Electronic Supplementary Information of:

"Smart" Theranostic Lanthanide Nanoprobes with Simultaneous Up-conversion Fluorescence and Tunable T_1-T_2 Magnetic Resonance Imaging Contrast and Near-Infrared Activated Photodynamic Therapy

Yan Zhang,[a] Gautom Kumar Das,[a] Vimalan Vijayaragavan,[b] Qing Chi Xu,[a] Parasuraman Padmanabhan,[c] Kishore K. Bhakoo,[b] Subramanian Tamil Selvan[d] and Timothy Thatt Yang Tan[a*]

[a] School of Chemical and Biomedical Engineering, Nanyang Technological University, 62 Nanyang Drive, Singapore 637459

[b] Translational Molecular Imaging Group, Singapore Bioimaging Consortium, Helios Building, 11 Biopolis Way, Singapore 138667

[c] The Lee Kong Chian School of Medicine, Nanyang Technological University, 50 Nanyang Drive, Research Techno Plaza, Level 4, X-Frontier Block, Singapore 637553.

[d]Institute of Materials Research and Engineering, 3 Research Link, Singapore 117602.

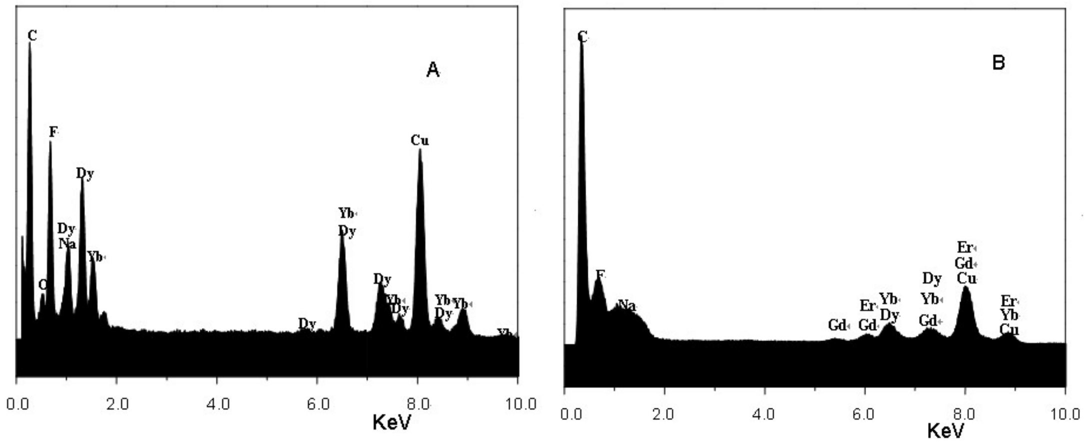

Fig. S1. Energy-dispersive X-ray spectroscopy (EDX) analysis of (A) $NaDyF_4:Yb^{3+}$ and (B) $NaDyF_4:Yb^{3+}/NaGdF_4:Yb^{3+},Er^{3+}$ NCs, revealing the presence of the Gd, Er after secondary growth on the $NaDyF_4:Yb^{3+}$ seeds NCs.

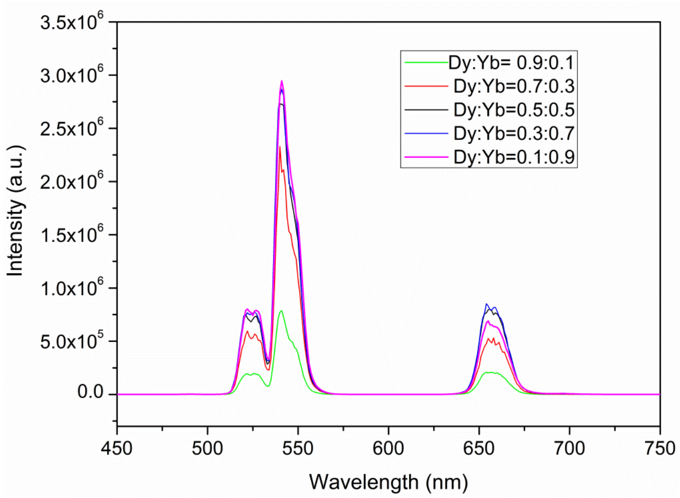

Fig. S2. The effect of different doping concentration of Yb^{3+} in the $NaDyF_4:Yb^{3+}$ towards the overall $NaDyF_4:Yb^{3+}/NaGdF_4:Yb^{3+},Er^{3+}$ fluorescent intensity. All samples were dispersed in chloroform (1 mg/ml), spectra were recorded at a power of 1 W.

