

Electronic Supplementary Information

**Highly-stable and homogenous perovskite-based luminescent  
films with honeycomb-patterned surfaces**

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## Experimental Section

### Materials

Caesium carbonate ( $\text{Cs}_2\text{CO}_3$ , 99.0%, AR grade), Lead (II) bromide ( $\text{PbBr}_2$ , 99.0%, AR grade), toluene (99.8%), Styrene (99.0%), Methanol (99.5%), oleic acid (OA, 90%), oleylamine (OLA, 80%~90%), MA-POSS ( $\text{C}_{35}\text{H}_{74}\text{O}_{14}\text{Si}_8$ , 99.9%, Fw=943.64, powder), GMA ( $\text{C}_7\text{H}_{10}\text{O}_3$ , 97%, Fw=142.15) were straightway used without purifications. azobisisobutyronitrile (AIBN,  $\text{C}_8\text{H}_{12}\text{N}_4$ , Fw=164.21) was recrystallized in the anhydrous ethanol. Dibutyl ketone were stirred over  $\text{CaH}_2$  for 12 h at room temperature, and then distilled under reduced pressure prior to use.

### Synthesis of $\text{CsPbBr}_3$ NCs

$\text{CsPbBr}_3$  nanocubes were prepared following a modified procedure.<sup>1</sup> styrene (10 mL), oleic acid (OA, 0.3 mL), oleylamine (OLA, 0.3 mL), and  $\text{PbBr}_2$  (69 mg) were loaded into a 25 mL 3-neck flask and dried under vacuum for 30 min at 80 °C. After complete dissolution was achieved, the temperature was raised to 140 °C under  $\text{N}_2$ , followed by quick injection of the cesium oleate solution ( $\text{Cs}_2\text{CO}_3/\text{OA}$ , 0.4 mL, 0.125 M in styrene). Five seconds later, the reaction mixture was cooled to room temperature by an ice/water bath.

### Preparation of PGMA-co-PMAPOSS

The polymer of PGMA-co-PMAPOSS was prepared by free radical polymerization using a molar ratio of GMA:MAPOSS=1:0.4 and AIBN (1 wt%) at 70°C in dibutyl ketone for 8 h. After the redundant dibutyl ketone was moved by rotary evaporation, the final reacting solution was precipitated in excess methanol to obtain the white polymer powder.

### Fabrication of PGMA-co-PMAPOSS@ $\text{CsPbBr}_3$ porous films by BF method

The patterned surfaces were fabricated via a dynamic breath-figure (BF) method. Typically, PGMA-co-PMAPOSS (5mL, 4-10 wt% in toluene) and  $\text{CsPbBr}_3$  NCs (1 mL, 0.5 mg/mL in styrene) was mixed in 10 mL transparent glass bottle and 0.5 ml solution was drop-casted onto a flat glass sheet. Then, the coated glasses were dried under a moist atmosphere (relative humidity: 50-85%) at room temperature. Finally, the

patterned films were obtained. Films with diverse honeycomb-patterned surfaces can be easily regulated by changing the air velocity, humidity, temperature, polymer concentration and type, or solvent. Firstly, porous films with two different substrates were prepared by casting 0.5 ml PMMA and PGPO polymer solutions (toluene, 6%) on glass plates under 85% humidity. Subsequently, using the BF method to form the PGPO@NCs porous films on glass substrates with polymer concentrations of 4, 6, and 10 wt% under 85% humidity for investigating the effect of polymer concentration on porous films. In addition, We prepared the films formed from PGMA-co-PMAPOSS solution (0.5Ml, 6 wt%) under different humidities (ambient humidity, 65–85% and above 85%) by BF method.

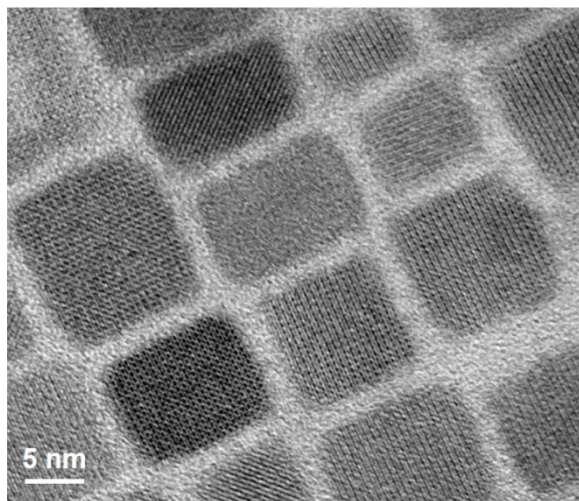
### **Stability Tests**

The PGMA-co-PMAPOSS@CsPbBr<sub>3</sub> porous films were exposed to UV light irradiation (365 nm, 0.5 W·cm<sup>-2</sup>) at room temperature, before being subjected to further characterization.

