Supporting Information

Mitigating Sn^{2+} Oxidation and Enhancing Device Performance in Tin-Based Perovskites Solar Cell via CsTFA Additive Strategy

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Table S1. Summary of key photovoltaic parameters of devices doped with different concentrations of CsTFA.

	*V*oc(V)	*J*sc(mA/cm^2)	FF	PCE (%)
0 mg/mL	0.559	20.4	0.645	7.35
0.4 mg/mL	0.583	20.0	0.670	7.82
0.8 mg/mL	0.592	20.6	0.688	8.38
1.2 mg/mL	0.595	21.1	0.647	8.11

Table S2. Summary of the theoretical values of the weight percent of each element in the perovskite precursor (regardless of solvent), and on the film surface obtained from EDS test results, and in the pure CsTFA.

element	wt% (perovskite precursor)	wt% (EDS)	wt% (CsTFA)
I	68.33	37.09	
Sn	22.68	12.58	
N	5.07	6.93	
C	2.21	2.10	9.77
F	0.70	3.73	23.18
Ge	0.63	1.73	
S	0.27	3.11	
Cs	0.09	23.77	54.05
O	0.02	8.96	13.01

Table S3. Fitting parameters of the EIS measurement

Sample	R_s (Ω)	R_{rec} (Ω)
Control	7.43	967
Target	7.29	451440

Table S4. The average photovoltaic parameter statistics for 15 devices.

Sample	V_{OC} (V)	FF (%)	J_{SC} (mA/cm^2)	PCE (%)
Control	0.556±0.016	60.9±1.8	20.3±0.4	6.88±0.25
Target	0.579±0.012	67.3±1.4	20.8±0.6	8.09±0.19

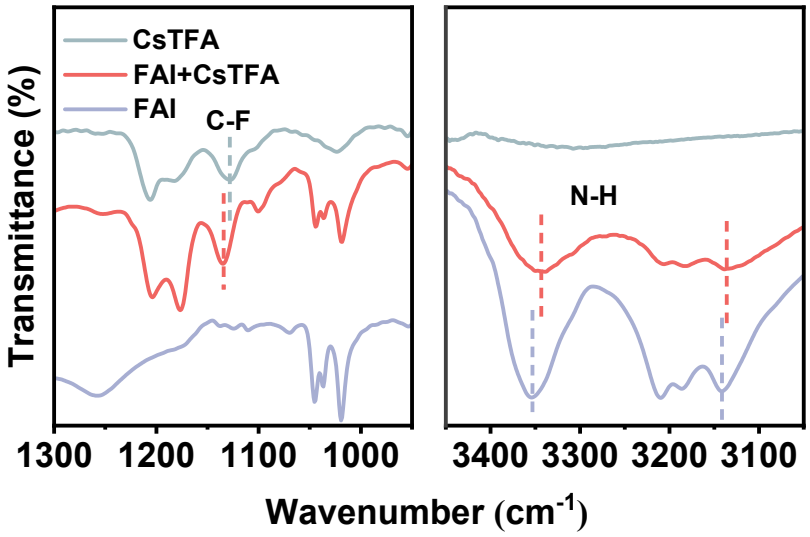


Figure S1. FTIR spectra of CsTFA, FAI and the mixture of CsTFA and FAI. C-F stretching vibration (left) and N-H stretching vibration (right).

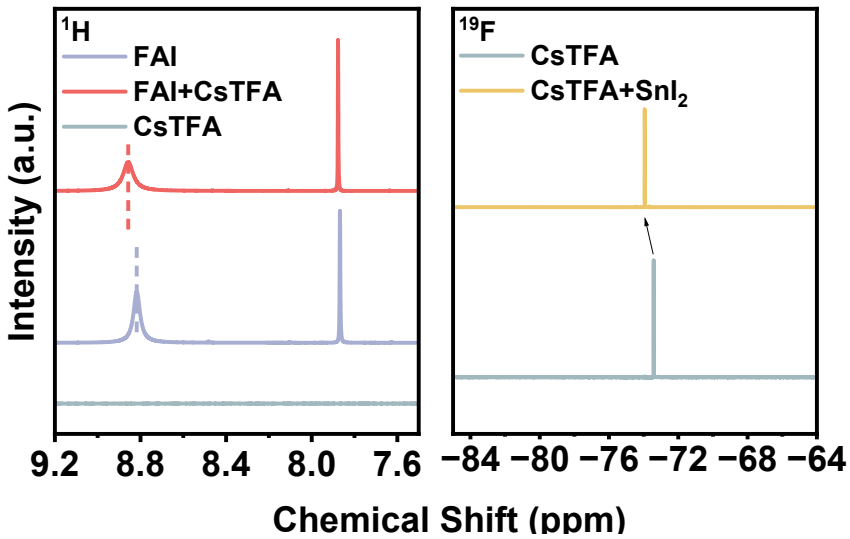


Figure S2. ^{1}H (left) NMR spectra of CsTFA, FAI and the mixture of CsTFA and FAI. ^{19}F (right) NMR spectra of CsTFA and the mixture of CsTFA and SnI_2.

