

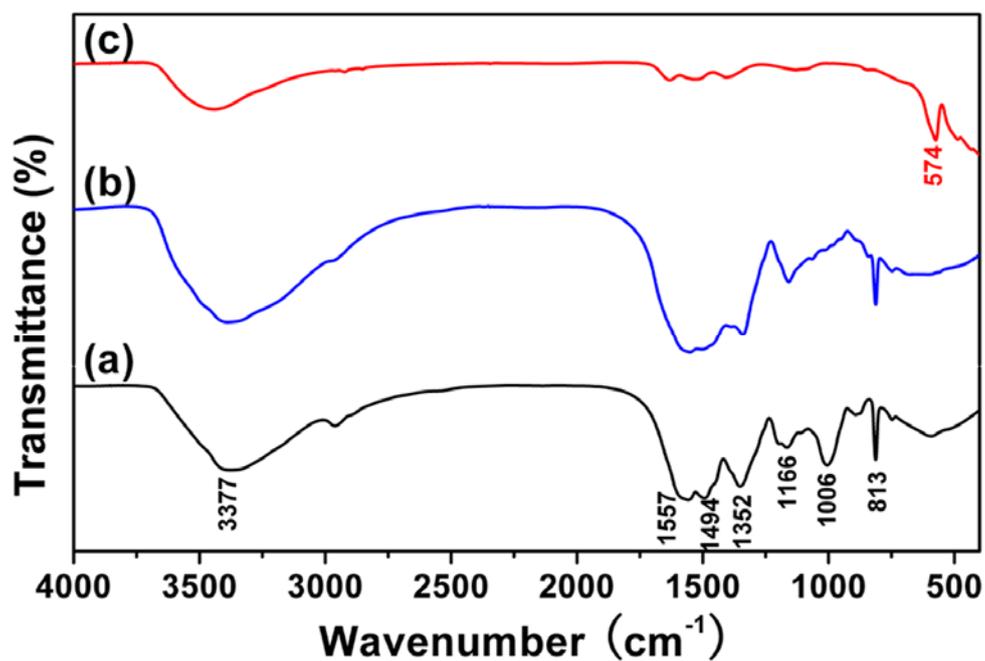
## Electronic supplementary information

### Synthesis and Characterization of Highly Uniform $\text{Lu}_2\text{O}_3:\text{Ln}^{3+}$ (Ln = Eu, Er, Yb) Luminescent Hollow Microspheres

