

Supporting Information

The Mechanism of Universal Green Antisolvent for Intermediate Phase Controlled High-Efficiency Formamidinium-Based Perovskite Solar Cells

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Table S1 Physical characteristics of antisolvents commonly used to prepare PSCs

Solvent	Relative Polarity	Boiling Point (°C)
Water	1	100
Chlorobenzene (CB)	0.188	131.7
Anisole (ANS)	0.198	153.6
Diethyl ether (DE)	0.117	34.6
Diisopropyl ether (DIE)	0.110	68.3
Dibutyl ether (DBE)	0.071	140.3

Physical constants taken from reference¹.

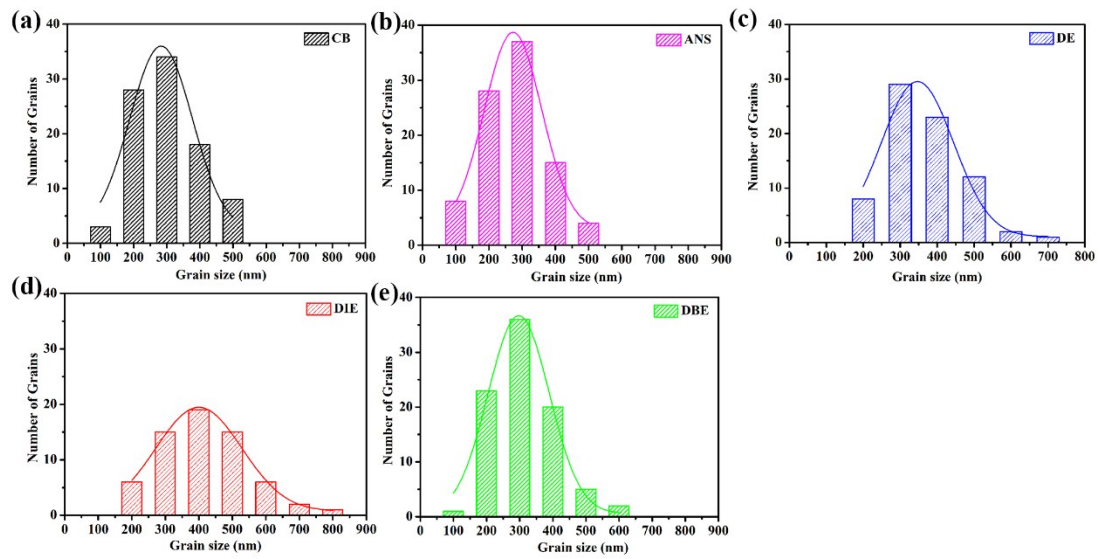


Figure S1. Statistical distributions of grain sizes of perovskite films prepared using (a) CB, (b) ANS, (c) DE, (d) DIE, and (e) DBE as antisolvents.