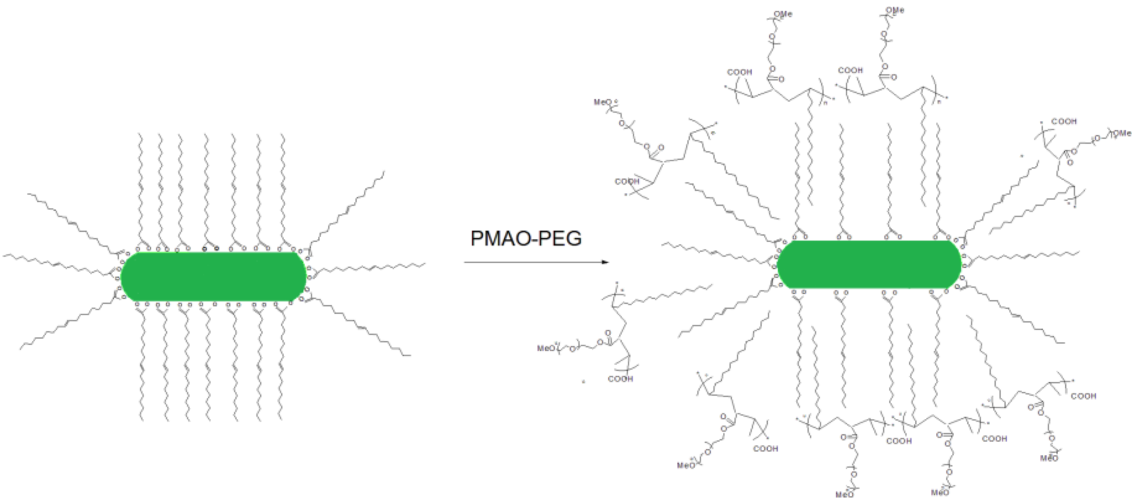

Fig. S3. Schematic representation of the intercalated NCs via PMAO-PEG.

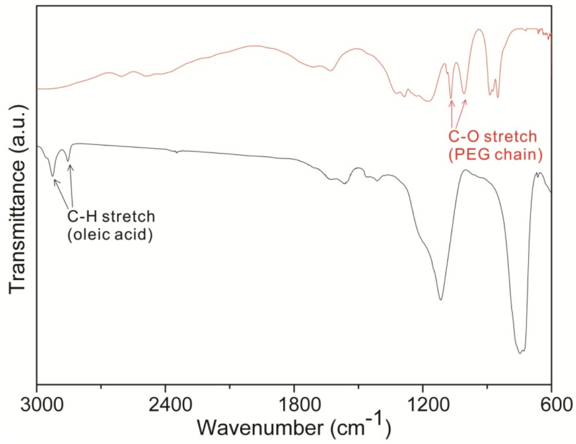

Fig. S4. FTIR spectra of functionalized $NaDyF_4:Yb^{3+}/NaGdF_4:Yb^{3+},Er^{3+}$ NCs. The result shows that peak intensity at 2880 cm^{-1} and 2820 cm^{-1} increase, which is ascribed to the C-H stretch in oleic acid. The strong peak at 1100 cm^{-1} corresponds to C-O bonds in the PEG backbone.

