Supporting Information

Control of the morphology of PbI_2 films for efficient perovskite solar cells by strong Lewis base additives

Xiaobing Cao,[a] Lili Zhi,[b] Yahui Li,[a] Fei Fang,[a,c] Xian Cui, [a] Youwei Yao,[c] Lijie Ci,[b] Kongxian Ding,[d] Jinquan Wei[a]*

[a]State Key Lab of New Ceramic and Fine Processing, School of Materials Science and Engineering, Tsinghua University, Beijing 100084, P.R. China

[b]School of Materials Science & Engineering, Shandong University, Jinan 250061, Shandong, P.R. China

[c]Institute of Advanced Materials, Graduate School at Shenzhen, Tsinghua University, Shenzhen 518055, P.R. China

[d]Shenzhen Jiawei Solar Lighting Co., Ltd., Fuping Road New Industrial Zone No. 1-4, Longgang District, Shenzhen 518112, Guangdong, P.R. China

*E-mail: jqwei@tsinghua.edu.cn

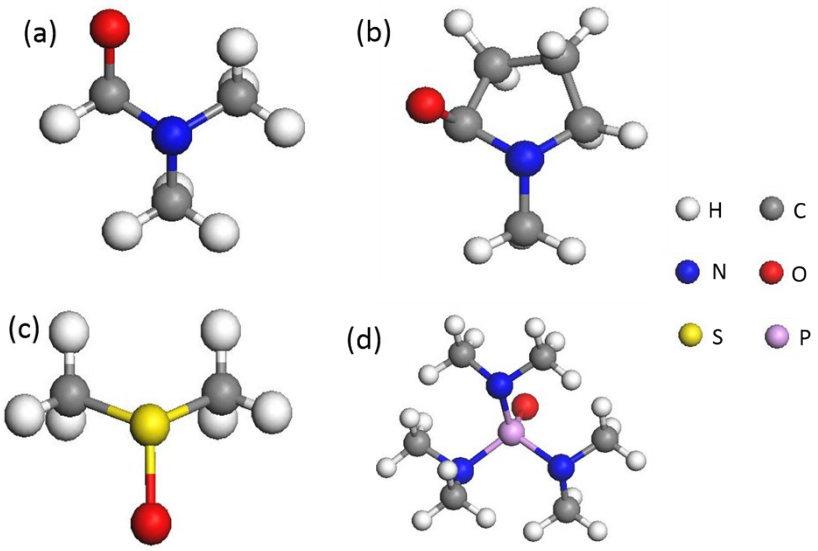

Figure S1 Molecule structure of the solvents. (a) DMF, (b) NMP, (c) DMSO, (d) HMPA

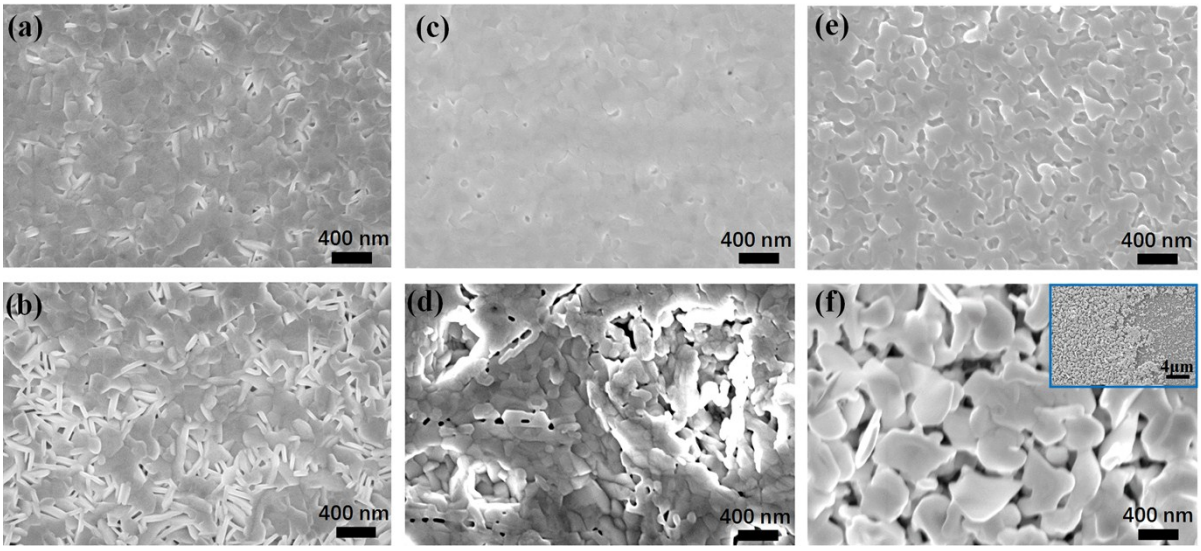

Figure S2. SEM images of the PbI_2 films fabricated from PbI_2/DMF solution with different Lewis base additives after annealing. (a) 10% NMP, (b) 20% NMP, (c) 10% DMSO, (d) 30% DMSO, (e) 2% HMPA, (f) 10% HMPA. Too much or too little additives (NMP, DMSO, or HMPA) in the PbI_2/DMF solution will significantly reduce pore structure, or lead to too many pores and even forming discontinuous films. Inset is a low magnification SEM image of the PbI_2 film fabricated from 10% HMPA, showing a discontinuous film.

