

**An Efficient and Stable Tin-Based Perovskite Solar Cells Passivated by
Aminoguanidine Hydrochloride**

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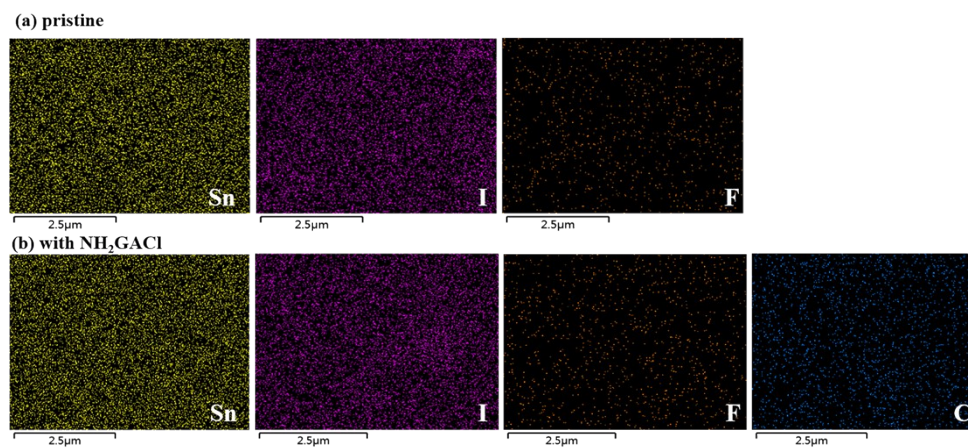


Figure S1. Energy-dispersive X-ray (EDS) spectroscopy mapping of Sn, I, F, and Cl in (a) pristine and (b) NH_2GACl incorporated perovskite film.

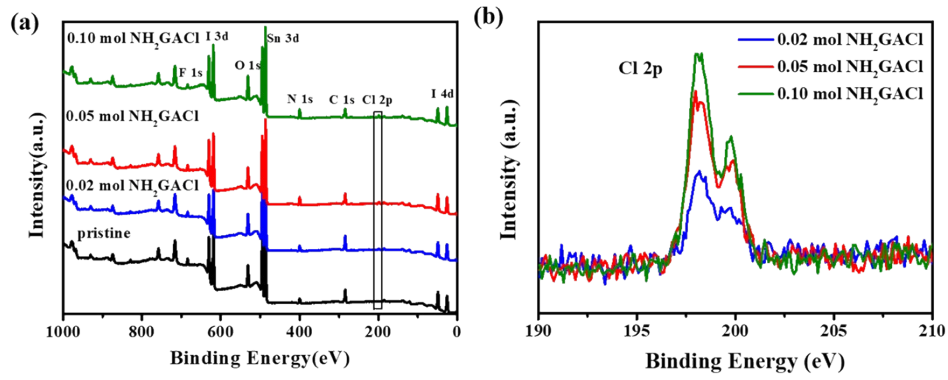


Figure S2. (a) XPS spectra of the perovskite films. (b) XPS spectra (Cl 2p) of the perovskite films with 0.02 mol, 0.05 mol and 0.10 mol NH_2GACl .

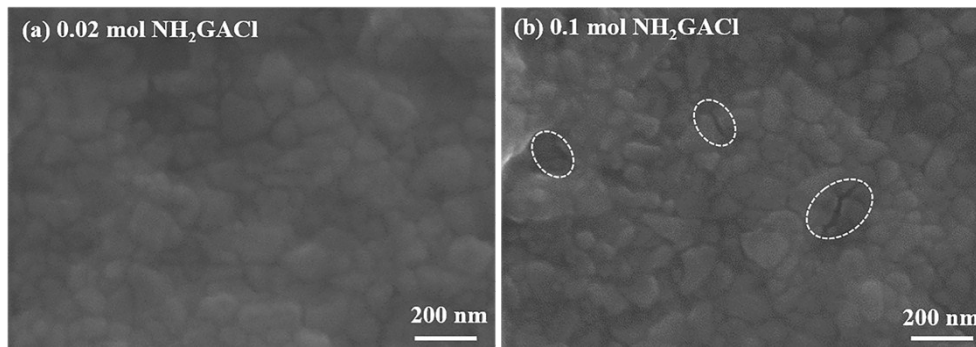


Figure S3. SEM images of the perovskite films with (a) 0.02 mol and (b) 0.10 mol NH₂GACI-doped on ITO/PEDOT:PSS layers.

