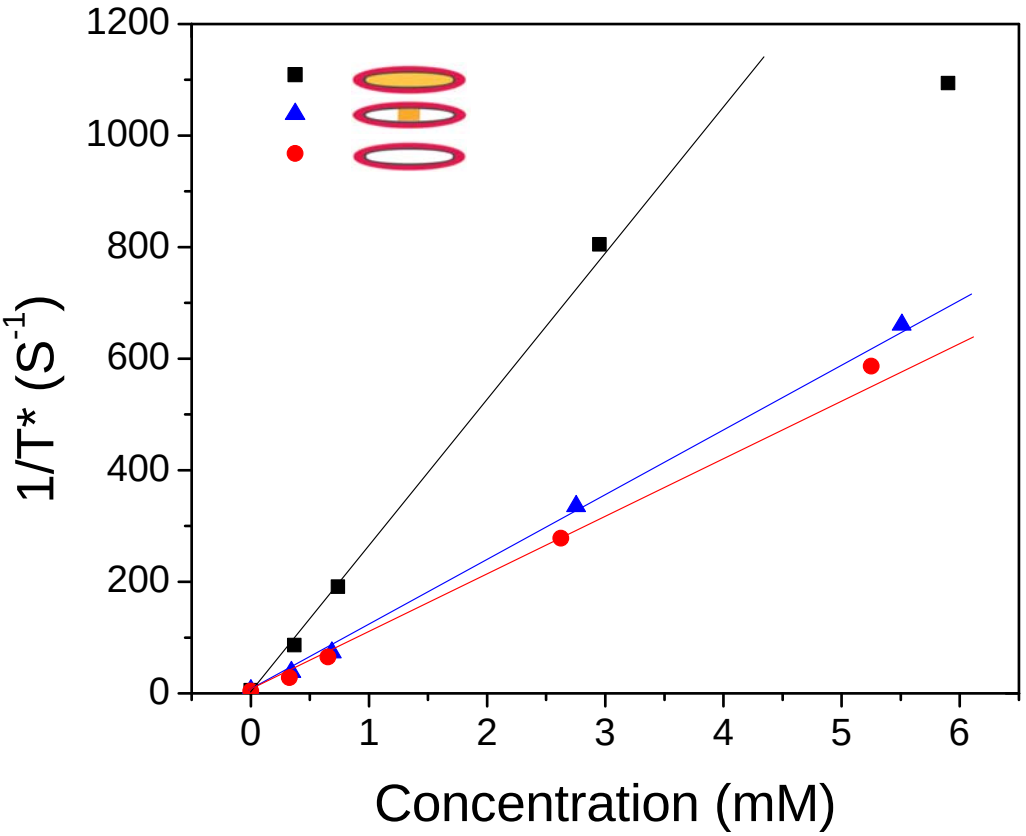

Fig. S5 The relaxation rate curves, $1/T_2$*, as a function of particle concentration. To calculate relaxivity, r_2*, the curve is fit to a straight line for concentrations up to 0.4 mg/mL) ■: nanorice, ▲: nanoeyes (iron oxide core was incubated in oxalic acid for 9.5 h), ● hollow nanorice.

Table S1. ICP analysis of Gd^{3+} and Fe^{3+} in nanorice, nanoeyes, and hollow nanorice in 0.8, 0.4, 0.1, 0.05 mg/ml of solution.The 0 value for Fe^{3+} means < 0.01 mg/L, i.e. below the limit of detection.

Type of nanoparticle \ Weight concentration		0.8 mg/ml	0.4 mg/ml	0.1 mg/ml	0.05 mg/ml
Nanorice	Gd^{3+}	4.700 mM	2.350 mM	0.588 mM	0.294 mM
	Fe^{3+}	1.200 mM	0.600 mM	0.150 mM	0.075 mM
Nanoeyes	Gd^{3+}	4.780 mM	2.390 mM	0.598 mM	0.299 mM
	Fe^{3+}	0.730 mM	0.365 mM	0.091 mM	0.046 mM
Hollow nanorice	Gd^{3+}	5.250 mM	2.626 mM	0.656 mM	0.328 mM
	Fe^{3+}	0 mM	0 mM	0 mM	0 mM

Table S2. r_2 and r_2* calculated based on molar concentration Gd^{3+}, Fe^{3+}, Gd^{3+}+Fe^{3+}, and weight concentration of particles.

Type of nanoparticle \ Relaxivity		r_2	r_2*
Nanorice	Weight concentration	514 ml $mg^{-1}s^{-1}$	2029 ml $mg^{-1}s^{-1}$
	Molar concentration (Gd^{3+})	86.28 $mM^{-1}s^{-1}$	344.10 $mM^{-1}s^{-1}$
	Molar concentration (Fe^{3+})	337.92 $mM^{-1}s^{-1}$	1347.71 $mM^{-1}s^{-1}$
	Molar concentration (Gd^{3+}+Fe^{3+})	68.73 $mM^{-1}s^{-1}$	274.11 $mM^{-1}s^{-1}$
Nanoeyes	Weight concentration	454 ml $mg^{-1}s^{-1}$	847 ml $mg^{-1}s^{-1}$
	Molar concentration (Gd^{3+})	66.97 $mM^{-1}s^{-1}$	138.82 $mM^{-1}s^{-1}$
	Molar concentration (Fe^{3+})	438.54 $mM^{-1}s^{-1}$	909.00 $mM^{-1}s^{-1}$
	Molar concentration (Gd^{3+}+Fe^{3+})	58.10 $mM^{-1}s^{-1}$	120.43 $mM^{-1}s^{-1}$
Hollow nanorice	Weight concentration	322 ml $mg^{-1}s^{-1}$	701 ml $mg^{-1}s^{-1}$
	Molar concentration (Gd^{3+})	46.00 $mM^{-1}s^{-1}$	111.76 $mM^{-1}s^{-1}$