Electronic Supplementary Information

Highly Luminescent and Stable Quasi-2D Perovskite Quantum Dots by Introducing Large Organic Cations

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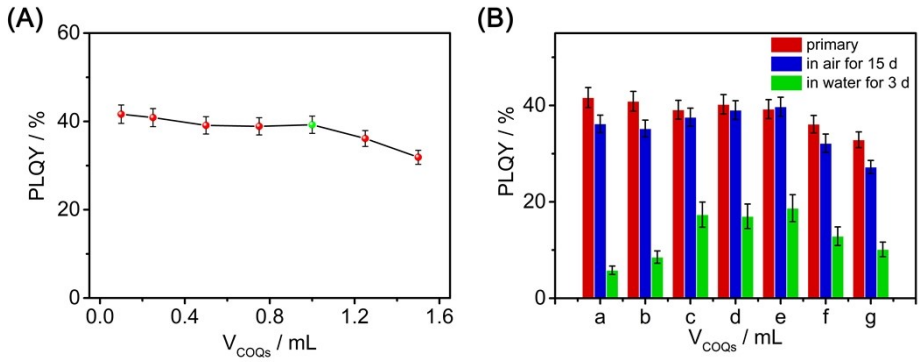

Figure S1 Optimization of the volume of CQDs-doping. (A) PLQY characterizations and (B) Air and water stability of CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$ with different CQDs-doping volumes (a~g: 0.1, 0.25, 0.5, 0.75, 1, 1.25 and 1.5 mL).

As shown in Figure S1(A), when the volume of CQDs ranges from 0.1 to 1 mL, the photoluminescence quantum yield (PLQY) of CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$ has not changed significantly. Then increases the volume of CQDs continuously, the PLQY of perovskite decreases slightly. Therefore, we consider that the volume of CQDs should not exceed 1 mL. Simultaneously, in order to further determine the optimal volume of CQDs, we have characterized the environmental stability of perovskite with different CQDs volumes. As shown in Figure S1(B), the perovskite which doped 1 mL CQDs (column e) shows the best air and water stability. Therefore, the optimal volume of CQDs is 1 mL at last.

Table S1 The detailed FL lifetimes of the perovskites.

Materials	τ_1/ns	f_1/%	τ_2/ns	f_2/%	τ_{ave}/ns
$MAPbBr_3$	6.60	82	44.77	18	13.46
MA:BA = 1:0.5	9.91	81	50.98	19	17.86
MA:BA = 1:1	13.22	85	69.11	15	21.62
MA:BA = 1:2	14.92	87	91.27	13	24.58
MA:BA = 1:4	1.97	93	22.39	7	3.40
BA_2PbBr_4	2.43	87	8.71	13	3.22

The τ_1 and τ_2 relate to the decay time constants of a fast and slow component respectively, while *f* corresponds to the proportion of each component, the average lifetime of τ_{ave} is given by the formula:

$$\tau_{ave} = f_1\tau_1 + f_2\tau_2$$

The fast τ_1 is mainly due to a non-radiative recombination causes by defects, whereas the slow τ_2 can be attributed to the radiative recombination.

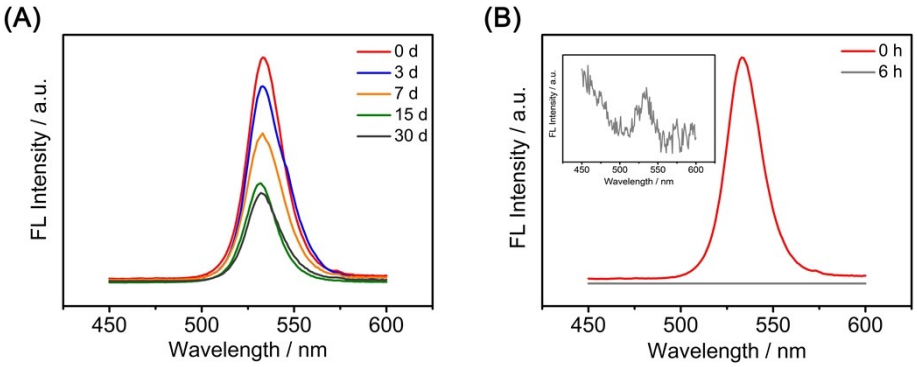

Figure S2 Stability of $MAPbBr_3$ in (A) air and (B) water. The illustration is the enlarged FL characterization of $MAPbBr_3$ in water for 6 h.

