Supporting Information

The Morphology and Surface Charge-Dependent Cellular Uptake Efficiency of Upconversion Nanostructures Revealed by Single-Particle Optical Microscopy

Di Zhang,[‡a] Lin Wei,[‡b] Meile Zhong,[b] Lehui Xiao,[*,a,b] Hung-Wing Li,[c] and Jianfang Wang[d]

[a] State Key Laboratory of Medicinal Chemical Biology, Tianjin Key Laboratory of Biosensing and Molecular Recognition, College of Chemistry, Nankai University, Tianjin, 300071, China;

[b] Key Laboratory of Chemical Biology & Traditional Chinese Medicine Research, Key Laboratory of Phytochemical R&D of Hunan Province, College of Chemistry and Chemical Engineering, Hunan Normal University, Changsha, 410082, China;

[c] Department of Chemistry, Hong Kong Baptist University, Kowloon Tong, Hong Kong, SAR China;

[d] Department of Physics, The Chinese University of Hong Kong, Shatin, Hong Kong SAR, China.

[‡] These authors contributed equally to this work.

[*] Corresponding author

Email: lehuixiao@nankai.edu.cn

Fax: +86-022-23500201

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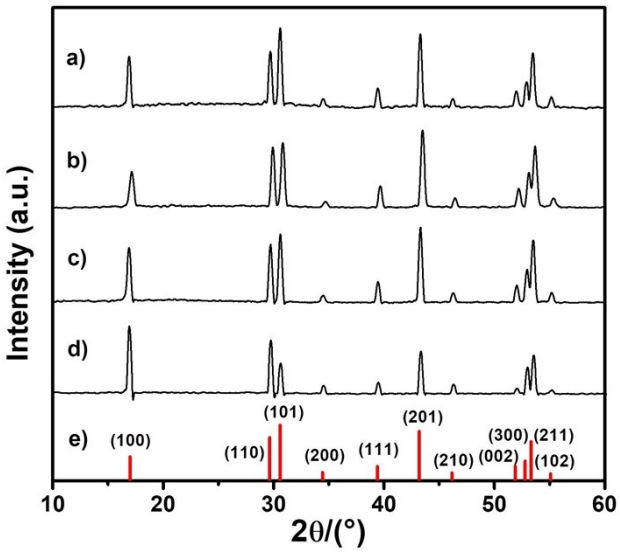

Fig. S1. X-ray power diffraction (XRD) spectra of $NaYF_4$:Yb^{3+}, Er^{3+} UCNPs with various shapes a) UCNPs-1, b) UCNPs-2, c) UCNPs-3, d) UCNPs-4 and e) Line pattern of the calculated hexagonal phase $NaYF_4$ (PDF No. 16-0334).

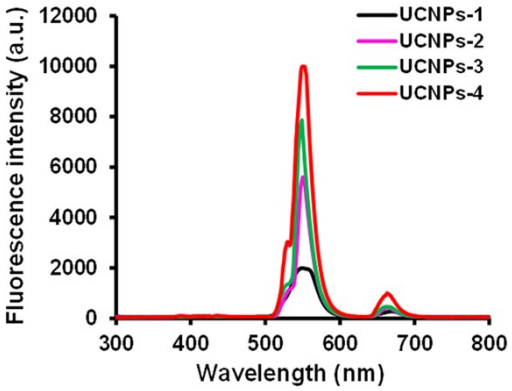

Figure S2. The fluorescence emission spectra of polymer-coated UCNPs dispersed in deionized water at the concentration of 1 mg/mL under excitation at 980 nm.

