

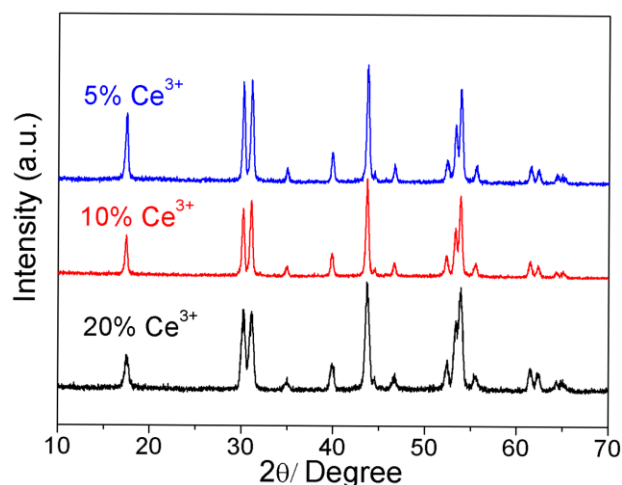
**Electronic supplementary information (ESI)**

**Sub-10 nm and monodisperse  $\beta$ -NaYF<sub>4</sub>:Yb,Tm,Gd nanocrystals with intense ultraviolet upconversion luminescence**

Feng Shi and Yue Zhao\*

Département de chimie, Université de Sherbrooke, Sherbrooke, Québec, Canada J1K 2R1  
Tel: 819-8217090; Fax: 819-8218017. [yue.zhao@usherbrooke.ca](mailto:yue.zhao@usherbrooke.ca)

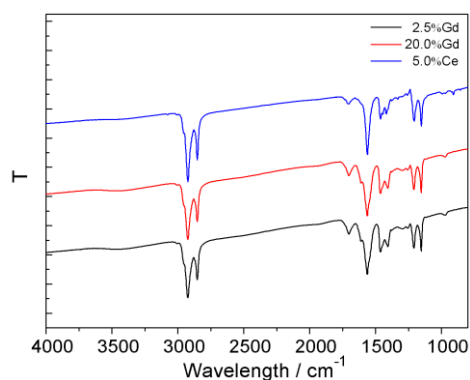
**1. XRD Characterization**



**Fig. S1** XRD patterns of the NaYF<sub>4</sub>:18%Yb,0.5%Tm,W%Ce NCs with different Ce<sup>3+</sup> doping content (W = 5, 10, and 20 mol%).

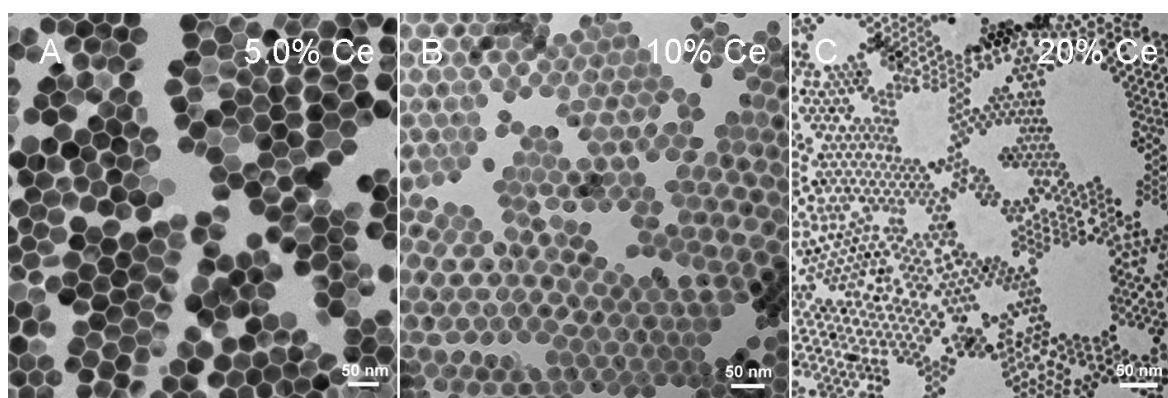
**2. FTIR Analysis**

The surface functional groups attached on the  $\beta$ -NaYF<sub>4</sub>:Ln<sup>3+</sup> NCs were identified with FT-IR as shown in Fig.S2. The peaks at 2926 and 2853 cm<sup>-1</sup> are assigned to the asymmetric and symmetric stretching vibrations of methylene (–CH<sub>2</sub>–) in the long alkyl chain of the oleic acid (OA) molecules. The peaks at 1708, 1566 and 1461 cm<sup>-1</sup> are assigned to the C=O stretching vibration frequency, asymmetric and symmetric stretching vibration of the carboxylic group (–COOH) of the bound oleic acid, respectively. The spectra confirmed the presence of OA molecules on the surface of the NCs.

