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Electronic Supplementary Information

Highly Luminescent $CsPbBr_3$ Nanorods Synthesized by a Ligand-Regulated Reaction at Water-Oil Interface

Qiang Jing, Yucong Su, Xing Xing, Zhenda Lu*

National Laboratory of Solid State Microstructures, College of Engineering and Applied Sciences and Collaborative Innovation Center of Advanced Microstructures, Jiangsu Key Laboratory of Artificial Functional Materials, Nanjing University, Nanjing 210093, China

*Email: luzhenda@nju.edu.cn

Experimental section

Materials

1-octadecene (ODE, Aladdin, 90%), oleic acid (OA, Aladdin, 90%), oleylamine (OAm, Aladdin, 80-90%), cesium acetate (CsAc, Aladdin, 99.9% metals basis), Cs_2CO_3 (Aladdin, 99.9%), lead acetate trihydrate ($PbAc_2{\cdot}3H_2O$, Aladdin, 99.99% metals basis), $PbBr_2$ (Aladdin, 99.0%), tetraoctylammonium bromide (TOAB, Aladdin, 98%), cyclohexane (Sinopharm Chemical Reagent Co. , Ltd ≥ 99.7%, AR), acetone (Sinopharm Chemical Reagent Co. , Ltd ≥ 99.5%, AR), toluene (Sinopharm Chemical Reagent Co. , Ltd ≥ 99.5%, AR). All chemicals were used as received without further purification.

Preparation of Cs_4PbBr_6 NCs

ODE (10 mL), OA (2 mL), OAm (2mL), CsAc (0.2 mmol) and $PbAc_2$ (0.4 mmol) were loaded into a 50 mL 3-neck flask, then the mixture was dried for 15 min at 90 °C. After complete solubilisation of CsAc and $PbAc_2$, the temperature was decreased to 75 ºC, and 3 mL TOAB solution (0.4 mmol TOAB dissolved in 3 mL toluene) was swiftly injected and 10s later the reaction mixture was cooled down by an ice-water bath. After that, acetone with the volume ratio of 1:1 to original dispersion was added to precipitate Cs_4PbBr_6 NCs. The resulting NCs were collected by centrifugation at 8000 rpm for 3 min, and then re-dispersed into 10 mL cyclohexane.

Water-triggered transformation process

The transformation process was conducted under ambient condition. Typically, 2 mL above Cs_4PbBr_6 solution was added into a 15 mL centrifuge tube, then 0.5 mL water was directly injected into the dispersion and the mixture was shaken vigorously for 20s to acquire NRs. The resulting product was collected by centrifugation at 8000 rpm for 3 min, and then re-dispersed into 4 mL cyclohexane. This centrifugation process was repeated twice to obtain $CsPbBr_3$ NRs with high purity.

Composition tuning through a halide ion exchange reaction

At first, the halide precursor solutions were prepared by dissolving 0.2 mmol of $PbCl_2$ or PbI_2 powder in a mixture of 10 ml of toluene, 0.2 ml of OA and 0.2 ml of OAm at 100 °C under continuous stirring until the precursor dissolves. Then, the appropriate amount of precursor was added to the $CsPbBr_3$ NRs dispersion to initiate the halide ion exchange. The reaction mixtures were kept under stirring for 30-40 min at 40 °C followed by a centrifugation at 8000 rpm to remove the unreacted reagents. The purified NRs samples were redispersed in cyclohexane for further characterization.

Growth mechanism research

First, 0.02 mmol TOAB was dissolved in 2 mL toluene to be used later. Then 2 mL above hot-injection acquired Cs_4PbBr_6 solution was respectively added into four 15 mL centrifuge tubes, and 0 μL, 10 μL, 20 μL and 100 μL above TOAB solution were respectively added into the centrifuge tubes. Then 0.5 mL water was respectively injected into the centrifuge tubes and the mixture was shaken vigorously for 20s, the resulting products were collected by centrifugation at 8000 rpm for 3 min, and then re-dispersed into 4 mL cyclohexane respectively.

