

Electronic Supplementary Information

Low-dimensional Iodide Perovskite Nanocrystals Enables Efficient Red Emission

Laura Martínez-Sarti,¹ Seung Hyeon Jo,² Young-Hoon Kim,² Michele Sessolo,¹ Francisco Palazon,^{1,*} Tae-Woo Lee² and Henk J. Bolink.¹

¹ Instituto de Ciencia Molecular (ICMol), Universidad de Valencia, Catedrático José Beltrán, 2, 46980 Paterna, Spain

² Department of Materials Science and Engineering, Institute of Engineering Research, Research Institute of Advanced Materials, Nano Systems Institute (NSI), BK21 PLUS SNU Materials Division for Educating Creative Global Leaders, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea

Experimental section

Synthesis of the MA-Cs mix cation NCs

For the MA-Cs nanocrystals (NCs) synthesis, 0.8 mmol of PbBr_2 , 8 mL of 1-octadecene (ODE), 1.2 mL of oleylamine (or 0.73 mL of decylamine, 0.6 mL of octylamine or 0.48 mL of hexylamine) and 1.2 mL of oleic acid (OA) were mixed together, and the solution was labelled as *Pb solution*. Simultaneously, 0.64 mmol of methylammonium iodide (MAI) and 0.16 mmol of CsI (for a 0.8:0.2 MA-Cs ratio) were added to a solution with 8 mL of 1-butanol (1-BuOH), 4 mL of ODE and 1 mL of OA, labelling the results as *MACs solution*. Both solutions were heated at 130 °C under continuous stirring for approximately 1 hour. Subsequently, and after cooling them down, 1 mL of *Pb solution* was injected drop by drop into 1 mL of *MACs solution* under vigorous stirring at room temperature. A dark red precipitate was immediately observed, indicating the formation of the NCs. Then, the dispersion was centrifuged at 12 krpm for 10 minutes, followed by a redispersion of the obtained precipitate in toluene. When a homogeneous dispersion was obtained, the result was centrifuged a second time at 3750 rpm for 10 minutes. The bright red luminescent supernatant was then studied and used as-obtained.

For the further purified samples, the synthesis was performed as described with the difference of adding 3 mL of 1-BuOH to the NCs dispersion prior to the first centrifugation step. The following steps were kept the same, taking the precipitate and redispersing it in toluene.

Optical characterization

The photoluminescence (PL) characteristics were studied using a Xe lamp coupled to a monochromator as the excitation source and an integrated sphere coupled to a spectrometer (Hamamatsu C9920-02 with a Hamamatsu PMA-11 optical detector) in order to quantitatively determine the PLQYs. Samples were excited at 530 nm and neat toluene was used as reference. Most samples had a 0.4 - 0.5 of absorption for an accurate quantitative PLQY value. UV-visible spectra of the colloidal dispersions were recorded using quartz cuvettes in a UV-visible spectrophotometer Agilent 8453E.

Transmission electron microscopy

TEM images were obtained with a JEOL JEM1010 transmission electron microscope operated at 100 kV.

X-ray diffraction

X-ray diffraction was measured with a Panalytical Empyrean diffractometer equipped with $\text{CuK}\alpha$ anode operated at 45 kV and 30 mA and a Pixel 1D detector in scanning line mode. Single scans were acquired in the $2\theta = 5^\circ$ to 35° range in Bragg-Brentano geometry in air.

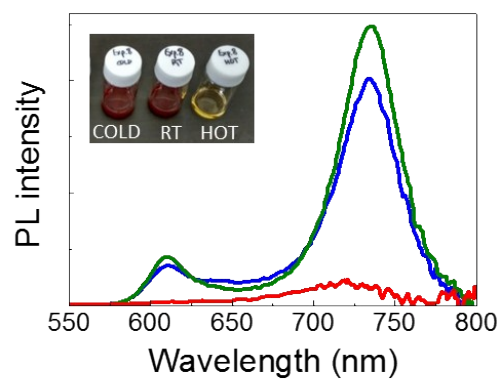


Fig. S1 PL emission out of samples synthesized at 0 °C (blue), room temperature (green) and 134 °C (red). Inset shows a photograph under visible white light of the three colloidal dispersions.