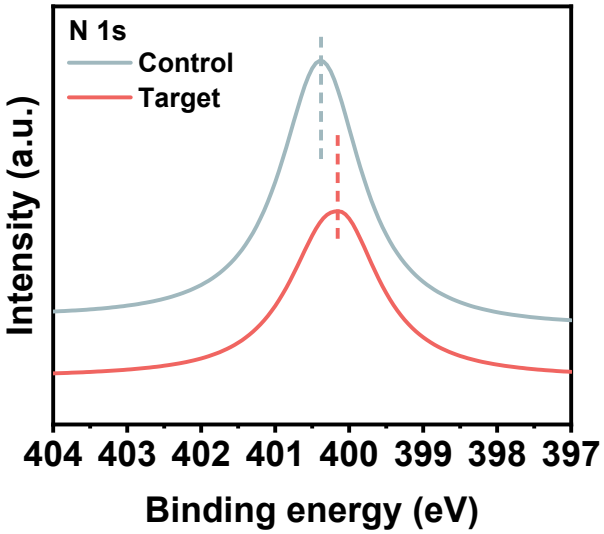


Figure S3. XPS spectra of N 1s peaks of the perovskite films.

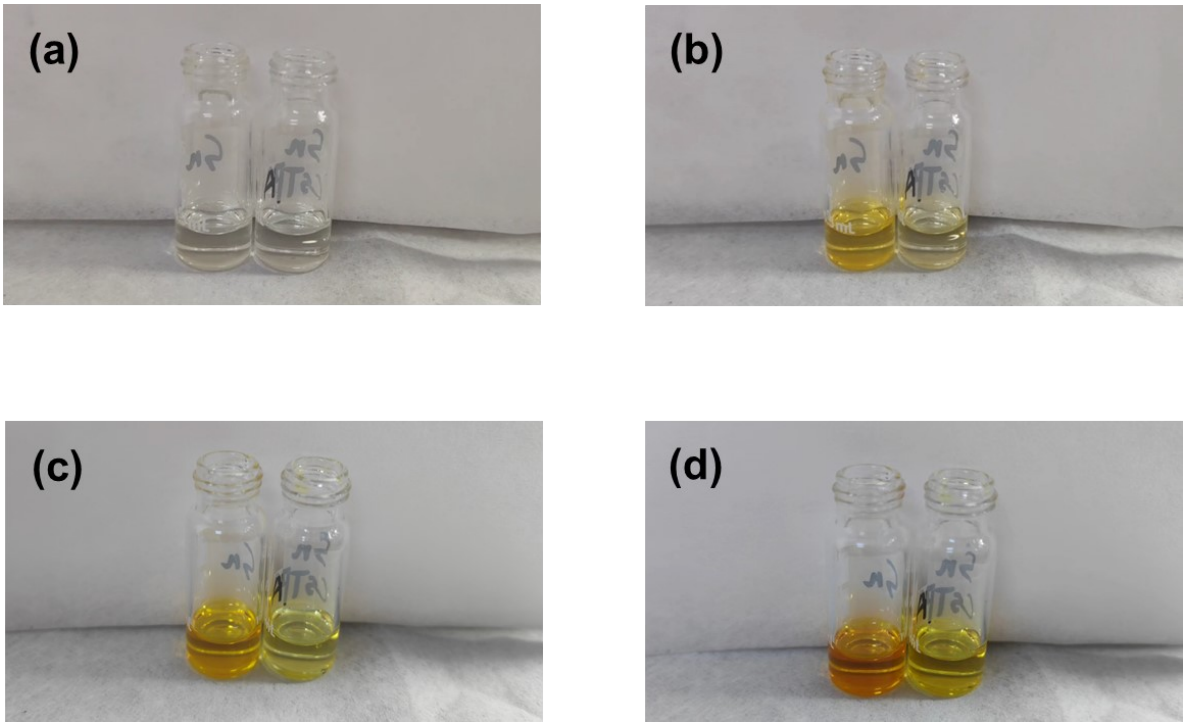


Figure S4. The digital pictures of SnI_2 solution with (right) and without (left) CsTFA doped placed in ambient condition（50-60% RH, 20℃）for (a) 0min (b) 5min (c) 10min (d) 30min.