Characterization

Transmission electron microscopy (TEM) was measured by Tecnai G^2 F20, FEI. The UV-vis absorption spectra and Photoluminescence (PL) emission spectra were measured by the Ocean Optics USB2000+ spectrometer. X-ray powder diffraction (XRD) measurements employed a Bruker AXS D8 X-ray diffractometer equipped with monochromatized Cu Kα radiation (λ=1.5418 Å). The absolute PL QY was determined using a Quantaurus-QY absolute photoluminescence quantum yield spectrometer (C11347-11, Hamamatsu Photonics, Japan). Time-resolved fluorescence measurements were performed using a time-correlated single photon counting setup (TCSPC, SPC-130-EM, BDL-488-SMN) system.

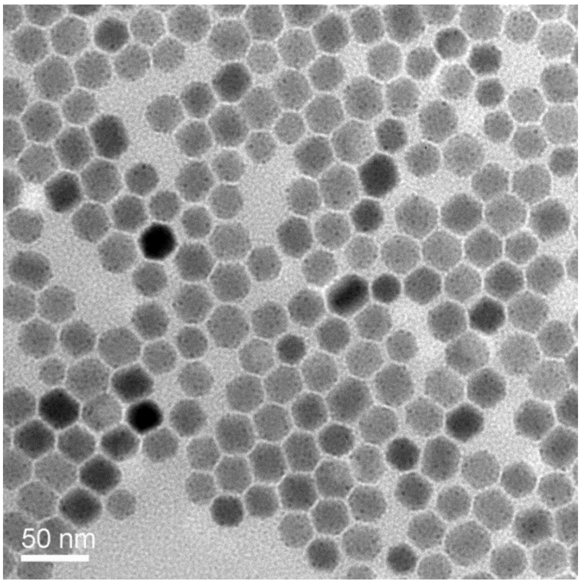

Fig. S1. TEM image of Cs_4PbBr_6 NCs

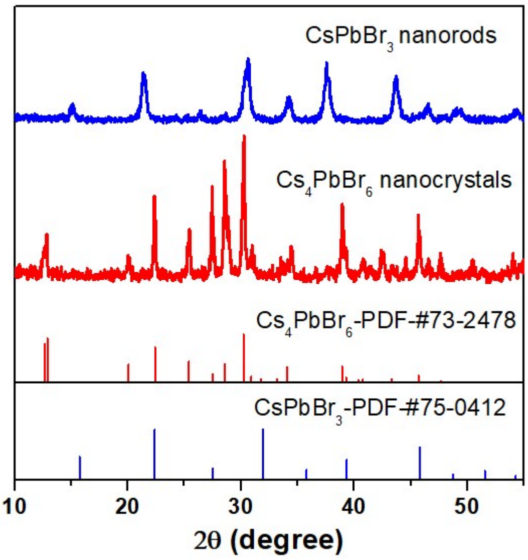

Fig. S2. XRD pattern of Cs_4PbBr_6 NCs and $CsPbBr_3$ NRs.