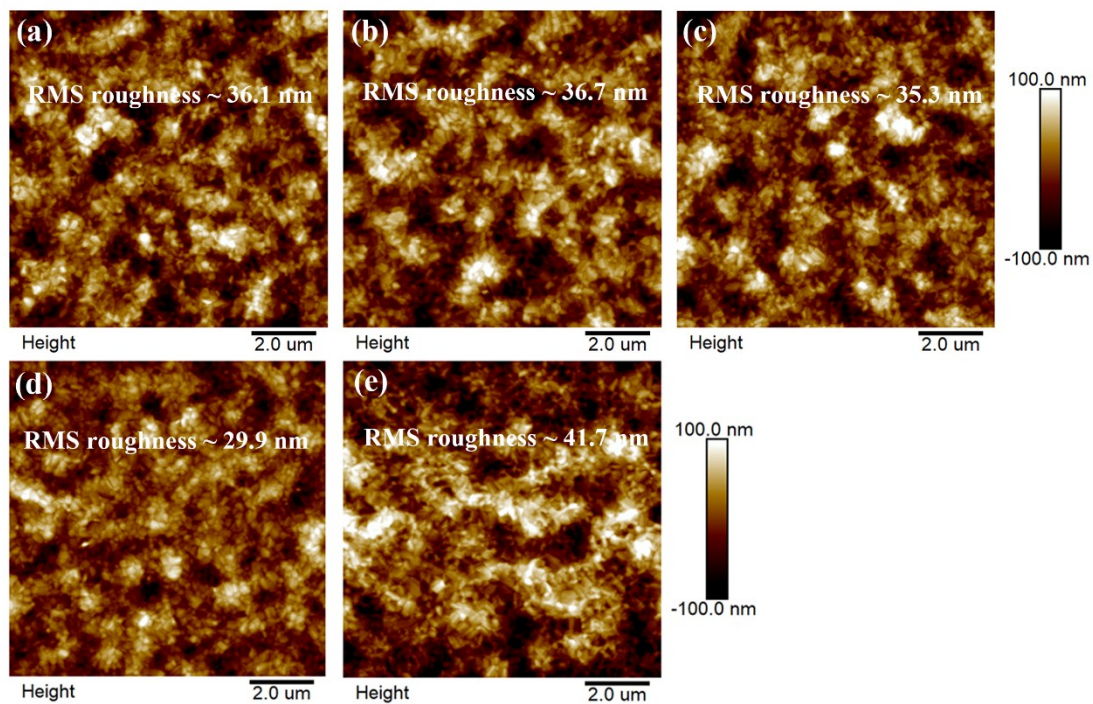


Figure S2. Top-view AFM images of perovskite films prepared using (a) CB, (b) ANS, (c) DE, (d) DIE, and (e) DBE as antisolvents.

