

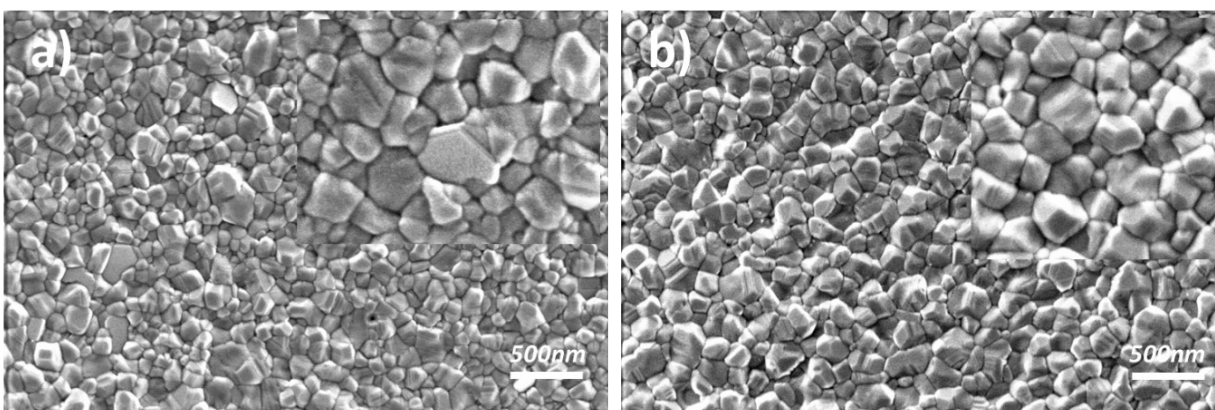
## Supporting information

### Decreased surface defects and non-radiative recombination via passivation of halide perovskite film by 2-Thiophenecarboxylic acid in triple-cation perovskite solar cells

