

Supporting Information

Alkali-metal-activated perovskite quantum dots glasses for high-efficiency and long-term stable luminescent solar concentrators

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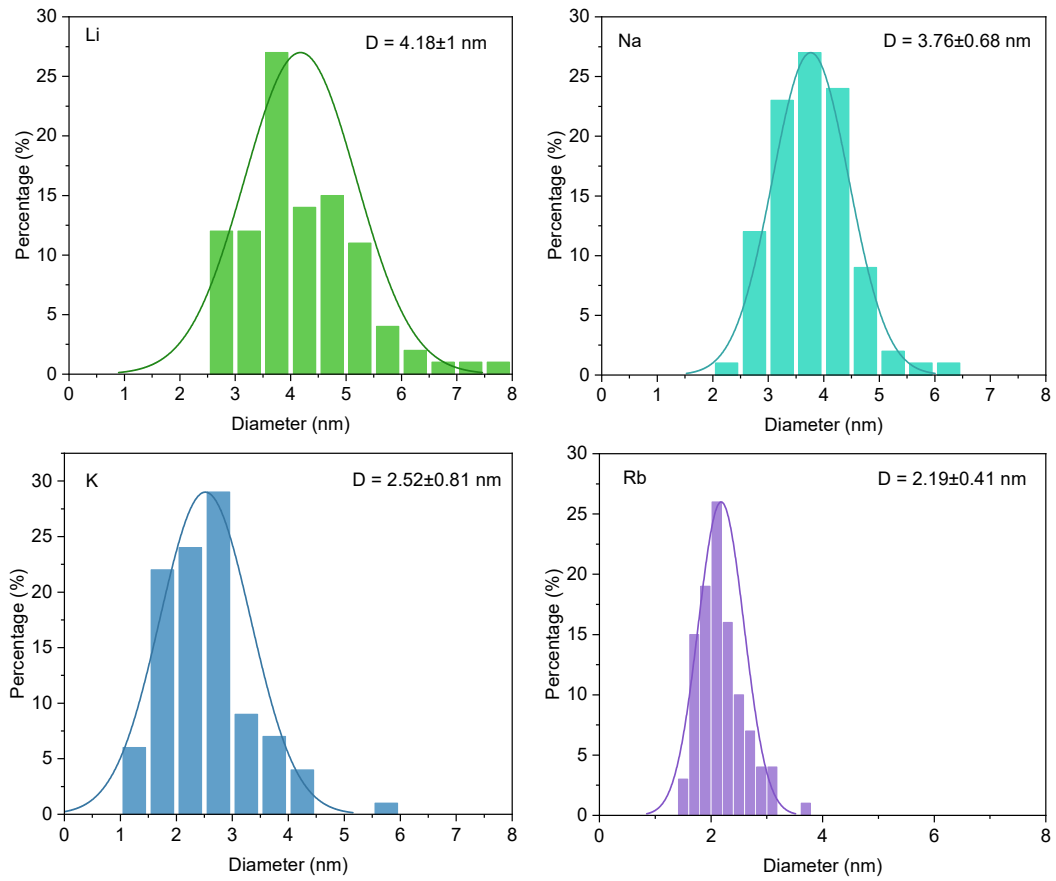


Figure S1. The particle size distribution of PQDs in glass samples.

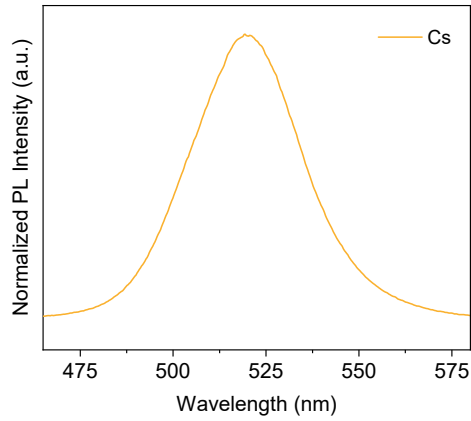


Figure S2. PL spectrum of Cs-activated CsPbBr₃ QDs glass.

