Supporting Information

$MAPbI_3$ incorporated with carboxyl groups chelated titania for planar perovskite solar cells in low-temperature process

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Synthesis of CH_3NH_3I

20 ml of hydroiodic acid was slowly dropped in to 50 ml of CH_3NH_2 and stirred for 2 h at 0 ° C. Then the solvent was removed by rotary evaporator. The as-prepared powders was dissolved in ethanol and re-crystalized with diethyl ether. The process was repeated three times, resulting in CH_3NH_3I.

Preparation of h-TAc

Titanium (IV) isopropoxide (12 g) was mixed with acetic acid (2.4 g). After 10 min, the solution was slowly dropped in to 200g of deionized water. After 12-h stirring at room temperature, the solution was added with 2 g of nitric acid and heated at 80 ℃ for 75 min, resulted a stable light-blue suspension of TiO_2 (TAc). The as-prepared TAc solution (100g) was placed in a 225ml autoclave and heated at 250 ° C for 12 hours. The resulting solid was washed three times with deionized water through centrifugation (12000 rpm for 30 min). The purified solid was re-dispersed into DMF, resulting in h-TAc solution (5.8 wt%).

Table S1. Particle size distribution of h-TAc.

	Distribution Result (nm)	D10 (nm)	D50 (nm)	D90 (nm)
h-TAc	82.3	55.5	74.7	115.1

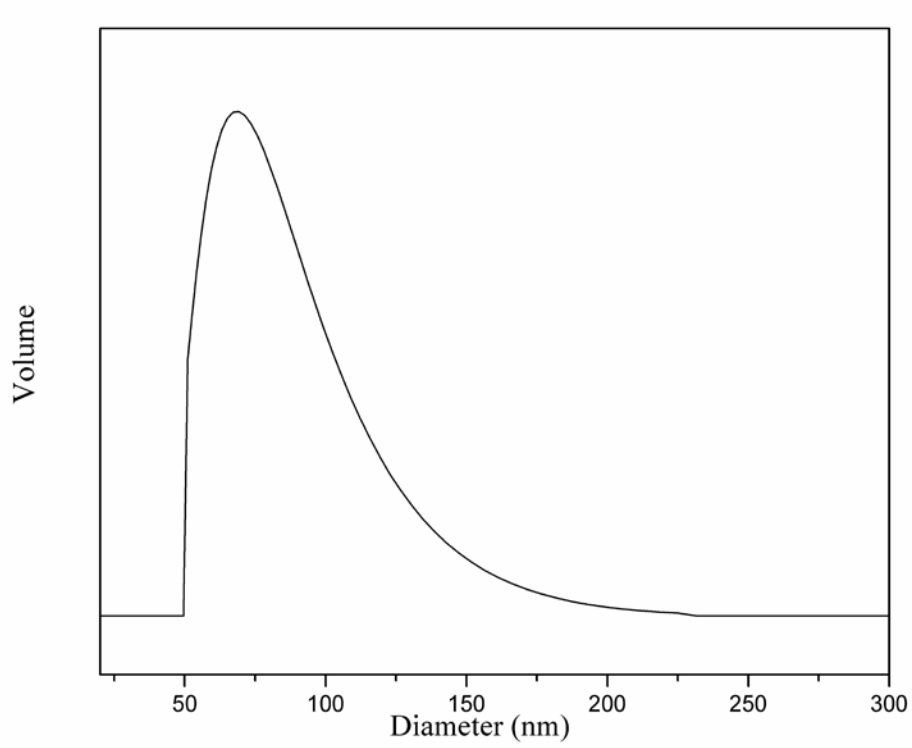


Fig. S1. Particle size distribution of h-TAc.