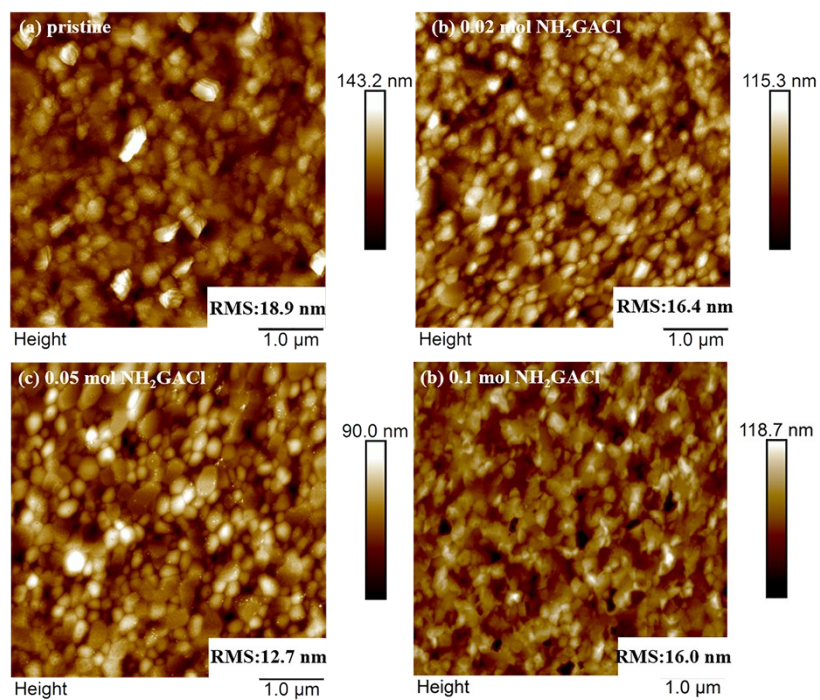


Figure S4. AFM images of the perovskite films on ITO/PEDOT:PSS layers with various proportions of NH₂GACl additive: (a) pristine, (b) 0.02 mol, (c) 0.05 mol and (d) 0.10 mol, respectively.

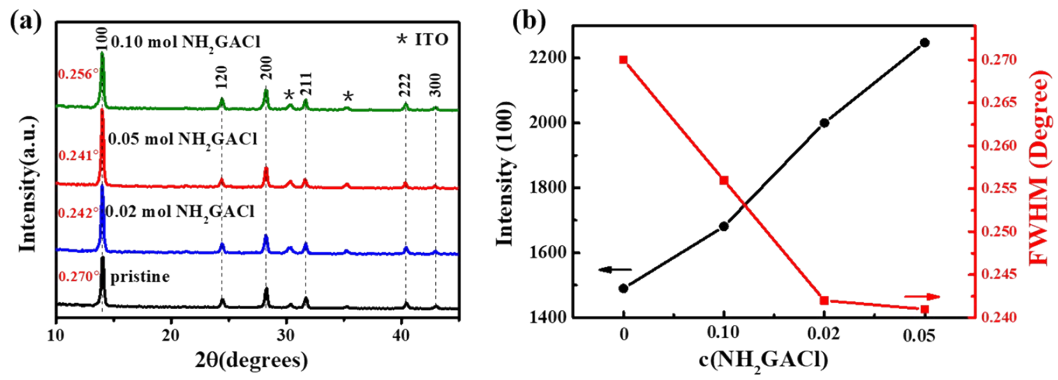


Figure S5. (a) X-ray diffraction patterns and (b) the corresponding full width at half maximum diffraction peaks of the perovskite films with varying concentrations of NH_2GACl additive (0 mol, 0.02 mol, 0.05 mol and 0.10 mol).

