

## Supporting information

### Electron Deficient 4-Nitrophthalonitrile Passivated Efficient

### Perovskite Solar Cells with Efficiency Exceeding 22%

Longhui Deng,<sup>a,b,c</sup> Zhihao Zhang,<sup>b,c</sup> Yifeng Gao,<sup>b,c</sup> Qiu Xiong,<sup>b,c</sup> Zicheng Li,<sup>b,c</sup> Jianbin Xu,<sup>b,c</sup> Zilong Zhang,<sup>b,c</sup>  
Jun Chen<sup>\*a</sup>, Peng Gao<sup>\*b,c</sup>

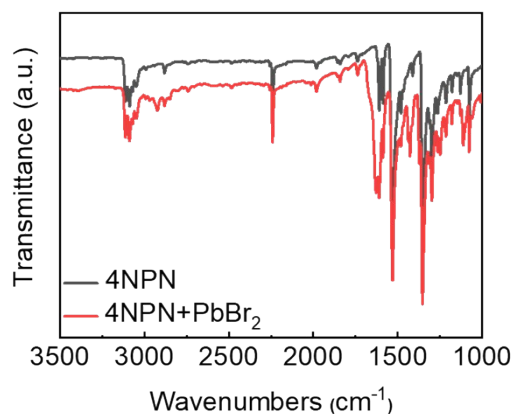


Figure S1. FTIR spectra of pure 4NPN and with PbBr<sub>2</sub> mixture.

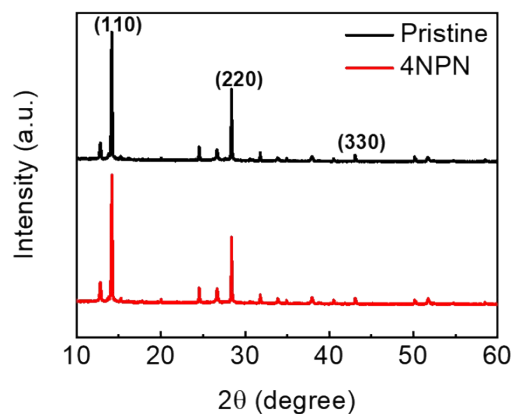


Figure S2. XRD patterns of perovskite films with and without 4NPN.

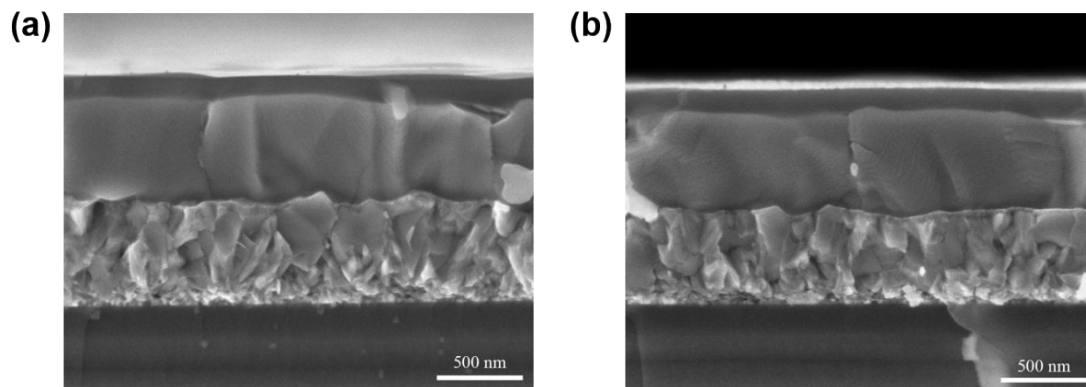


Figure S3. Cross-section SEM images of PSCs.

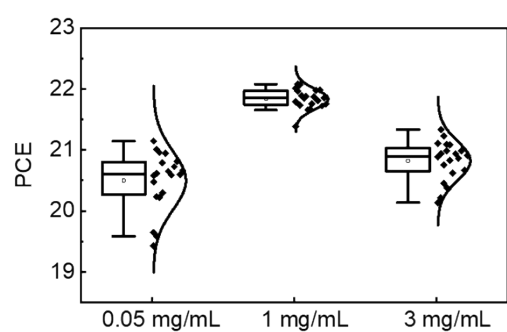


Figure S4. PCE of the PSCs with different concentration 4NPN.

