Electronic Supplementary Material (ESI) for Nanoscale.

Supplementary Information

Acid-mediated phase transition synthesis of stable nanocrystals for high-power LED backlights

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In this work, the precursor concentration of Cs_4PbBr_6 NCs plays a crucial role in the occurrence of the water-induced process. The introduction of water into the system with high precursor concentration hardly induced the phase transition process. As the dilution degree increased, the fluorescence emitted by the induced product under UV light changed from sky blue to green, which corresponded to the red shift of the PL spectrum (Figure S1a, b) as well as the narrowing of the FWHM of the PL spectrum Table S1). At the same time, the absorption peaks corresponding to the induced products at higher precursor concentrations were weaker and enhanced with dilution degree. When it was further diluted to 6.88 mg/ml, it was found that the PL decreased, and the peak position blue shifted with wider FWHM. The appearance of the absorption peak at 310 nm indicated the existence of Cs_4PbBr_6 NCs. This can be attributed to the low monomer concentration in the solution which limited the further growth of the NCs leading to the existence of mixed phases. Using the Tauc plot method to process the absorption spectra[1-3], the band gaps of the induced products of different dilution concentrations were obtained (Figure S2). As for high concentration or precursor without dilution, the band gap was around 3.8 eV, which was consistent with the band gap of Cs_4PbBr_6 NCs reported in the literature.[4] With the increase of dilution, the calculated band gap was close to 2.8 eV, which is consistent with $CsPbBr_3$ NCs. Through experiments, a more suitable precursor concentration 10 mg/ml was determined, and subsequent experiments were carried out under this condition.