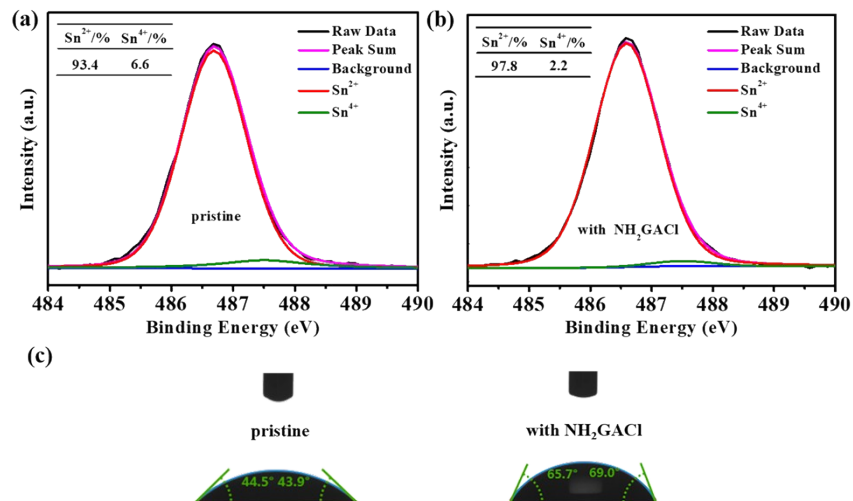


Figure S6. (a, b) X-ray photoelectron spectra (Sn 3d) of the pristine and perovskite films modified with NH₂GACl. (c) The contact angles between perovskite films (the pristine or NH₂GACl-modified) and water.

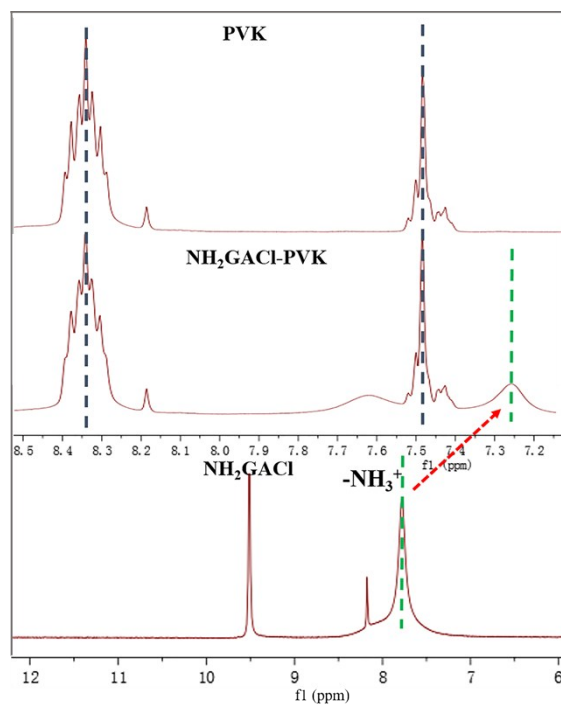


Figure S7. ¹H NMR spectra of NH₂GACI, perovskite and perovskite- NH₂GACI mixture solution in deuterated *N, N*-dimethylformamide-d₇ (DMF-d₇).

