

## Electronic supplementary information

### **Efficient Planar Perovskite Solar Cells via Low-Pressure Vapor-Assisted Solution Process with TiO<sub>2</sub>/Fullerene as Electron Collection Bilayer**

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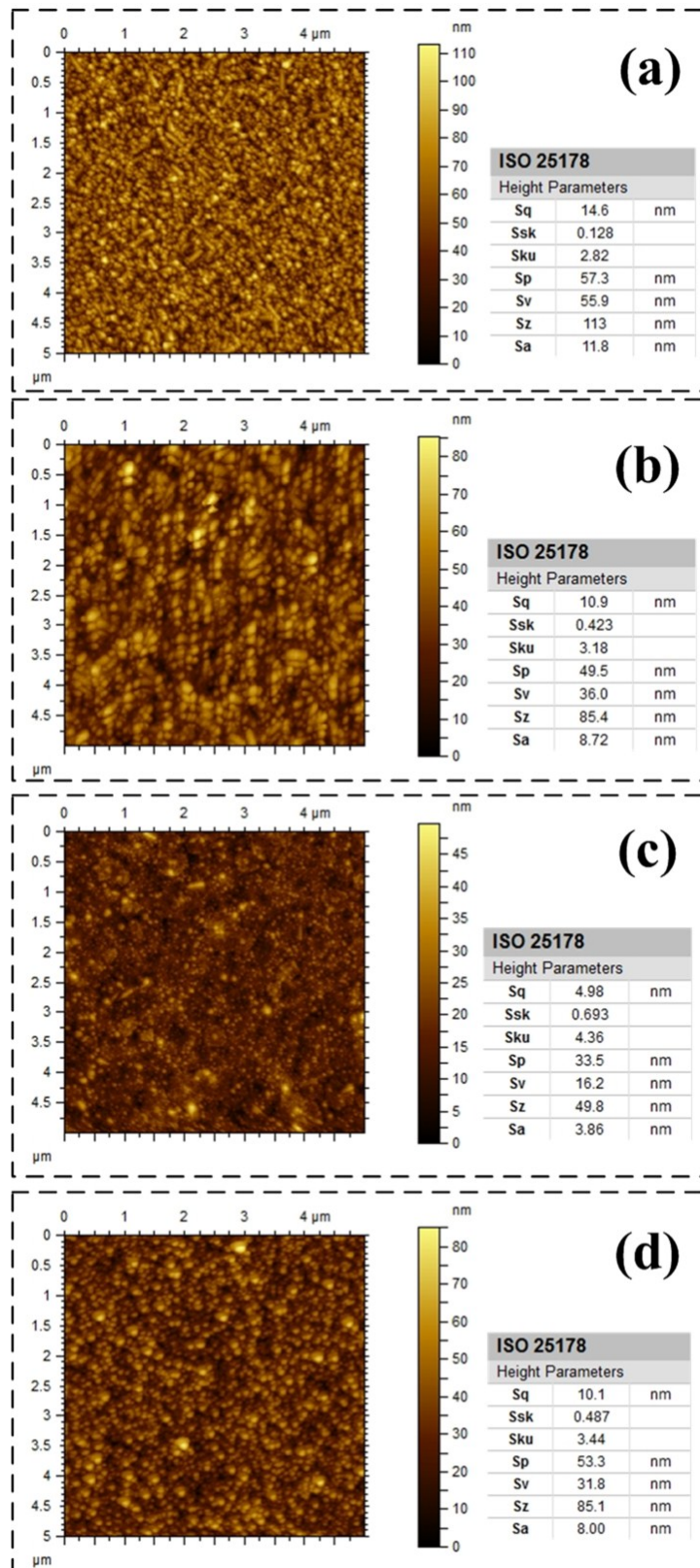


Fig. S1 AFM images of (a) bare FTO substrate, (b)  $\text{TiO}_2$  layer on FTO substrate, and  $\text{C}_{60}$  layers on  $\text{TiO}_2/\text{FTO}$  substrate (c) before and (d) after processed with DMF solution.