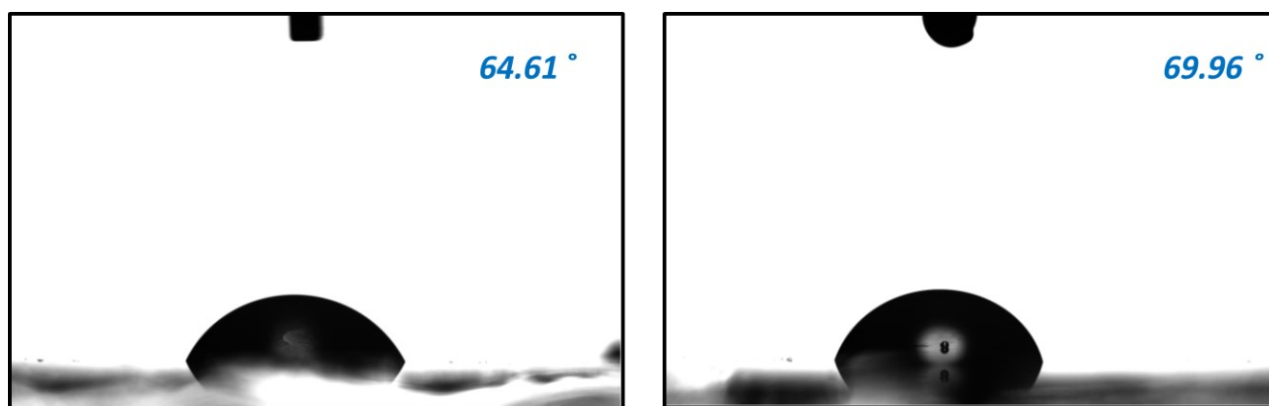
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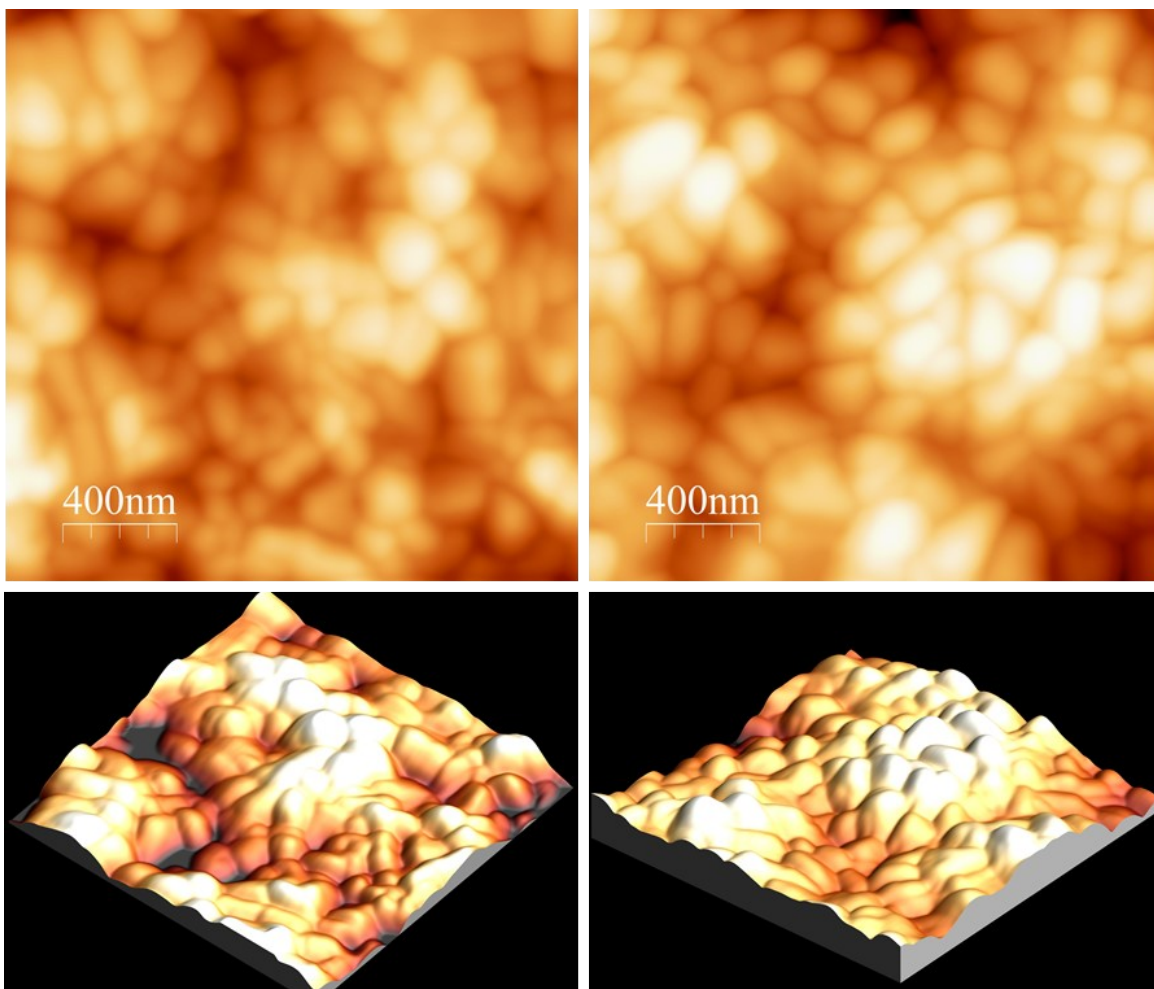
KEYWORDS perovskite, solar cell, defect passivation, recombination, long-term stability