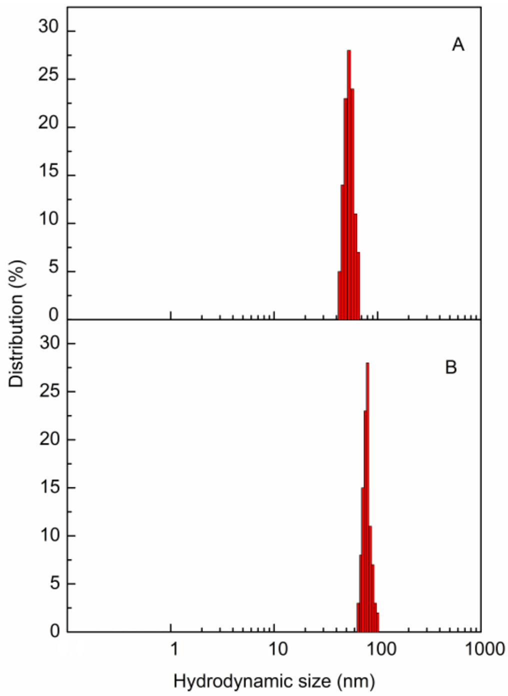

Fig. S5. Hydrodynamic size of nanocrystals: oleic acid-coated NCs (A), PMAO-PEG-NCs in DI water (B). The sizes of A and B in water were determined to be 56 nm and 84 nm, respectively. The size increase (~28 nm) is attributed to the PEG coating.

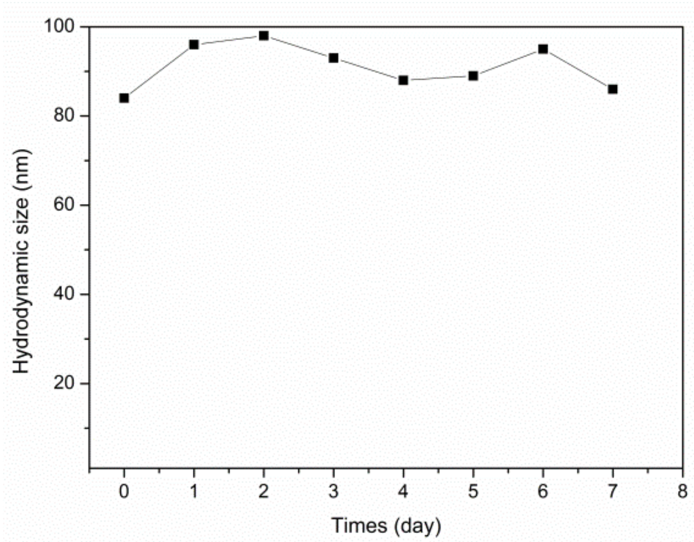

Fig. S6 Size variation of PMAO-PEG-NCs obtained by DLS. No significant size change was observed up to 7 days, demonstrating the excellent colloidal stability of the PMAO-PEG functionalized nanocrystals.

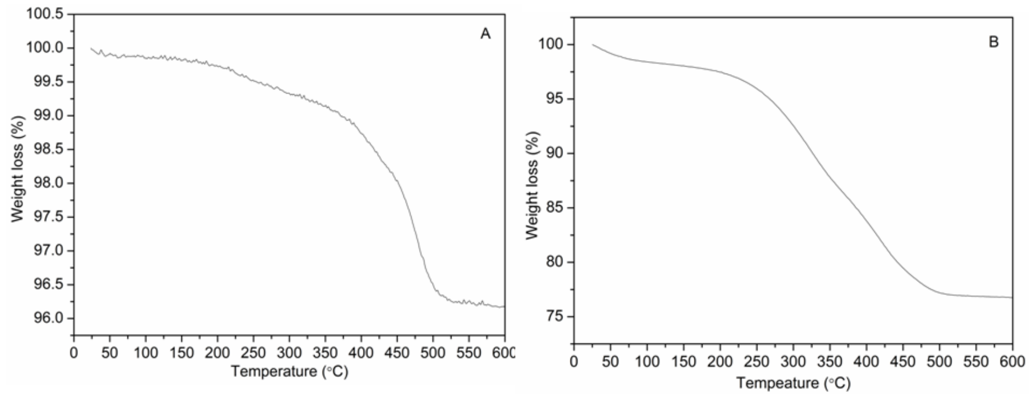

Fig. S7. Thermogravimetric analysis curves for oleic-acid capped NCs (A) and PMAO-PEG-NCs (B). The weight fraction of before and after the polymer coating of the NCs showed 19% weight loss due to the polymer.