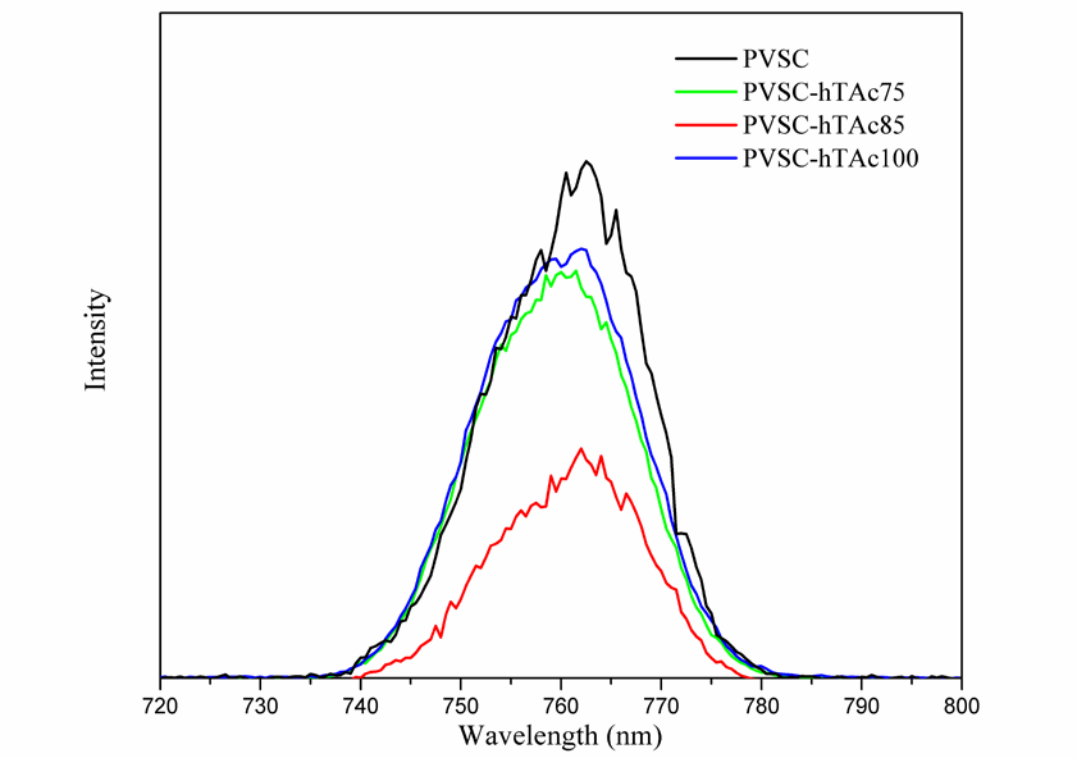


Fig. S2. PL spectra of $MAPbI_3$ layers incorporated with various h-TAc amounts.

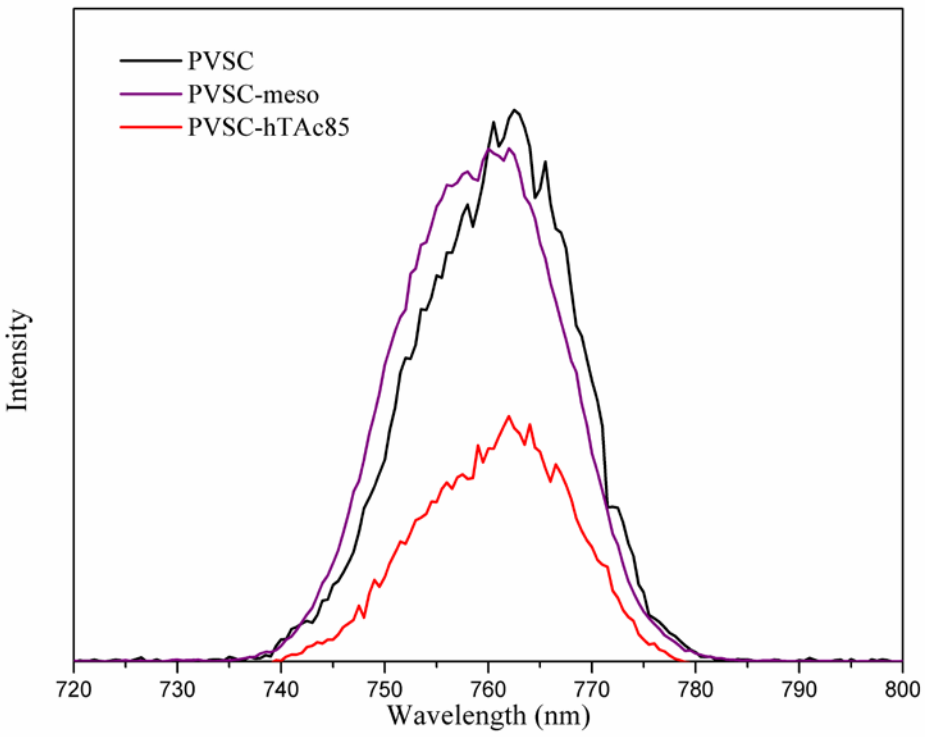


Fig. S3. PL spectra of PVSC, PVSC-meso, and PVSC-hTAc85.