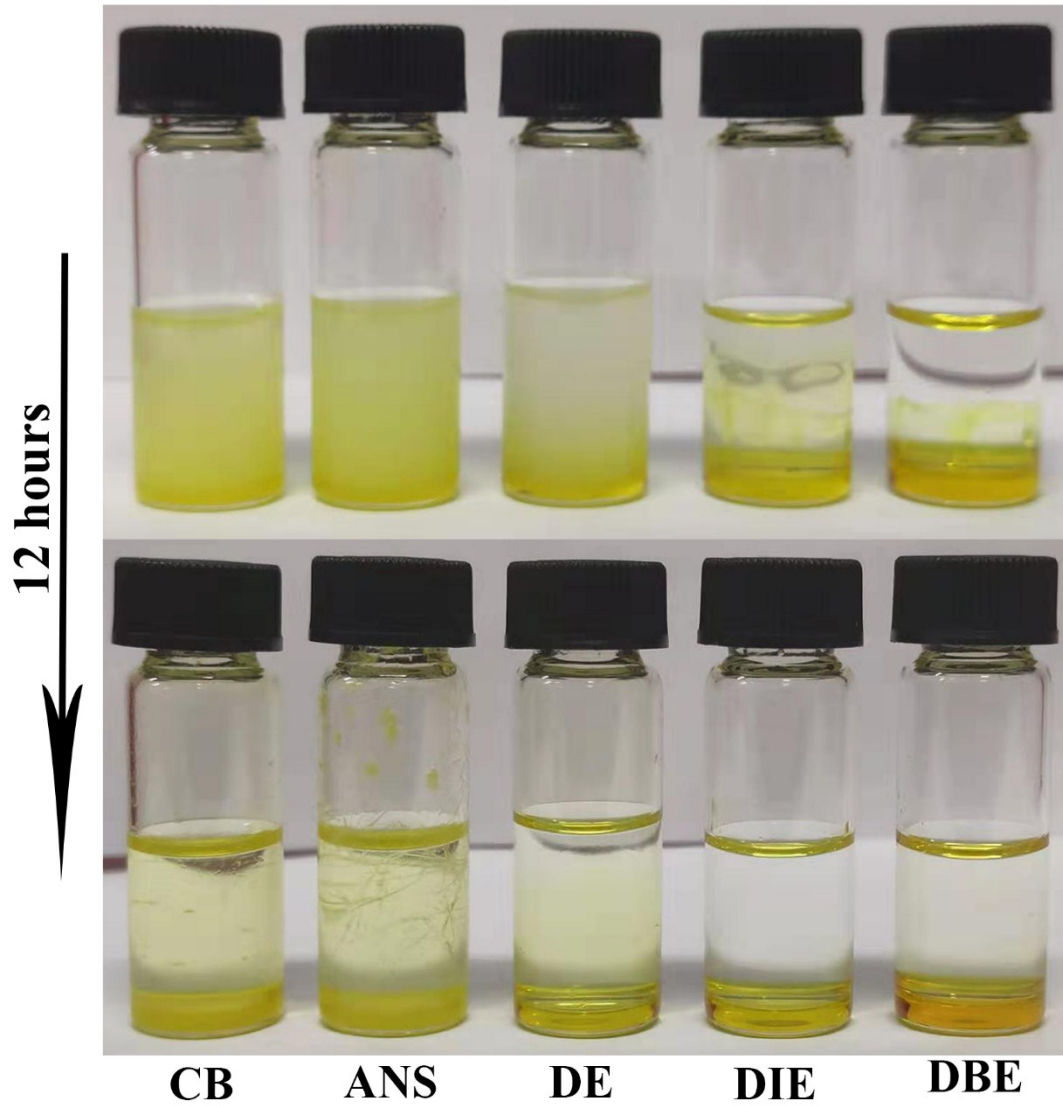


Figure S3. Photographs taken 0 and 12 h after adding various antisolvents into solutions of the perovskite precursor.

Table S2 Performances of PSC devices prepared on mp-TiO₂ as the ETL, with treatment using various common antisolvents

ET L	Antisolvent	Volume (μ L)	Perovskite system	PCE (%)	Published year	Ref.
Mesoporous TiO ₂	CB	100	Cs _{0.1} (FA _{0.83} MA _{0.17}) _{0.9} Pb(I _{0.83} Br _{0.17}) ₃	21.17%	2016	[2]
Mesoporous TiO ₂	DE	800	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	19.5%	2017	[3]
Mesoporous TiO ₂	ANS	200	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	19.4%	2018	[4]
Mesoporous TiO ₂	ANS	100	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.9} Br _{0.1}) ₃	20.2%	2018	[5]
Mesoporous TiO ₂	CB	200	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	20.8%	2018	[6]
Mesoporous TiO ₂	TL	200	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.9} Br _{0.1}) ₃	19.9%	2018	[6]
Mesoporous TiO ₂	TL	200	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	18.37%	2018	[7]
Mesoporous TiO ₂	ANS	800	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	20.53%	2018	[7]
Mesoporous TiO ₂	DIE	500	Cs _{0.05} (FA _{0.83} MA _{0.17}) _{0.95} Pb(I _{0.83} Br _{0.17}) ₃	21.26%		This work

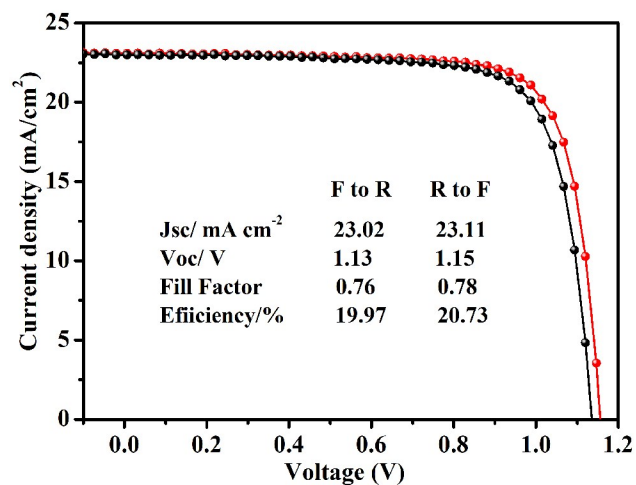


Figure S4. J - V characteristics of triple-mixed perovskite solar cells that had been prepared through treatment with DIE. Scan rate: 20 mV/s.

Table S3. Parameters determined from the TRPL spectra of FA/MA/Cs perovskite films that had been prepared through treatment with CB and DIE

Antisolvent	A_1 (%)	τ_1 (ns)	A_2 (%)	τ_2 (ns)	τ_{ave} (ns)
CB	11.24	4.67	88.76	46.08	41.42
DIE	10.97	4.97	89.03	52.42	47.22