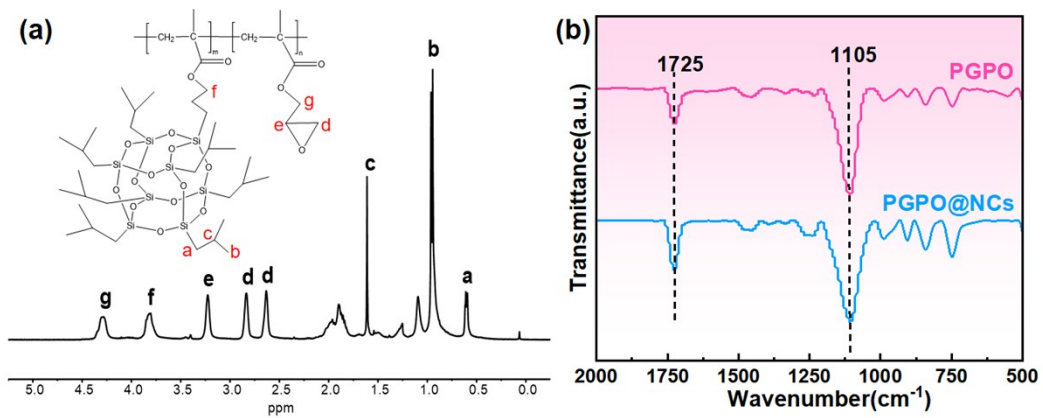
### **Characterization**

SEM images were acquired on a Gemini SEM 500 Field-Emission Scanning Electron Microscope, with an EDS mapping system for elemental x-ray analysis. TEM and high-resolution TEM (HR-TEM) data of the synthesized CNCs were acquired on a JEOL JEM-2100 transmission electron microscope at an accelerating voltage of 200 kV. UV–vis absorption spectra were acquired on a Lambda 950 spectrometer (PerkinElmer, US). FTIR measurement was performed on a Tensor27 type Fourier infrared spectrometer at the detection range of 500–4000 cm<sup>-1</sup> (Bruker, Germany). Proton nuclear magnetic resonance (<sup>1</sup>H-NMR) measurement was performed on a Bruker AV-500 (400 Hz) spectrometer using CDCl<sub>3</sub> as the solvent and tetramethylsilane (TMS) as the internal reference. The PL emission spectra, decay lifetime and absolute quantum yield of CNCs were measured by an FLS 980 series steady/transient fluorescence spectrometer (Edinburgh Instruments, UK). X-ray diffraction (XRD) patterns of all samples were recorded on a D8-Advance spectrometer

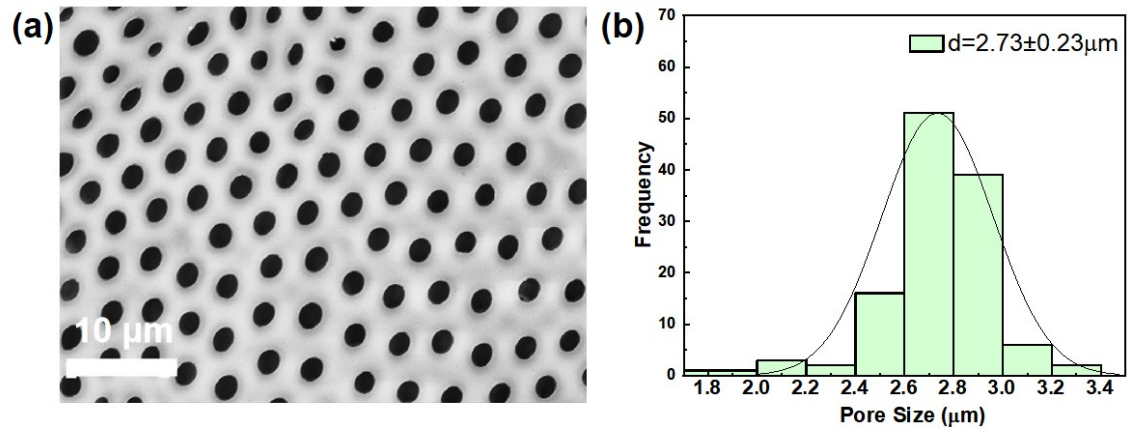
(Bruker, Germany) with Cu K $\alpha$  radiation ( $\lambda=1.54 \text{ \AA}$ ) in the range from  $10^\circ$  to  $60^\circ$ . X-ray photoelectron spectroscopy (XPS) was measured on an EscaLab Xi + spectrometer (Thermo Fisher Scientific, US) to analyze the elemental composition and chemical state of the samples. The static contact angles (SCAs) for evaluating the hydrophobicity of the porous film were recorded using an DSA100S contact angle goniometer (Kruss, Germany). The morphology of the film surfaces was evaluated by confocal laser scanning microscope (Mannheim, Germany).