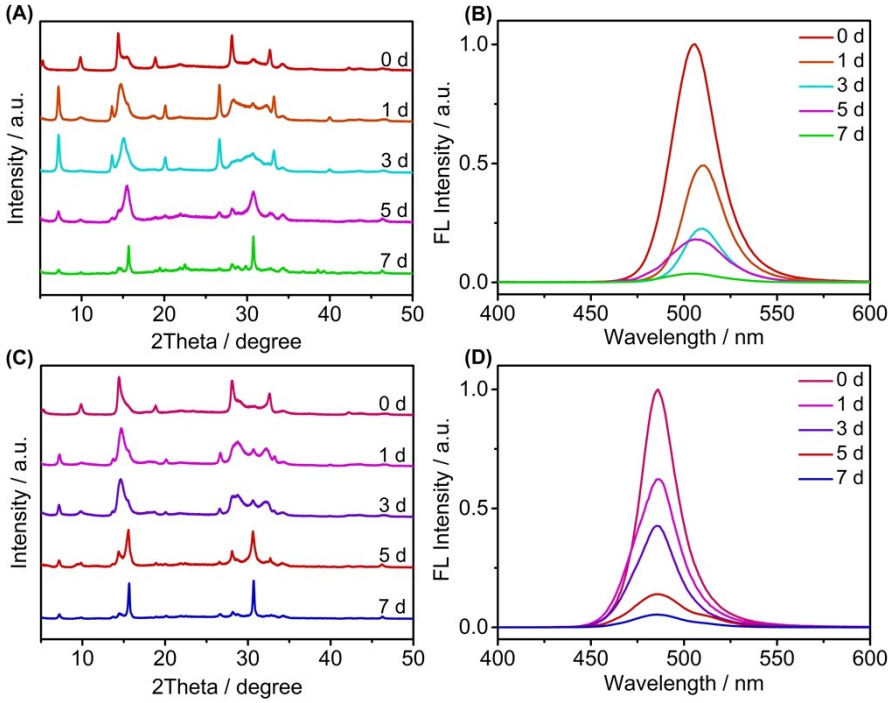

Figure S3 Stability of quasi-2D perovskites in water. (A) XRD and (B) FL spectra of $(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1), (C) XRD and (D) FL spectra of CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) stores in water for 7 days.

Table S2 A summary of different quasi-2D PQDs.

Quasi-2D Material	PLQY	Stability	Application	Ref.
$BA_2DMA_{1.6}Cs_2Pb_3Br_{11.6}$	52.8%	null	PeLED	[1]
$PEA_2DMA_{1.2}Cs_2Pb_3Br_{11.2}$	63.2%			
PEA inserted $CsPbBr_3$	10.0% (EQE)	null	PeLED	[2]
Polymer capped PEA-$MAPbBr_3$	65%	50 d in air and water	color-conversion films	[3]
BA doped $FAPbBr_3$	16%	null	PeLED	[4]
CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$	39.3%	more than 30 d in air and 3 d in water	FL assay	*This work*

References:

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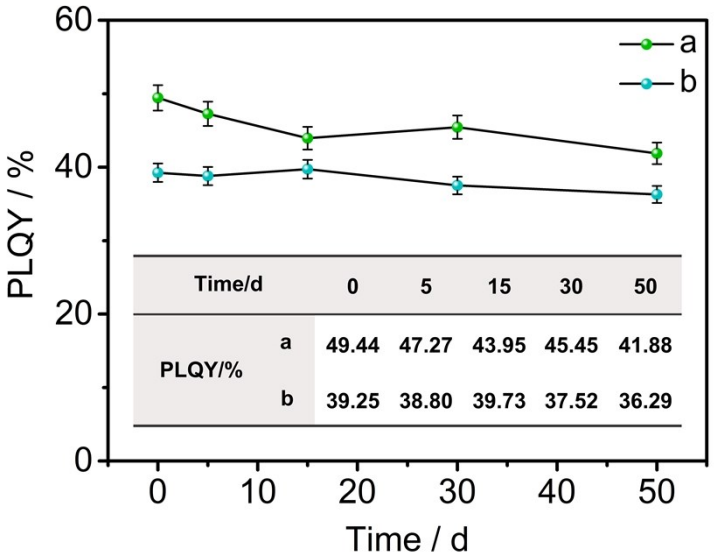
[4] Alehdaghi, H.; Kanwat, A.; Zirak, M.; Moyen, E.; Choi, W. C.; Jang, J. Quasi-2D organic cation-doped formamidinium lead bromide ($FAPbBr_3$) perovskite light-emitting diodes by long alkyl chain. *Org. Electron.* **2020**, *79*, 105626.



Time/d		0	5	15	30	50
PLQY/%	a	49.44	47.27	43.95	45.45	41.88
	b	39.25	38.80	39.73	37.52	36.29

Figure S4 PLQY characterizations of (a) $(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) and (b) CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) in air for 50 days.

Under the optimized conditions in Figure S5, the detecting process of H_2O_2 is described as follows. Firstly, 213 μL of the prepared CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) is dispersed in 2 mL of toluene to form a long-term stable colloidal solution, the concentration of Br^- in this solution is about 4 mM. Then, 10 μL of H_2O_2 with different concentrations were added in 100 μL ethyl acetate with 80 mM I^-, respectively. After 5 min redox reaction, the above mixture is added into 2 mL CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) solution. Here, the concentration of H_2O_2 in redox reaction determines the amount of residual I^-, and the remaining I^- changes the emission wavelength of CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) via halide exchange. In combination with the above processes, the semi-quantitative colorimetric detection of H_2O_2 can be realized by monitoring the change of perovskite fluorescence wavelength.

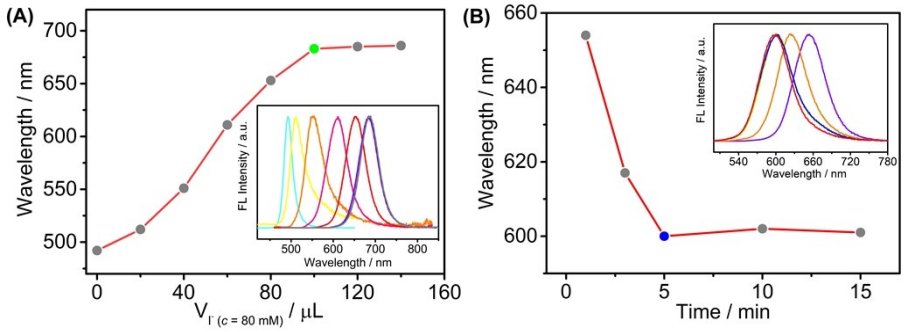


Figure S5 (A) Optimization of the volume of I^- (80 mM) in 2 mL CQDs- $(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) solution; (B) Optimization of reaction time between I^- (100 μL, 80 mM) and H_2O_2 (10 μL, 1 mM) in 2 mL CQDs-$(BA)_2(MA)_{x-1}Pb_xBr_{3x+1}$(1:1) solution.