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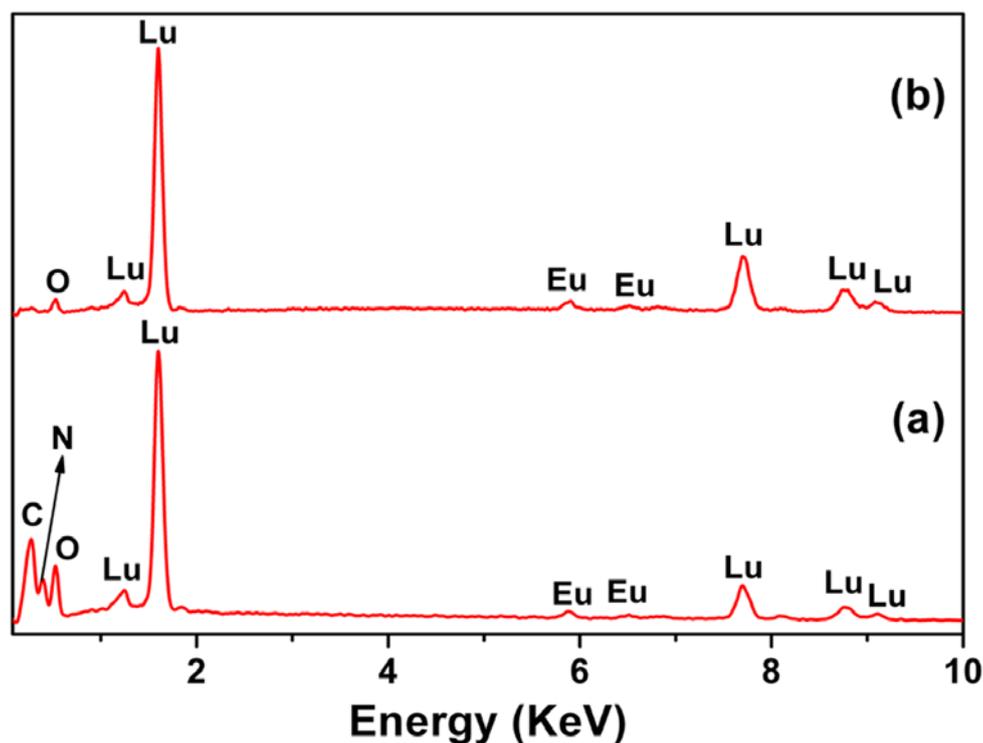
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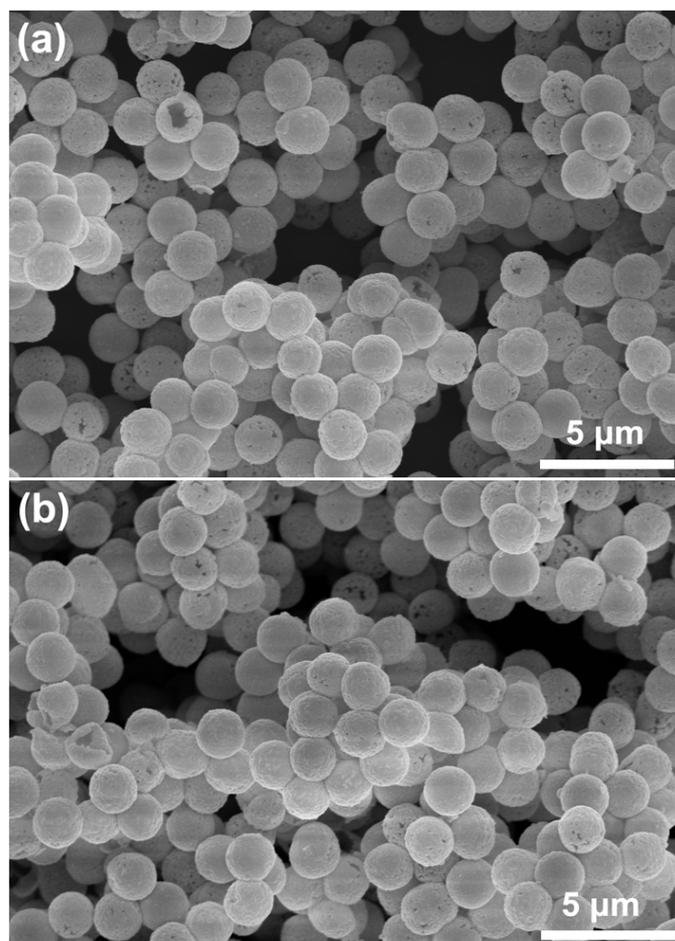
**Figure S1.** FT-IR spectra of (a) pure MF templates, (b) uncalcined precursor, and (c)  $\text{Lu}_2\text{O}_3:\text{Eu}^{3+}$  hollow microspheres.

The FT-IR spectra were used to identify the functional groups of the MF template, the core-shell structured precursor, and the final Lu<sub>2</sub>O<sub>3</sub> product. The FT-IR spectrum of MF templates (Figure 3a) shows the characteristic absorption bands of MF templates, which are identical with the previous reports.<sup>1,2</sup> The absorption bands at about 3377, 1557 (1494, 1352), 1166, 1006, and 813 cm<sup>-1</sup> are assigned to the vibration of hydroxy/amino (–OH/–NH<sub>2</sub>), amino (–NH<sub>2</sub>), amine (C–N), ether (C–O–C), and C–N–C groups, respectively. The FT-IR spectrum of the core-shell structured precursor is similar to that of the MF templates (Figure 3b). However, it can be observed that the absorption band of ether groups (1006 cm<sup>-1</sup>) nearly disappears, which may be caused by the coating of the lutetium precursor nanoparticles on the surfaces of MF templates (Figure 5). Figure 3c shows the FT-IR spectrum of the calcined Lu<sub>2</sub>O<sub>3</sub> hollow microspheres. It can be seen that most of functional groups of the MF template disappears, and some very weak absorption bands in the range of 1000 to 1750 cm<sup>-1</sup> can be detected because the MF resin is very sensitive to the FT-IR analysis. The result indicates that the MF templates can be effectively removed during the calcination process. Moreover, a new IR band centered about 574 cm<sup>-1</sup> appears which can be assigned to the Lu–O stretching frequencies of the cubic Lu<sub>2</sub>O<sub>3</sub>.<sup>3</sup> The result is consistent with that of XRD result and further confirms the formation of crystalline Lu<sub>2</sub>O<sub>3</sub> via the urea-based homogeneous precipitation and the calcination process.