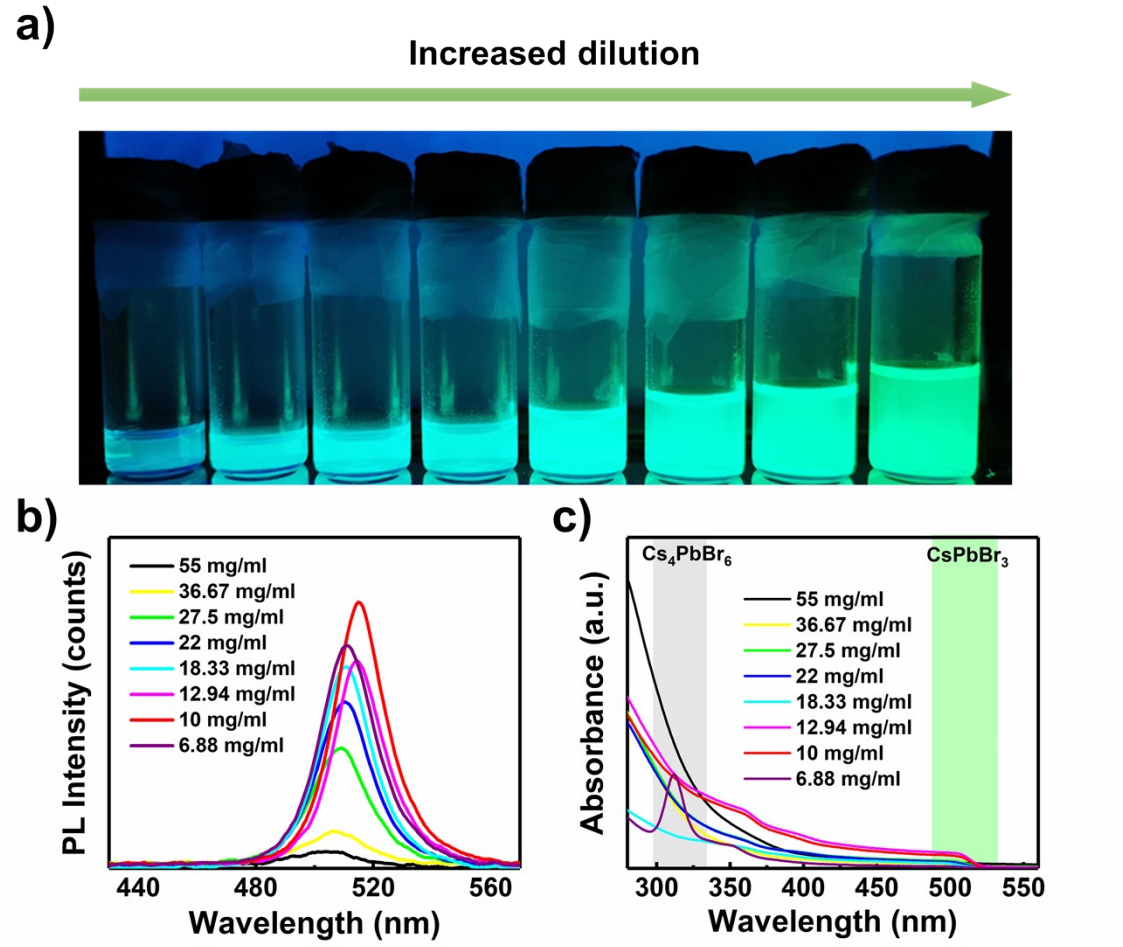

Figure S1. a) The image of products at different dilutions placed under UV light (365 nm). b) The PL spectra and c) absorption spectra of products at different dilution concentrations.

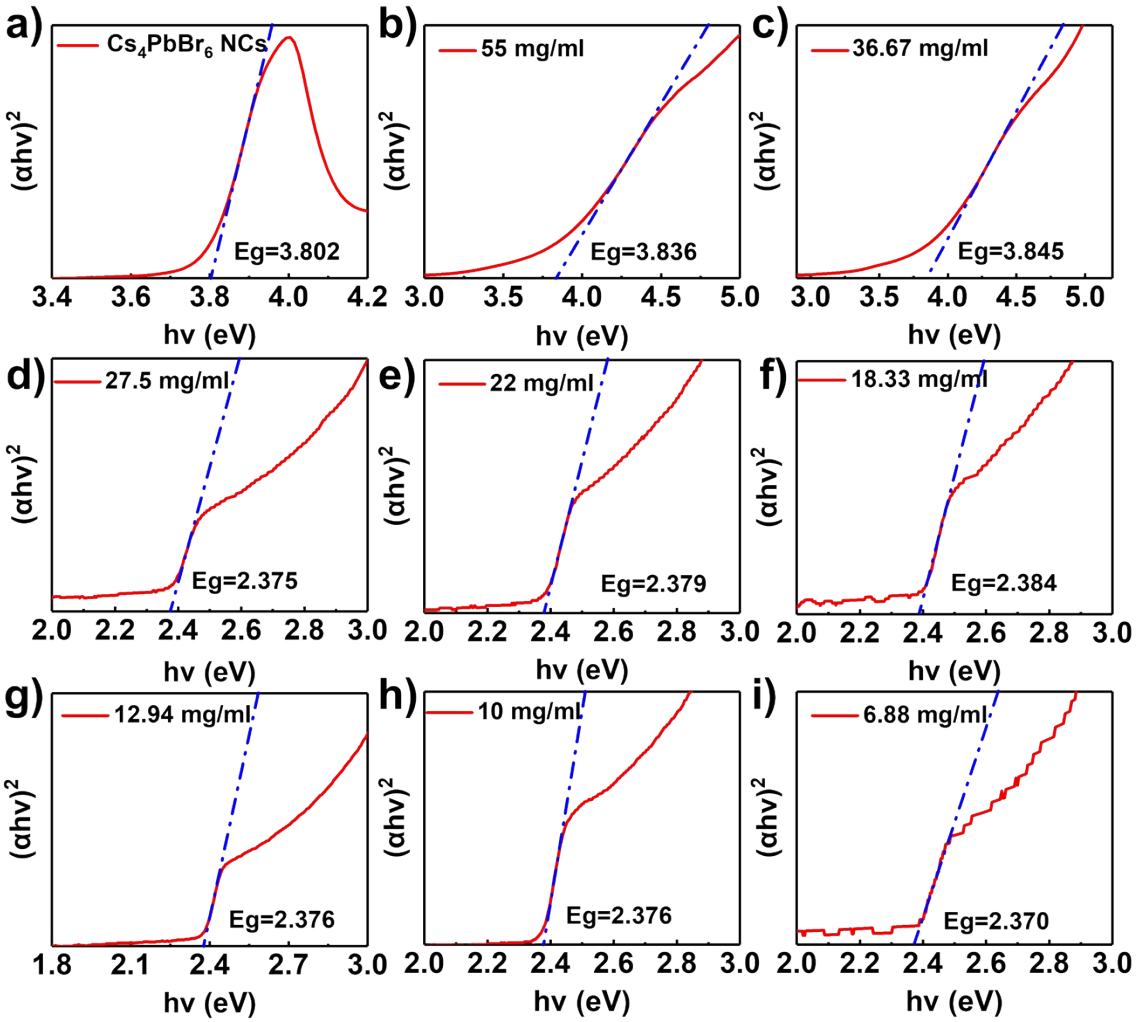

Figure S2. Calculation of band gaps at different dilutions using the Tauc plot method.

