Electronic Supplementary Material (ESI) for Chemical Communications.

Supporting Information

Air stable highly luminescent 2D tin halide perovskite nanocrystals as photodetector†

Sukanya Ghosh[a], Jitendra Kumar[b], Gaurav Kumar Nim[a], Monojit Bag*[b] and Prasenjit Kar*[a]

[a]Department of Chemistry, Indian Institute of Technology Roorkee, Uttarakhand-247667, India

[b]Department of Physics, Indian Institute of Technology Roorkee, Uttarakhand-247667, India

Email: kar.prasen@gmail.com, prasenjit.kar@cy.iitr.ac.in

Experimental section

Chemical reagents

We have used the starting materials without further purification after receiving them. Tin oxide (SnO) and oleyl amine were purchased from Sigma Aldrich. Hydrobromic acid (HBr, Rankem) and hypophosphorous acid (H_3PO_2) were ordered from local vendors.

Synthesis of the perovskite materials

We have synthesized the material with a typical aqueous acid-base method by following the previous report.[25] An amount of 0.75 mmol (0.101 g) stannous oxide (SnO) was sonicated until completely dissolved in 2.5 ml hydrobromic acid (HBr). Then, to prevent the tin oxidizing, 15 mL aqueous hypophosphorous acid (H_3PO_2) was added to the above solution. After that, 475 µL n-oleylamine was added to the aforementioned tin-precursor solution with vigorous stirring. The temperature of the solution was raised to 80 °C and the reaction was continued for 30 minutes. The colorless resulting product was gently cooled down at 4 °C to produce a bright yellow fluorescence under UV light. Finally, we have obtained the desired product after the filtration process.

Device fabrication process

The blade coating procedure was used to prepare the device for optoelectronic application. We have placed the produced material onto the indium titanium oxide (ITO) substrate that has been designed for application purposes. ITO substrates were patterned to produce a channel with a channel length of 0.1 mm and a channel width of 2 mm.

Characterization techniques:

1. Absorption, excitation, and emission spectroscopy

Ultra Violet-Visible (UV-Vis) absorbance was measured on a Shimadzu UV-Vis 2450 spectrophotometer in the range of 200-800 nm. Photoluminescence and excitation spectra were recorded in the Horiba scientific Fluoromax-4C spectrophotometer. The emission spectra were recorded in the range of 400-800 nm wavelengths, while the excitation spectrum was recorded between 300-500 nm wavelength. The slit widths and step size of excitations and emissions were 2.0, 2.0, and 1.0, respectively.

2. Fourier Transform Infrared Spectroscopy (FTIR) spectroscopy

FTIR spectra of the materials were recorded by using Thermo scientific Nicolet 6700. The experiments were performed using the KBr pellet making technique with a scan range between 400 to 4000 cm^{-1} over eight scans at a resolution of 4 cm^{-1} and an interval of 1 cm^{-1}.

3. Powder X-ray Diffraction (P-XRD) measurement

Powder XRD was performed on a Rigaku Smart Lab automated multipurpose X-ray diffractometer with a wavelength of 0.154 nm (Cu Kα) and an accelerating voltage of 9kW in the range of 10º to 50º.

4. Field Emission Scanning Electron Microscopy (FE-SEM)

FE-SEM Carl Zeiss Gemini was used to analyze the surface morphology of perovskite materials. The sample was gold coated with an operating voltage of 20 kV.

5. Transmission Electron Microscopy (TEM)

TEM images were collected by using FEI TECHNAI G2 20 S-TWIN. A drop of diluted samples was deposited on a carbon-coated copper grid. Again a drop was added before drying it, and drying was carried at room temperature.

6. X-Ray Photoelectron Spectroscopy (XPS)

Surface analysis of the material was carried out on XPS with model no. PHI 5000 Versa Probe III.

7. Thermogravimetric analysis (TGA)

Thermal analyses were performed on SII 6300 EXSTAR. The sample was heated in a temperature range of 0- 800 °C at a 10 °C/ min heating rate under a nitrogen atmosphere.