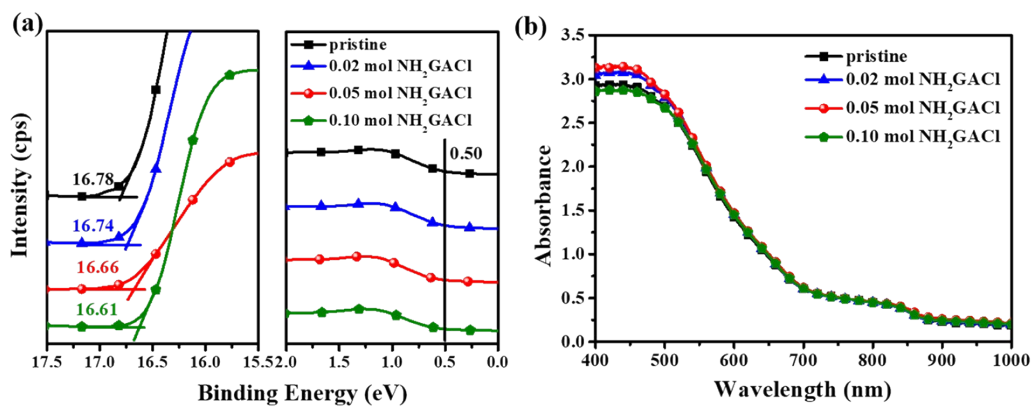


Figure S8. (a) Ultraviolet photoelectron spectroscopy (UPS) patterns and (b) UV-vis absorbance spectra of the pristine, 0.02 mol, 0.05 mol and 0.10 mol NH₂GACI-modified perovskite films.

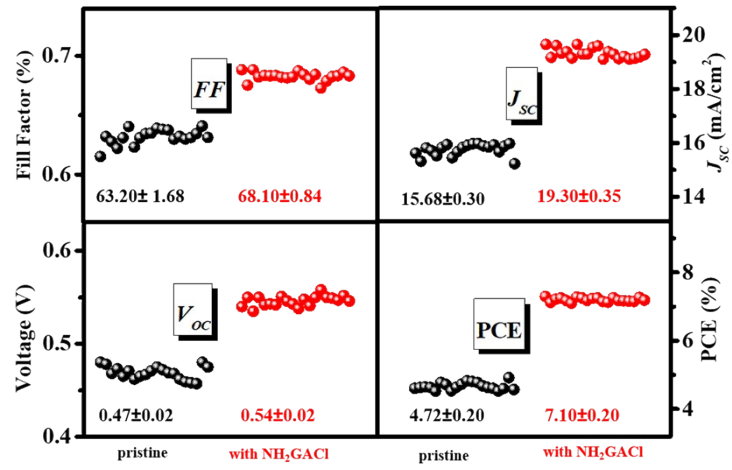


Figure S9. A graphical representation of the device characteristics (20 devices).

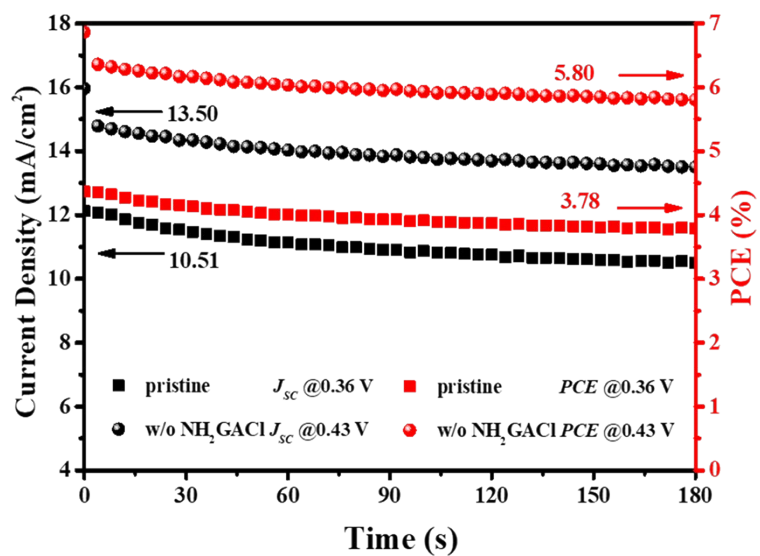


Figure S10. Steady-state photocurrent (left) and stabilized PCE (right) of the perovskite devices measured at the maximum power point.