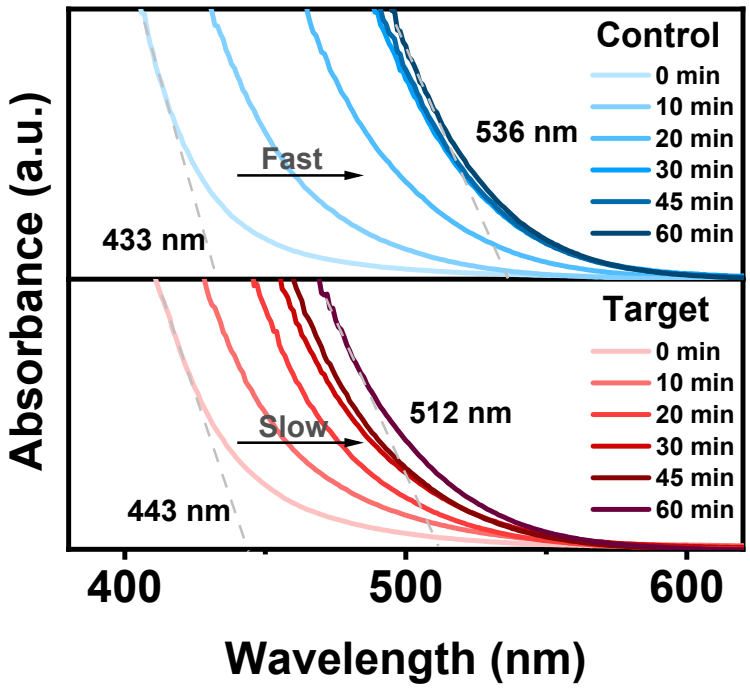


Figure S5. UV–vis absorption spectra of the SnI_2 precursors(with and without CsTFA) tested over time in the atmospheric air.

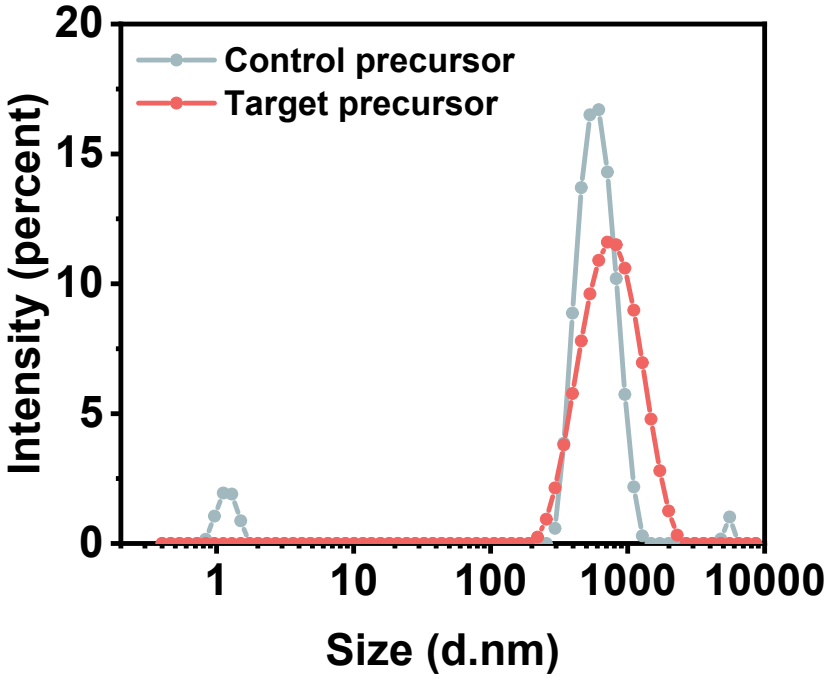


Figure S6. Dynamic light scattering data showing the particle size distribution in the precursor solutions.