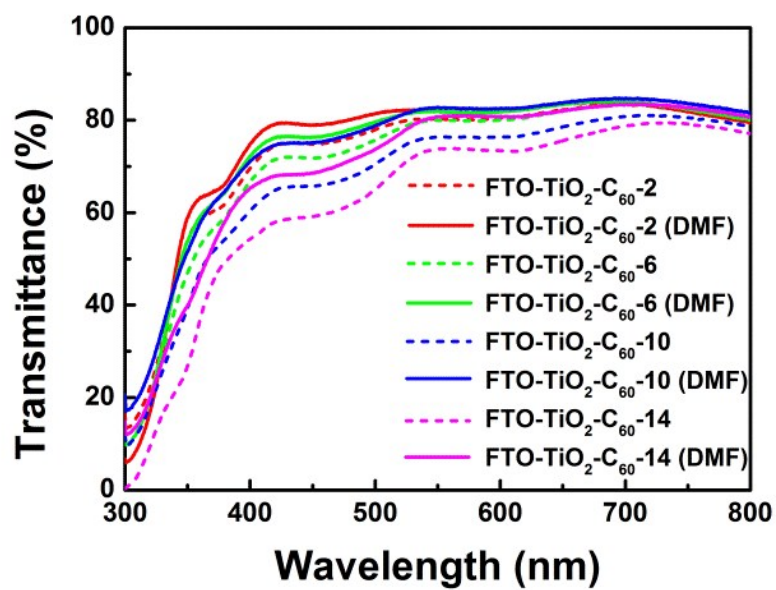


Fig. S2 Transmission spectra of FTO/TiO<sub>2</sub>/C<sub>60</sub>-x (x=2, 6, 10, and 14) samples before and after processed with DMF solutions.