Table S1. The impact of the dilution degree of the precursor on the half-peak width and peak position of the fluorescence spectrum.

Concentration (mg/ml)	PL Peak (nm)	FWHM (nm)
55	504.79	30.92604
36.67	506.35	26.69579
27.5	509.47	23.42387
22	510.24	22.11278
18.33	511.02	21.36878
12.94	514.14	20.55895
10	514.92	20.8541
6.88	511.02	22.53928

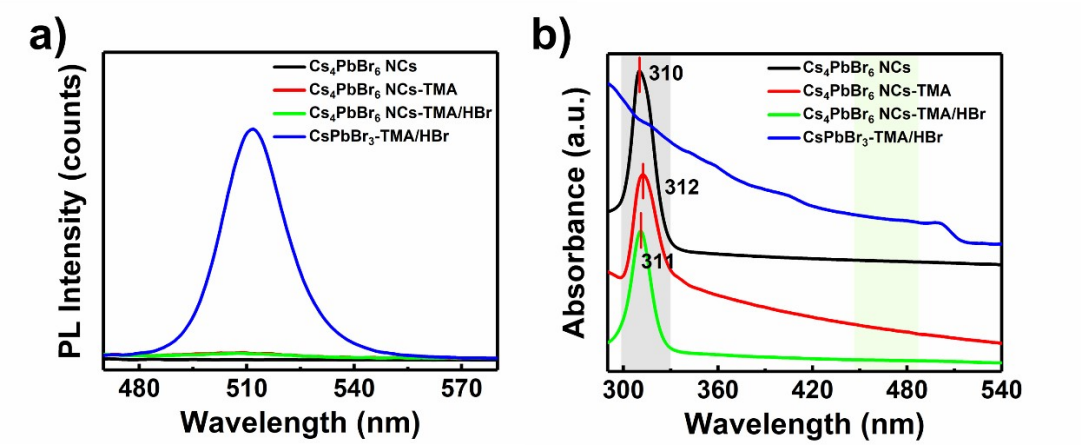

Figure S3. The a) PL and b) absorption spectra of Cs_4PbBr_6 NCs precursor、Cs_4PbBr_6-TMA、Cs_4PbBr_6-TMA/HBr and $CsPbBr_3$-TMA/HBr.

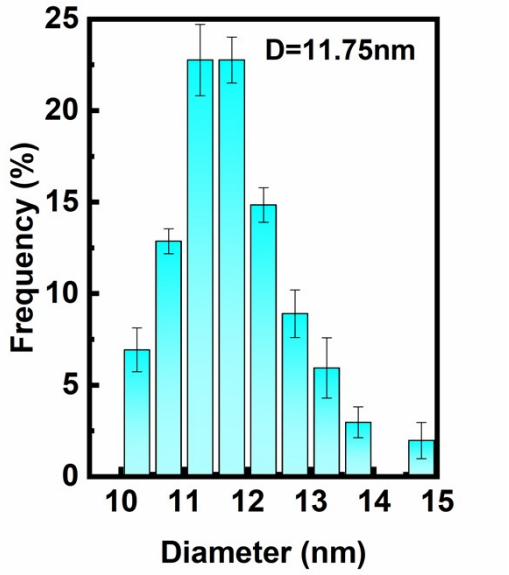

Figure S4. Particle size distribution of Cs_4PbBr_6 NCs precursor.

