

Skillfully Deflected the Question: A Small Amount of Piperazine-1,4-dium Iodide

Radically Enhances the Thermal Stability of CsPbI₃ Perovskite

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Supporting information

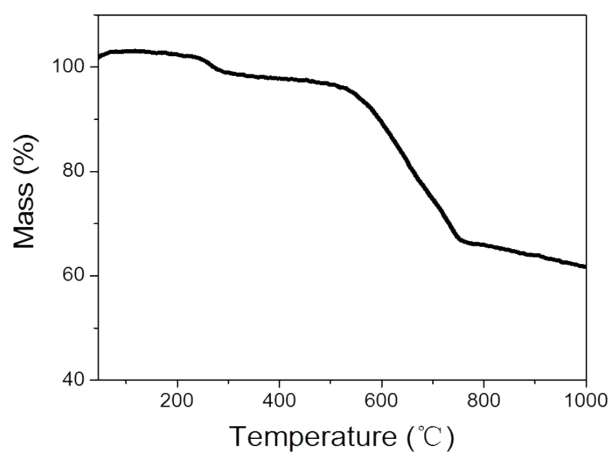


Figure S1. TG analysis of the pristine CsPbI₃ film. Three weight loss stages at 250 °C, 540 °C and 770 °C, corresponding to the sublimation of dimethylammonium iodide (DMAI), PbI₂ and CsI, respectively. The ratio of DMAI/CsI is calculated to be about 8.2% in the film.

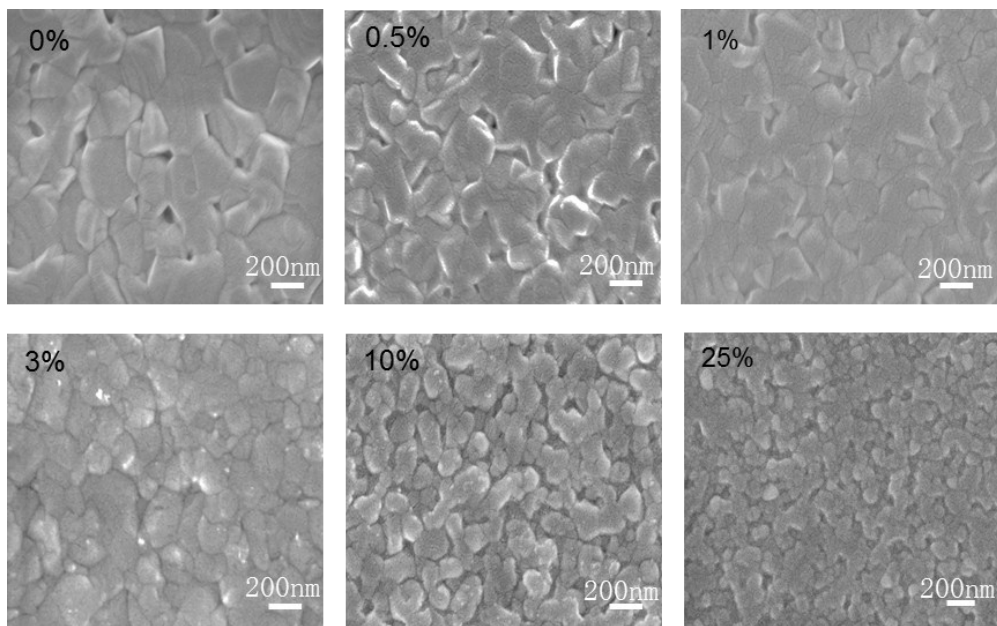


Figure S2. Top-view SEM images of the CsPbI₃·xPZDI₂ films with different x values.