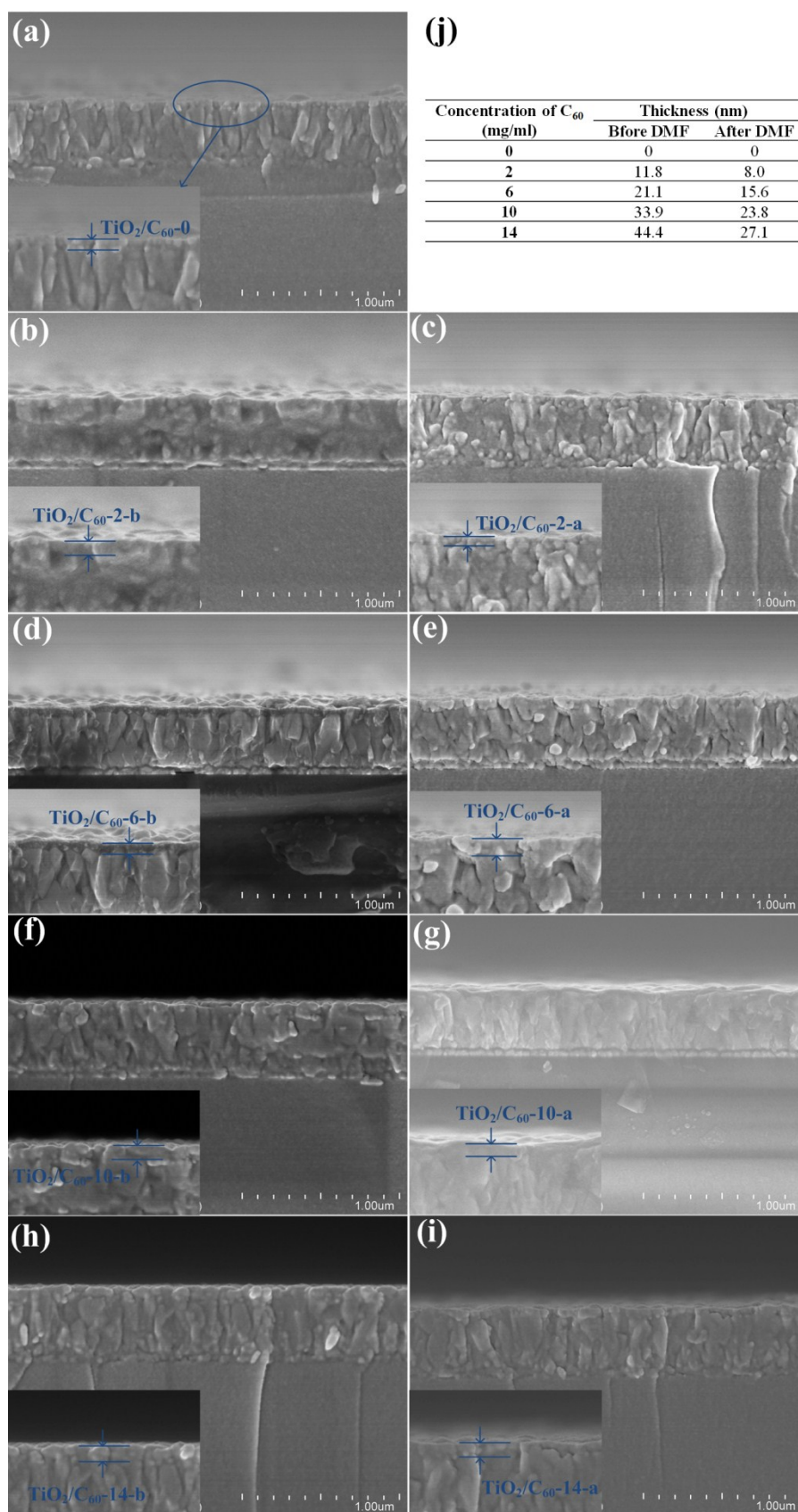


Fig. S3 Cross-sectional SEM images of FTO/TiO<sub>2</sub>/C<sub>60</sub>-*x* samples. (a) *x*=0. Only TiO<sub>2</sub> layer was deposited on the FTO substrate. (b) and (c) *x*=2. (d) and (e) *x*=6. (f) and (g) *x*=10. (h) and (i) *x*=14. (b), (d), (f) and (h) are the as-fabricated samples without the

DMF process. (c), (e), (g) and (i) are samples after the DMF blank solvent coating process. Multipoint measurement method was used to obtain the thicknesses from the SEM images. The average thicknesses of the  $C_{60-x}$  ( $x=2, 6, 10$  and  $14$ ) layers before and after the DMF processes were calculated by the differences between the thicknesses of the  $TiO_2/C_{60-x}$  ( $x=2, 6, 10$  and  $14$ ) layers and the  $TiO_2/C_{60-x}$  ( $x=0$ ) layer, which were summarized in (j).

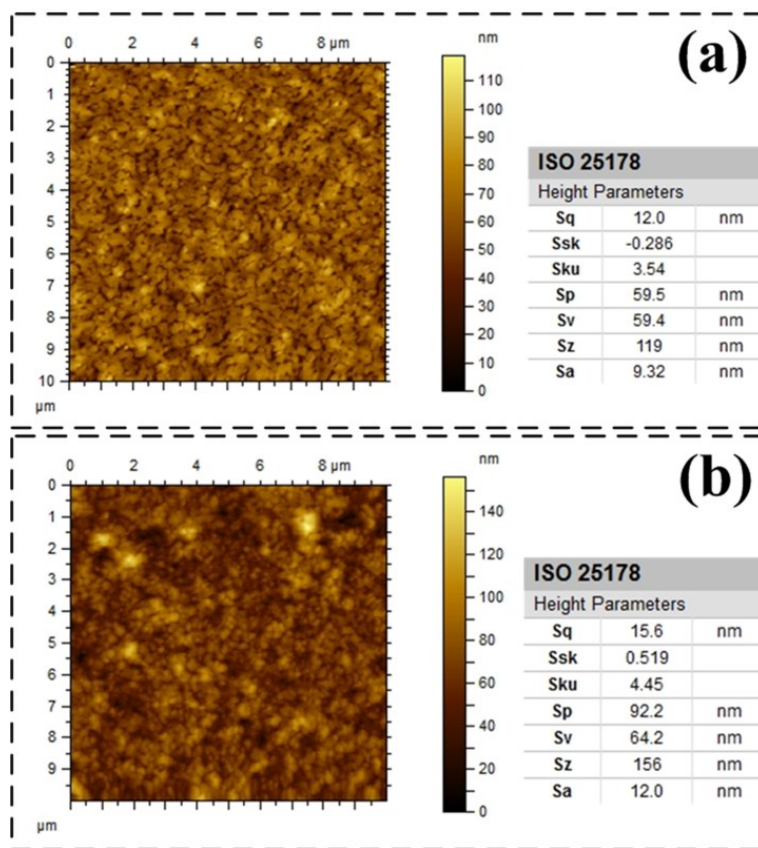


Fig. S4 AFM images of  $PbI_2$  layer prepared through spin coating on (a) FTO/ $TiO_2$  and (b) FTO/ $TiO_2/C_{60-6}$  substrates.