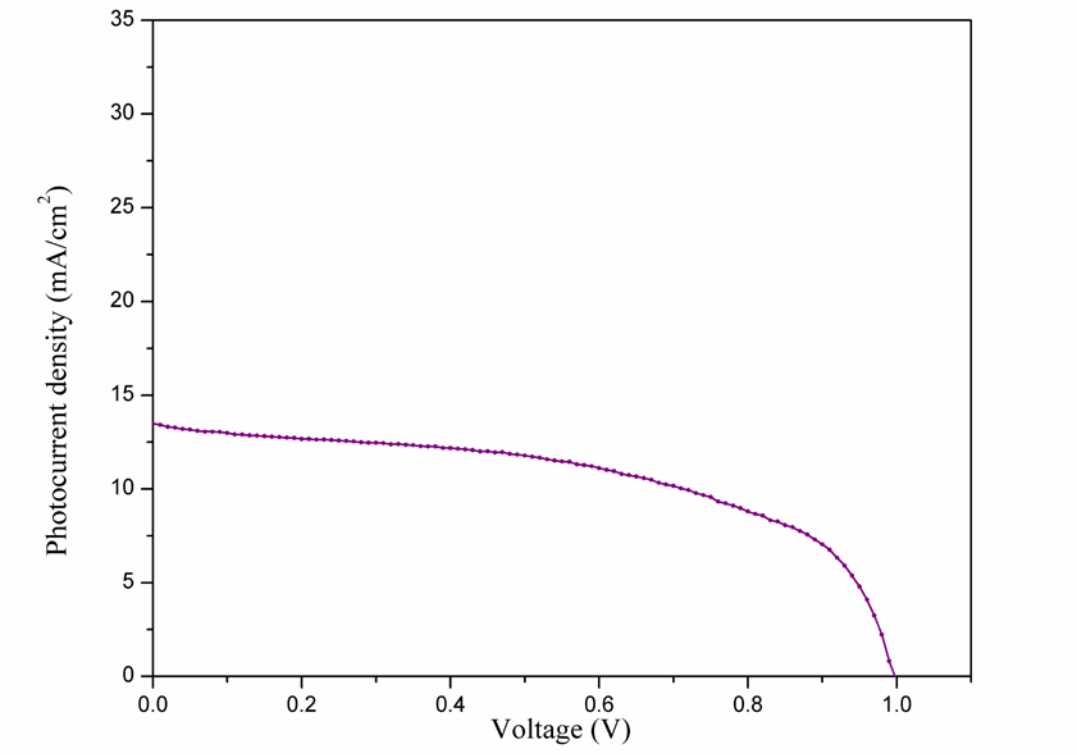
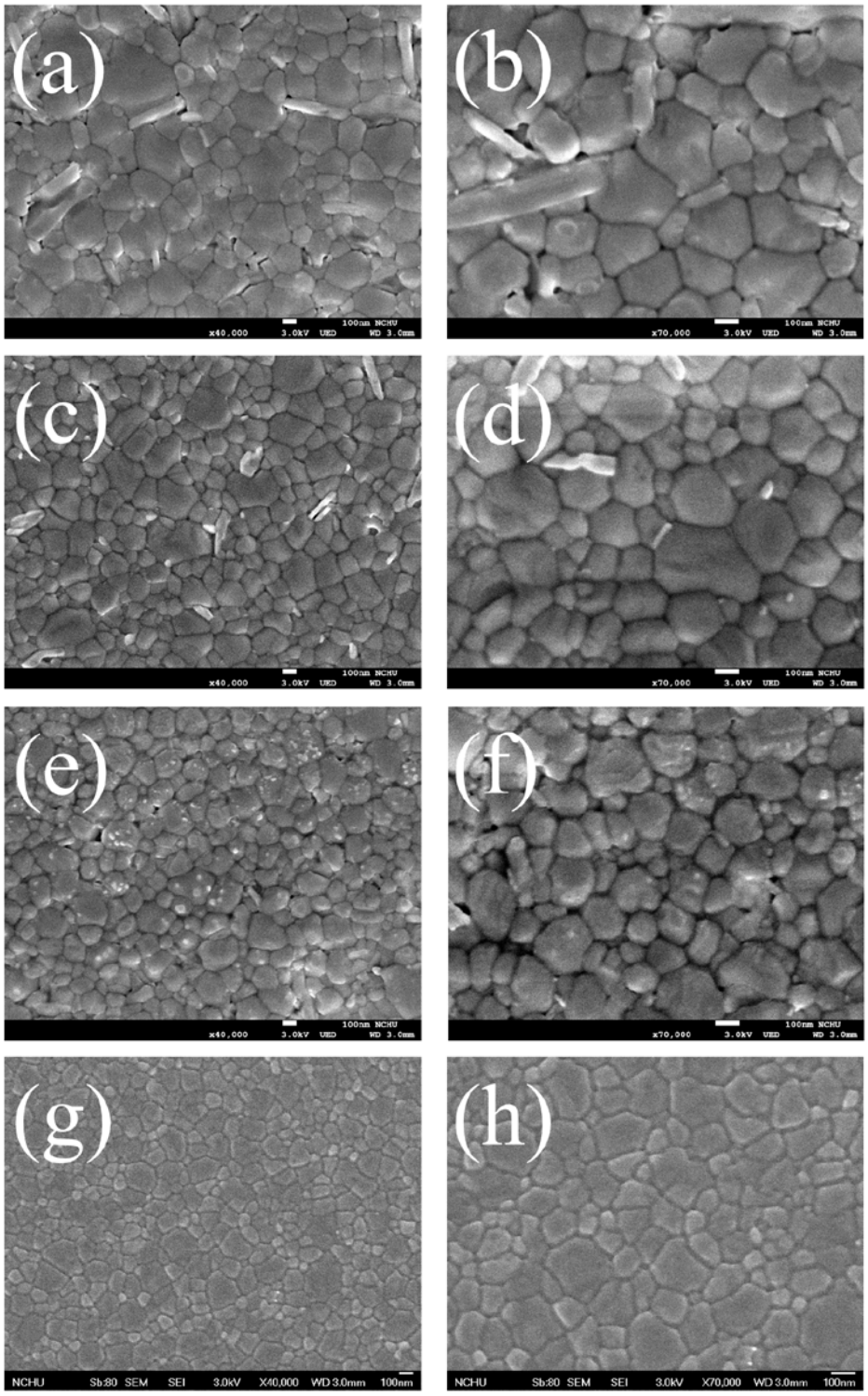