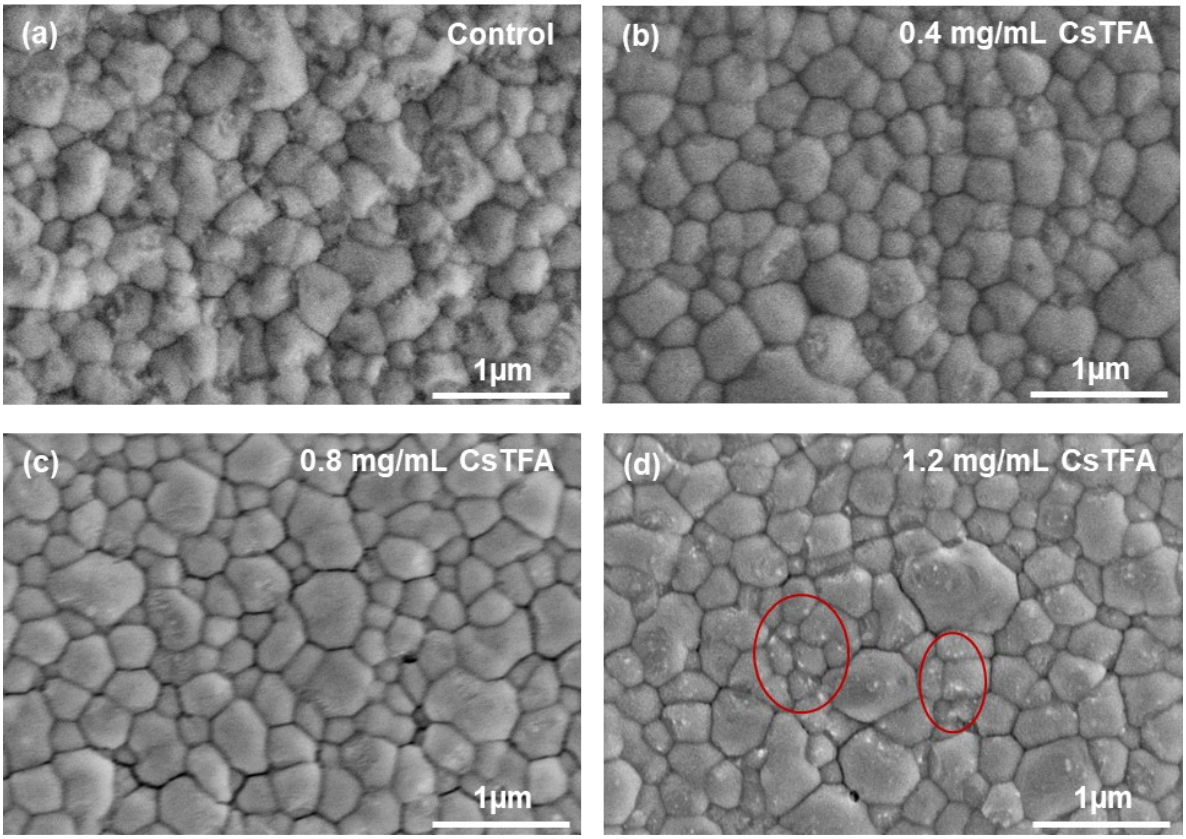


Figure S7. The SEM images (scale = 1μm) of (a) the control perovskite film and the (b) 0.4 mg/mL, (c) 0.8 mg/mL and (d) 1.2 mg/mL CsTFA-doped perovskite film.