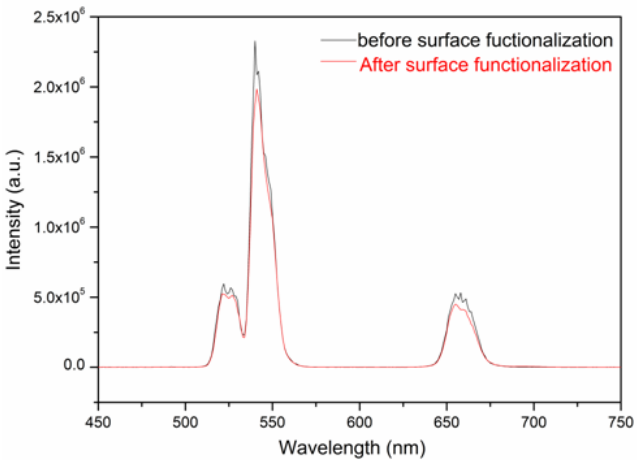

Fig. S8. UC emission of the $NaDyF_4:Yb^{3+}/NaGdF_4:Yb^{3+},Er^{3+}$ NCs before and after surface coating. Samples concentration is 1 mg/ml and spectra were recorded at a power of 1 W.

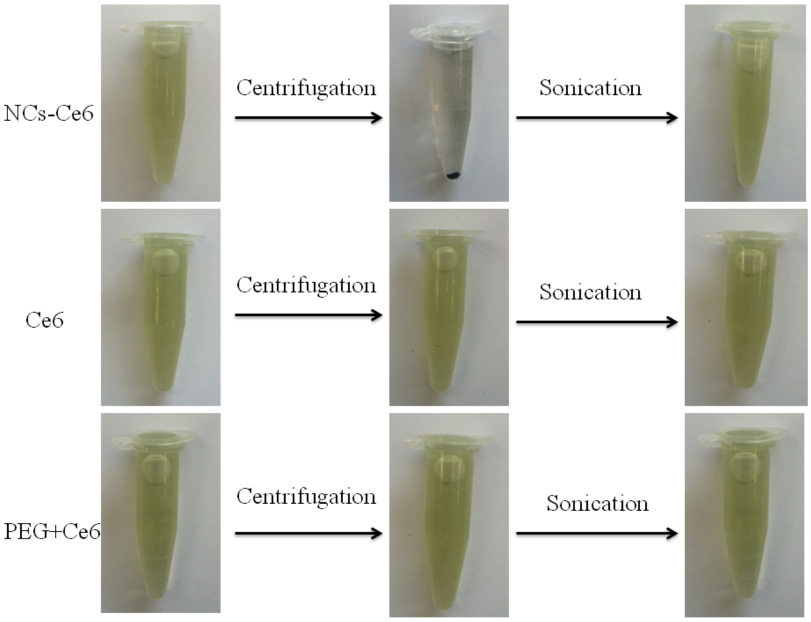

Fig. S9. Photos of NCs-Ce6, Free Ce6, and PEG-Ce6 solutions after centrifugation and then sonication.

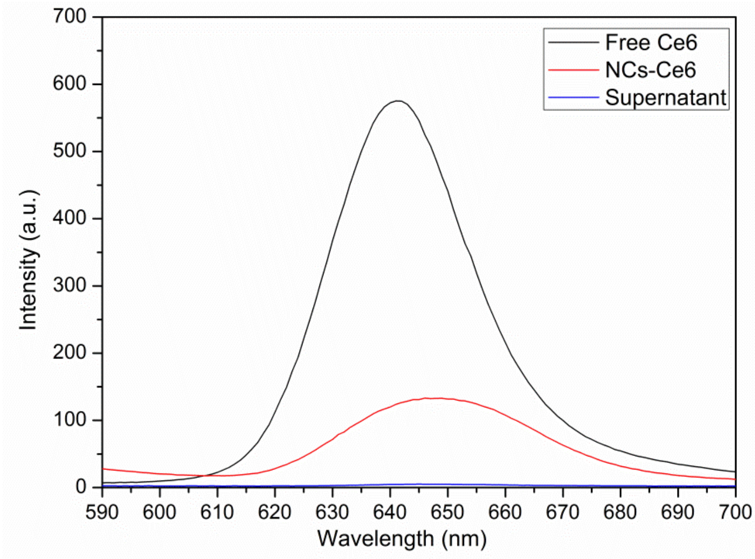

Fig. S10. Fluorescence spectra of free Ce6, NCs-Ce6 and the supernatant, measured under 400 nm excitation.

