Electronic Supplementary Material (ESI) for Green Chemistry.

Supporting Information

Antisolvent Effects in Green Solvent Engineering of FA-based Quasi-2D Ruddlesden-Popper Perovskite Films for Efficient Solar Cells

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Fig. S1 The optical image solution of FA-based quasi-2D perovskite in TEP.

Table S1 Physical properties of solvents and antisolvents.

Solvents	Boiling Point(℃)	Viscosity	Polarity	GHS symbol
N,N-Dimethylf-ormamide (DMF)	153	1.3	6.4	
Chlorobenzene (CB)	132	0.8	2.70	
Triethyl phosphate (TEP)	219	1.6	3.30	
Dibutyl ether (DBE)	143	0.7	0.72	
Petroleum ether(PE)	60~90	0.3	0.01	

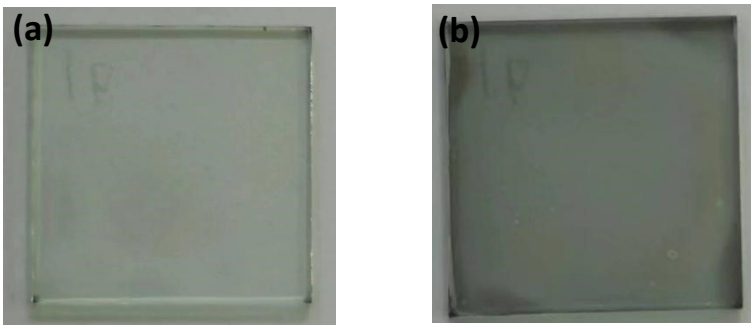

Fig. S2 The photograph of films prepared from TEP without dipping antisolvent, (a) the unannealed film; (b) the annealed perovskite film.

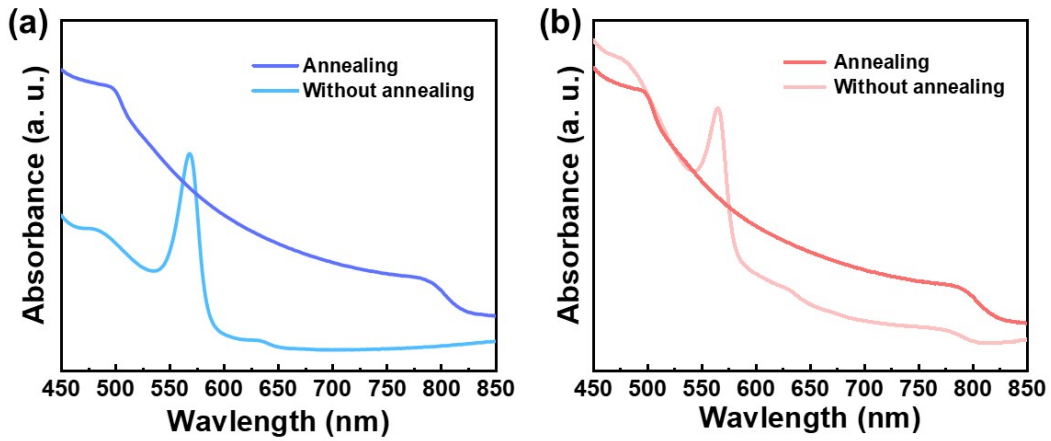

Fig. S3 The UV absorption spectra of intermediate phase and quasi-2D perovskite film prepared from DBE and PE. (a) DBE; (b) PE.

