

# Supporting Information

## Multi-Shelled Upconversion Nanostructures with Enhanced Photoluminescence Intensity *via* Successive Epitaxial Layer-by-Layer Formation (SELF) Strategy for High-Level Anticounterfeiting

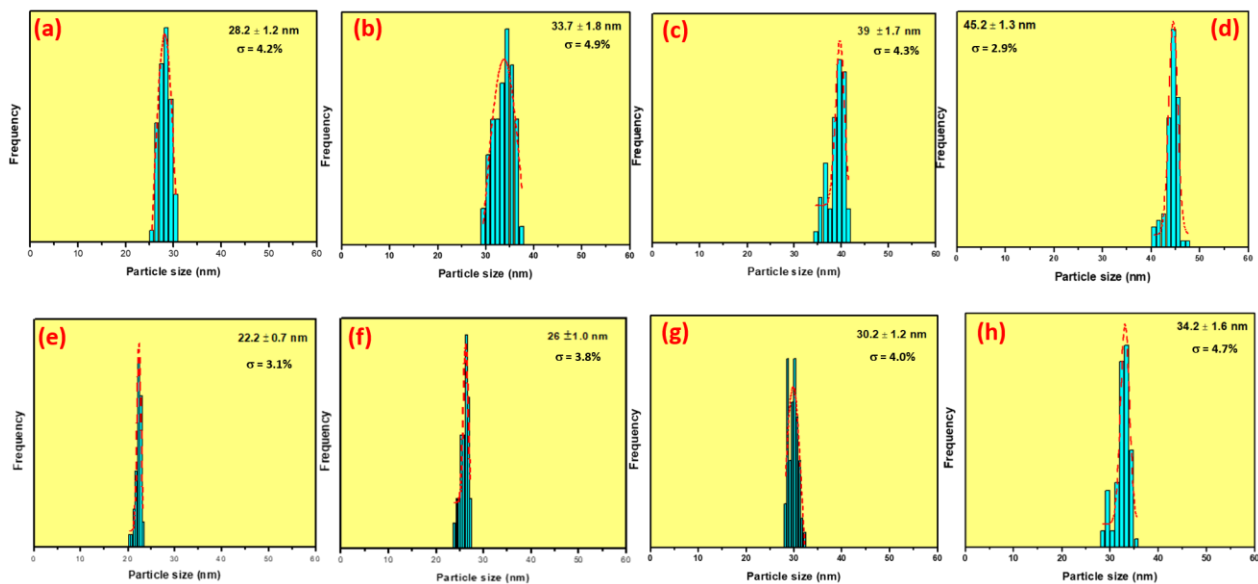
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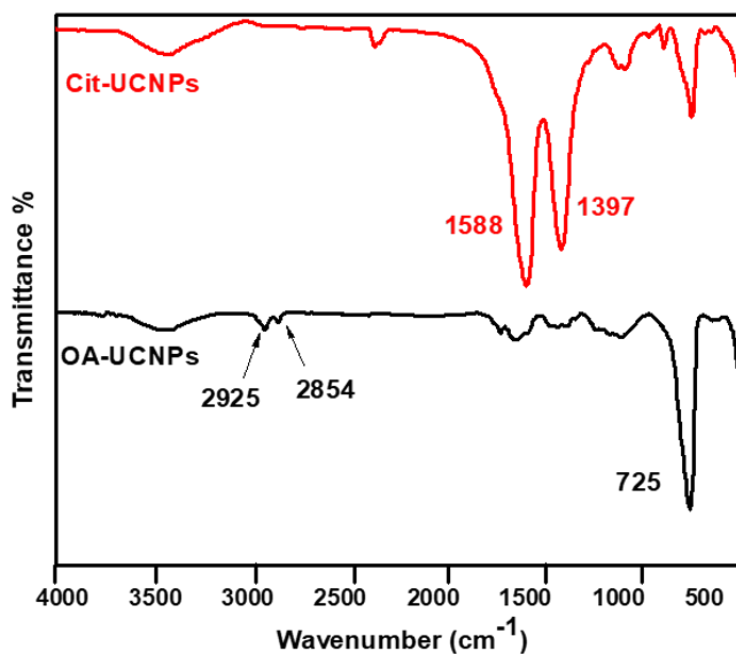
<sup>‡</sup> National Institute of Standards and Technology (NIST), 100 Bureau Dr., Gaithersburg,  
Maryland 20899, USA