Fig. S4. Photocurrent density-voltage curves of PVSC-meso.



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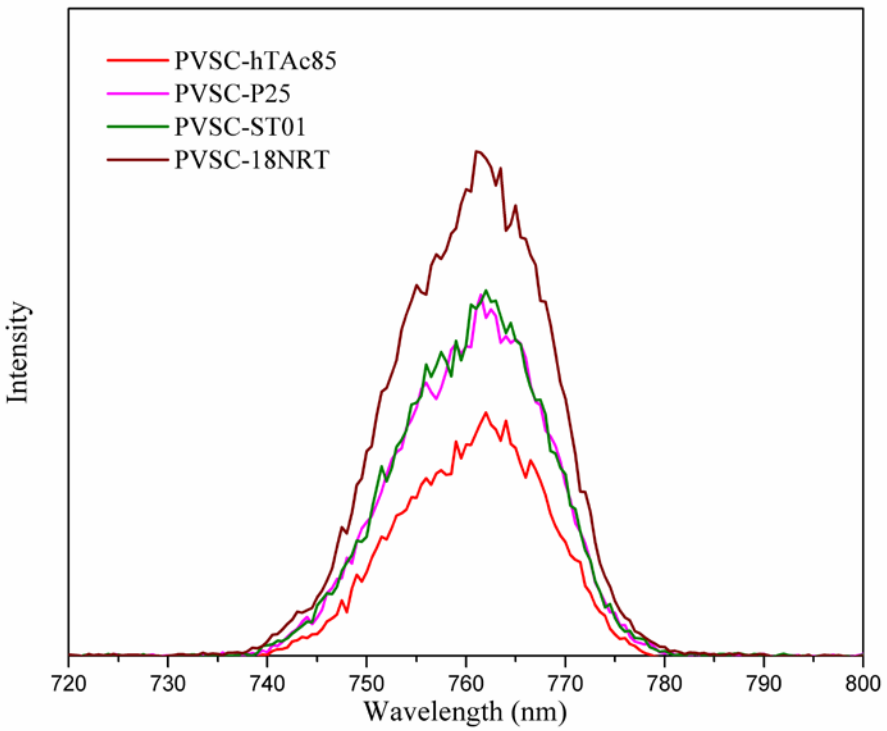

Fig. S6. PL spectra of $MAPbI_3$ layers incorporated with different kinds of TiO_2.