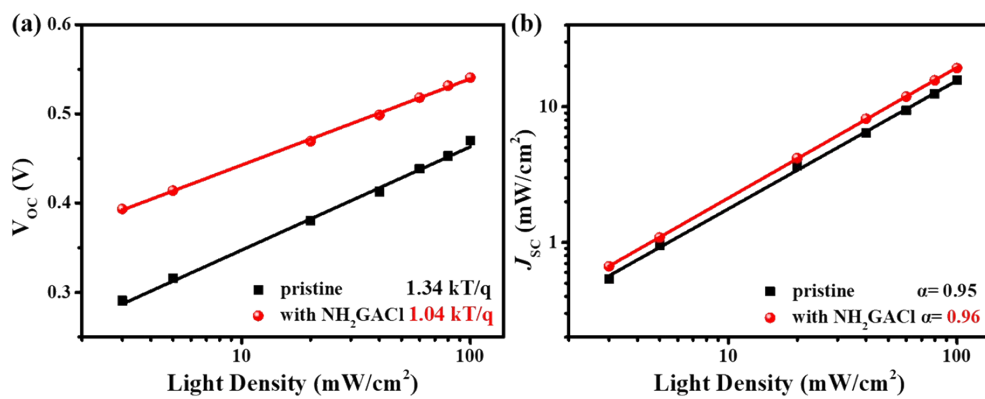


Figure S11. (a) V_{oc} and (b) J_{sc} of the perovskite solar cells without and with NH_2GACl additive measured under various illumination levels.

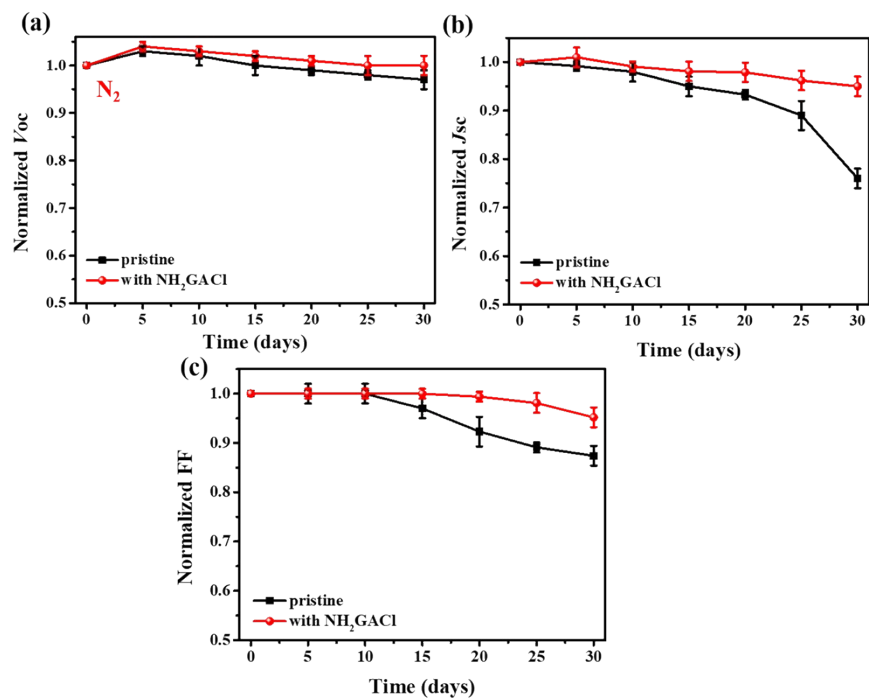


Figure S12. Stability of the pristine and NH_2GACl -modified perovskite solar cells in nitrogen at 25 °C without encapsulation. (a) Normalized V_{oc} . (b) Normalized J_{sc} . (c) Normalized FF.

