Electronic Supplementary Material (ESI) for Nanoscale.

Supplement Information

Solvent Annealing of PbI_2 for High-Quality Crystallization of Perovskite Films for Solar Cells with Efficiency Exceeding 18%

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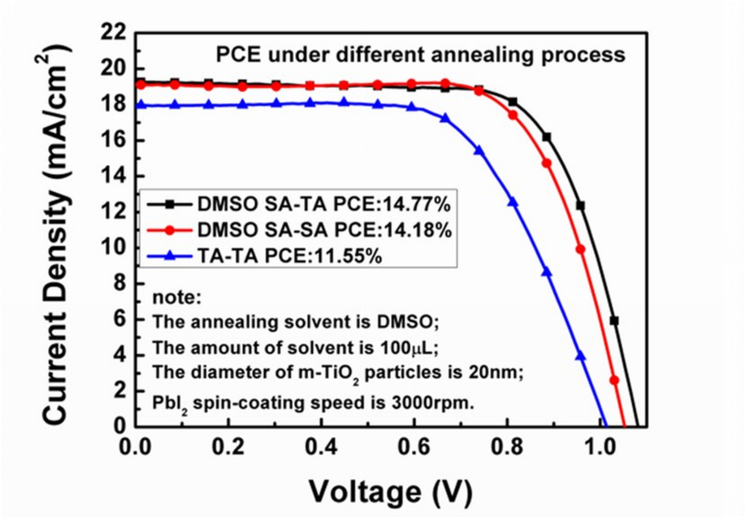
In this investigation, using the DMSO SA-TA process, a series of experiment parameters were studied to optimize the performance of solar cells. At first, we studied the TA-TA, DMSO SA-TA, DMSO SA-SA as shown in Figure S1, because the TA-SA process did not result in good results as described in the text. We found that the DMSO SA-TA annealing process is the best among TA-TA and DMSO SA-SA processes. This result is consistent with our previous conclusion using DMF in the text. It should be noted that we used the same petri dish. We studied the effect of different DMSO volumes on the device performance as shown in Figure S2. We found negligible difference in PCE by using different volumes of DMSO solution. We chose the volume of 50 μl in our subsequent experiments. The diameter of m-TiO_2

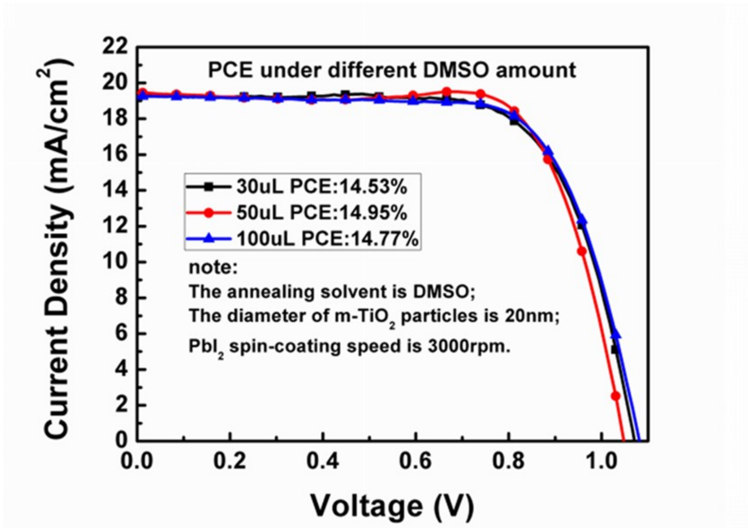
and the spin speed of PbI_2 were also investigated (Figure S3 and Figure S4). It can be seen in Figure S3 that m-TiO2 with the diameter of 30 nm results in better PCE. The first spin speed of PbI_2 significantly affected the device performance. As shown in Figure S4, the first spin speeds of 2500 rpm, 3000 rpm, and 3500 rpm resulted in PCEs of 14%, 15.7%, AND 17.1% separately. In addition, we studied thermal annealing (TA) of PbI_2 and the DMSO annealing of PbI_2 at 100°C for 10 min. After thermal annealing at 100°C, PbI_2 exhibits smooth and dense surface, while after annealing PbI_2 in DMSO at 100°C we obtained a surface that looks like needles but are actual many PbI_2 nanowires as shown in Figure S5. This suggests that lower temperature DMSO annealing is better for porous PbI_2。

Figure.S1 J-V curves and device performance of devices fabricated using different annealing processes (TA-TA, DMSO SA-TA and DMSO SA-SA).