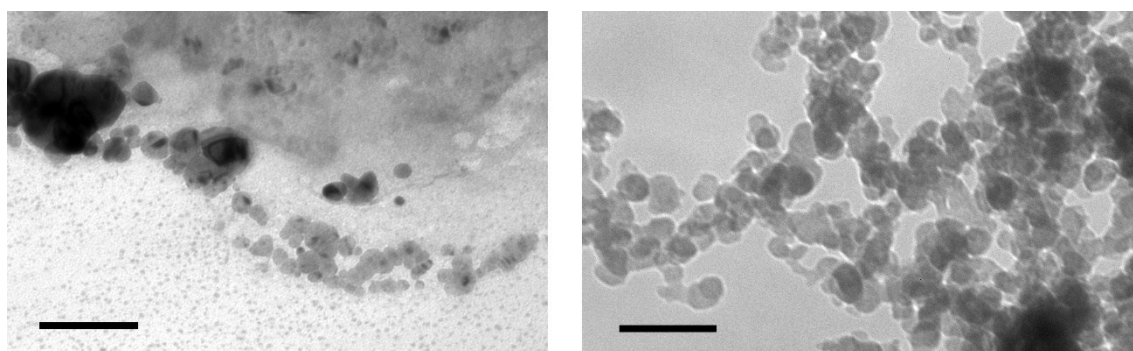


Fig. S2 TEM images of samples synthesized with hexylamine (left) and decylamine (right) after washing with butanol. Scale bars are 100 nm.

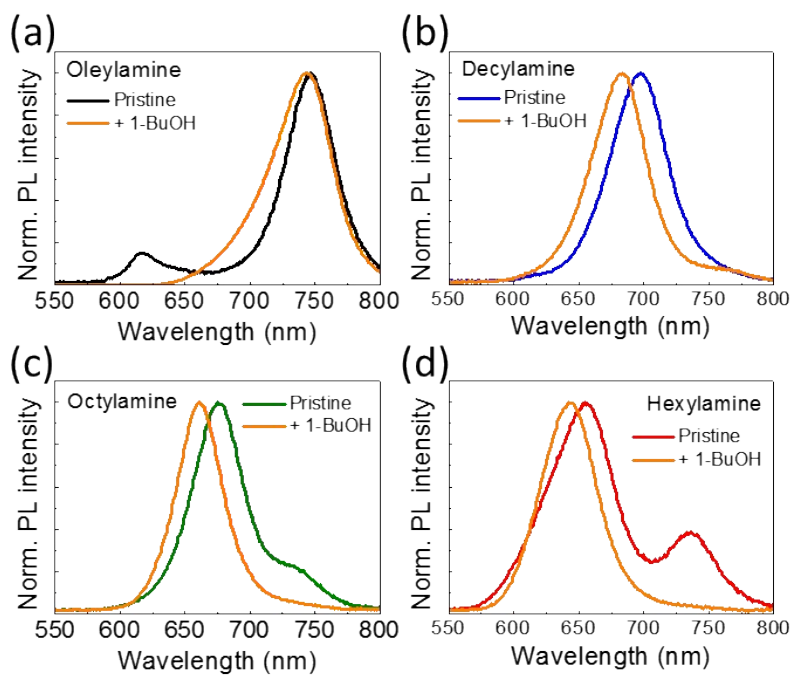


Fig. S3 PL spectra comparison between pristine and further purified NCs (orange lines) for samples with (a) oleylamine, (b) decylamine, (c) octylamine and (d) hexylamine.