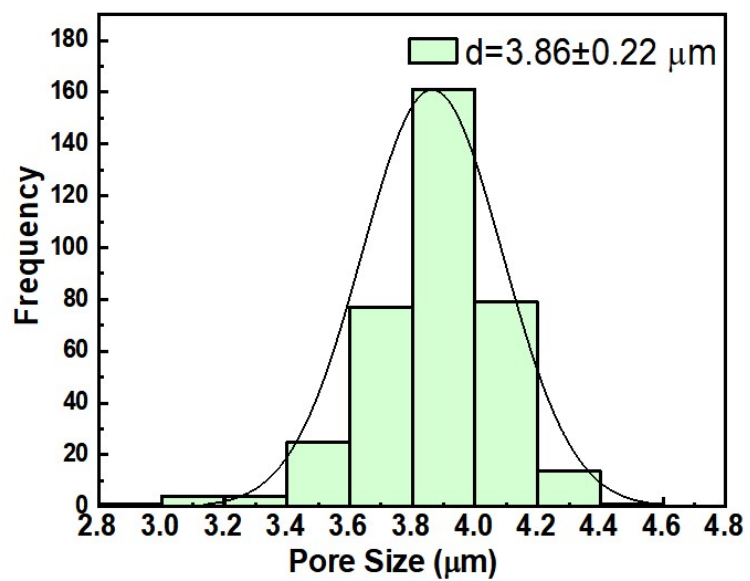
**Fig. S1** TEM image of the CsPbBr<sub>3</sub> NCs



**Fig. S2** (a) <sup>1</sup>H-NMR spectrum of the PGMA-*co*-PMAPOSS, (b) FTIR spectra of the polymer (PGMA-*co*-PMAPOSS) and patterned film of PGMA-*co*-PMAPOSS@CsPbBr<sub>3</sub>.

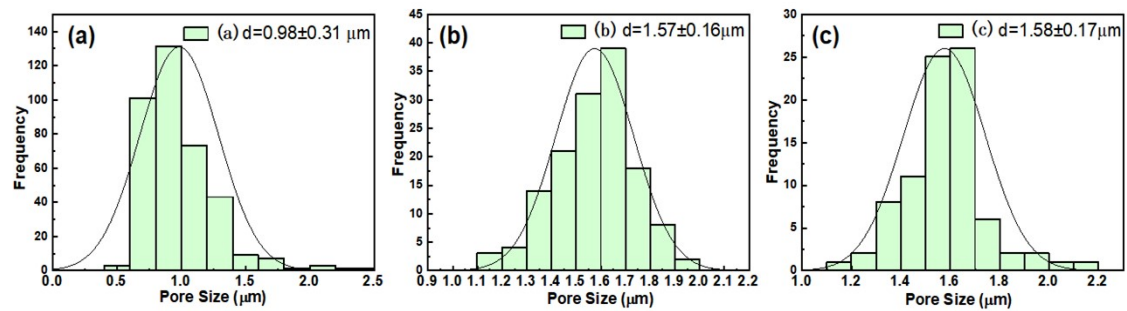


**Fig. S3** (a) SEM image of the PMMA film under 85% humidity (toluene, 6%). (b) The pore size distribution of the PMMA film.