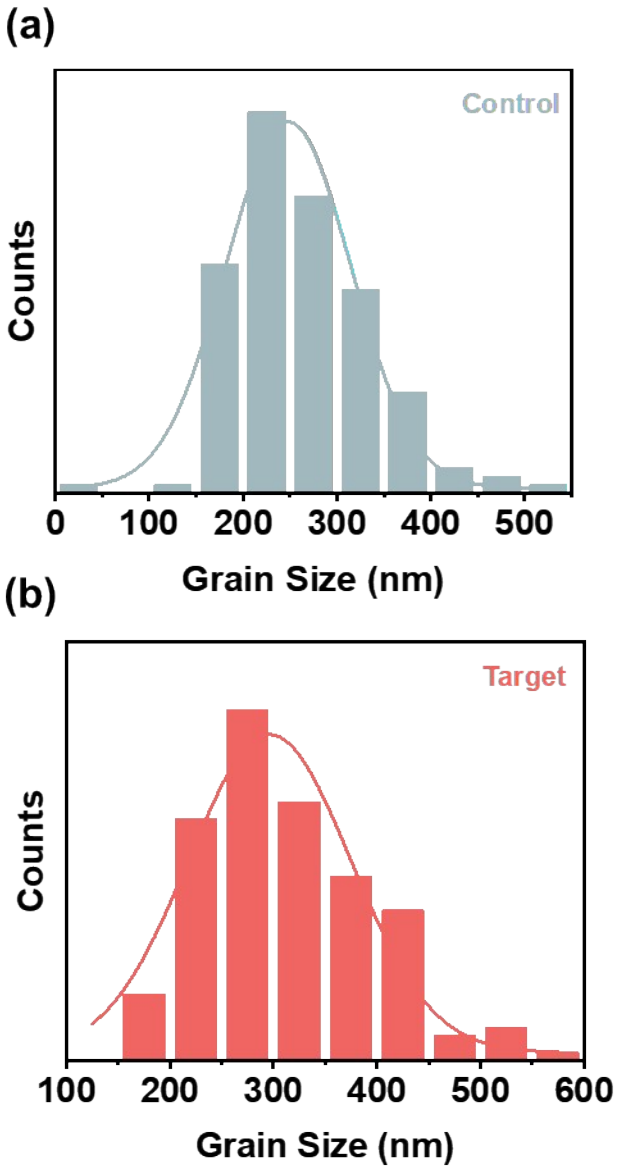


Figure S8. The grain size distribution histograms of (a) the control perovskite film and (b) the target perovskite film with 0.8 mg/mL CsTFA.

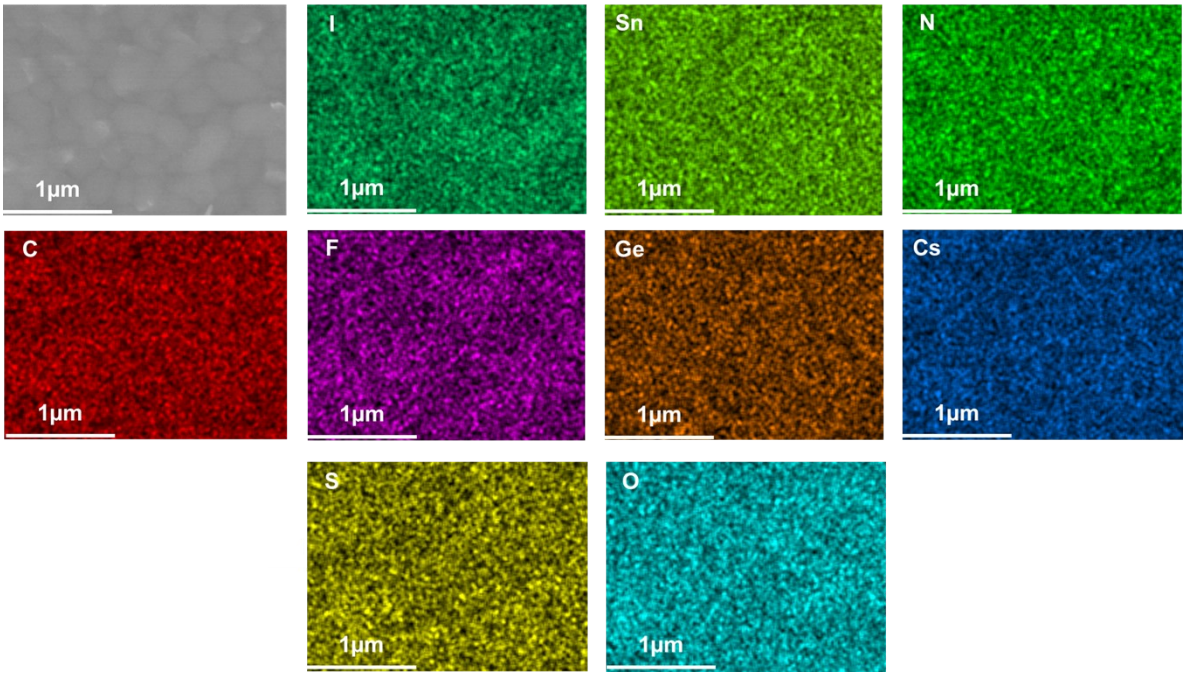


Figure S9. The EDS images (scale = 1μm) of the I、Sn、N、C、F、Ge、Cs、S、O of CsTFA-doped perovskite film.