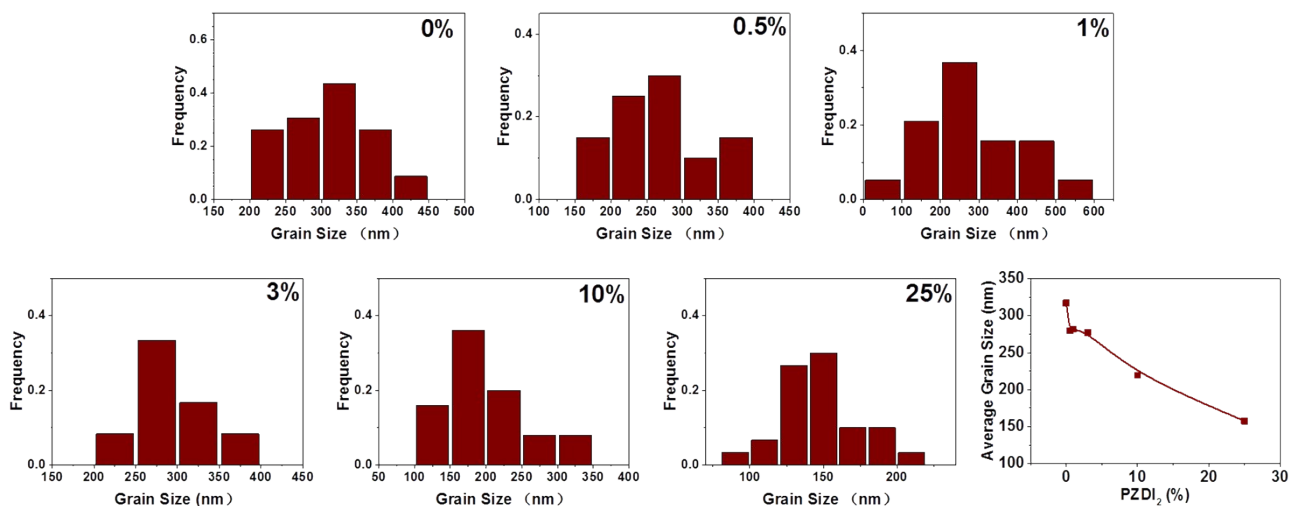


Figure S3. Grain-size distributions that are taken from the corresponding SEM images and relationship of the average grain size with PZDI₂ contents ($x < 25\%$).

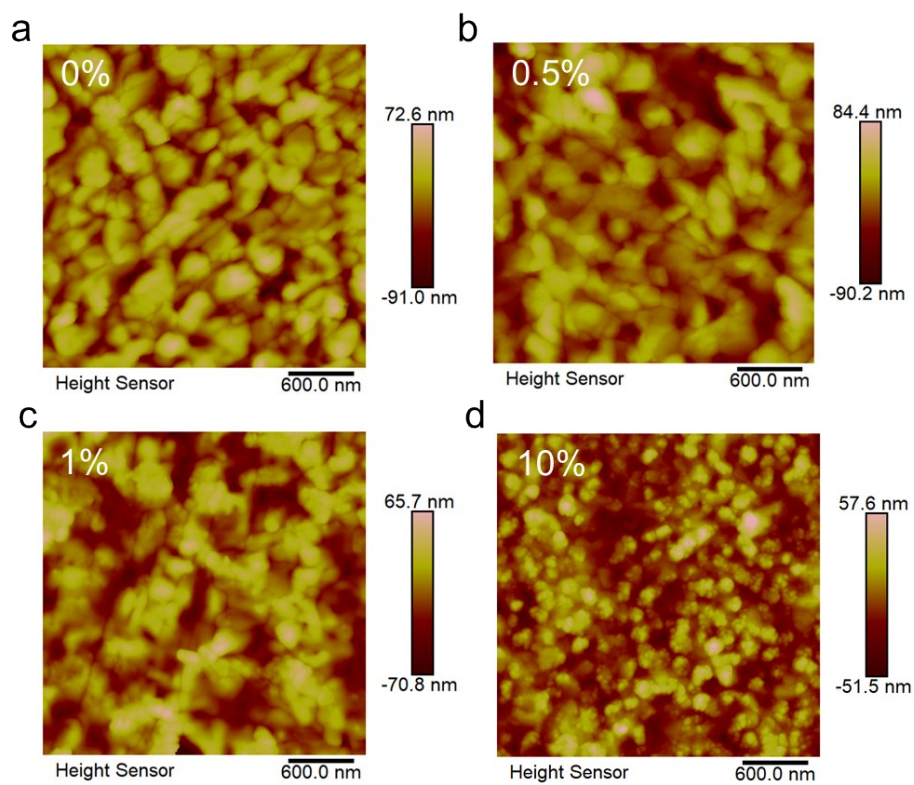


Figure S4. AFM images of CsPbI₃·xPZDI₂ films: (a) x = 0, (b) x = 0.5%, (c) x = 1% and (d) x = 10%.