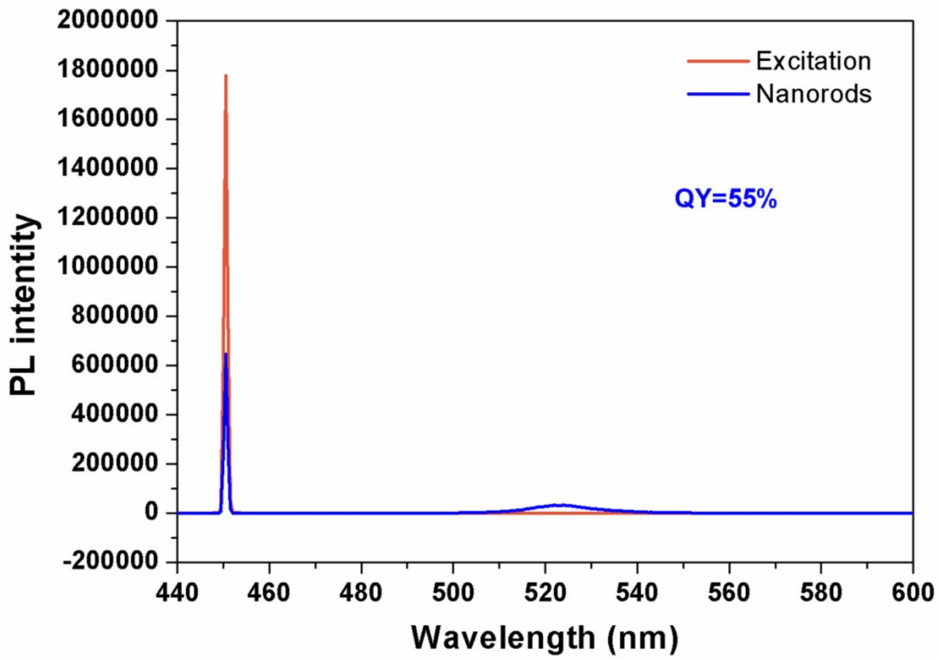

Fig. S3. PL QY measurements of $CsPbBr_3$ NRs.

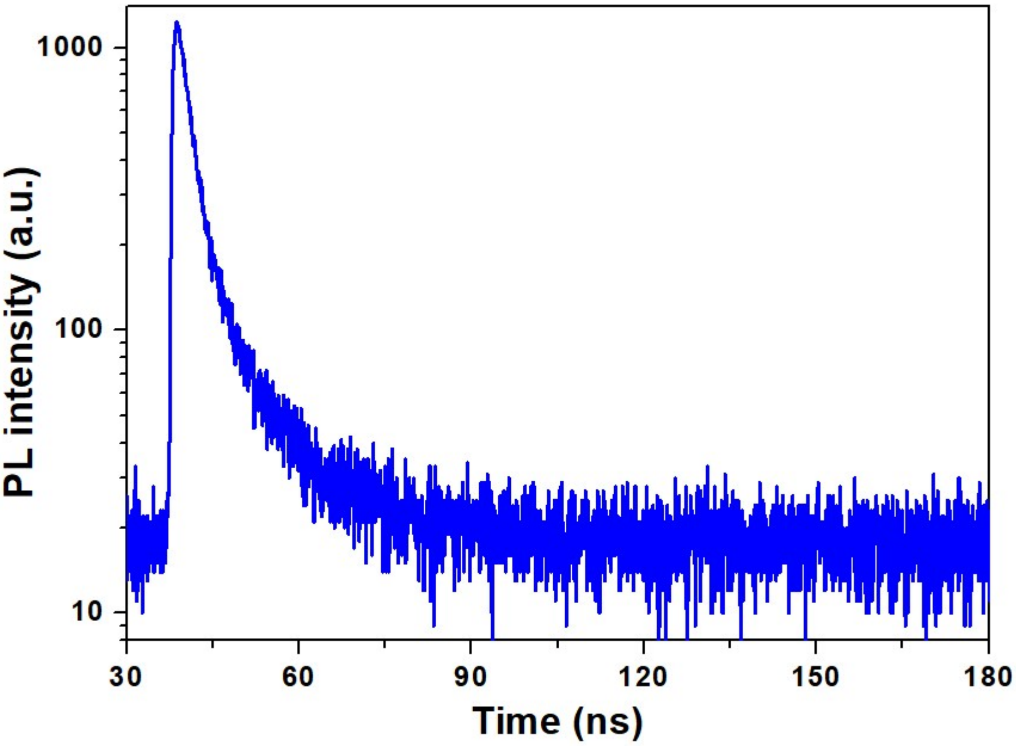

Fig. S4. PL decay of $CsPbBr_3$ NRs.