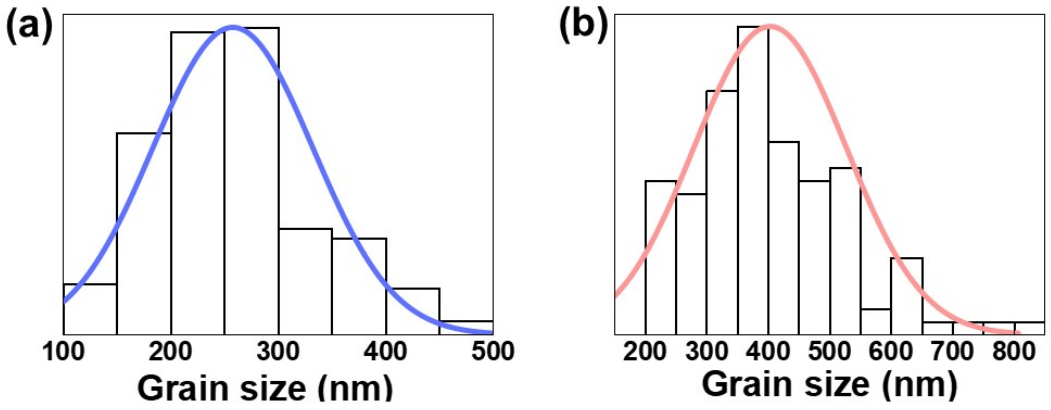

Fig. S4 The distribution histogram of grain sizes from FA-based quasi-2D perovskite films fabricated with (a) DBE (b) PE.

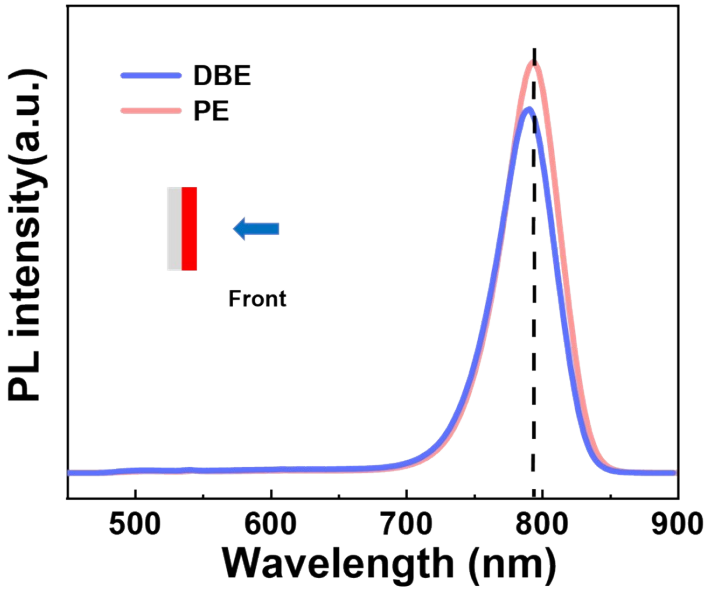

Fig. S5 The steady-state PL spectra from top (film) to bottom (glass) side of prepared films.

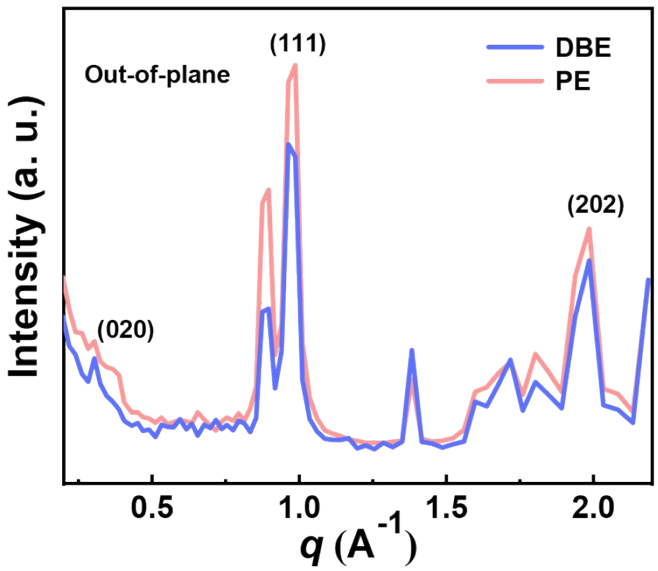

Fig. S6 The out-plane curves derived from GIWAXS patterns.