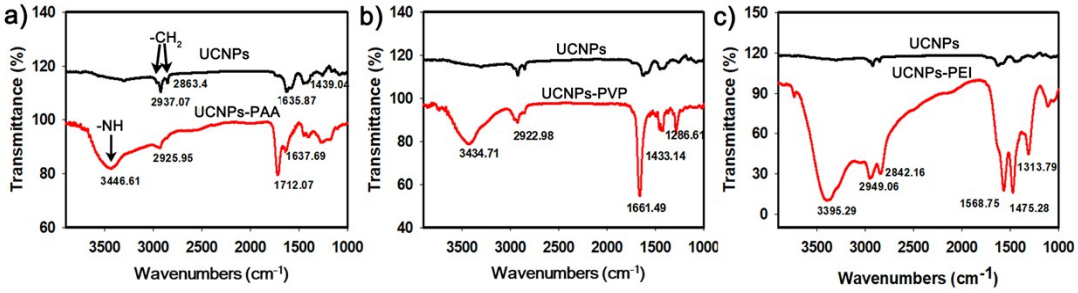

Figure S3. The FT-IR spectra of a) PAA, b) PVP, c) PEI modified UCNPs and untreated UCNPs. Absorption peaks at 2937 and 2863 cm^{-1} correspond to the stretching vibration of methylene groups, which are the result of sodium citrate on the surface of UCNPs. Absorption peaks at 3446 and 1712 cm^{-1} in a) are assigned to the vibrational absorption of hydroxyl groups and carbonyl groups, respectively, indicating the presence of carboxylic acid in PAA. An absorption peak at 1661 cm^{-1} in b) reveals the stretching vibration of C=O in PVP. Absorption peaks at 3395 and 1568 cm^{-1} in c) are the results of imino groups in polymer PEI.

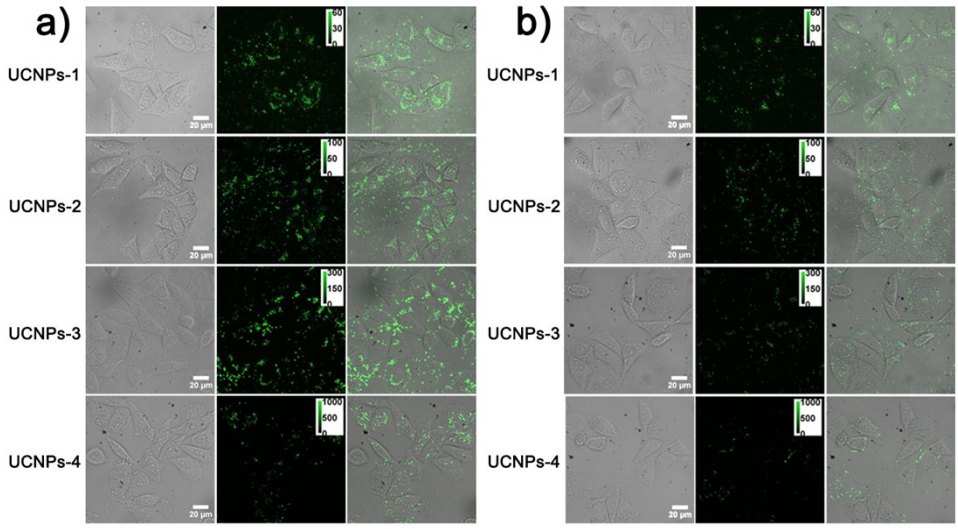

Figure S4. a) and b) are the fluorescence microscopic characterizations of HeLa cells co-cultured with PEI-modified UCNPs-1, -2, -3 and -4 at 37 and 4 ^{o}C for 4h respectively. The images from left to right are the bright-field, fluorescence and merged microscopic images respectively.

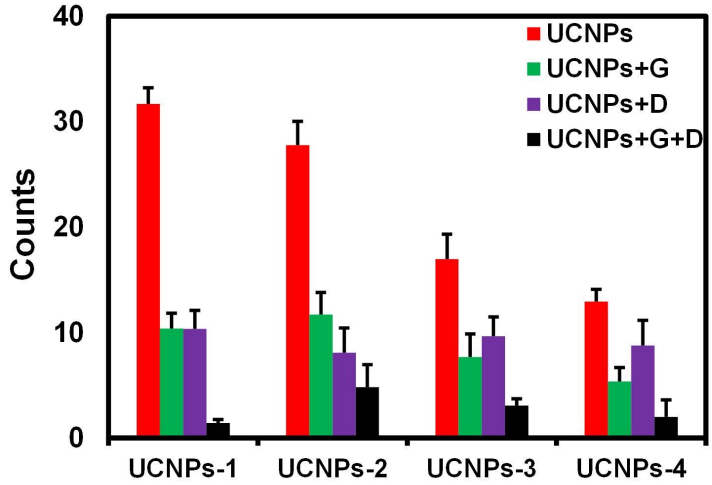

Figure S5. The statistically counted number of UCNPs-PEI with various morphologies in single HeLa cells co-incubated without drug treatment (red), with Genistein (green), Dynasore (purple), and both of them (black) respectively.