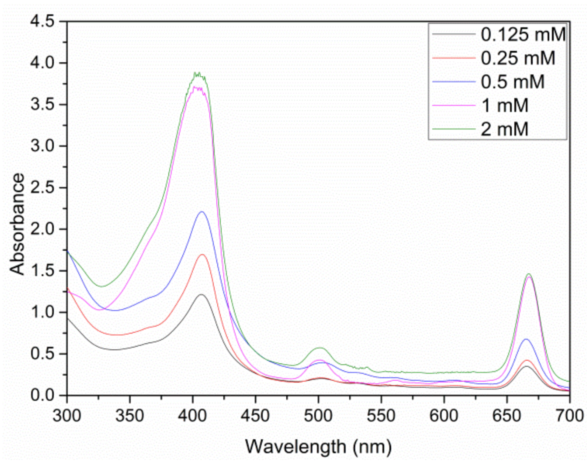

Fig. S11. UV-vis absorbance spectra of NCs-Ce6 loaded with different concentration of Ce6. Concentration of NCs in samples kept the same.

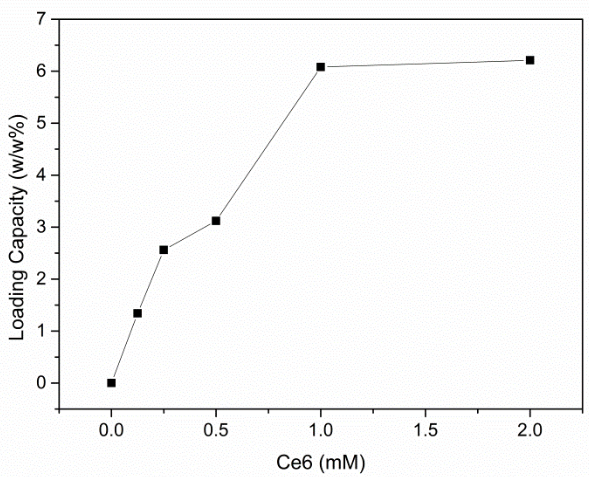

Fig. S12. Loading capacity of Ce6 of NCs-Ce6 at different Ce6 concentration.

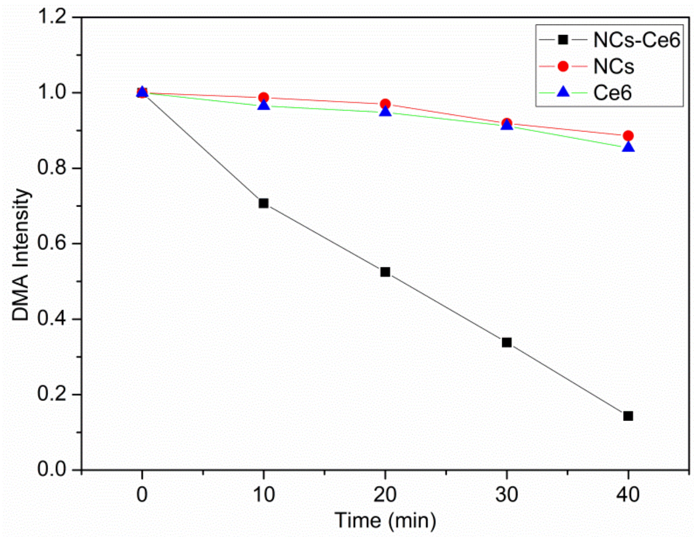

Fig. S13. Normalized change of DMA fluorescence from NCs–Ce6, bare NCs and pure Ce6 as a result of singlet oxygen generation under 980 nm irradiation.