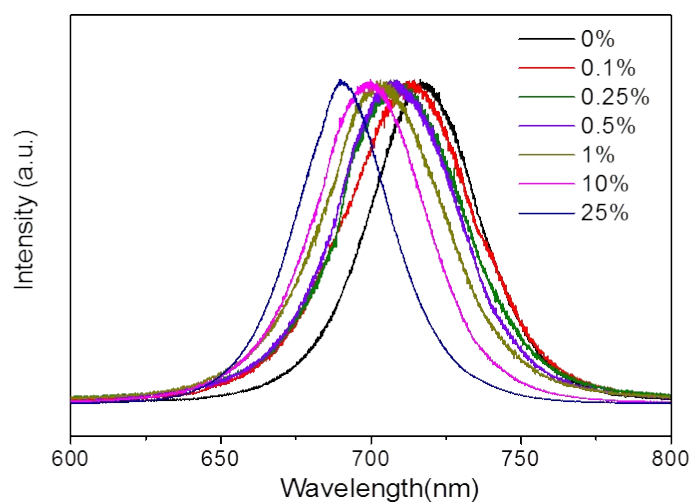


Figure S5. Steady-state PL spectra of the CsPbI₃·xPZDI₂ films deposited on glass side.

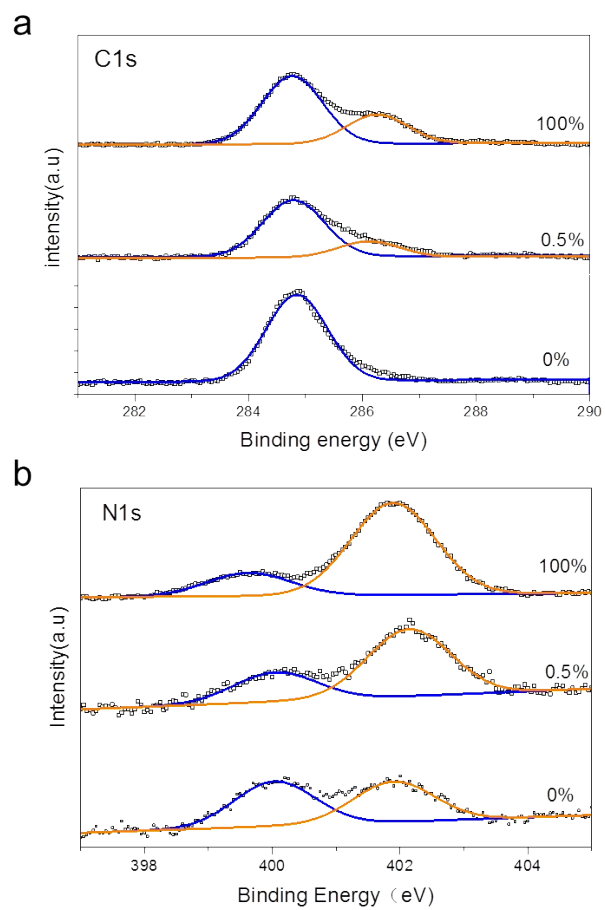


Figure S6. XPS spectra of (a) C 1s and (b) N 1s for CsPbI₃, CsPbI₃·0.5%PZDI₂ and CsPbI₃·100%PZDI₂ films.