A Cs-activated CsPbBr₃ QDs glass sample was prepared using the composition 93B₂O₃-93SiO₂-60ZnO-5CaF₂-12Cs₂CO₃-5PbBr₂-15CsBr under the same conditions. It shows an orange appearance with a PLQY of 12% and a PL peak at 520 nm. Compared with the Cs-activated sample, the Li- and Na-activated CsPbBr₃ QDs glass samples exhibit no shift in their PL peaks, both remaining at approximately 520 nm. This demonstrates that Li⁺ and Na⁺ do not incorporate into the crystal lattice of CsPbBr₃ QDs.

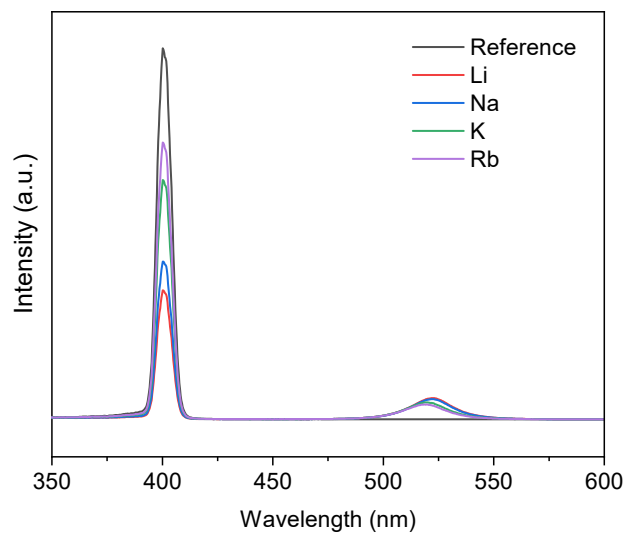


Figure S3. The PLQY spectra of Li-, Na-, K-, and Rb-activated PQDs glasses.

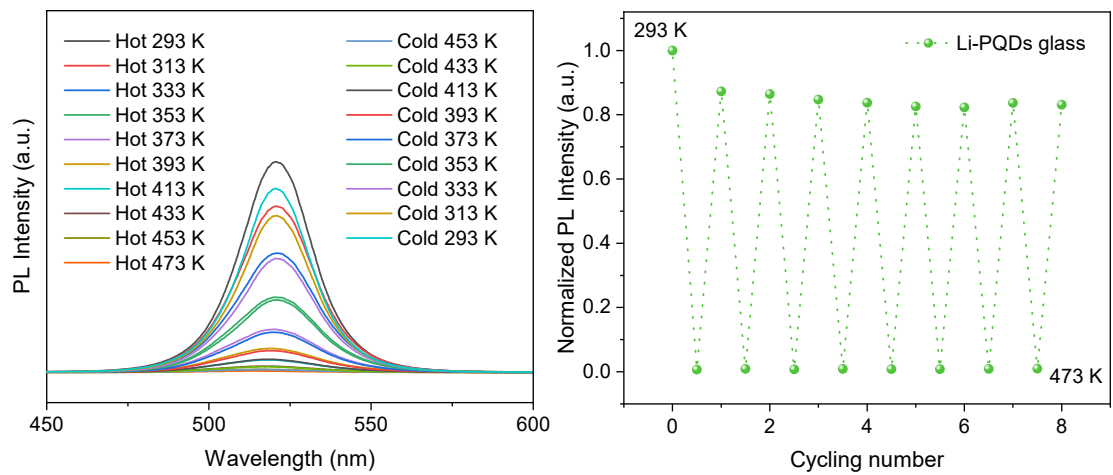


Figure S4. The PL intensity of Li-activated CsPbBr₃ QDs glass under cyclic thermal stability test.

