Supporting Information

Fabrication of high quality perovskite films by modulating the Pb-O bonds

in Lewis acid-base adducts

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Figure S1. Top-view SEM images of the MAPbI₃ films fabricated from PbI₂ Lewis adducts which prepared from PbI₂/DMF solution with different Lewis bases additives. (a) 20% NMP, (b) 10 %DMSO, (c) 5% HMPA.



Figure S2. The distribution of grain size in the perovskite films fabricated from Lewis adducts which prepared from PbI₂/DMF solution with different Lewis bases additives. (a) Pure DMF, (b) 10% NMP, (c) 8% DMSO, (d) 2% HMPA. The results are obtained from the SEM images using a software of Nano Measurer 1.2.



Figure S3. SEM images of the annealed PbI_2 films fabricated from different solutions.

(a) Pure DMF, (b)10% NMP, (c)8% DMSO, (d)2% HMPA.



Figure S4. Low magnification SEM images of perovskite film fabricated from solutions with different DMSO additive. (a)4% DMSO, (b)8% DMSO, (c)12% DMSO. The largest perovskite grains fabricated from 8% DMSO exceed 1µm as emphasized in pictures. Deviation from the optimized concentration will reduce the size of perovskite grains.



Figure S5. Topological AFM images (inset: 3D topographic images) of the perovskite films fabricated from Lewis adducts which prepared from PbI₂/DMF solution with different Lewis bases additives. (a) Pure DMF, (b) 10% NMP, (c) 8% DMSO, (d) 2% HMPA



Figure S6. XRD curves of PbI_2 (dark) and PbI_2 -based Lewis adduct (red). The lattice spacing of PbI_2 increases from 6.98 Å to 9.23 Å after forming Lewis adduct of $PbI_2 \cdot DMF$ calculated from XRD curves through the Bragg law. The lattice of PbI_2 is expanded more than 30% due to the intercalation of solvent molecule through Pb-O bonds.



Figure S7. (a) XRD patterns and (b) Enlarged XRD patterns of the perovskite films prepared from Lewis adducts with different Lewis base additives. (c) UV-vis absorption spectra of the perovskite films fabricated from solutions with different Lewis base additives.



Figure S8. Molecule structure of the solvents. (a) DMF, (b) NMP, (c) DMSO, (d) HMPA



Figure S9 IPCE spectra of the perovskite solar cells



Figure S10. Hysteresis behaviors of the perovskite solar cells fabricated from Lewis adducts which prepared from PbI₂/DMF solution with different Lewis base additives. (a) Pure DMF, (b) 10% NMP, (c) 8% DMSO, (d) 2% HMPA. The serious hysteresis behavior may derive from ion migration ^{1, 2} or ferroelectric properties of MAPbI₃. ^{3, 4, 5}

References

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