**Figure S1.** SEM images of without (a) and with 2TiCOOH (b) passivation of perovskite layer.



**Figure S2.** Contact angle measurements of without (a) and with 2TiCOOH (b) passivation of perovskite layer.



**Figure S3.** AFM image of without (a) and with  $2\text{TiCOOH}$  (b) passivation of perovskite layer

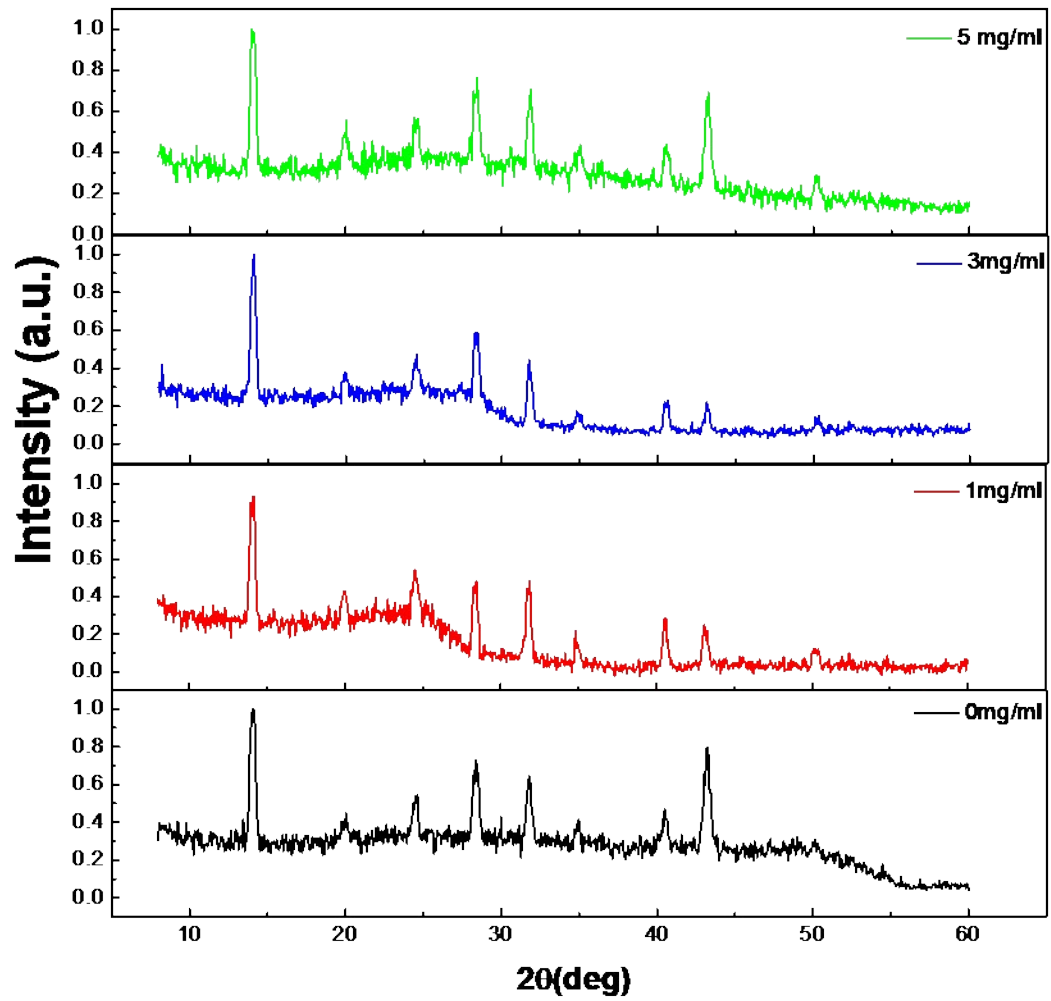
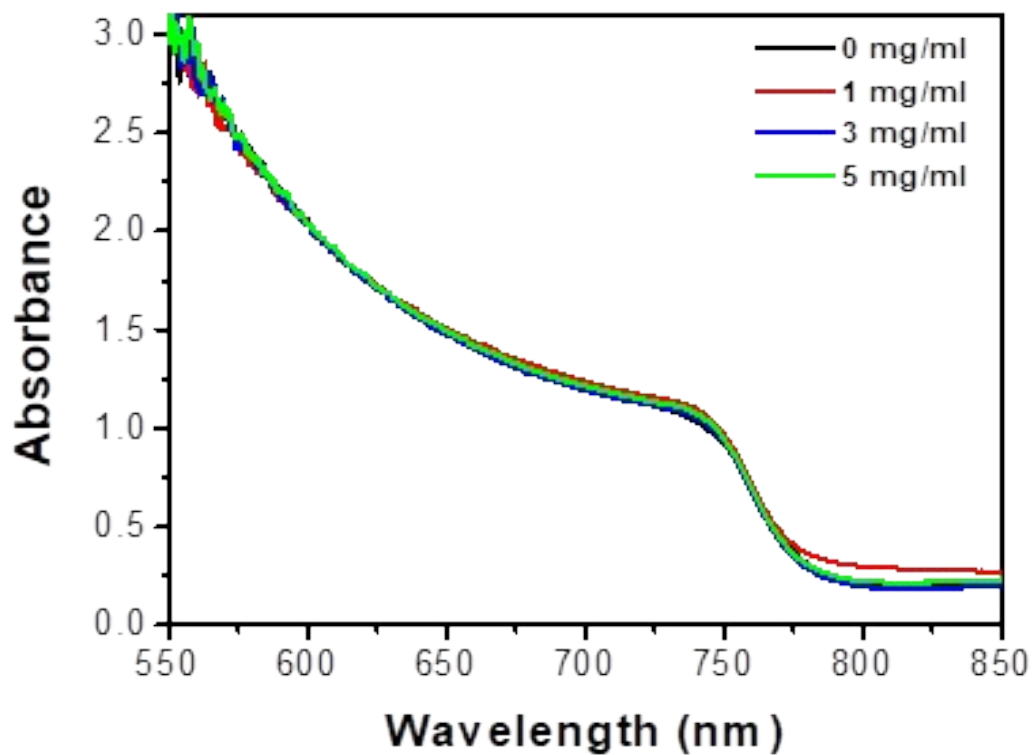


