Supporting Information

Enhancement of quantum yield of LaPO₄:Ce³⁺:Tb³⁺ nanocrystals by carbon nanotube induced suppression of the 1-dimensional growth

Jie Fang,ᵃᵇ Yanglong Guo,ᵃ Guanzhong Lu,ᵃᵃ Colin L. Rastonᵇ and K. Swaminathan Iyerᵇ

ᵃ Key Laboratory for Advanced Materials and Research Institute of Industrial Catalysis, East China University of Science and Technology, Shanghai 200237, P. R. China. E-mail: gzhlu@ecust.edu.cn
ᵇ Centre for Strategic Nano-Fabrication, School of Biomedical, Biomolecular and Chemical Sciences The University of Western Australia, Crawley, WA 6009, Australia. E-mail: swaminatha.iyer@uwa.edu.au

Experimental

All chemicals utilized in the synthesis were purchased from Sigma-Aldrich without further purification. High purity single wall carbon nanotubes (SWCNTs) was purchased from Chengdu Organic Chemicals Co. Ltd., Chinese Academy of Sciences. The SWCNT was functionalized using a literature method for producing water soluble SWCNTs. Briefly, the SWCNT was functionalized by treating 10 mg in acid mixture of 10ml of concentrated HNO₃ and 10 ml of concentrated H₂SO₄ followed by heated at 80°C for 2.5 hours.¹ The SWCNTs were purified by multiple washes with water to neutral pH.

LaPO₄:Ce³⁺:Tb³⁺ and LaPO₄:Ce³⁺:Tb³⁺@SWCNT were prepared with the literature method using a previously described rotating tube microfluidic platform to aid room temperature crystallization of well defined nanoparticles.² In a typical synthesis of LaPO₄:Ce³⁺:Tb³⁺, 1 mM LnCl₃ solution (a mixture of 40% LaCl₃, 45% CeCl₃ and 15% TbCl₃ with a total concentration of 1 mM) and 1mM NaH₂PO₄ were fed from two feed jets into the rotating tube continuously at a feed rate of 60 ml/min, and rotational speed of the tube was fixed at 1700 rpm. The products were collected at
the other end of the tube after a residence time of about 7 sec. For the synthesis of composite, LaPO₄:Ce³⁺:Tb³⁺@SWCNT, a mixture solution of LnCl₃ and SWCNT was fed instead of LnCl₃ with concentration of 1 mM for LnCl₃ and 1.5 mg/100 ml for SWCNT. The samples were washed, purified via multiple centrifugations and resuspended in water.

Photoluminescence quantum yields (QY) of the colloidal solutions were measured by comparing with Rhodamin 6G (in absolute ethanol solution, QY=95%), as previously described. The absorbance was recorded at 272 nm which was used as excitation wavelength in the photoluminescence measurements. Absorbance of LaPO₄:Ce³⁺:Tb³⁺ in the LaPO₄:Ce³⁺:Tb³⁺@SWCNT nanocomposite was determined by background subtraction of the absorbance of same concentration of SWCNT solution.

**Characterization**

Transmission electron microscopy images were obtained using TEM Jeol 3000F operated at 300 kV. So were high-resolution transmission electron microscopy (HRTEM) images. The UV-Vis absorbance and fluorescence spectra were measured on UV/Vis-Perkin Elmer and Varian Spectrofluorometer respectively. Powder X-ray diffraction pattern was measured using an Oxford Diffraction Gemini-R CCD diffractometer (using 132 Cu K (alpha) = 1.54178 Å radiation).

![Figure SI 1](image-url). Low magnification TEM images of a) LaPO₄:Ce³⁺:Tb³⁺@SWCNT and b) LaPO₄:Ce³⁺:Tb³⁺.
Results and discussion

In the low magnification TEM images shown in Figure SI 1, both LaPO$_4$:Ce$^{3+}$:Tb$^{3+}$@SWCNT and LaPO$_4$:Ce$^{3+}$:Tb$^{3+}$ demonstrate a 1-dimensional arranged structure with the length up to microns. The background subtracted XRD pattern of LaPO$_4$:Ce$^{3+}$:Tb$^{3+}$@SWCNT confirms its hexagonal phase when compared with the standard PDF card 4-635. And the broaden peaks indicate the very small size of the particles. (Figure SI 2).

References