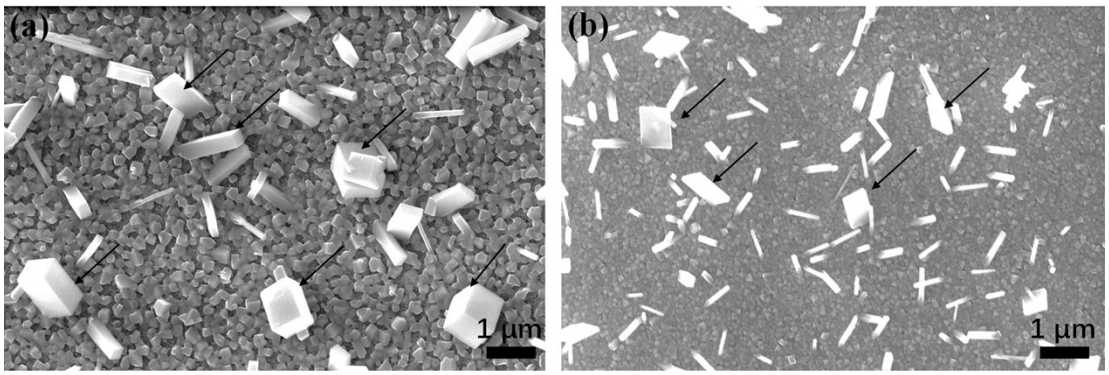

Figure S3. SEM images of perovskite film fabricated from different reaction times and MAI concentrations in the 2-isopropyl (IPA) solution. (a) Reaction for 20 min in 10 mg mL^{-1} MAI/IPA solution, (b) reaction for 10 min in 12 mg mL^{-1} MAI/IPA solution. Iodine-rich environment at the surface of perovskite film can provide driving force for the growth of cub-like $MAPbI_3$ (as shown by arrows) via dissolution and recrystallization growth process, which leads to rough surface the perovskite films.

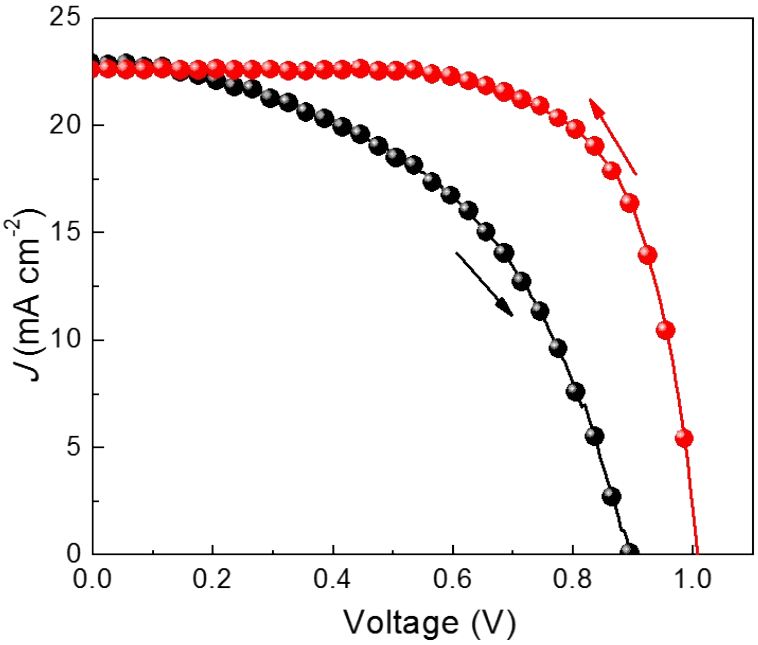

Figure S4. Hysteresis behaviors of a perovskite solar cell fabricated from solution with 20% DMSO additive. The perovskite solar cells exhibit typical hysteresis behaviors. There is obvious discrepancy between forward scan (dark line) and reverse scan (red line) density-voltage (*J-V*) curves.

Table S1 The statistical photovoltaic parameters of PSCs fabricated from different Lewis basicity solutions

Samples	J_{sc} (mA cm^{-2})	V_{oc} (V)	*FF*	PCE (%)
Pure DMF	19.48±1.34	0.97±0.02	0.57±0.04	10.47±1.13
30% NMP	20.36±1.10	0.98±0.01	0.65±0.03	13.10±0.82
20% DMSO	22.24±0.65	0.99±0.01	0.66±0.02	14.68±0.82
5% HMPA	18.32±1.23	0.92±0.03	0.59±0.05	10.11±1.21