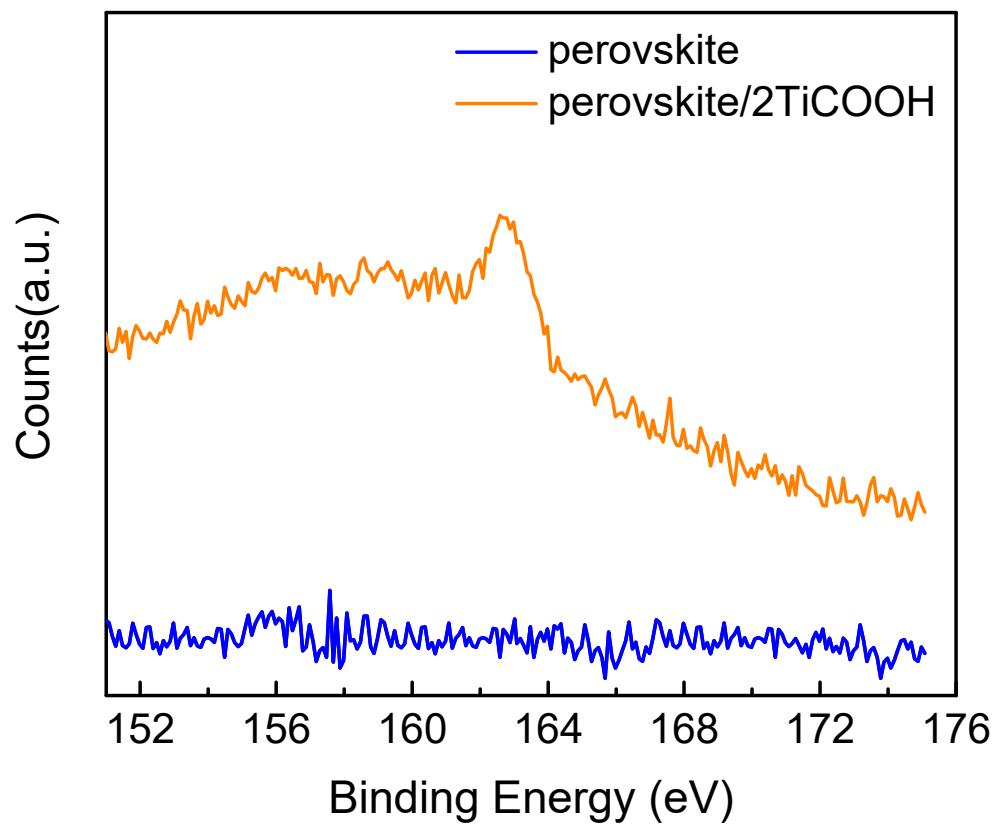
Figure S4. XRD results of without and with 2TiCOOH passivation of perovskite film.