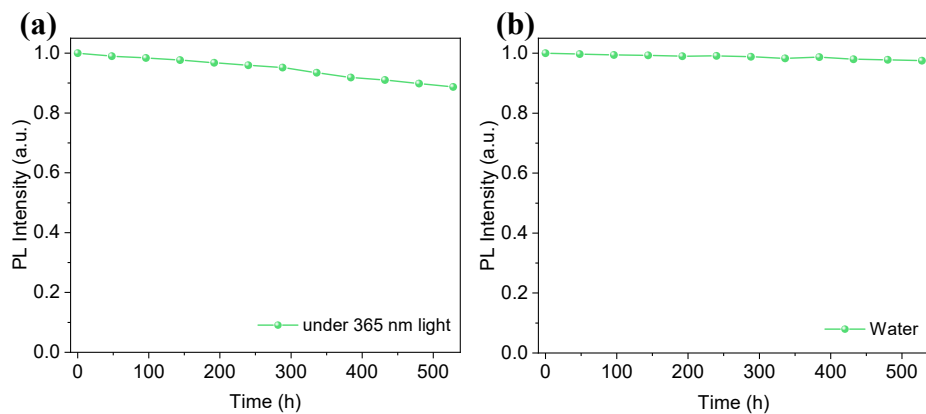


Figure S5. PL intensity of Li-activated CsPbBr₃ QDs glass under a 365 nm LED light (a) and in water (b) for 500 hours.

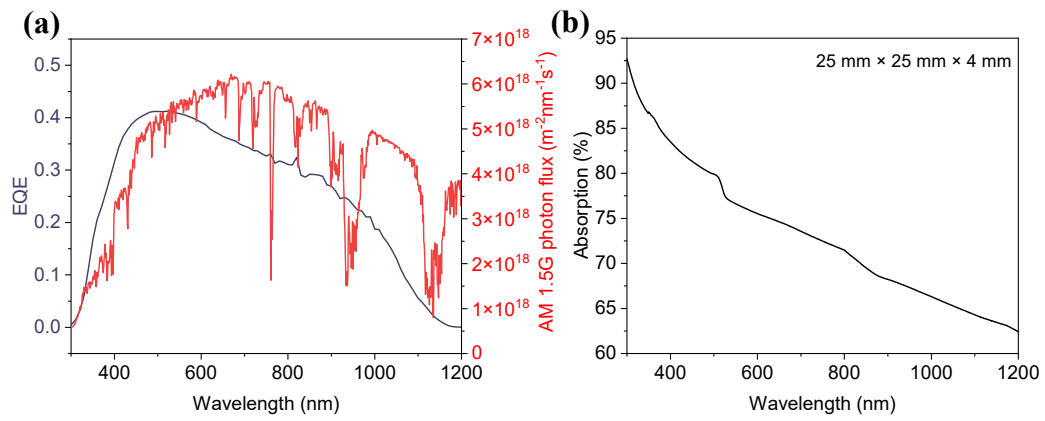


Figure S6. (a) The EQE spectrum (blue line) of the Si-cell and the solar spectrum (red line). (b) The UV-vis absorption spectrum of the LSC (25 mm \times 25 mm \times 4 mm) and 73% of the total solar photon flux is absorbed by the LSC device.

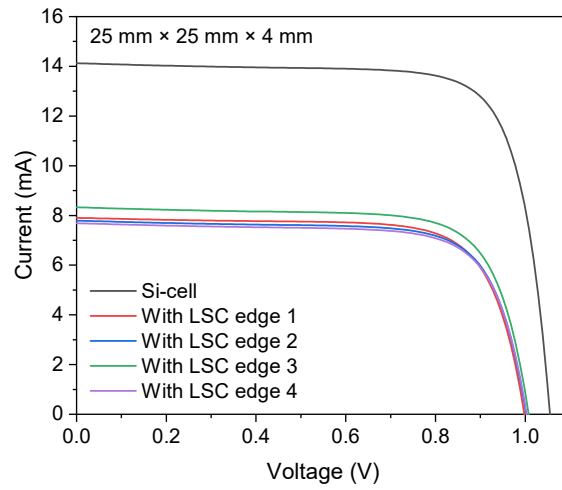


Figure S7. I-V curves of the Si-cell without and with coupling to the four edges of PQDs glass LSC device (25 mm × 25 mm × 4 mm).