8. Temperature-dependent Photoluminescence (PL)

Temperature-dependent Photoluminescence has been studied in the Horiba scientific Fluoromax-4C spectrophotometer. The spectra were recorded in the range of 400-800 nm wavelengths. Slit widths and step size of excitations and emissions were 2.0, 2.0, and 1.0, respectively. We have heated the material at a particular temperature for five minutes and then it was cooled down. After that, we have recorded the PL spectra of the corresponding material.

Table S1. Elemental composition by SEM-EDX.

Element	Wt%	Atomic%
Br	72.26	79.46
Sn	27.74	20.54

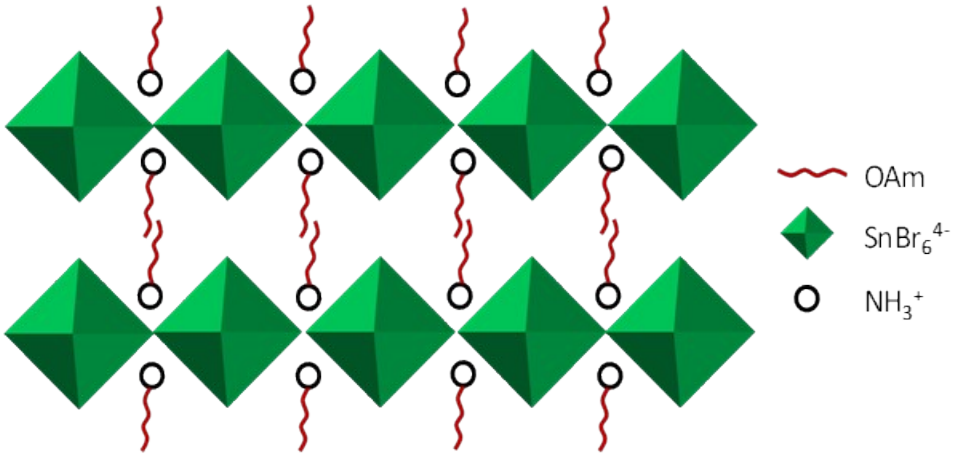

Fig. S1. Probable structure of the 2D perovskite material.

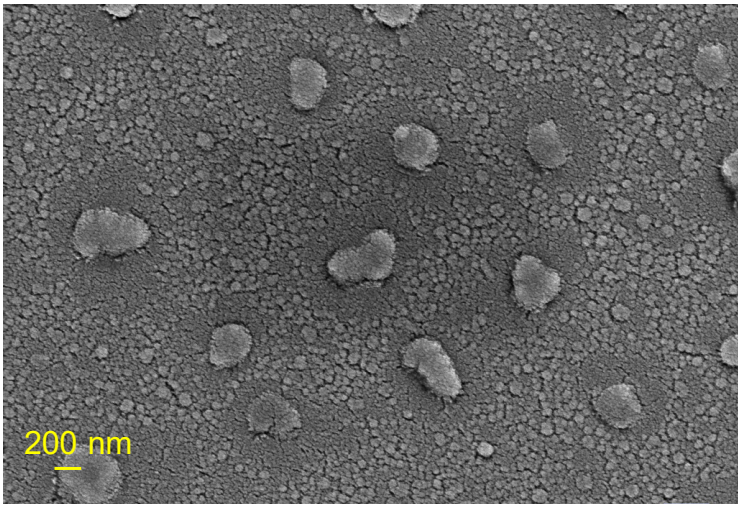

Fig. S2. FE-SEM images of the nanocrystals at 200 nm scale bar.

