

## Supporting information

### **Simple CsI Doping Outperforms Complex Organic Additives in Carbon– Based Perovskite Solar Cells**

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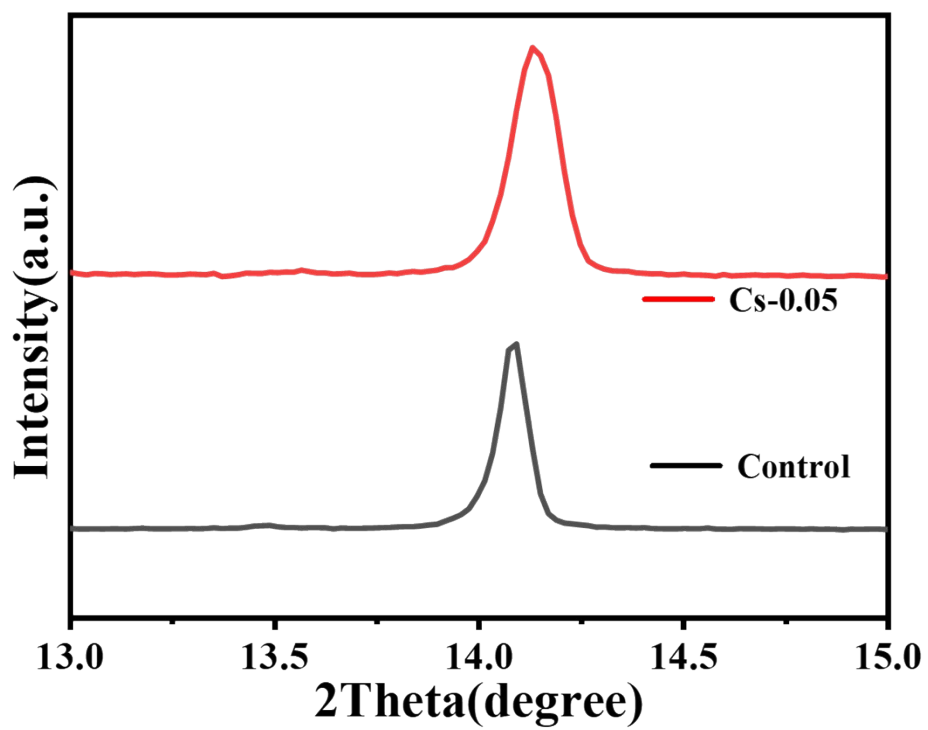
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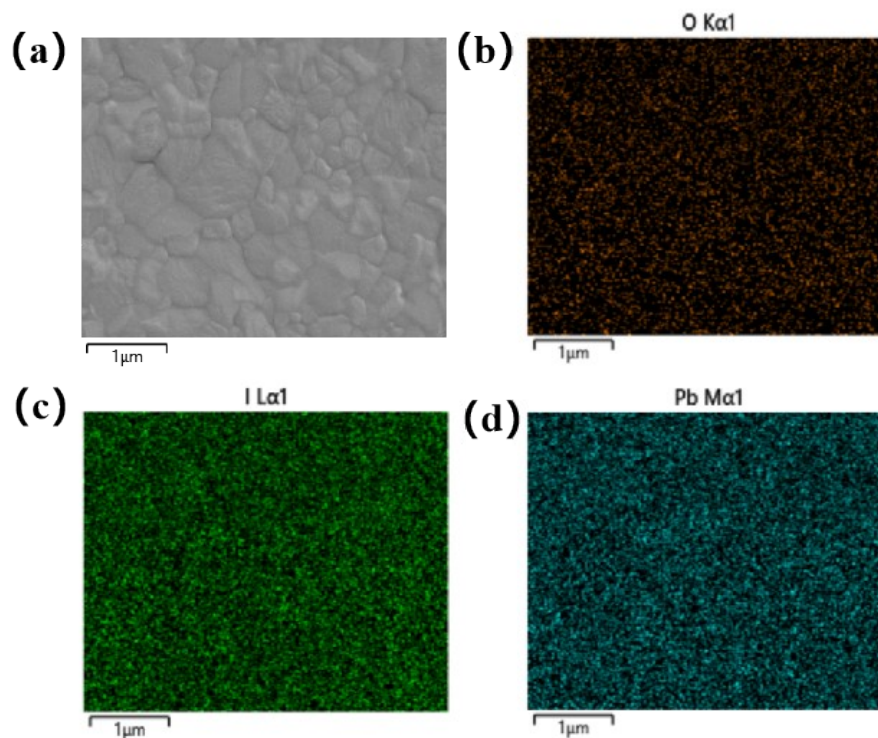
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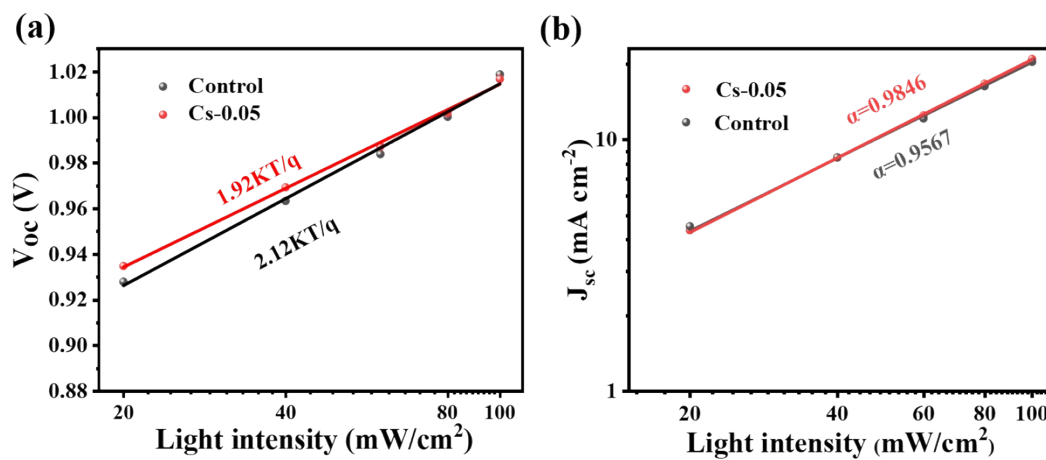
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**Fig. S1** Local magnification of XRD of perovskite films with different concentrations of CsI additives: Control, Cs-0.05.