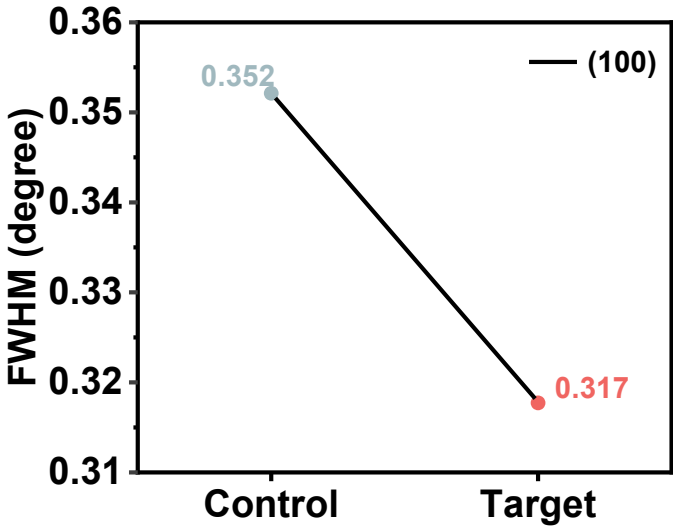
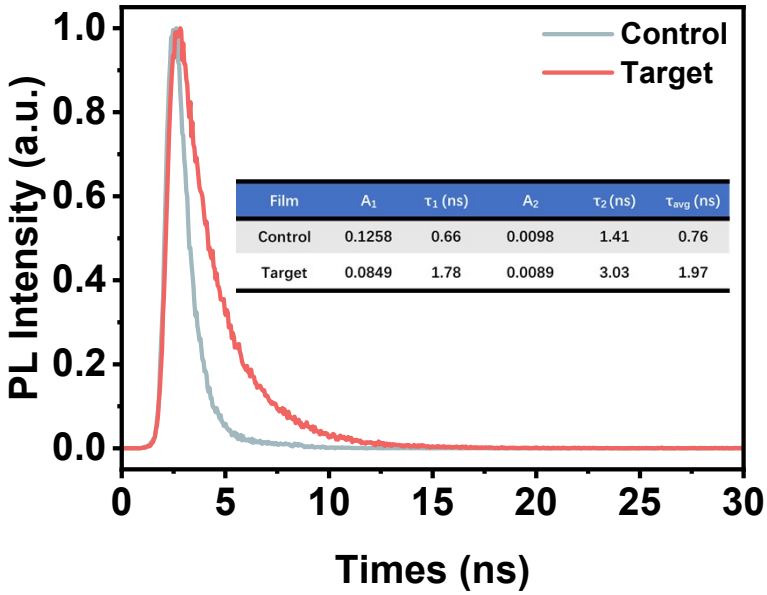


Figure S10. The full width half maximum (FWHM) data of the (100) peaks of perovskite films.



Film	A_1	τ_1 (ns)	A_2	τ_2 (ns)	τ_{avg} (ns)
Control	0.1258	0.66	0.0098	1.41	0.76
Target	0.0849	1.78	0.0089	3.03	1.97

Figure S11. TRPL spectra of glass/perovskite films.
Notes: The time-resolved PL decay curves were fitted by the equation:

$$I(t) = A_1(-\frac{t}{\tau_1}) + A_2(-\frac{t}{\tau_2})$$

The τ_{avg} was calculated using the equation:

$$\tau_{avg} = \frac{A_1 \times \tau_1^2 + A_2 \times \tau_2^2}{A_1 \times \tau_1 + A_2 \times \tau_2}$$

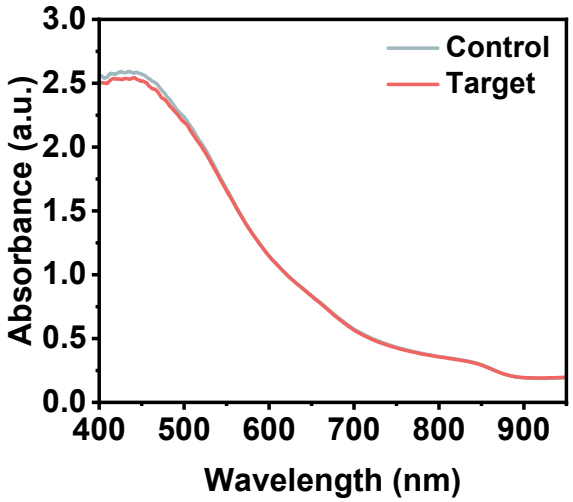


Figure S12. UV–vis absorption spectra of perovskite films.