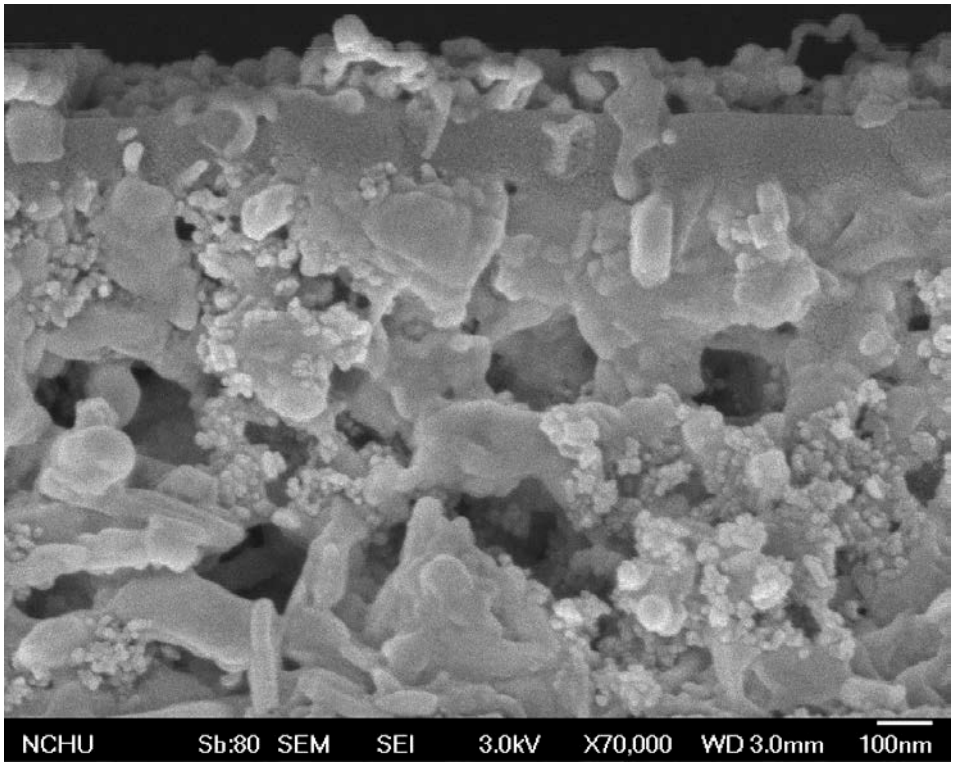

Fig. S7. Cross-sectional SEM image of PVSC-18NRT.

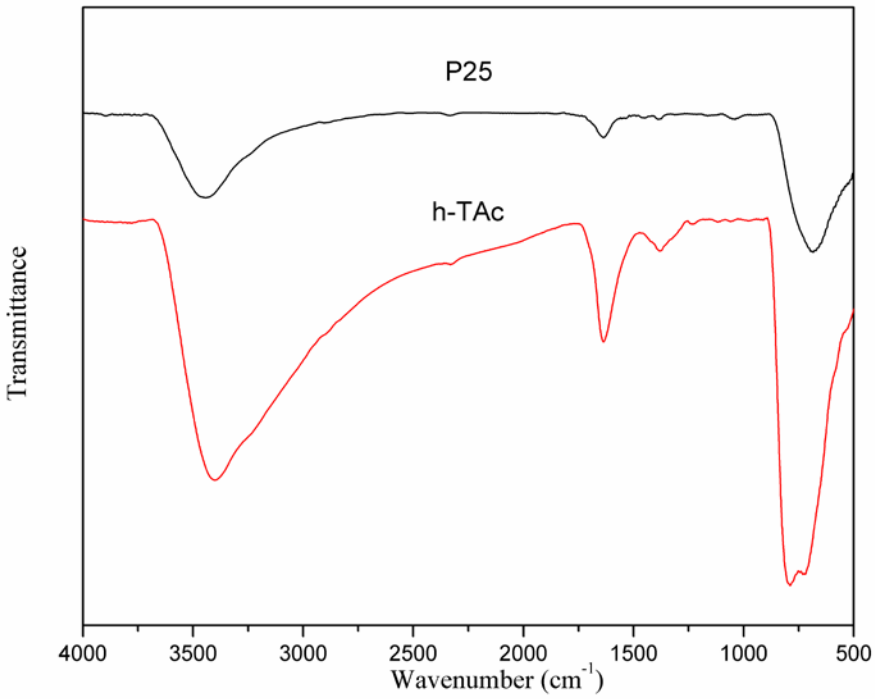

Fig. S8. FTIR spectra of h-TAc and P25.