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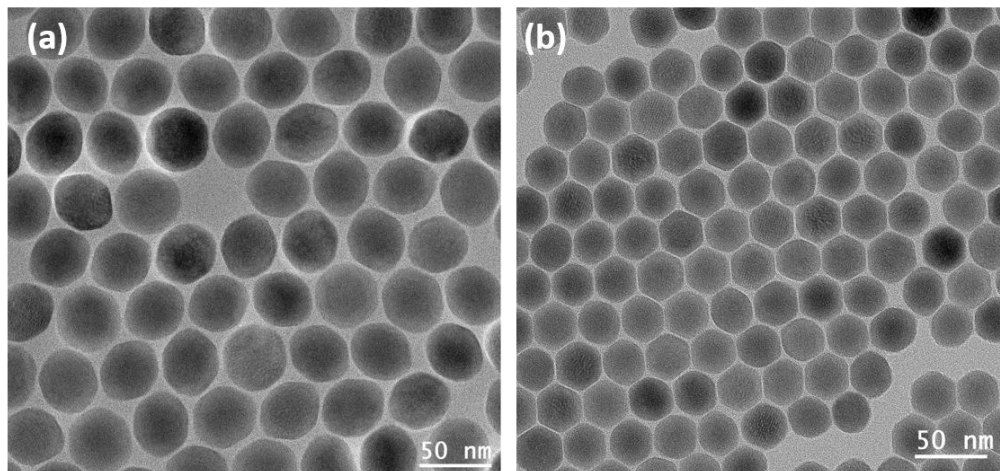
Email: [hjing2@gmu.edu](mailto:hjing2@gmu.edu); Phone: 1-703-993-5221; Fax: 1-703-993-1040.



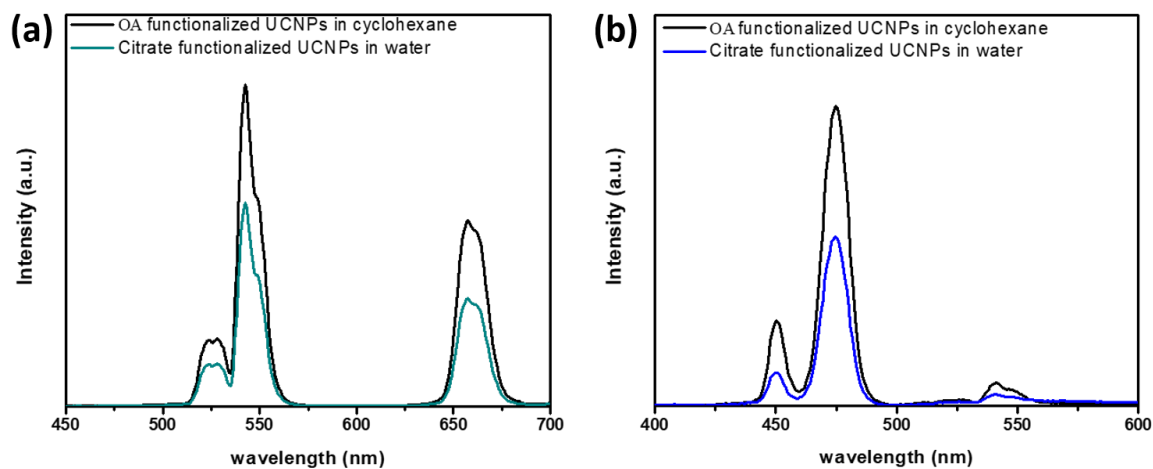
**Figure S1.** Size histogram of  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Er<sup>3+</sup>@NaYF<sub>4</sub> UCNPs with (a) 0, (b) 10, (c) 20, (d) 30 shell layers and  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Tm<sup>3+</sup>@NaYF<sub>4</sub> UCNPs with (e) 0, (f) 10, (g) 20, (h) 30 layers.