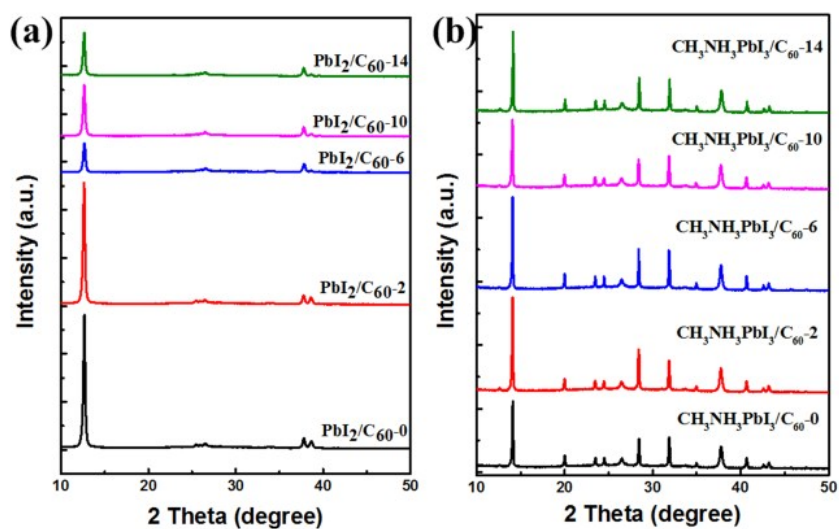


Fig. S5 XRD patterns of (a) FTO/TiO<sub>2</sub>/C<sub>60</sub>/PbI<sub>2</sub> samples and (b) FTO/TiO<sub>2</sub>/C<sub>60</sub>/CH<sub>3</sub>NH<sub>3</sub>PbI<sub>3</sub> samples depend on the C<sub>60</sub> solution concentration.

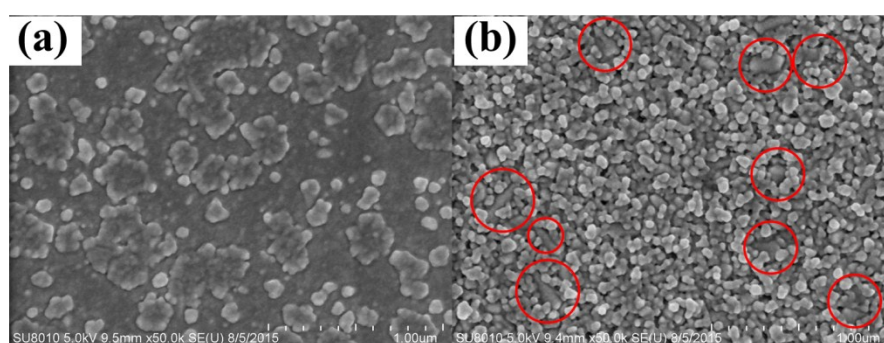


Fig. S6 SEM images of the C<sub>60</sub>/FTO (a) before and (b) after processed with DMF

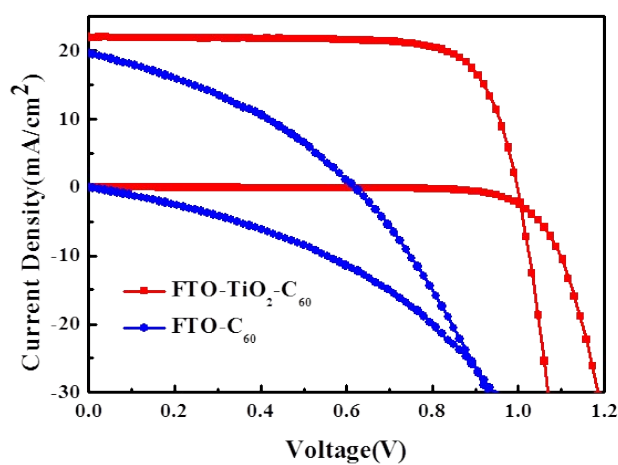


Fig. S7 *J-V* curves of PSCs with and without c-TiO<sub>2</sub> layer under light and dark