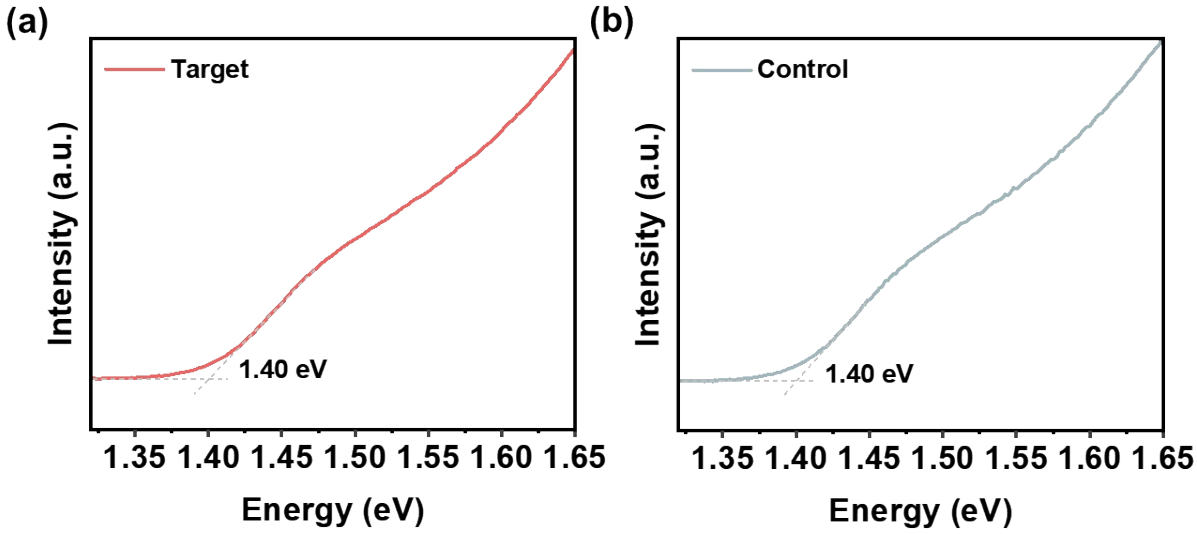


Figure S13. Tauc plots of the (a) control and (b) target perovskite films.

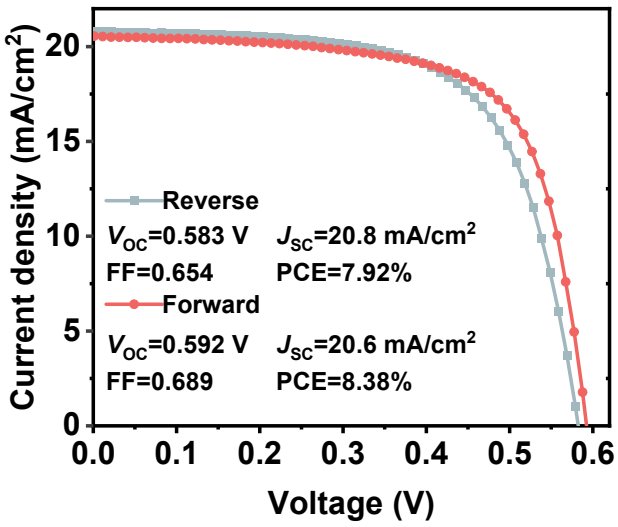


Figure S14. Best *J*–*V* data in forward and reverse scans.