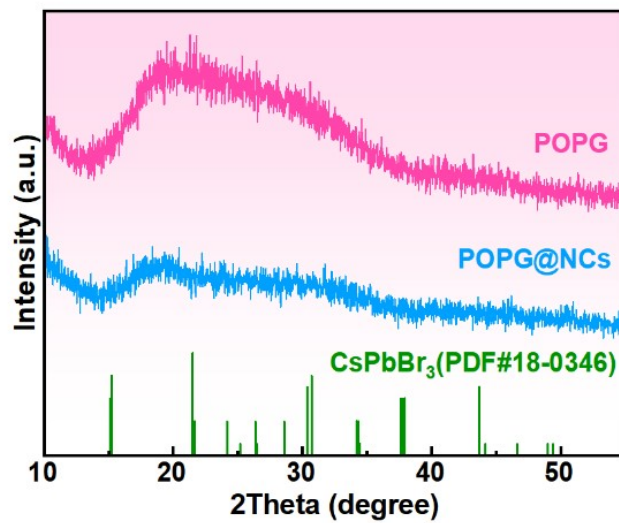


**Fig. S4** The pore size distribution of the PGMA-*co*-PMAPOSS film

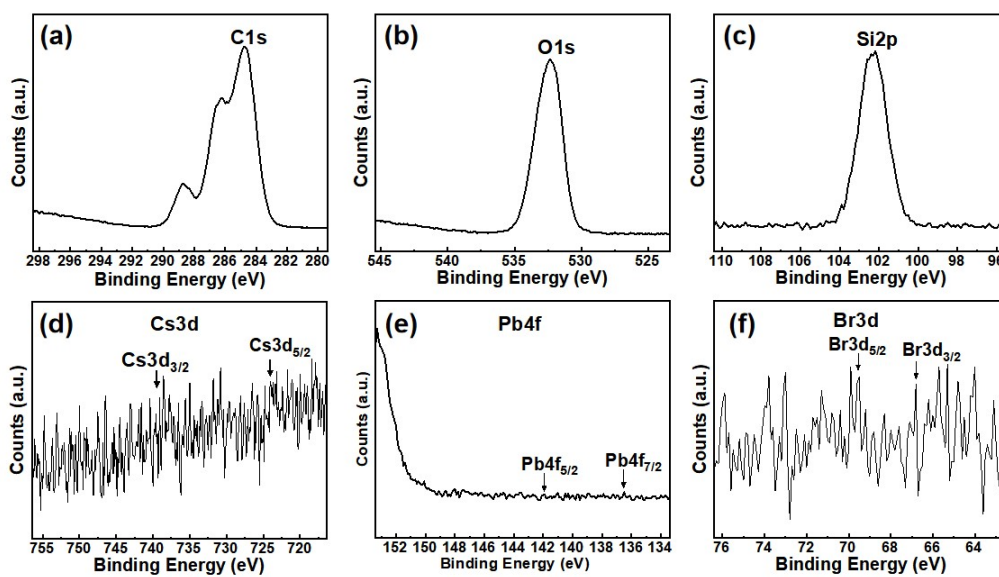




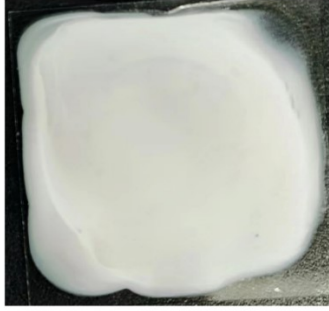
**Fig. S5** The pore size distributions of the patterned films with PGMA-PMAPOSS polymer concentrations of (a) 4%, (b) 6%, and (c) 10 wt% under 85% humidity, respectively.



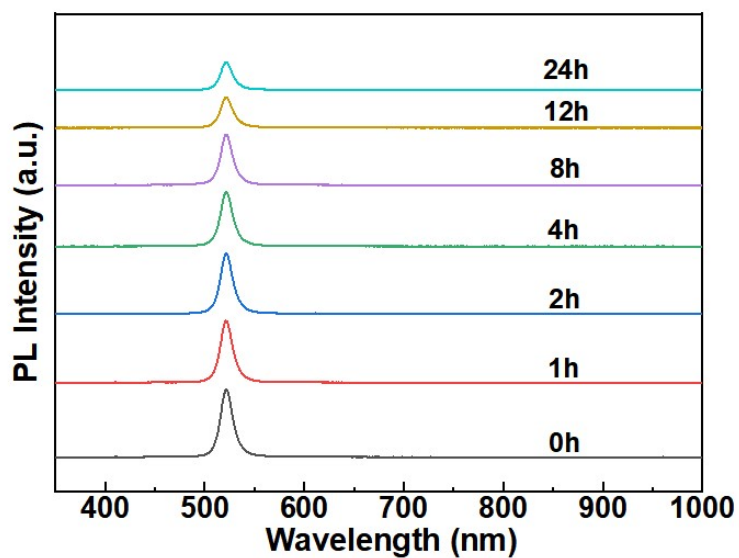
**Fig. S6** XRD patterns of PGMA-PMAPOSS, PGMA-*co*-PMAPOSS@CsPbBr<sub>3</sub> and CsPbBr<sub>3</sub> NCs



**Fig. S7** High-resolution XPS analysis of C1s (a), O1s (b), Si2p (c), Cs3d (d), Pb4f (e) and Br3d (f) of PGMA-co-PMAPOSS@CsPbBr<sub>3</sub> film



**Fig. S8** The optical photograph of the patterned PGMA-*co*-PMAPOSS@CsPbBr<sub>3</sub> film.



**Fig. S9** PL spectra of the patterned films upon exposing to UV light (365 nm) over time.

I. Protesescu, L.; Yakunin, S.; Bodnarchuk, M. I.; Krieg, F.; Caputo, R.; Hendon, C. H.; Yang, R. X.; Walsh, A.; Kovalenko, M. V. Nanocrystals of Cesium Lead Halide Perovskites (CsPbX<sub>3</sub>, X = Cl, Br, and I): Novel Optoelectronic Materials Showing Bright Emission with Wide Color Gamut. *Nano Lett.* **2015**, *15*, 3692-3696.