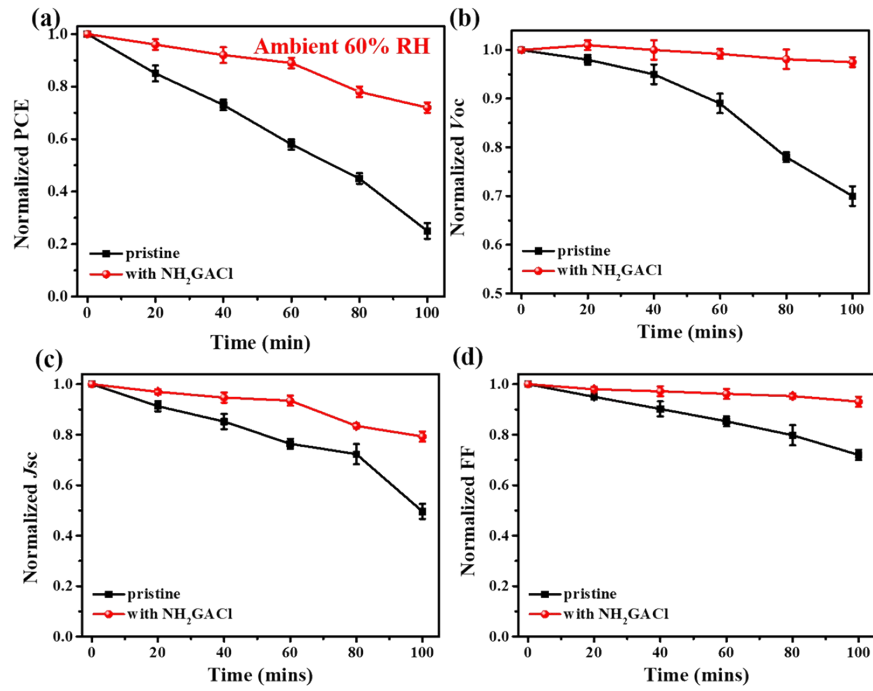


Figure S13. Stability of the pristine and NH₂GACI-modified perovskite solar cells under relative humidity (RH) 60% without encapsulation. (a) Normalized PCE, (b) Normalized V_{oc} , (c) Normalized J_{sc} , (d) Normalized FF.

Table S1. Photovoltaic parameters of the perovskite solar cells with different concentrations of NH₂GACl doped in precursor solution.

Devices	J_{sc} (mA cm ⁻²)	V_{oc} (V)	FF (%)	PCE (%)
pristine	15.98	0.48	64.09	4.92
0.02 mol NH ₂ GACl	18.88	0.50	67.89	6.42
0.05 mol NH ₂ GACl	19.65	0.54	68.84	7.30
0.10 mol NH ₂ GACl	14.52	0.45	63.48	4.19

Table S2 The different device active areas of Sn-perovskite solar cells in the previous literatures and this work.

device active areas (cm ²)	PCE (%)	Ref.
0.04	12.40	1
0.09	10.1	2
0.0222	9.6	3
0.04	9.0	4
0.04	7.3	This work

1. X. Jiang, F. Wang, Q. Wei, H. Li, Y. Shang, W. Zhou, C. Wang, P. Cheng, Q. Chen, L. Chen and Z. Ning, *Nat. Commun.*, 2020, DOI: 10.1038/s41467-020-15078-2.
2. T. Wu, X. Liu, X. He, Y. Wang, X. Meng, T. Noda, X. Yang and L. Han, *Sci. China Chem.*, 2020, **63**, 107-115.
3. E. Jokar, C.-H. Chien, C.-M. Tsai, A. Fathi and E. W.-G. Diau, *Adv. Mater.*, 2019, **31**, 1804835.
4. S. Shao, J. Liu, G. Portale, H.-H. Fang, G. R. Blake, G. H. ten Brink, L. J. A. Koster and M. A. Loi, *Adv. Energy Mater.*, 2018, **8**, 1702019.