Supporting Information


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Contents

Figure S1-S9

Table S1
**Figure S1.** Photos of perovskite precursor solutions with (a) 0 vol%, (b) 10 vol%, (c) 20 vol%, (d) 30 vol% and (e) 40% CB.

**Figure S2.** Photovoltaic performance of PSCs with the MAPbI$_3$ films deposited from precursor solutions added with different percentages of CB. (a) $J_{sc}$, (b) $V_{oc}$, (c) FF and (d) PCEs of PSCs obtained from 15 devices for each condition.
**Figure S3.** Grain sizes of perovskite thin films on PTAA deposited from precursor solutions added with different percentages of CB. SEM images of films deposited from solutions with (a) 10 vol% and (b) 30 vol% CB. The scale bar is 1 µm. Corresponding size distributions of grains in perovskite films added with CB of (c) 10 vol% and (d) 30 vol%.
Figure S4. AFM images of perovskite films deposited from precursor solutions added with CB of (a) 0 vol%, (b) 5 vol%, (c) 10 vol%, (d) 20 vol%, and (e) 30 vol%. The scale bar was 1 µm.
Figure S5. XRD patterns of (a) thermal-annealed perovskite films prepared from the precursor solutions added with different percentages of CB, (b) characteristic (110) peak of the thermal-annealed films, and (c) as-fabricated perovskite films before thermal annealing.
Figure S6. Time-resolved PL curves of perovskites films fabricated from precursor solutions with different percentages of CB. There was no CB in the precursor solution for the control sample.

Figure S7. UV-visible absorption spectra of different co-solvents without perovskite precursors.
Figure S8. The LaMer model describing the concentration change of the precursor solution as a function of time at a constant evaporation rate of the solvents.

Figure S9. SEM images of MAPbI$_3$ films on PTAA. The MAPbI$_3$ films were prepared (a) without CB in precursor solution and anti-solvent dripping during spin coating, (b) with 20% CB in precursor solution and without anti-solvent dripping during spin coating, (c) without CB
in precursor solution but with anti-solvent dripping during spin coating, and (d) with 20% CB in precursor solution and with anti-solvent dripping during spin coating.

**Supplementary Tables**

**Table S1.** Parameters of fitting the time resolved photoluminescence decay curves of perovskite films fabricated from precursor solutions with different percentages of CB.

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