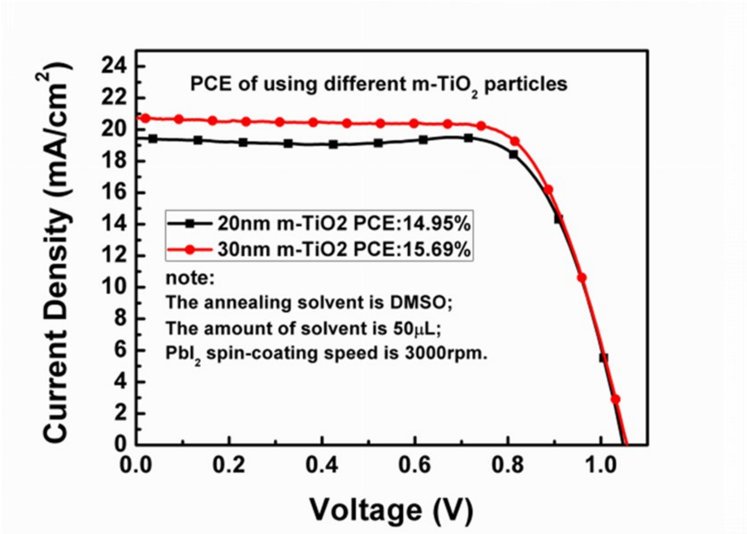
Annealing method	V_{oc} (V)	J_{sc} (mA/cm²)	FF (%)	PCE (%)
DMSO SA-TA	1.08	19.27	70.9	14.8
DMSO SA-SA	1.05	19.11	70.5	14.2
TA-TA	1.01	17.94	63.5	11.6

Figure.S2 J-V curves and device performance of solar cells fabricated using different volumes of DMSO solvent in the DMSO SA-TA process.



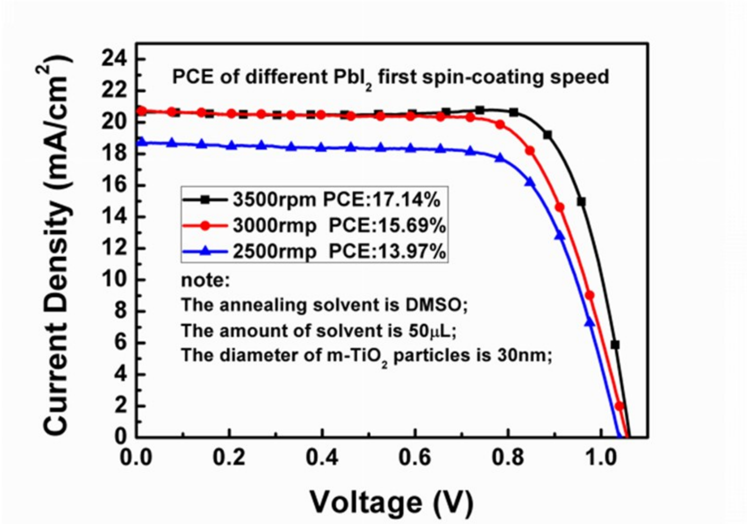
Amount of DMSO in SA process (uL)	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	PCE (%)
30	1.07	19.28	70.4	14.5
50	1.05	19.46	73.4	14.9
100	1.03	20.10	67.5	14.0

Figure.S3 J-V curves and device performance of devices fabricated using m-TiO_2 with different diameters.



Diameter of m-TiO_2 particles (nm)	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	PCE (%)
20	1.05	19.46	73.4	14.9
30	1.05	20.72	71.7	15.7

Figure.S4 J-V curves and device performance of devices fabricated using different spin-coating speeds for PbI_2.



Different spin-coating speed of PbI_2 (rpm)	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	PCE (%)
2500	1.04	18.70	71.9	13.9
3000	1.05	20.72	71.7	15.7
3500	1.06	20.68	78.1	17.1

Figure.S5 SEM images of Surface morphology of PbI_2 films obtained using different annealing processes at 100 °C.