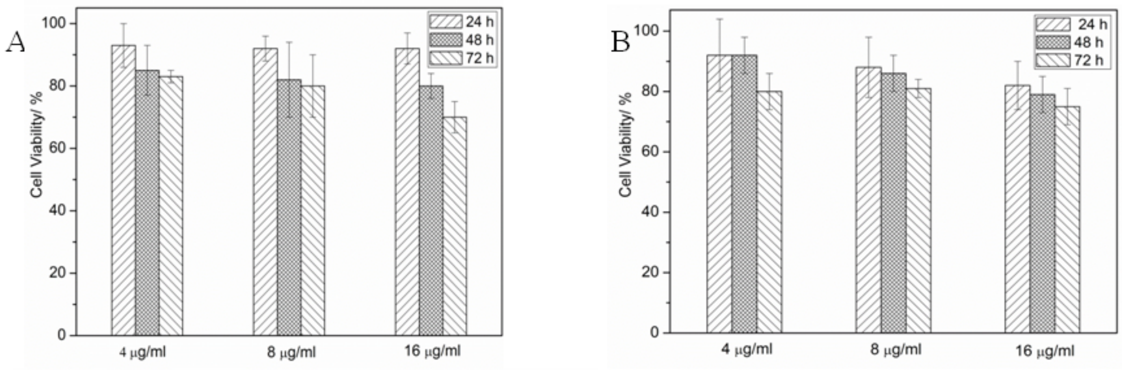

Fig. S14. Cell viability of HeLa cells incubated with different concentration of (A) NCs and (B) NCs-Ce6 at 24 h, 48 h, 72 h at 37 °C.

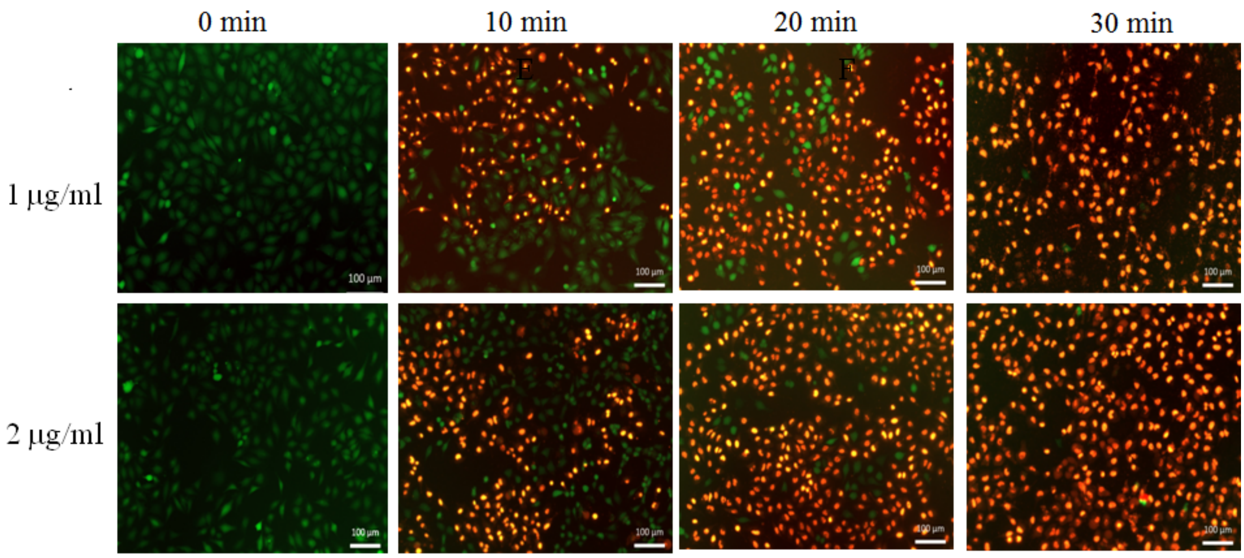

Fig. S15. Detection of photodamage by fluorescence microscopy using fluorescent probes at the NCs-Ce6 concentration of 1 μg/ml (top row) and 2 μg/ml (bottom row) at time of 0 min, 10 min, 20 min, 30 min, respectively (double-staining with calcein-AM and ethidium homodimer). Dead cells: red fluorescence of ethidium homodimer; live cells: green fluorescence of calcein-AM.