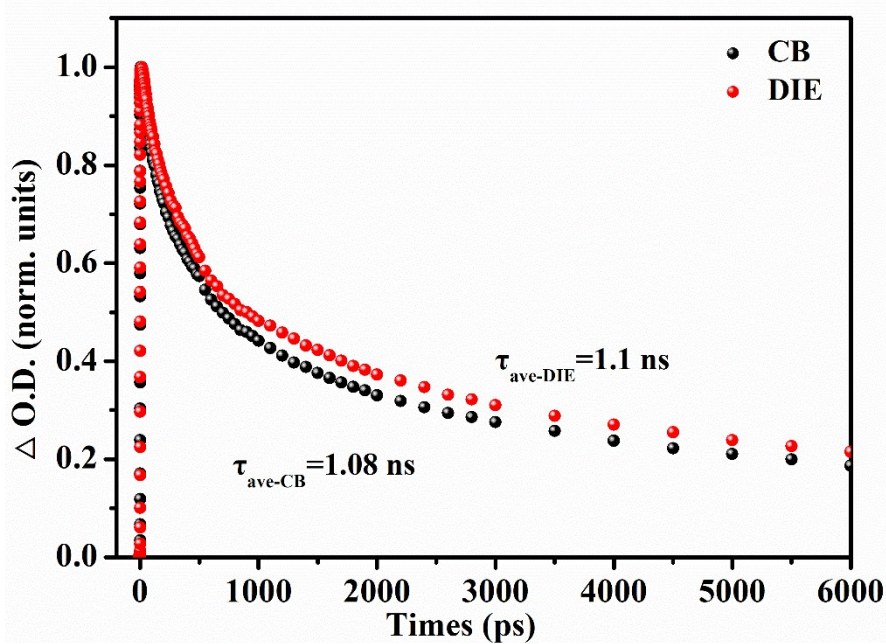


Figure S5. Normalized bleach kinetics for triple-mixed perovskite films treated with CB and DIE traced probed at 751 nm.

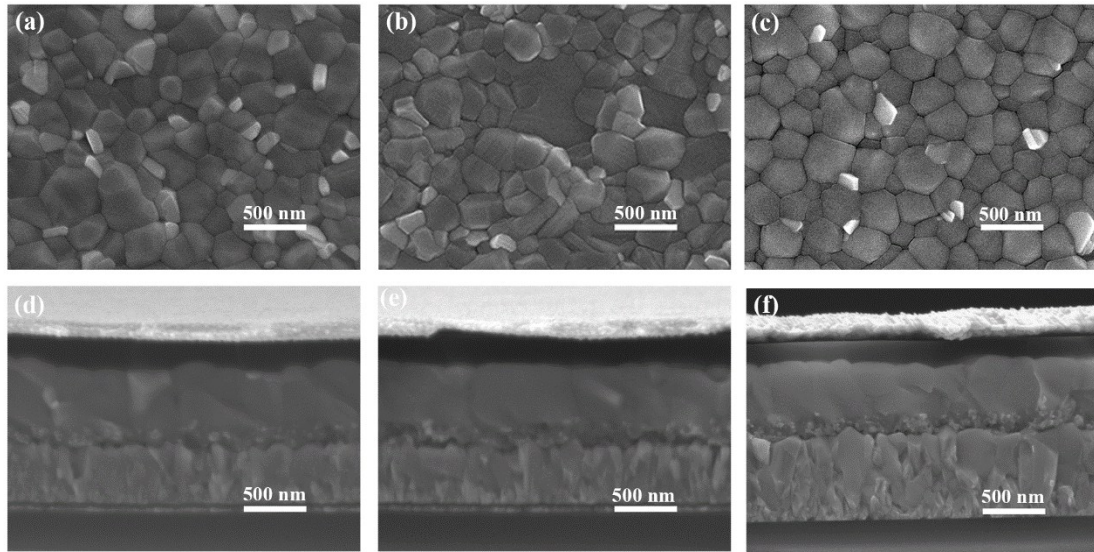


Figure S6. (a–c) Top-view SEM images of (a) FA/MA/Cs, (b) FA/MA, and (c) FA/Cs perovskite films that had been prepared through treatment with DIE. (d–f) Cross-sectional SEM images of complete (d) FA/MA/Cs, (e) FA/MA, and (f) FA/Cs perovskite devices.