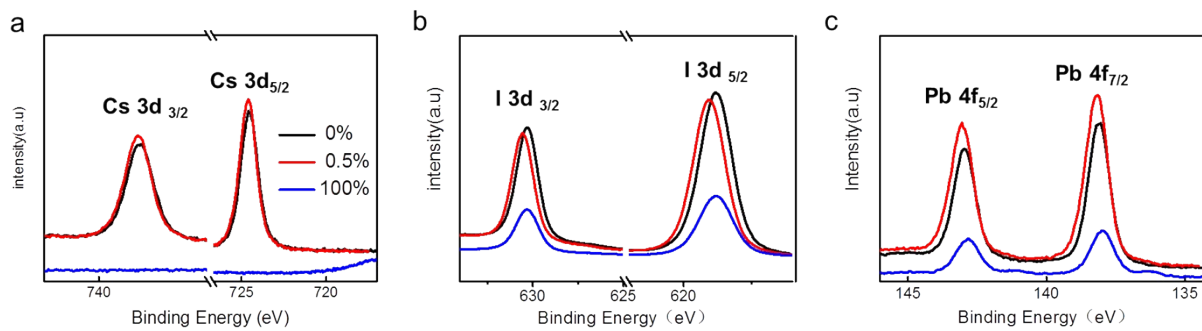


Figure S7. Comparison of XPS spectra of the CsPbI₃, CsPbI₃·0.5%PZDI₂ and CsPbI₃·100%PZDI₂ films: (a) Cs 3d, (b) I 3d and (c) Pb 4f.

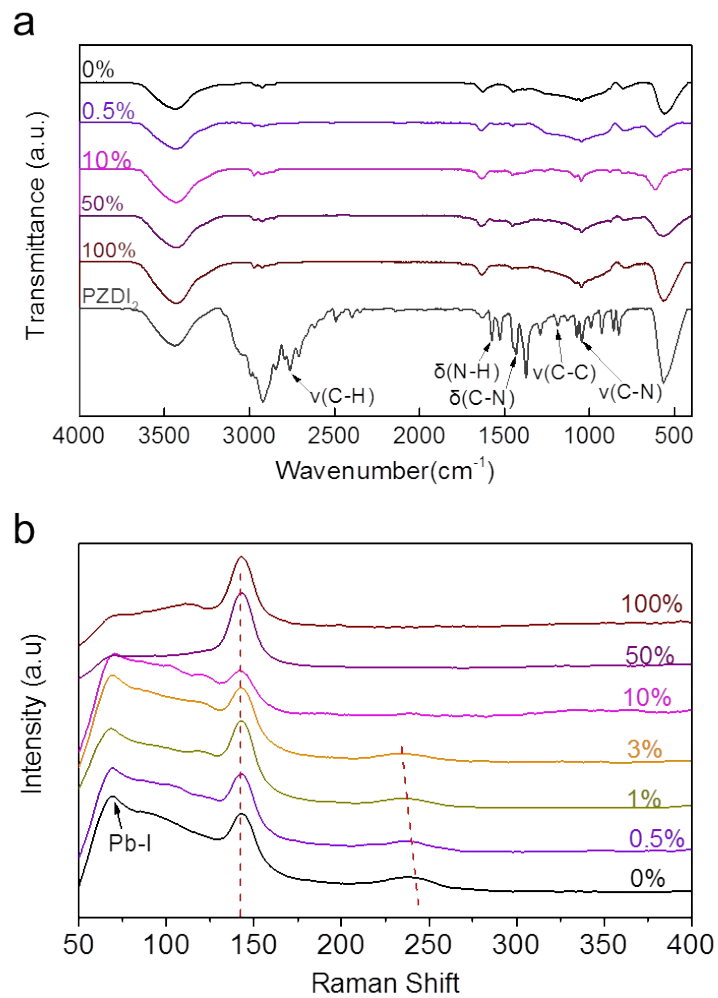


Figure S8. FTIR and Raman spectra of the CsPbI₃·xPZDI₂ samples: (a) FTIR spectra of CsPbI₃·xPZDI₂ and PZDI₂ powder and (b) Raman spectra of CsPbI₃·xPZDI₂ film. The traces are shifted vertically for clarity.