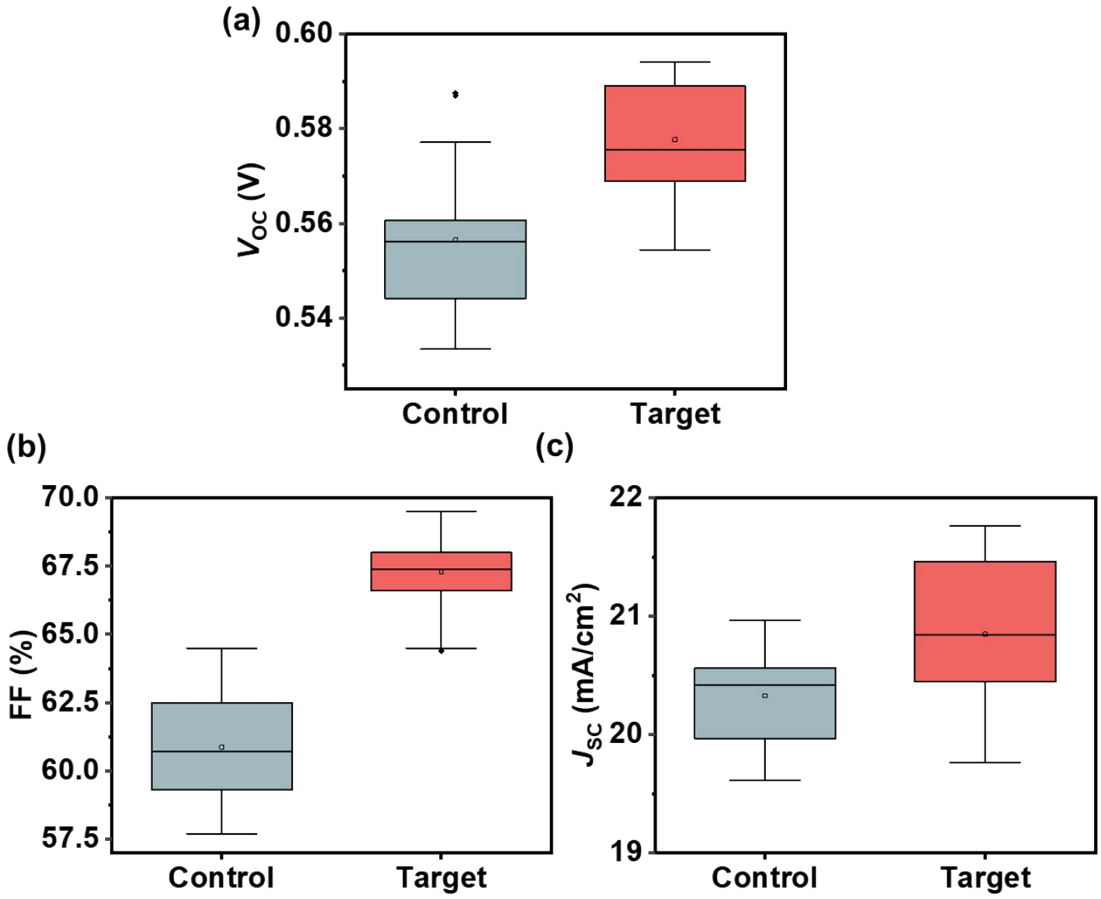


Figure S15. V_{OC}, FF and J_{SC} statistic diagrams of the control and target devices.

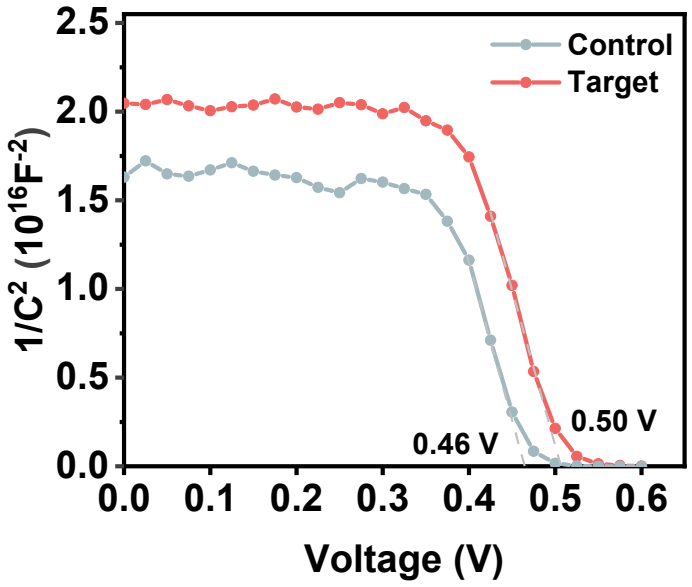


Figure S16. C^{-2}-V plots determined from the Mott-Schottky plot analysis.

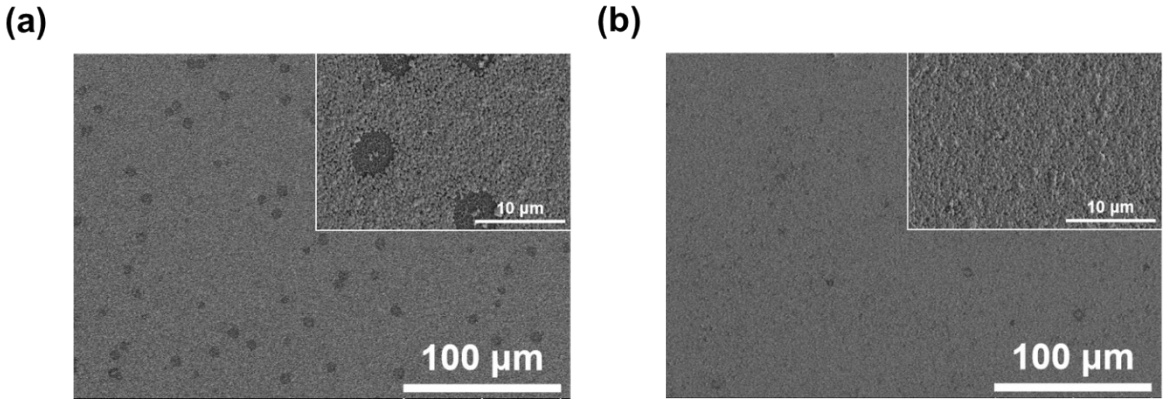


Figure S17. The SEM images of (a) control and (b) target of unencapsulated perovskite films after being exposed to ambient conditions for 2 hours.