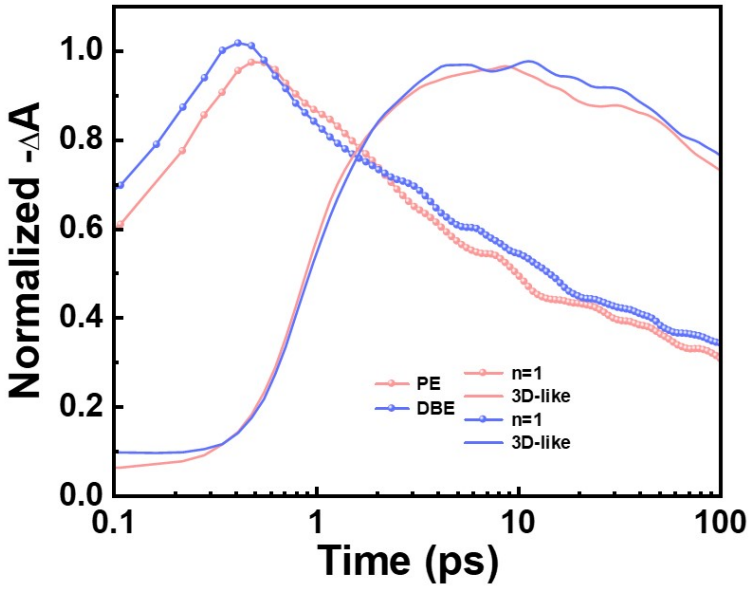

Fig. S7 The decay kinetics of different phases curves derived from TA spectral patterns.

Table S2 The fitting results from transient absorption spectra.

Antisolvents	n-value	τ_{et} (ps)	τ_1 (ps)	τ_2 (ps)	τ_3 (ps)
DBE	n=1	/	2.15	30.24	133.0
	n=∞	1.04	195.5	836.8	3141
PE	n=1	/	0.216	3.257	72.22
	n=∞	0.90	136.4	672.4	3630.0

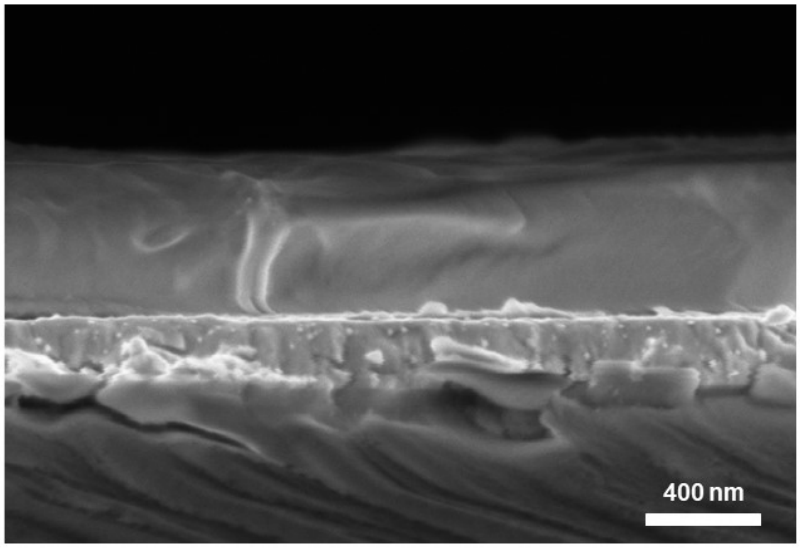

Fig. S8 The cross-sectional SEM image of FA-based quasi-2D perovskite film fabricated with antisolvent of PE.

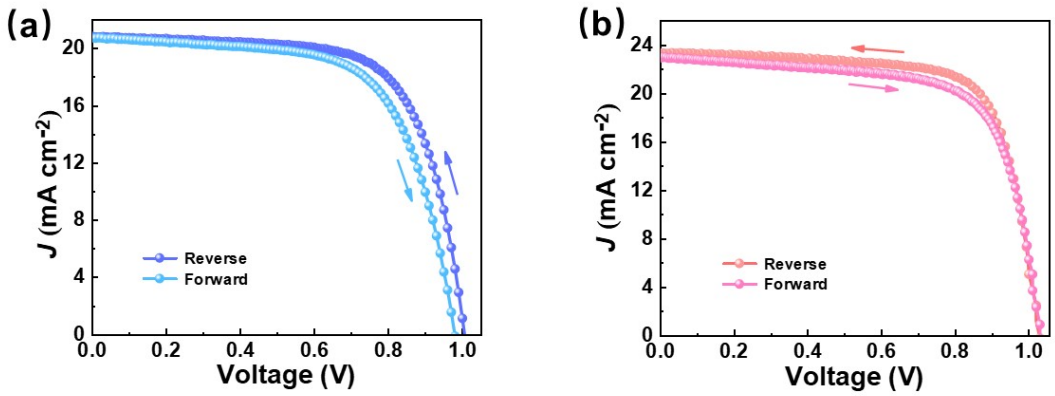

Fig. S9 The *J-V* curves obtained from reverse and forward scan of the best PSCs prepared from different antisolvents. (a) DBE; (b) PE.