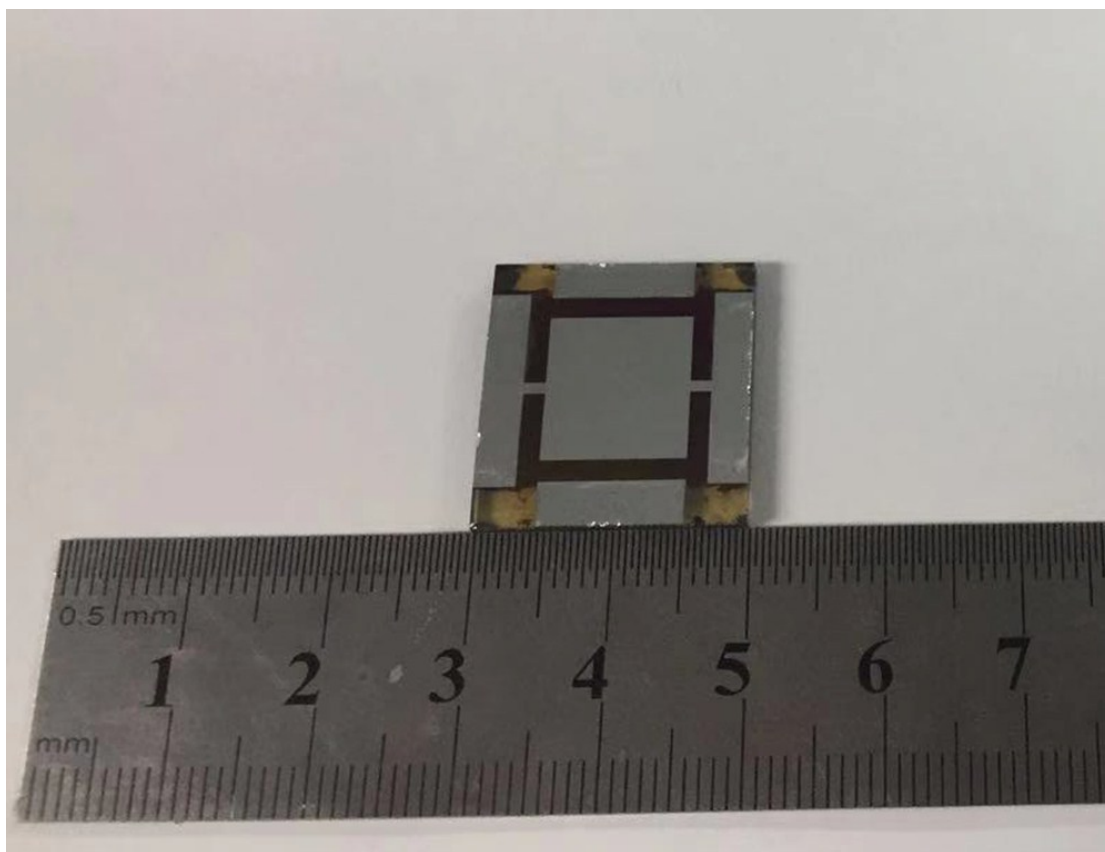


Figure S7. Photograph of a 1-cm² FA/MA/Cs PSC that had been prepared through treatment with DIE.

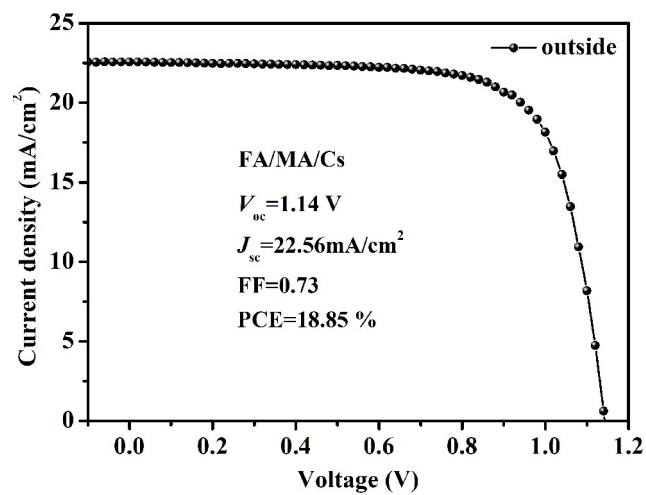


Figure S8. Current density–voltage (J – V) curve of the best-performing triple-anion PSC that had been prepared through treatment with DIE under ambient conditions (RH: 30–35%).

References

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