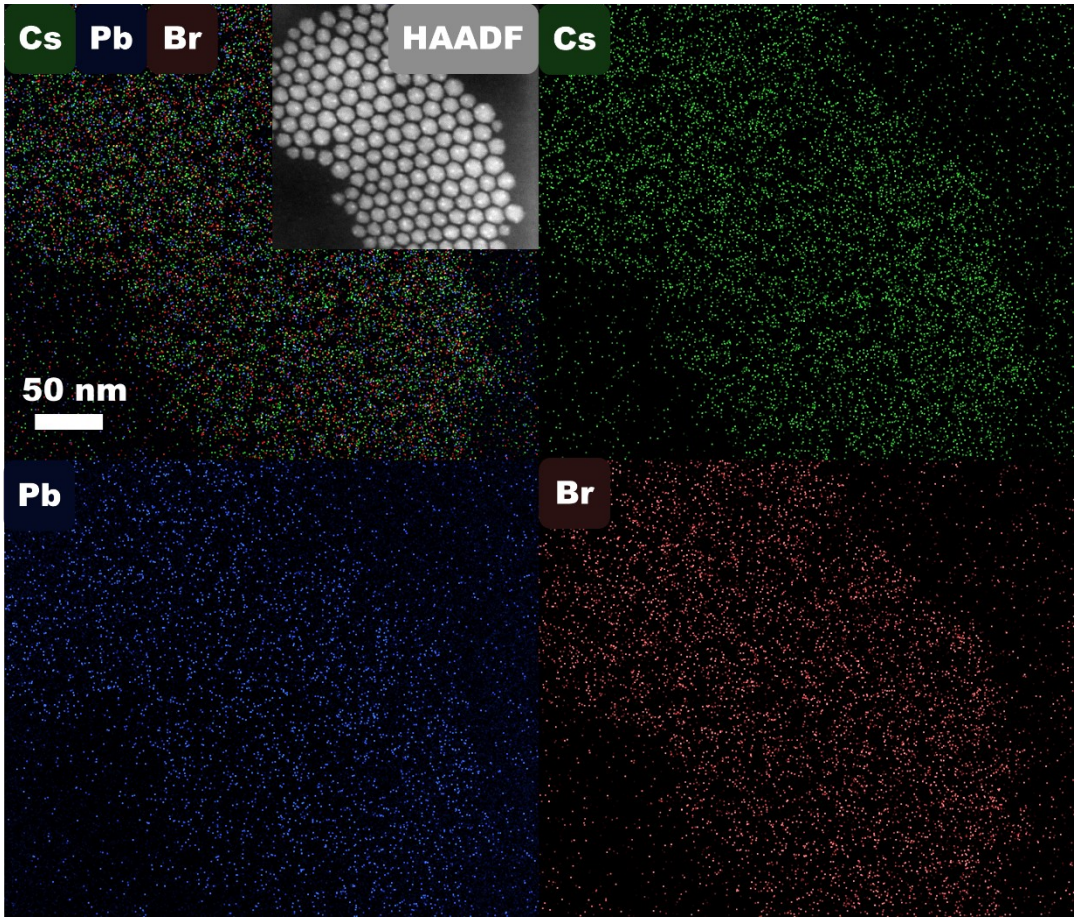

Figure S5. HAADF-STEM image of Cs_4PbBr_6 NCs.