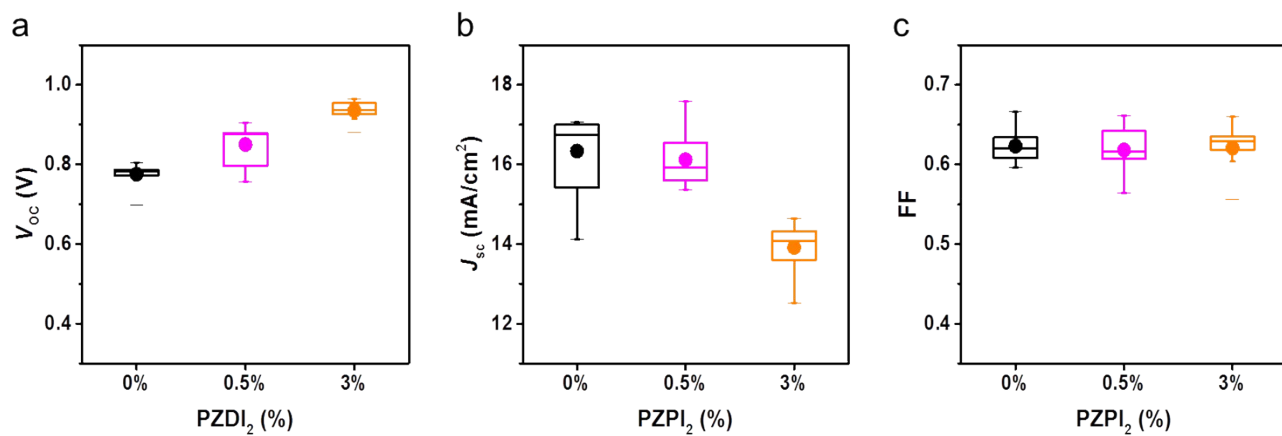


Figure S9. Distributions of the (a) V_{oc} , (b) J_{sc} and (c) FF obtained from CsPbI₃, CsPbI₃·0.5%PZDI₂ and CsPbI₃·3%PZDI₂ C-PSCs.

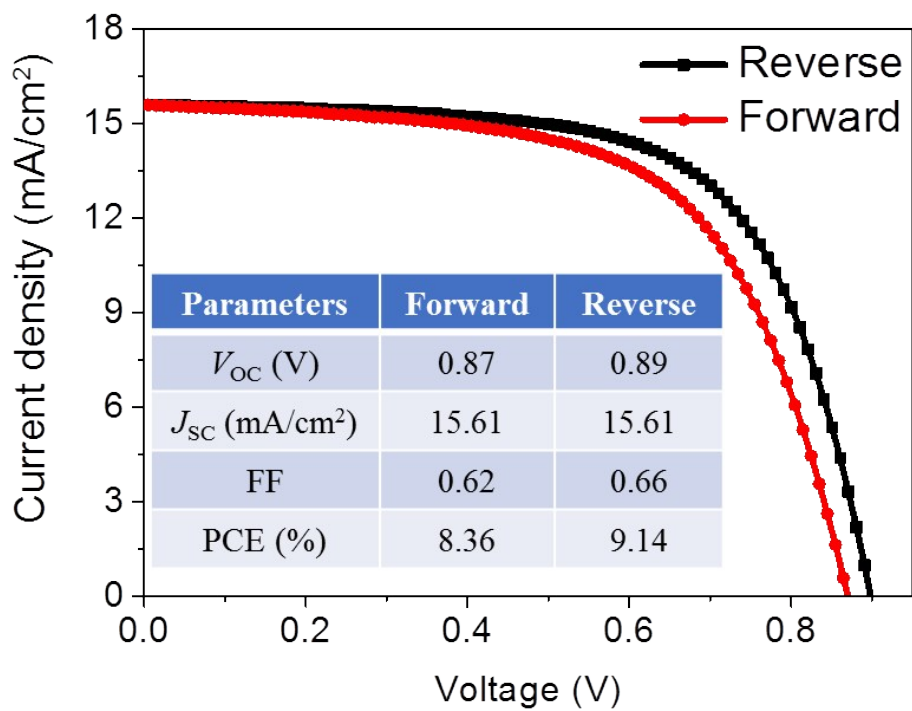


Figure S10. *J-V* curves of the CsPbI₃·0.5%PZDI₂ C-PSCs under forward and reverse scans. The hysteresis index is calculated to be 8.5%.