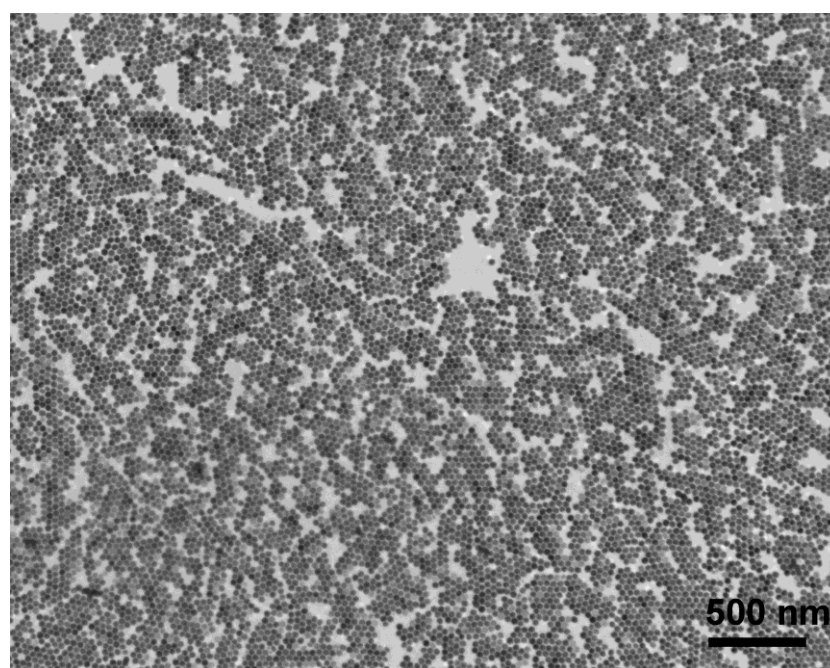


**Fig. S2** Representative FTIR spectra of the  $\text{NaYF}_4\text{:18\%Yb,0.5\%Tm,Gd/Ce}$  NCs.

### 3. TEM observations

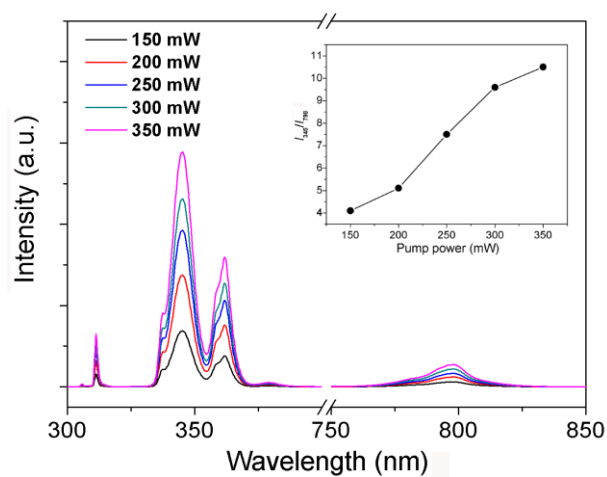


**Fig. S3** TEM images of  $\beta\text{-NaYF}_4\text{:18\%Yb,0.5\%Tm,W\%Ce}$  NCs with varying concentrations of  $\text{Ce}^{3+}$ : (A) 5 mol%, (B) 10% and (C) 20% . Scale bars = 50 nm.



**Fig. S4** Large area TEM image of  $\beta\text{-NaYF}_4\text{:18\%Yb,0.5\%Tm,5\%Ce}$  NCs.

#### 4. Upconversion luminescence properties



**Fig. S5** Excitation power dependence of UC emission spectra of  $\beta$ -NaYF<sub>4</sub>:18%Yb,0.5%Tm,20%Gd NCs. The inset is the fluorescence branching ratio of  $I_{345}/I_{798}$ .