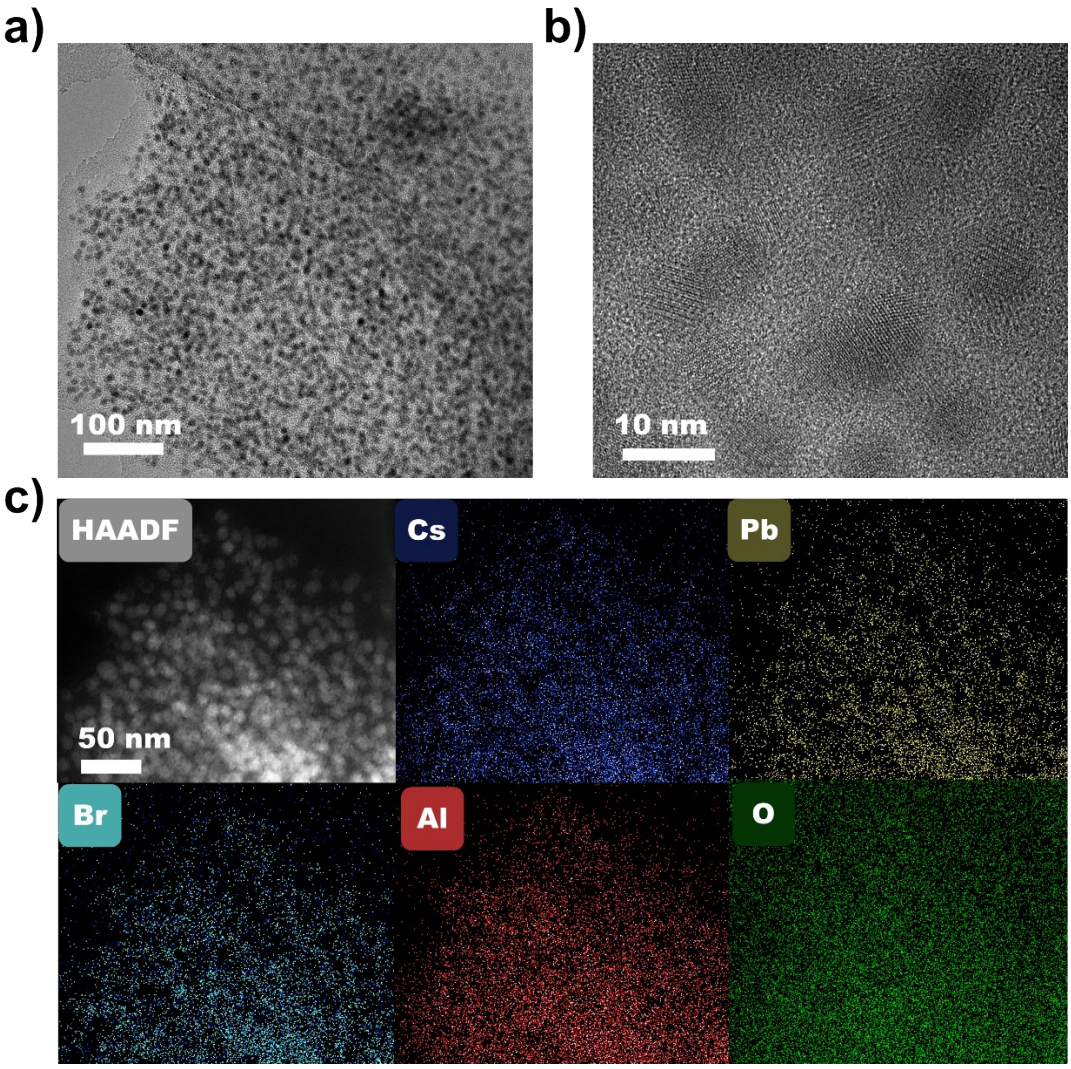

Figure S6. The a) TEM、b) HRTEM and c) HAADF-STEM images of Cs_4PbBr_6-TMA.

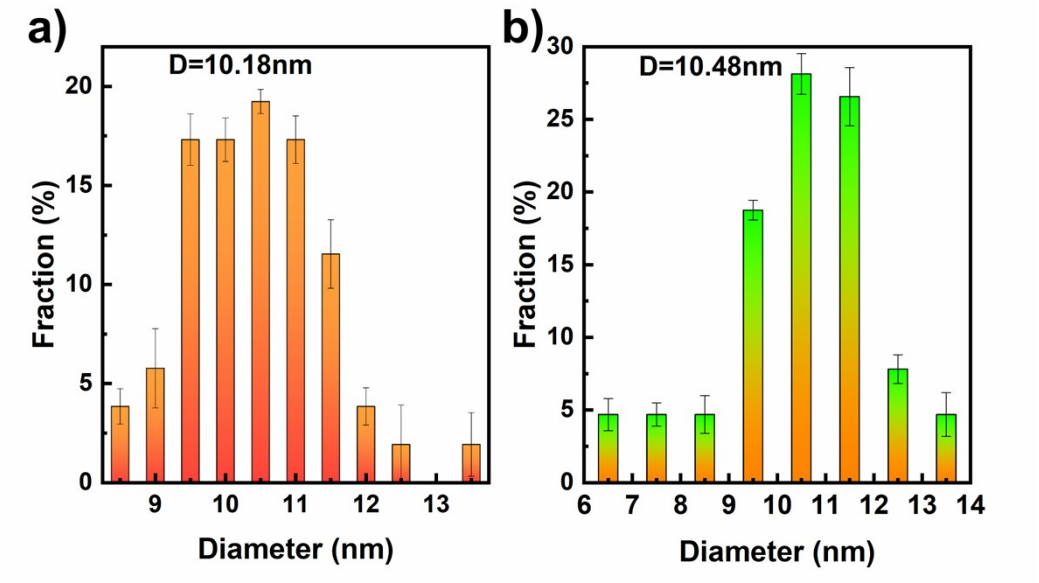

Figure S7. Particle size distributions of a) acid-free assisted water-triggered transformation product $CsPbBr_3$ NCs and b) acids co-assisted transformation product $CsPbBr_3$-TMA/HBr.