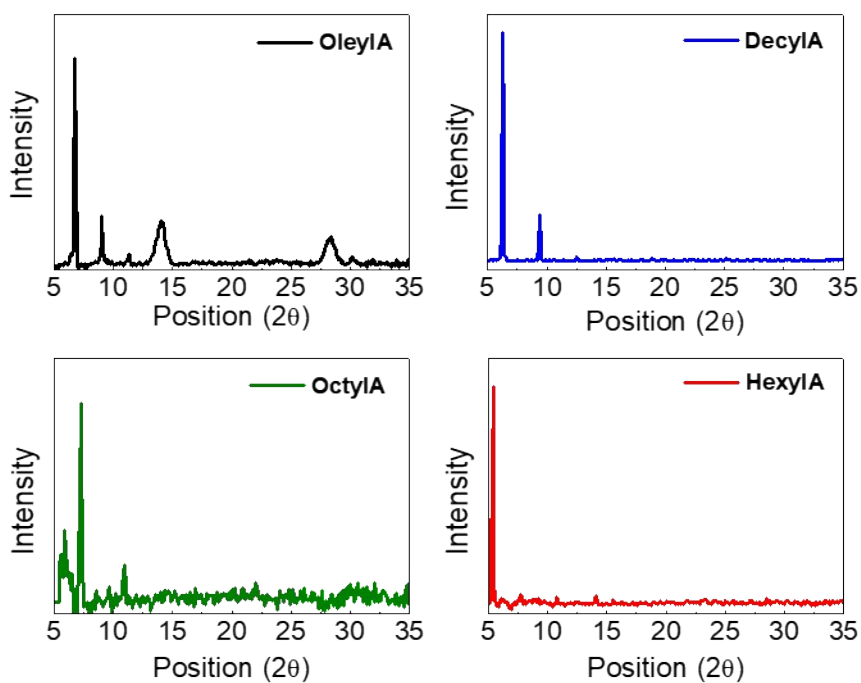


Fig. S4 X-ray diffraction pattern of the different further purified samples plotted from 5° to 35°. All samples show sharp peaks at low angles ascribed to quasi-2D nanocrystals. Only oleylA sample shows additional broad peaks corresponding to 3D NCs.

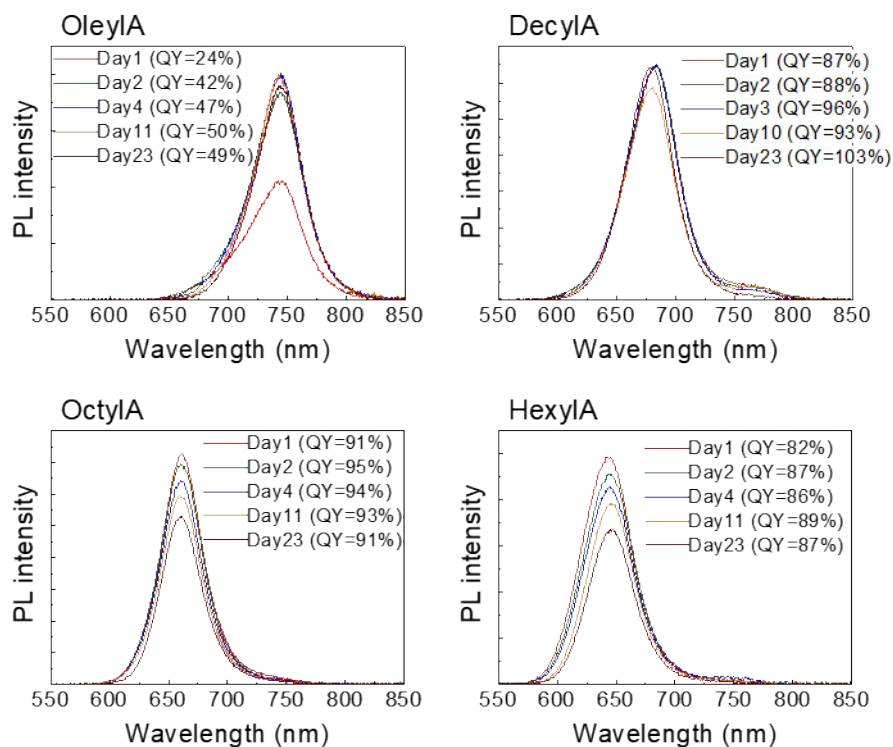


Fig. S5 PL spectra of different samples upon ageing.