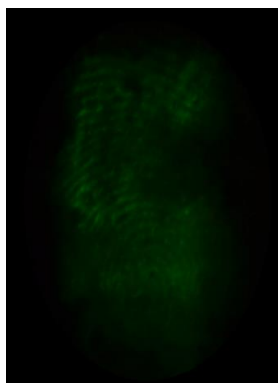
**Figure S2.** Fourier-transform infrared (FTIR) spectrum of oleic acid-functionalized (OA-UCNPs) and sodium citrate-modified (Cit-UCNPs) core-shell  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Er<sup>3+</sup>@NaYF<sub>4</sub> UCNPs with 30 layers.



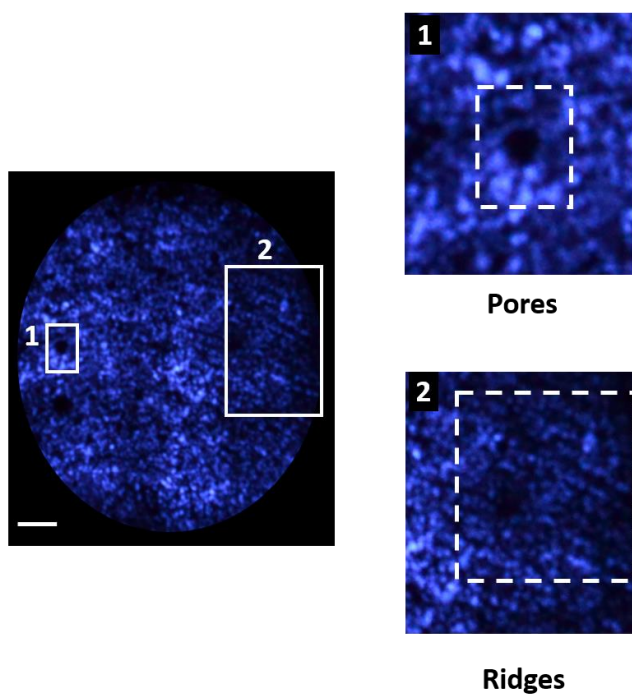
**Figure S3.** TEM images of hydrophilic core-shell (a)  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Er<sup>3+</sup>@NaYF<sub>4</sub> with 30 layers and (b)  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Tm<sup>3+</sup>@NaYF<sub>4</sub> with 30 layers UCNPs well-dispersed in water.



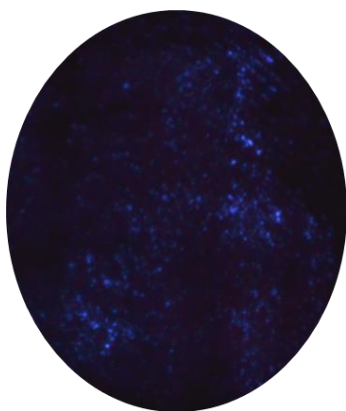
**Figure S4.** Upconversion photoluminescence spectra of hydrophilic core-shell (a)  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Er<sup>3+</sup>@NaYF<sub>4</sub> with 30 layers and (b)  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Tm<sup>3+</sup>@NaYF<sub>4</sub> with 30 layers UCNPs well-dispersed in water excited with 980 nm NIR laser.



**Figure S5.** Ambiguous image of illuminated latent fingerprint incubated with citrate functionalized  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Er<sup>3+</sup> core UCNPs on glass slides under 980 nm excitation (Power density: 3 W cm<sup>-2</sup>).



**Figure S6.** Image of illuminated latent fingerprint incubated with citrate functionalized 30-shell layered  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Tm<sup>3+</sup>@NaYF<sub>4</sub> UCNPs on glass slides under 980 nm excitation. The scale bar represents 2 mm. Magnified images of fingerprints with details including pores (1) and ridges (2) under 980 nm excitation (Power density: 3 W cm<sup>-2</sup>).



**Figure S7.** Ambiguous image of illuminated latent fingerprint incubated with citrate functionalized  $\beta$ -NaYF<sub>4</sub>: Yb<sup>3+</sup>/Tm<sup>3+</sup> core UCNPs on glass slides under 980 nm excitation (Power density: 3 W cm<sup>-2</sup>).