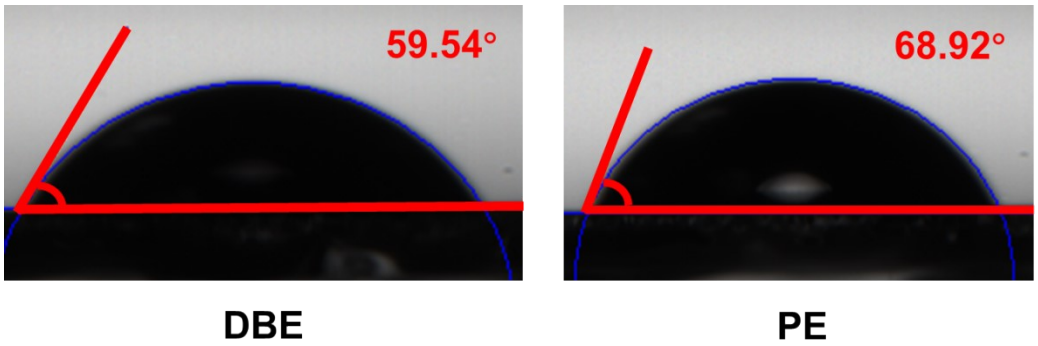

Fig. S10 Water contact angle images of the FA-based quasi-2D perovskite films fabricated with antisolvent of DBE and PE.

Table S3 The performance parameters of different n value FA-based quasi-2D perovskite solar cells prepared from traditional toxic solvent and green solvent system.

Solvents	Perovskites	n	V_{oc}(V)	J_{sc}(mA cm^{-2})	FF(%)	PCE(%)	Ref.
DMF/CB	$BA_2FA_8Pb_9I_{28}$	9	1.102	18.89	63.22	13.16	1
DMF/CB	$BA_2FA_8Pb_9I_{28}$	9	1.098	21.09	68.17	15.01	2
DMF/CB	($FPEA_2FA_8Pb_9I_{28}$)	9	1.07	20.88	72	16.15	3
DMF/CB	$EA_2FA_8Pb_9I_{28}$	9	1.09	21.89	73.05	17.4	4
DMF/IPA	$(ThMA)_2FA_4Pb_5I_{16}$	5	1.075	23.39	75.8	19.06	5
DMF/ Anisole	(β-$FPEA)_2(FA)_4Pb_5I_{16}$	5	1.13	22.13	76.71	19.11	6
DMF	$(4F\text{-}PEA)_2FA_4Pb_5I_{16}$	5	1.18	21.7	80.35	21.07	7
DMF	$PDAFA_3Pb_4I_{13}$	4	1.10	17.30	72.5	13.8	8
DMF	$PDA_{0.9}PA_{0.2}FA_3Pb_4I_{13}$	4	1.09	18.9	77.7	16.0	9
DMF/IPA	$BA_2FA_3Pb_4I_{13}$	4	1.062	21.62	78.96	18.14	10
DMF	$BDA(FA)_3Pb_4I_{13}$	4	1.15	19.5	76.4	17.2	11
DMF	$BA_2FA_2Pb_3I_{10}$	3	0.98	11.89	59	6.88	12
TEP/DEE	$BA_2FA_3Pb_4I_{13}$	4	1.00	20.83	68.7	14.31	This Work
TEP/PE	$BA_2FA_3Pb_4I_{13}$	4	1.03	23.34	72.5	17.42	This Work

n defines the number of inorganic octahedron $(MX_6)^{4-}$ slabs.

Table S4 The fitting results of TRPL.

Antisolvents	A_1	τ_1 (ns)	A_2	τ_2 (ns)	Average life time (ns)
DBE	60%	38.1	40%	137.0	160
PE	33%	27.2	67%	220.9	78

Table S5 The fitting results of impedance spectroscopy spectra.

Antisolvents	R_s (Ω)	R_{rec} (Ω)
DEE	53.11	7984
PE	34.5	56676

Reference

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