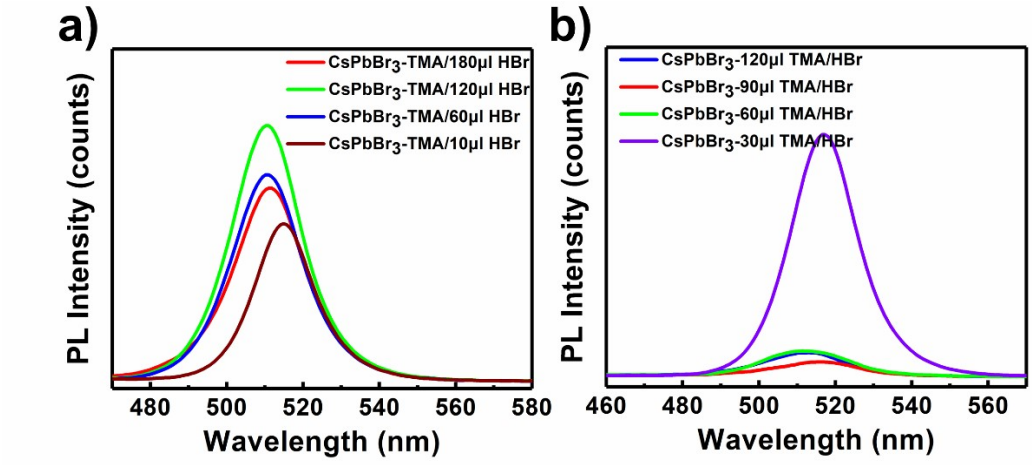

Figure S8. Effect of different content of hydrobromic acid and TMA treatments on PL spectrum of acids co-assisted transformation product $CsPbBr_3$-TMA/HBr.

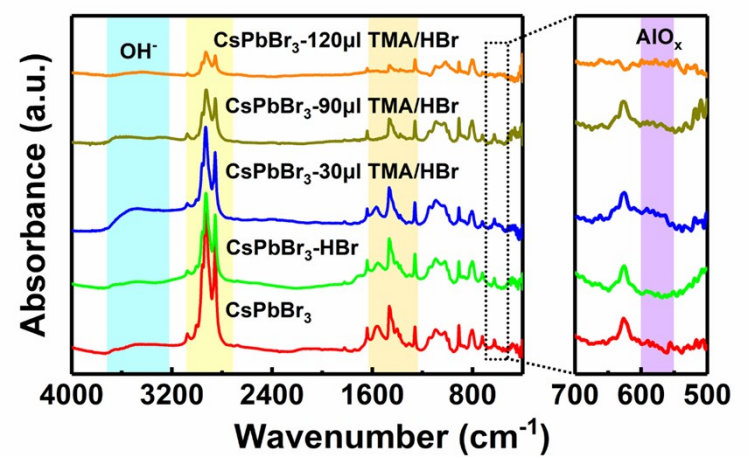

Figure S9. FTIR of samples treated with different TMA content and acid-free assisted water-triggered transformation product $CsPbBr_3$ NCs.

Table S2. The calculated area ratios of C-H bond based on the FTIR results.

sample	area of C-H bond	ratio (%)
$CsPbBr_3$	27.96715	100
$CsPbBr_3$-HBr	18.72214	66.94
$CsPbBr_3$-30μl TMA/HBr	18.2277	65.18
$CsPbBr_3$-90μl TMA/HBr	10.95813	39.18
$CsPbBr_3$-120μl TMA/HBr	8.29392	29.66

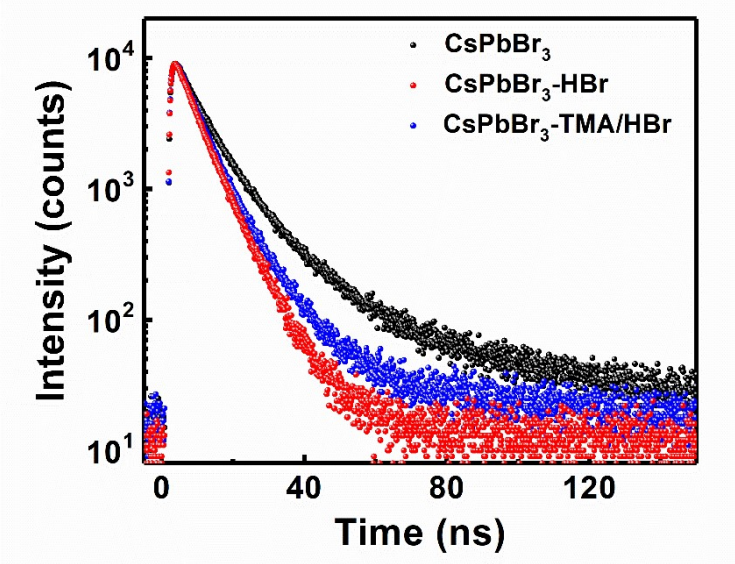

Figure S10. Time-resolved PL decay curves of $CsPbBr_3$、$CsPbBr_3$-HBr and $CsPbBr_3$-TMA/HBr.

