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In situ synthesis of coaxial $CsPbX_3$@polymer (X=Cl, Br, I) fibers with significantly enhanced water stability

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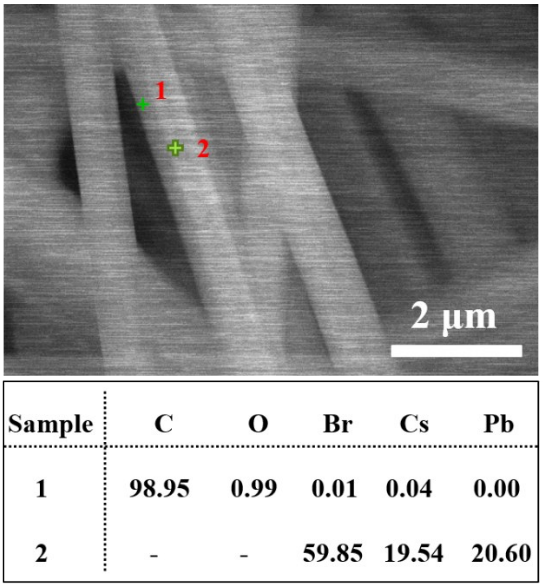
Experimental section

1.1 Materials: Lead(II) chloride ($PbCl_2$, 99%), lead(II) bromide ($PbBr_2$, 99%), lead(II) iodide (PbI_2, 99.9%), cesium chloride (CsCl, 99%), cesium bromide (CsBr, 99%), cesium iodide (CsI, 99.9%), oleylamine (OAm, 80%), oleic acid (OA, 90%), and PS (average MW ≈192000) were purchased from Aldrich. Dimethyl Formamide (DMF, analytical grade) and dimethylsulfoxide (DMSO, analytical grade) were obtained from Beijing Chemical Reagent Co. Ltd. China.

1.2 Preparation of spinning solution for core and shell: The core solution, 0.15 mmol PbX_2 and 0.15 mmol CsX were dissolved in 3 mL solvent of DMF (for $CsPbBr_3$ and $CsPbI_3$), or 1.5 mL DMF+1.5 mL DMSO cosolvent (for $CsPbCl_3$), followed by adding 0.2 mL OA and 0.06 mL OAm as the stabilizers. Then 0.9 g PS (300 mg mL^{-1}) were dissolved in the above precursor solution to form a homogeneously core solution, called as perovskite precursor. The shell solution was prepared by dissolving 0.9 g PS in 3 mL DMF (300 mg mL^{-1}).

1.3 Preparation of $CsPbX_3$@PS coaxial fibers: A two-fluid coaxial electrospinning process was used to fabricate the $CsPbX_3$@PS coaxial fibers. Schematic 1 shows the schematic of the experimental setup. Two syringes were used and each syringe was connected to a separate needle, for which one needle with diameter of 0.25 mm was placed inside the other with diameter of 0.85 mm to form the two-fluid coaxial electrospinning system, with the perovskite precursor solution in the core and the polymer solution in the shell. The two solutions were continuously fed into the coaxial needle by two syringe pumps. The flow rate of both the core and shell solutions was 0.02 mL min^{-1}. The tip of the needle was connected to a high-voltage power supply. The voltage was set at 15 kV and the working distance (the distance between the tip of the needle and collector) was 15 cm for collecting the coaxial fibers. The electrospinning process was operated at 25°C and 50% relative humidity. All of the collected fibers were placed in a conventional oven at 50°C for 2 h before characterization. In order to verify the importance of the core/shell structure, a comparison experiment was performed, typically $CsPbBr_3$@PS fibers which without shell layer were prepared too.

1.4 Characterization: The morphology and microstructure of obtained $CsPbX_3$@PS coaxial fibers were examined by means of X-ray diffraction (XRD, D8 Advance, Bruker, Germany) with *Cu-Kα* radiation with a wavelength of 1.5406 Å, and field emission scanning electron microscopy (FESEM, S-4800, Hitachi, Japan). The UV-visible absorption was recorded on an UV-visible scanning spectrophotometer (U-3900, Hitachi, Japan). The PL spectra were measured using a spectrometer (Fluromax-4P, Horiba Jobin Yvon, France).



Sample	C	O	Br	Cs	Pb
1	98.95	0.99	0.01	0.04	0.00
2	-	-	59.85	19.54	20.60

Figure S1. Energy spectrum analysis of the coaxial fiber.

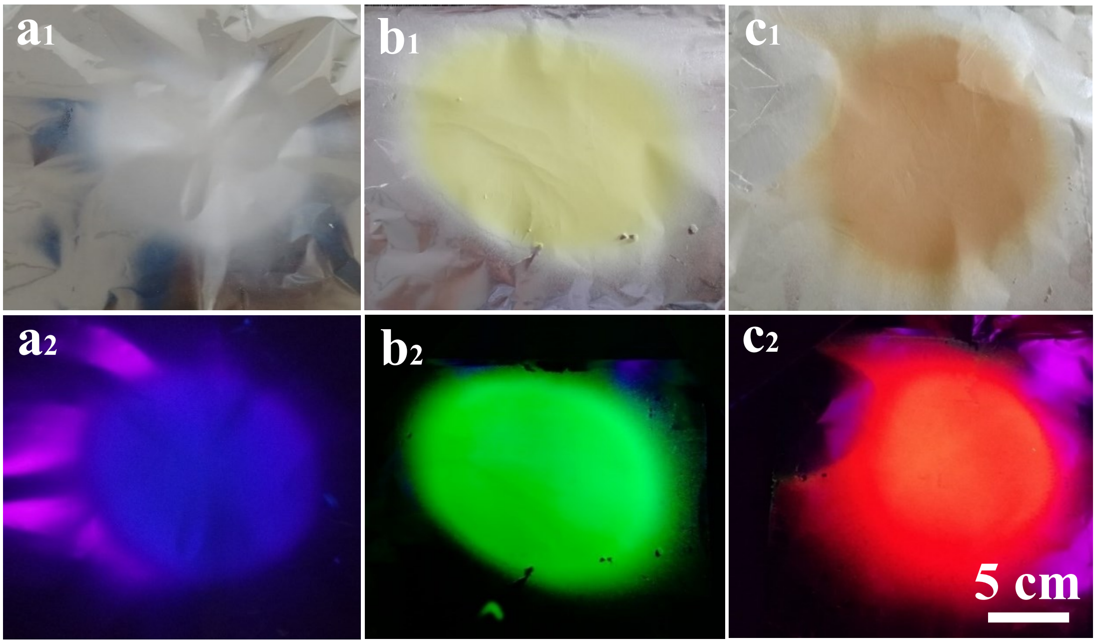


Figure S2. Digital photos of the large scale (a_1) $CsPbCl_3$@PS, (b_1) $CsPbBr_3$@PS, (c_1) $CsPbI_3$@PS coaxial fibers and (a_2-c_2) are their corresponding digital photos under 365 nm UV light.