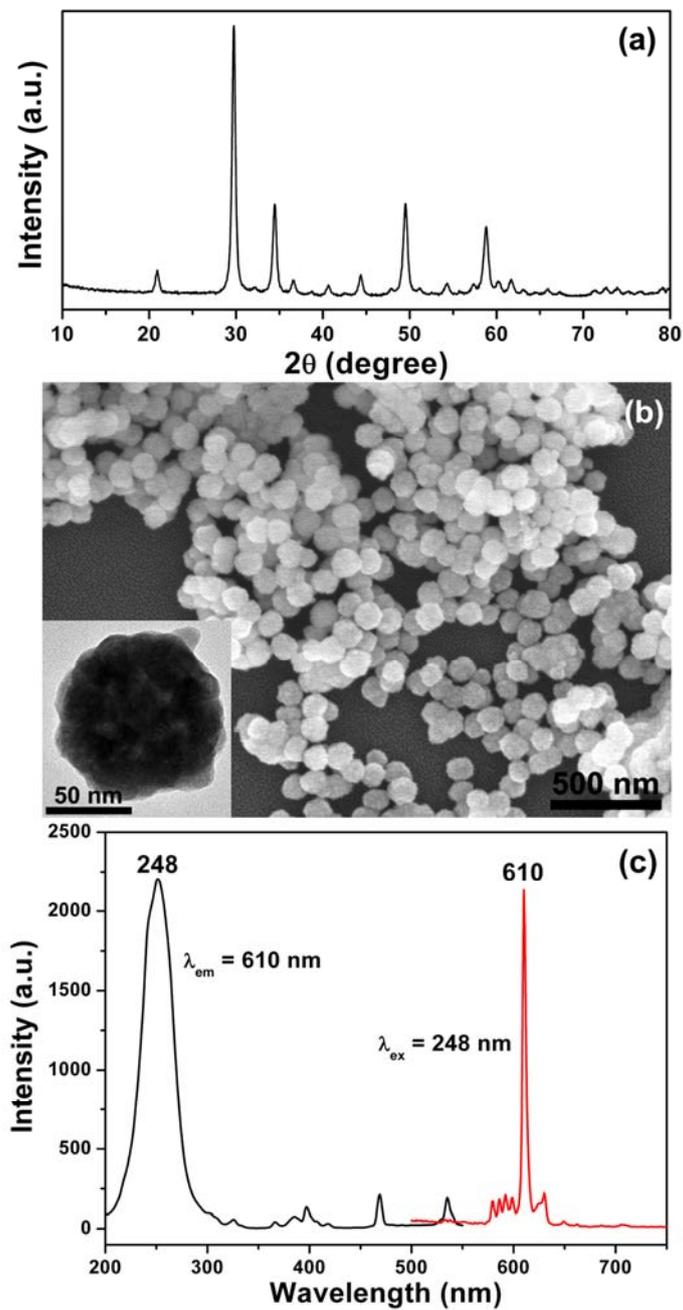


**Figure S2.** EDX spectra of (a) uncalcined precursor and (b) Lu<sub>2</sub>O<sub>3</sub>:Eu<sup>3+</sup> hollow microspheres.

The energy dispersive X-ray (EDX) spectra were further used to investigate the as-obtained core-shell structured precursor and the Lu<sub>2</sub>O<sub>3</sub>:Eu<sup>3+</sup> product. The EDX spectrum in Figure 4a confirms the presence of carbon (C), oxygen (O), nitrogen (N), lutetium (Lu), and europium (Eu) in the precursor before calcinations. The detected carbon element comes from the MF cores and the amorphous Lu(OH)CO<sub>3</sub> shell of the precursor, while the nitrogen element is due to the MF template. After calcination at 800 °C for 2 h, the final hollow microspheres are composed of three elements (O, Lu, and Eu), and the peaks of carbon and nitrogen elements can not be detected (Figure 4b). This result provides additional evidence that the MF templates have been burned out and the Lu(OH)CO<sub>3</sub>:Eu<sup>3+</sup> precursor shell has almost converted into crystalline Lu<sub>2</sub>O<sub>3</sub>:Eu<sup>3+</sup> during the calcination process.



**Figure S3.** SEM images of (a) Lu<sub>2</sub>O<sub>3</sub>:1%Er<sup>3+</sup>, (b) Lu<sub>2</sub>O<sub>3</sub>:5%Yb<sup>3+</sup>/1%Er<sup>3+</sup> hollow microspheres.



**Figure S4.** (a) XRD pattern, (b) SEM image, and (c) excitation and emission spectra of  $\text{Lu}_2\text{O}_3:\text{Eu}^{3+}$  nanoparticles prepared without MF microspheres as templates. Inset in (b) is the corresponding TEM image of an individual nanoparticle.

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