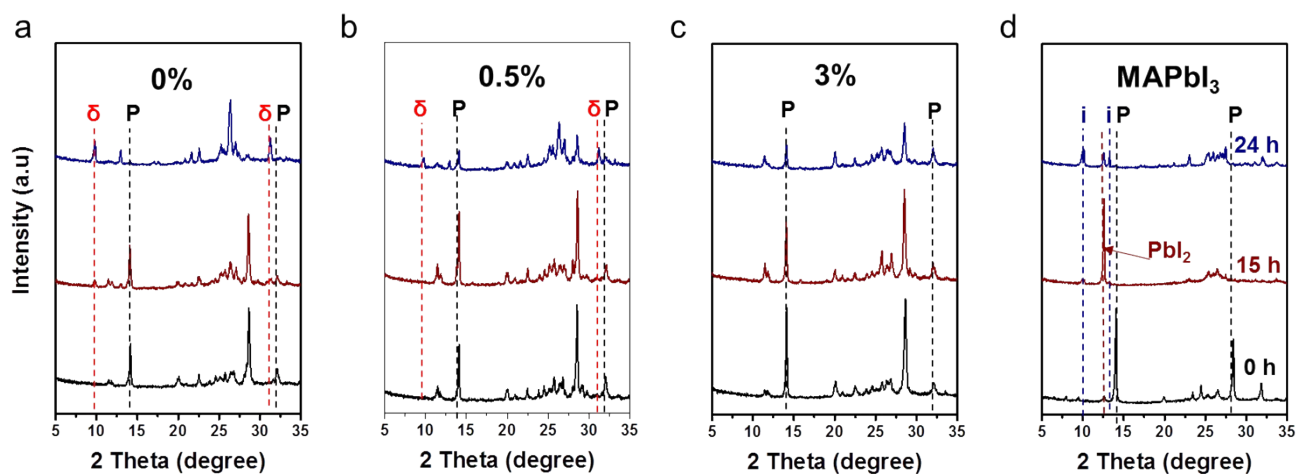


Figure S11. XRD patterns of the corresponding perovskite samples after heating at 100 °C for different duration: (a) CsPbI₃, (b) CsPbI₃-0.5%PZDI₂, (c) CsPbI₃-3%PZDI₂ and (d) MAPbI₃. The δ represents the yellow CsPbI₃ phase, while the P denotes the photoactive CsPbI₃ perovskite phases.

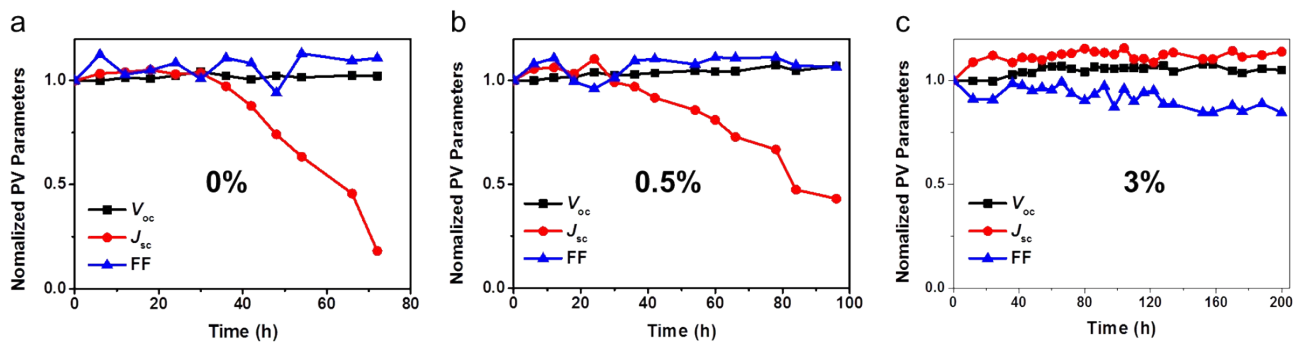


Figure S12. Data of the thermal stability tests of CsPbI₃-xPZDI₂ C-PSCs: Change of PV parameters with storage time at 85 °C in a dry air (RH ~ 10-20%): (a) CsPbI₃, (b) CsPbI₃-0.5%PZDI₂ and (c) CsPbI₃-3%PZDI₂.