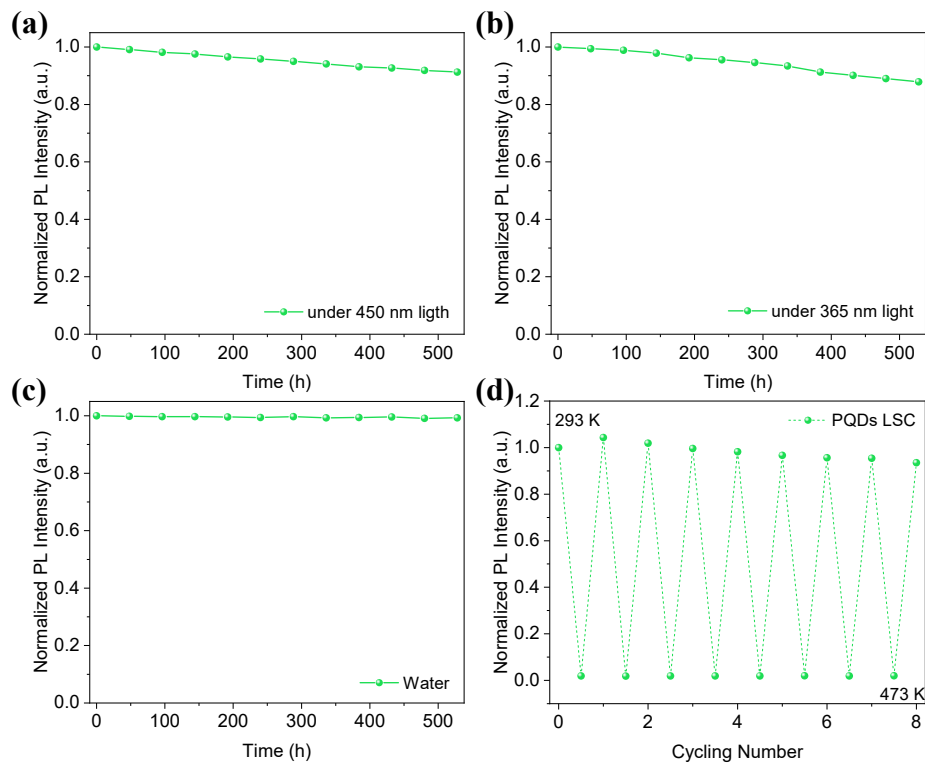


Figure S8. Stability characterization of PQDs LSC: PL intensity evolution of PQDs LSC (a) under 450 nm illumination for 500 h, (b) under 365 nm illumination for 500 h, (c) after 500 h immersion in water, and (d) over 8 thermal cycles between 293 K and 473 K.

Table S1. PL lifetime of CsPbBr₃ PQDs glass with different alkali metal ions addition.

Addition	τ_1 (ns)	A_1	τ_2 (ns)	A_2	τ_3 (ns)	A_3	τ_{avg} (ns)	R^2
LiBr	5.82	0.55	24.42	0.37	137.38	0.09	78.05	0.99
NaBr	4.78	0.51	20.34	0.38	113.16	0.10	68.55	0.99
KBr	4.35	0.45	19.24	0.41	105.55	0.10	63.11	0.99
RbBr	0.79	0.11	7.45	0.72	35.59	0.16	21.62	0.99

Table S2. XPS Cs 3d, Pb 4f and Br 3d spectrum binding energy of all samples.