conditions

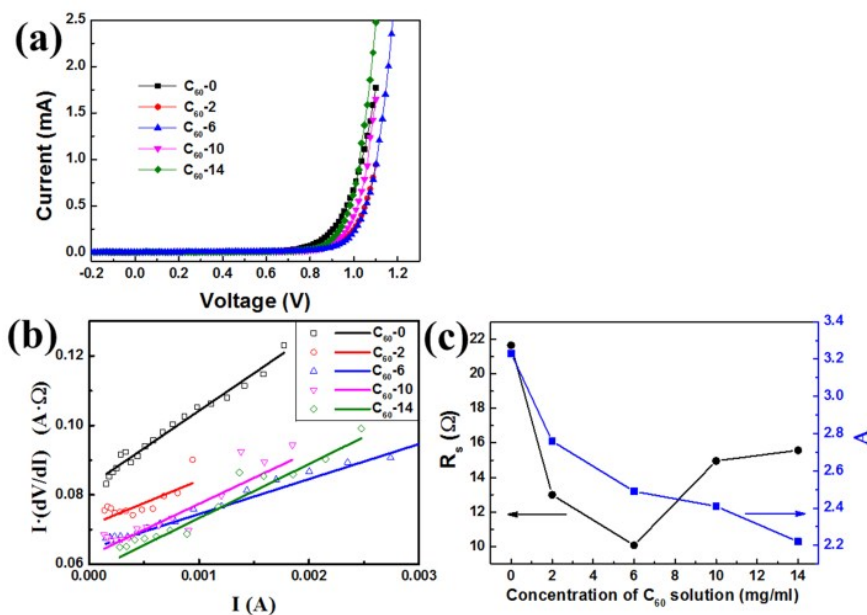


Fig. S8 (a) Current-voltage curves of PSCs without and with  $C_{60}$  interface layers which were prepared with different solution concentrations in dark. Data in (a) were

fitted with the formula:  $V = R_s I + (\ln I - \ln I_s) AkT/q$  or  $I \frac{dV}{dI} = R_s I + AkT/q$ . (b)

Plots of  $I \cdot (dV/dI)$  vs  $I$  which data came from curves in (a) and the linear fitting curves. (c) Series resistances ( $R_s$ ) and ideal factors ( $A$ ) derived from fitting curves in (b).

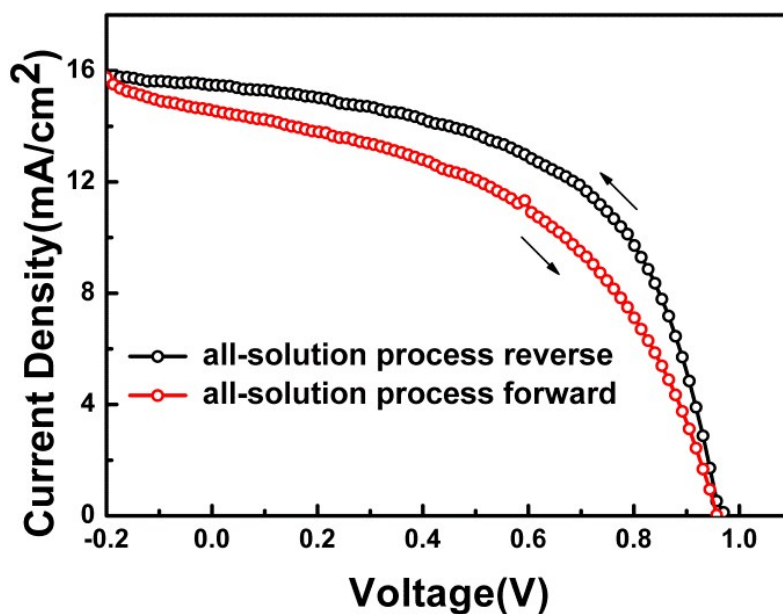


Fig. S9  $J$ - $V$  curves of the PSC with a high PCE via an all-solution process.