Table S3. The calculated fluorescence lifetime from time-resolved PL decay curves.

Sample	τ_1(ns)	A1(%)	τ_2(ns)	A2(%)	τ_{avg}
$CsPbBr_3$	7.18	47.22	40.66	52.78	36.09
$CsPbBr_3$-HBr	6.37	100	-	-	6.37
$CsPbBr_3$-TMA/HBr	6.90	100	-	-	6.90

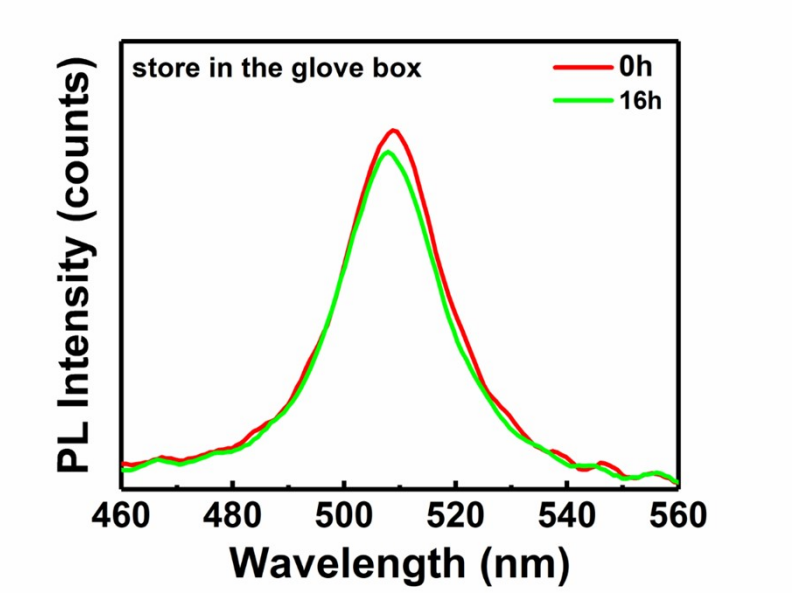

Figure S11. The PL change of $CsPbBr_3$ storage in the glove box.