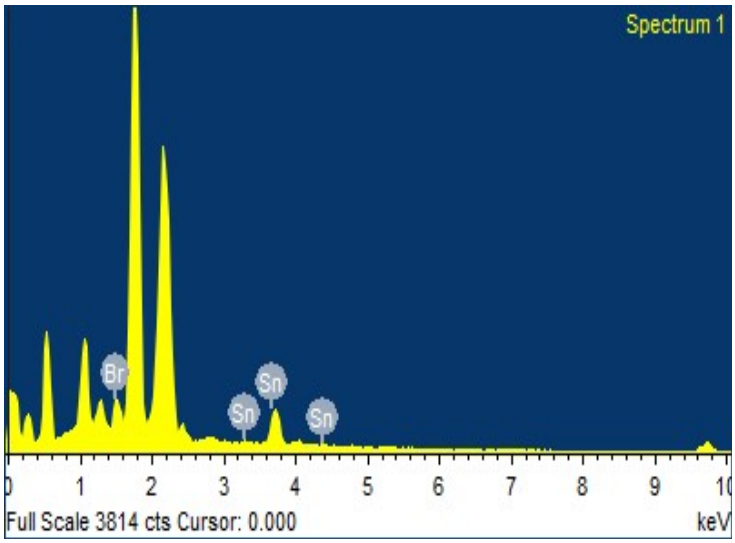

Fig. S3. SEM-EDX spectra of the nanocrystals.

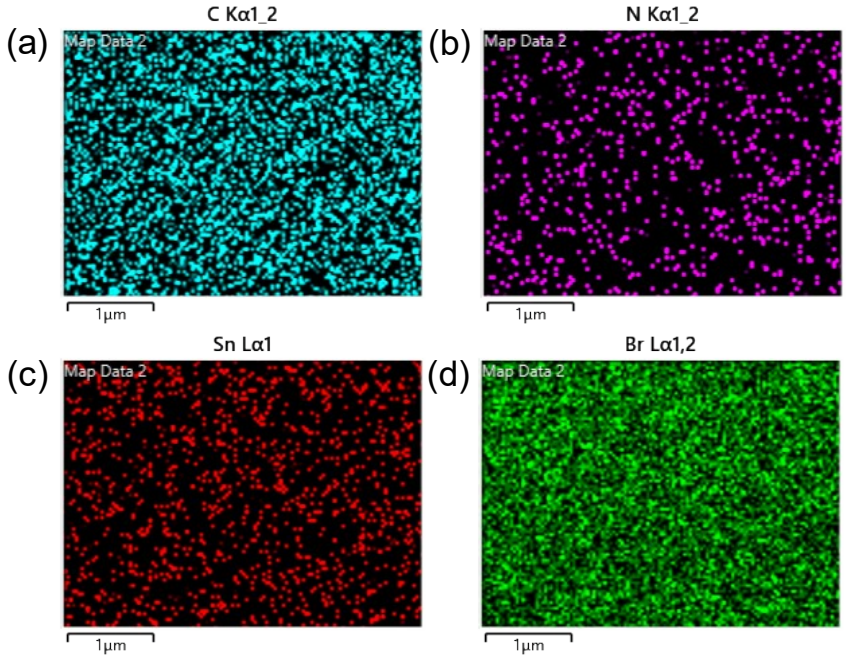

Fig. S4. SEM elemental mapping of the nanocrystals.

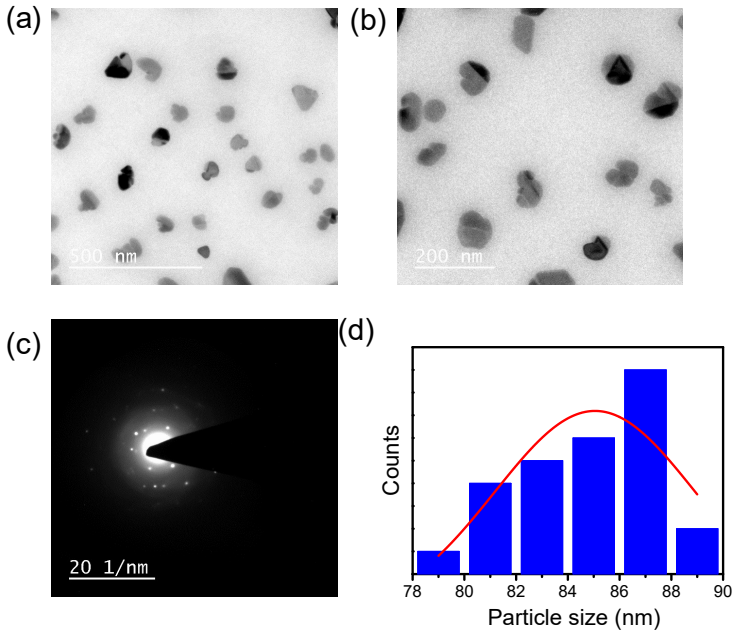

Fig. S5. TEM images of the nanocrystals at (a) 500 nm, (b) 200 nm scale bar; (c) SAED pattern of the nanocrystal, and (d) particle size distribution of the nanocrystal observed from TEM images.