Addition	Peak fitting	Binding energy (eV)
control	Cs 3d _{5/2}	726.96
	Cs 3d _{3/2}	740.92
	Pb 4f _{7/2}	143.19
	Pb 4f _{5/2}	147.46
	Br 3d _{5/2}	69.99
	Br 3d _{3/2}	72.16
LiBr	Cs 3d _{5/2}	726.36
	Cs 3d _{3/2}	740.34
	Pb 4f _{7/2}	143.28
	Pb 4f _{5/2}	147.53
	Br 3d _{5/2}	70.20
	Br 3d _{3/2}	72.61
NaBr	Cs 3d _{5/2}	726.56
	Cs 3d _{3/2}	740.53
	Pb 4f _{7/2}	143.34
	Pb 4f _{5/2}	147.43
	Br 3d _{5/2}	70.15
	Br 3d _{3/2}	72.42
KBr	Cs 3d _{5/2}	726.17
	Cs 3d _{3/2}	740.17

Table S2. XPS Cs 3d, Pb 4f and Br 3d spectrum binding energy of all samples.

Addition	Peak fitting	Binding energy (eV)
KBr	Pb 4f _{7/2}	143.45
	Pb 4f _{5/2}	147.60
	Br 3d _{5/2}	70.34
	Br 3d _{3/2}	72.72
RbBr	Cs 3d _{5/2}	726.96
	Cs 3d _{3/2}	740.93
	Pb 4f _{7/2}	143.78
	Pb 4f _{5/2}	147.97
	Br 3d _{5/2}	70.61
	Br 3d _{3/2}	73.02

Table S3. The normalized composition of the as-prepared glass.

Component	B ₂ O ₃	SiO ₂	ZnO	CaF ₂	Cs ₂ CO ₃	PbBr ₂	XBr	Tota
								1
mol%	32.86	32.86	21.20	1.77	4.24	1.77	5.30	100

Table S4. Performance of the Si-cell without and with coupling to the four edges of the PQDs glass LSC device (25 mm × 25 mm × 4 mm).

	V _{OC} (V)	J _{SC} (mA cm ⁻²)	FF (%)	η (%)	η _{opt} (%)	PCE (%)
		2)				
Si-cell	1.05	14.13	0.77	11.52	/	/
With LSC edge 1	1.00	7.91	0.74	5.85	35.83	0.92
With LSC edge 2	1.00	7.79	0.74	5.80	35.34	0.92
With LSC edge 3	1.00	8.32	0.74	6.22	37.74	0.98
With LSC edge 4	1.00	7.68	0.74	5.72	34.84	0.90

Supplementary Note 1–Determination of internal and external optical quantum efficiencies (η_{int} and η_{ext}) of a coupled LSC/Si-cell system.

The η_{int} of the perovskite LSC device is defined as the ratio of the number of photons emitted from the edge of the LSC to the number of photons absorbed by the LSC. It can be calculated using the following formula:

$$\eta_{\text{int}} = \frac{J_{\text{LSC}} \times Q_{\text{Total}}}{G \times J_{\text{SC}} \times Q_{\text{PL}} \times \eta_{\text{abs}}}$$

where G is the geometric gain factor, defined as $G = A_{\text{surface}}/A_{\text{edge}}$. J_{SC} and J_{LSC} represent the photogenerated current densities of the Si cell without and with coupling with the LSC edge, respectively. Q_{Total} and Q_{PL} are the average external quantum efficiencies (EQEs) of the Si cell over the entire solar spectrum and at the wavelength range around the PL peak of the perovskite LSC film, respectively. η_{abs} denotes the absorbance of the perovskite LSC under total solar flux. Here, the $J_{\text{LSC}}/J_{\text{SC}}$ of the 25 mm \times 25 mm \times 4 mm PQDs LSC device is 58.86%. Q_{Total} and Q_{PL} are 0.53 and 0.41, respectively. Consequently, the η_{int} is 66.8%.

In addition, the η_{ext} is defined as the ratio of the number of photons emitted from the LSC edges to the number of total incident photons. It can be expressed as follows:

$$\eta_{\text{ext}} = \frac{J_{\text{LSC}} \times Q_{\text{Total}}}{G \times J_{\text{SC}} \times Q_{\text{PL}}}$$

Consequently, the η_{ext} is 46.8%.