**Fig. S2** **a** SEM image of the Cs-0.05 PVK film. **b-d** Distribution plots of (b) I, (c) Pb, (d) Cs.



**Fig. S3** **a** Light Intensity Dependence of  $V_{oc}$ . **b** Light Intensity Dependence of  $J_{sc}$ .

**Table S1** The statistical parameters of time-resolved photoluminescence (TRPL) spectra fitted by a bi-exponential function.

Sample	$A_1$	$A_2$	$\tau_1(\text{ns})$	$\tau_2(\text{ns})$	$\tau_{\text{ave}}(\text{ns})$
Control	0.72	59.93	0.29	735.89	253.28
Cs-0.05	0.49	93.79	0.51	948.31	531.87

**Table S2** Calculated parameters and trap density ( $N_t$ ) of control and Cs-0.05 devices.

Sample	L (nm)	$V_{\text{TFL}}$ (V)	$N_t(\text{cm}^{-3})$
Control	500	0.90	$1.56 \times 10^{16}$
Cs-0.05	500	0.78	$1.35 \times 10^{16}$

**Table S3** Fitting parameters of C-PSCs from Nyquist plots.

<b>Sample</b>	<b>R<sub>s</sub> (Ω)</b>	<b>R<sub>rec</sub> (Ω)</b>
<b>Control</b>	28.2	3087
<b>Cs-0.05</b>	27.9	4709

**Table S4** Photovoltaic parameters of the best-performing control and Cs-0.05 devices measured under both reverse and forward voltage scans.

<b>Sample</b>	<b>V<sub>OC</sub> (V)</b>	<b>J<sub>SC</sub> (mA cm<sup>-2</sup>)</b>	<b>FF (%)</b>	<b>PCE (%)</b>
<b>Control</b>	1.002	21.99	60.13	13.25
<b>Cs-0.02</b>	1.084	21.92	71.86	16.04
<b>Cs-0.05</b>	1.042	22.31	74.45	17.31
<b>Cs-0.08</b>	1.028	22.18	70.21	16.01
<b>Cs-0.1</b>	1.016	21.91	69.55	15.47

**Table S5** Progress in the efficiency of carbon-based HTLperovskite solar cells.

Device Structure	PVK	PCE	Year
FTO/TiO <sub>2</sub> /PVK/PI/C[1]	MAPbI <sub>3</sub>	13.76%	2023
FTO/SnO <sub>2</sub> /PVK/Eu-TCPP MOF/C[2]	MAPbI <sub>3</sub>	18.13%	2023
ITO/SnO <sub>2</sub> /PVK/TFEP/C[3]	MAPbI <sub>3</sub>	17.78%	2023
FTO/SnO <sub>2</sub> /PVK/TPCA/C[4]	MAPbI <sub>3</sub>	13.64%	2024
FTO/SnO <sub>2</sub> /PVK /C(Mn <sub>3</sub> O <sub>4</sub> )[5]	MAPbI <sub>3</sub>	19.03%	2024
FTO/SnO <sub>2</sub> /PVK(DMAHC <sub>2</sub> O <sub>4</sub> )/C[6]	CsPbI <sub>3</sub>	18.48%	2024
FTO/SnO <sub>2</sub> /CsPbI <sub>2</sub> Br/NMB/C[7]	CsPbI <sub>2</sub> Br	14.15%	2024
FTO/SnO <sub>2</sub> /FAPbI <sub>3</sub> /MACI/C[8]	FAPbI <sub>3</sub>	20.31%	2024
FTO/TiO <sub>2</sub> /PVK/Metformin&HI/C[9]	MAPbI <sub>3</sub>	14.13%	2024
FTO/SnO <sub>2</sub> /PVK/TAI/C[10]	FA <sub>0.83</sub> Cs <sub>0.17</sub> PbI <sub>3</sub>	20.1%	2024
FTO/CsPbBr <sub>3</sub> /TiO <sub>2</sub> /ZrO <sub>2</sub> /C[11]	CsPbBr <sub>3</sub>	10.18%	2025
ITO/TiO <sub>2</sub> /Mg-SnO <sub>2</sub> /CsPbI <sub>2</sub> Br/C[12]	CsPbI <sub>2</sub> Br	17.42%	2025
FTO/SnO <sub>2</sub> /CsPbI <sub>3</sub> / Y(Ac) <sub>3</sub> /C[13]	CsPbI <sub>3</sub>	15.53%	2025
FTO/SnO <sub>2</sub> /PVK/C[14]	FA <sub>0.9</sub> Cs <sub>0.1</sub> PbI <sub>3</sub>	20.15%	2026

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