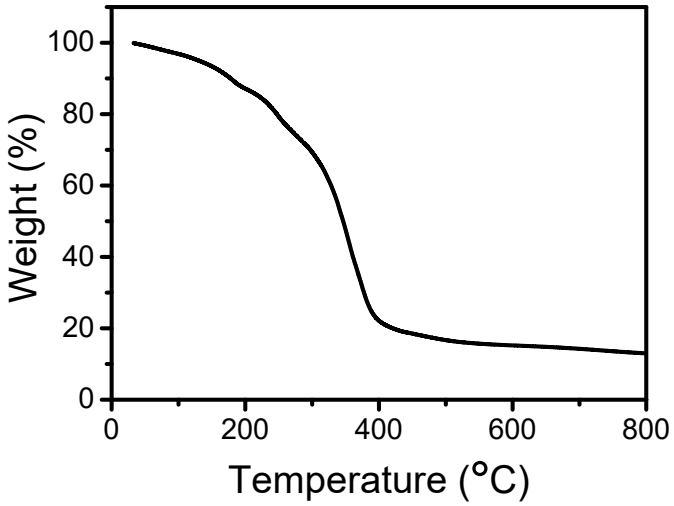

Fig. S6. TGA spectra of the nanocrystals.

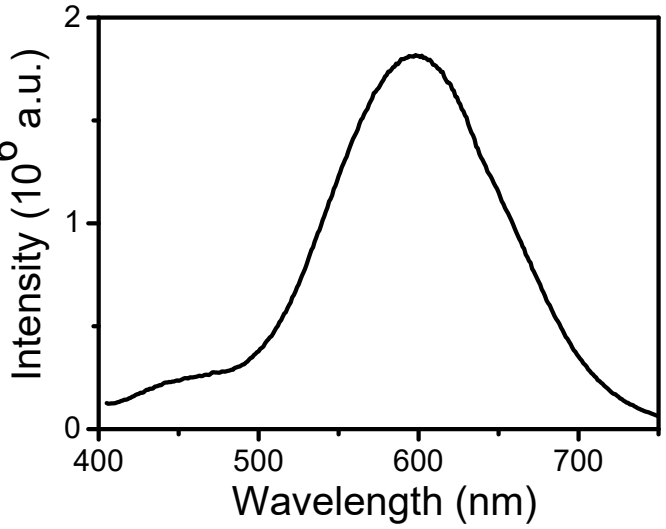

Fig. S7. PL spectra of the material after 3 months.

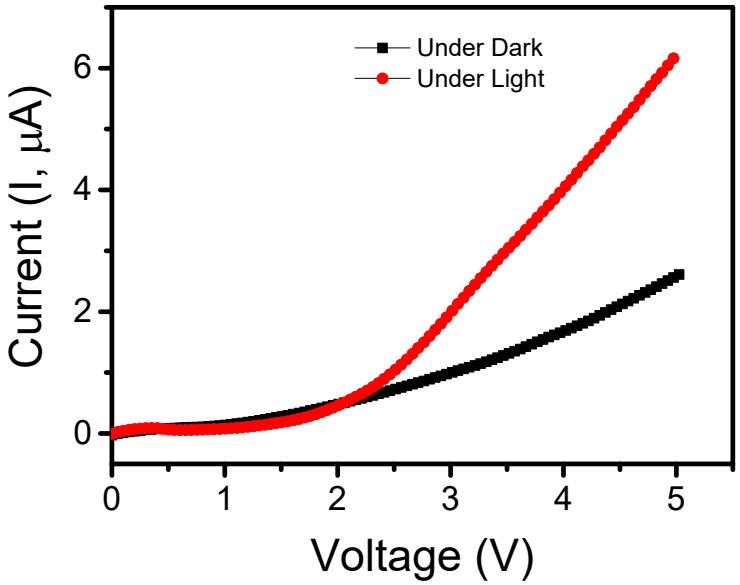

Fig. S8. I-V characteristics of photoreactor under dark and light conditions.