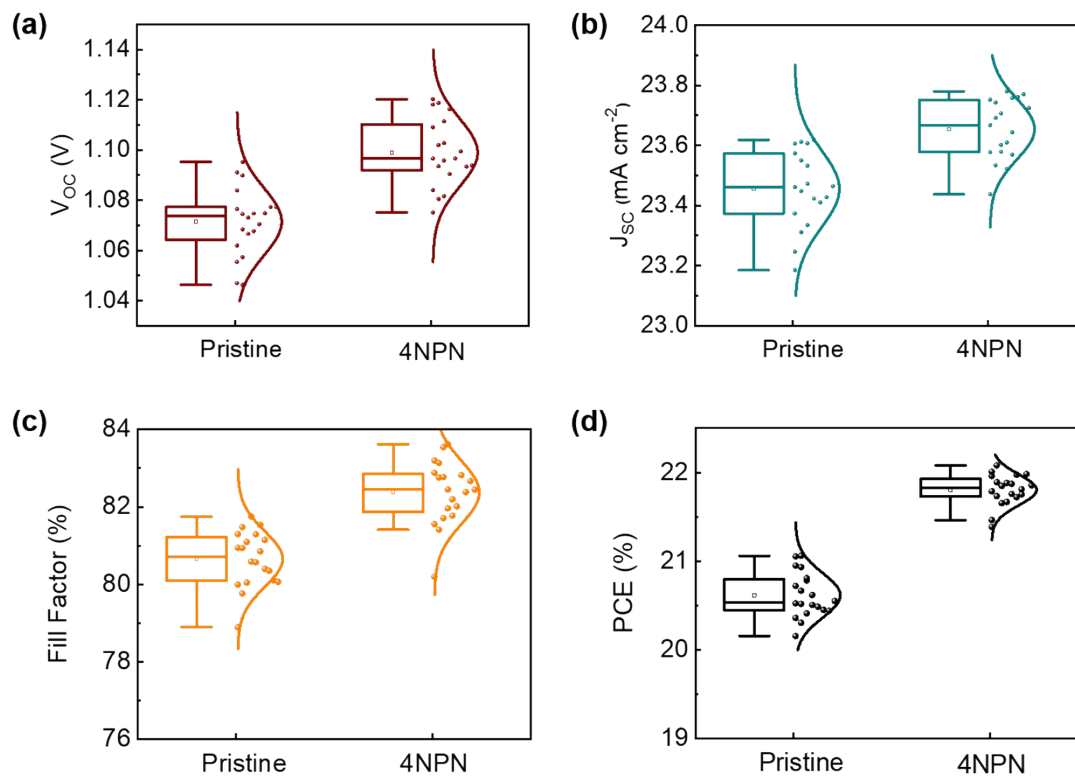


Figure S5. Count 20 perovskite solar cells without and with 4NPN of (a)  $V_{oc}$ , (b)  $J_{sc}$ , (c) FF, and (d) PCE.

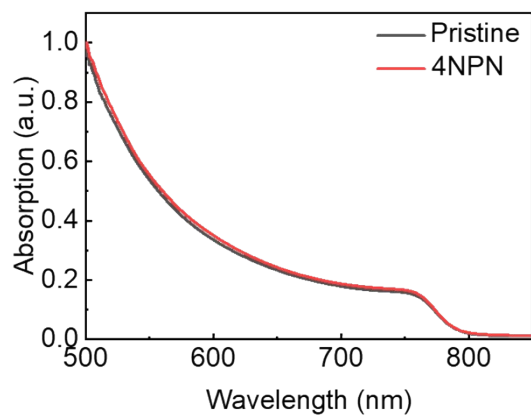


Figure S6. UV-vis absorption spectra.

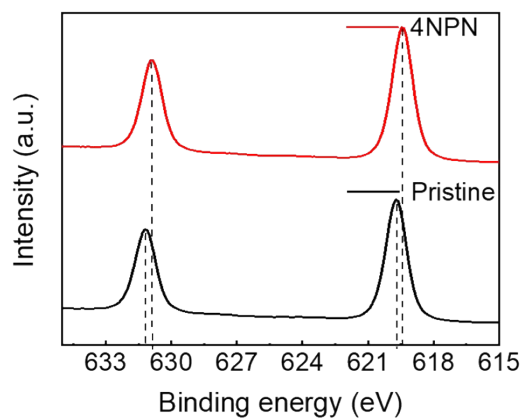


Figure S7. XPS results of I 3d core levels spectra of the pristine and adding with 4NPN perovskite surface.

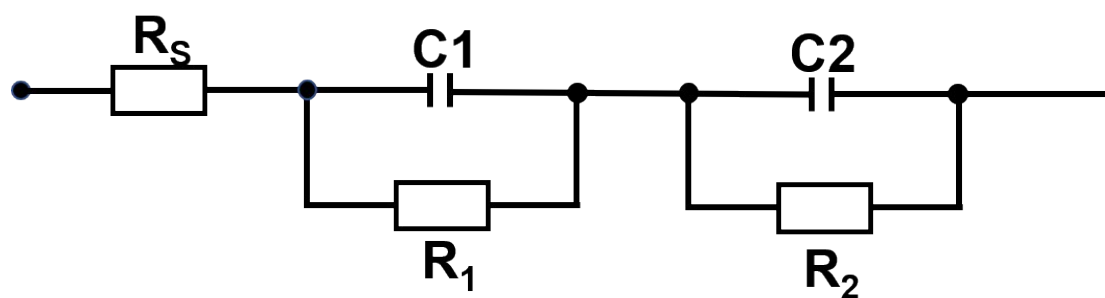


Figure S8. The equivalent circuit model of PSCs for EIS.

Table S1. Parameters of the time-resolved photoluminescence (TRPL) spectroscopy for perovskite films.

Sample	$A_1$ (%)	$\tau_1$ (ns)	$A_2$ (%)	$\tau_2$ (ns)	$\tau_{\text{avg}}$ (ns)
Pristine	59	8.1	19.4	70.8	54.50
4NPN	16.78	48.22	96.8	232.97	226.51