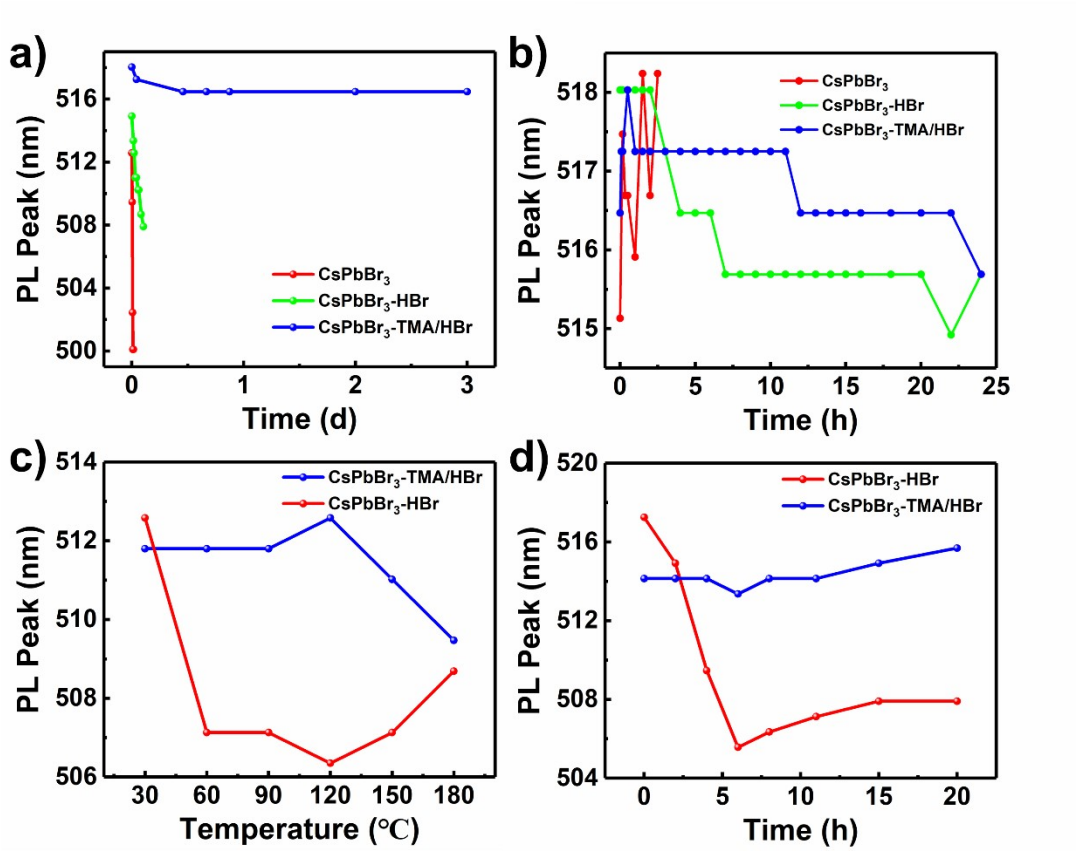

Figure S12. a) PL peak changes of air storage and b) water stability test of $CsPbBr_3$、$CsPbBr_3$-HBr and $CsPbBr_3$-TMA/HBr. c) PL peak changes of heat and d) light stability test of $CsPbBr_3$、$CsPbBr_3$-HBr and $CsPbBr_3$-TMA/HBr.

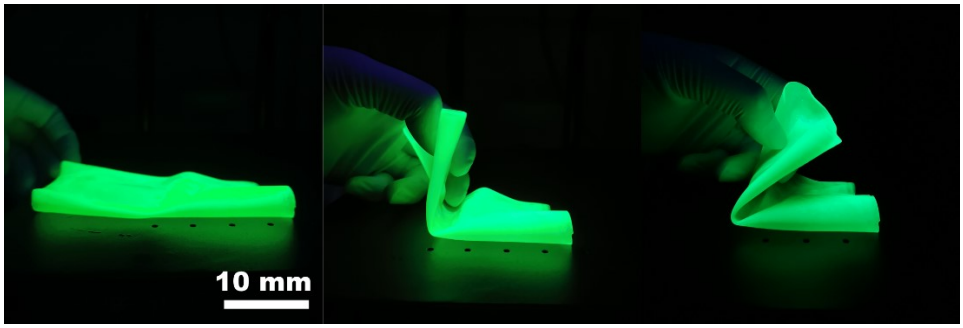

Figure S13. The quantum dot film bended.

Figure S14. The quantum dot film on the pattern of Huazhong University of Science and Technology.

Table S4. Comparison of the stability of samples of this work and other perovskite NCs samples.

Samples	air	water	Reference
$CsPbBr_3$ NCs	33 days (90%PL, 25 °C, 75%RH)	24 h (62%PL)	this work
$CsPbBr_3$@AlNO	30 days (95%PLQY, 25 °C, 20%RH)	24 h (115%PL)	[5]
SP-$CsPbBr_3$ NCs	60 days (~77%PLQY)	-	[6]
$ZnBr_2$-$CsPbBr_3$	6 days (60%PL)	-	[7]
$CsPbBr_3$ NCs	28 days (75%PLQY)	-	[8]
$CsPbBr_3$ NCs	1 month (90%PLQY)	-	[9]
$PbBr_2$-$CsPbBr_3$	10 days (90%PLQY)	-	[10]
$CsPbBr_3$ NCs	14 days (~70%PL)	3 h (75%PL)	[11]
$CsPbBr_3$ NCs	70 days (21%PLQY)	-	[12]
$CsPbBr_3$ NCs/AlO_x	45 days (100%PL)	1 h	[13]
OPA-$CsPbBr_3$ NCs	3 days (90%PL)	-	[14]
$CsPbBr_3$–TDPA QDs	-	300 minutes (80%PL)	[15]
$CsPbBr_3$/AlO_x	-	120 minutes (60%PL)	[16]
PS-capped $MAPbBr_3$/SiO_2 NCs	14 days (80%PL)	-	[17]
$CsPbBr_3$@Cs_4PbBr_6 NCs	-	24 h (0%PL)	[18]
$CsPbBr_3$ NCs	6 days	-	[19]

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