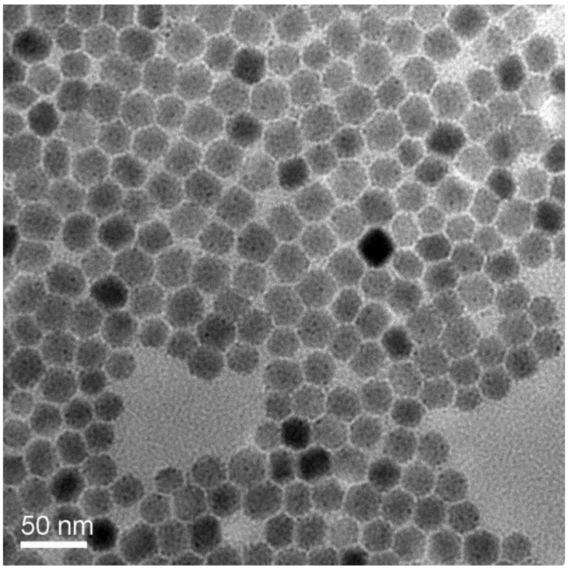

Fig. S5. TEM image of Cs_4PbBr_6 synthesized by hot-injection.

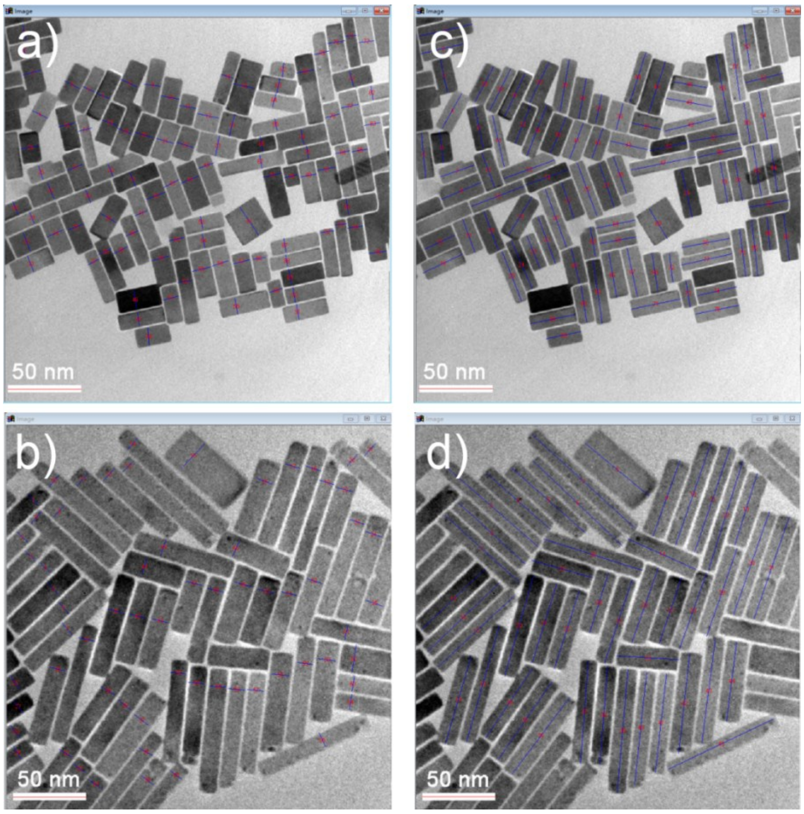

Fig. S6. (a) Width statistics photo of products that adding 10μL TOAB to Cs_4PbBr_6 solution and reaction with water. (b) width statistics photo of products that adding 20μL TOAB to Cs_4PbBr_6 solution and reaction with water. (c) length statistics photo of products that adding 10μL TOAB to Cs_4PbBr_6 solution and reaction with water. (d) length statistics photo of products that adding 20μL TOAB to Cs_4PbBr_6 solution and reaction with water.