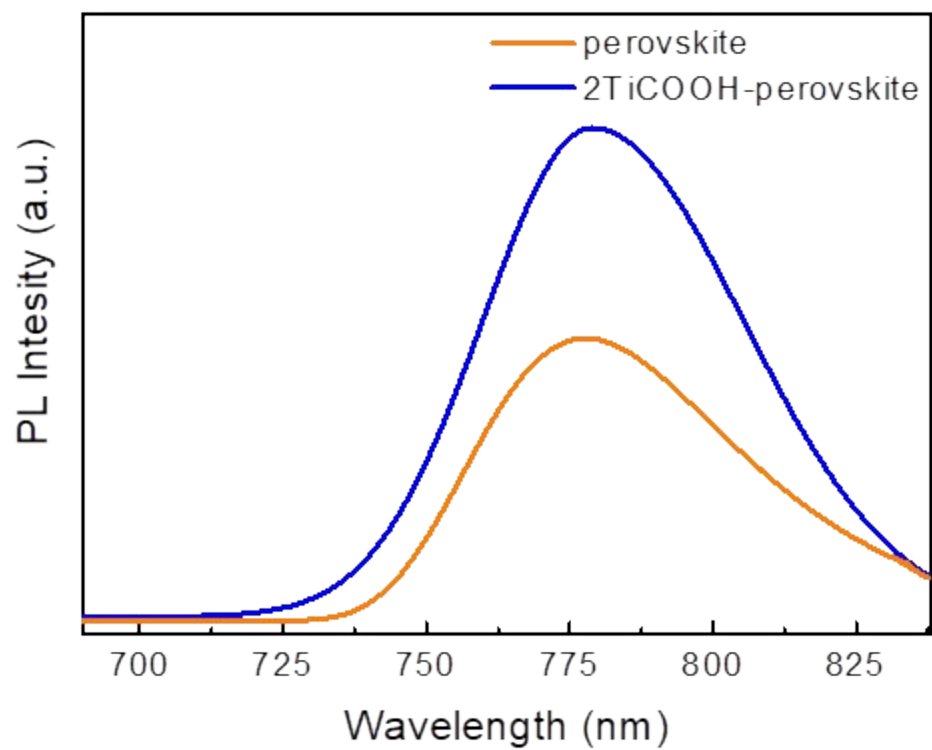
**Figure S5.** Uv-vis spectra of without and with 2TiCOOH passivation of perovskite film

**Table S1.** Dark current density voltage device parameters of perovskite solar cells without and with 2TiCOOH passivation.

	<b>Jo (mA/cm<sup>2</sup>)</b>	<b>n</b>
<b>0 mg/ml</b>	<b>9.96x10<sup>-7</sup></b>	<b>1.85</b>
<b>3 mg/ml</b>	<b>8.24x10<sup>-8</sup></b>	<b>1.58</b>



**Figure S6.** XPS results of S 2p peaks derived from 2TiCOOH passivated and control perovskite films.



**Figure S7.** Steady-state PL decay of glass/perovskite and glass/perovskite/2TiCOOH films.