Supporting Information

All green solvent engineering processed perovskite films for efficient solar cells in high humid atmosphere

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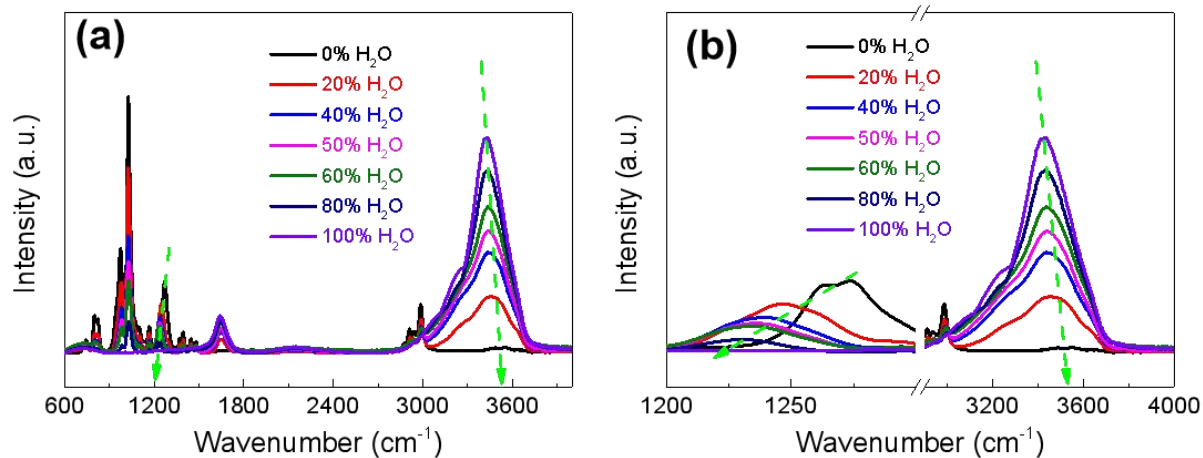
a：these authors contribute equally to this work.

Figure S1 The comparison of FTIR spectra of different solvent system of TEP+ x % H_2O (x=0~100). (a) the full spectra; (b) the enlarged spectra.
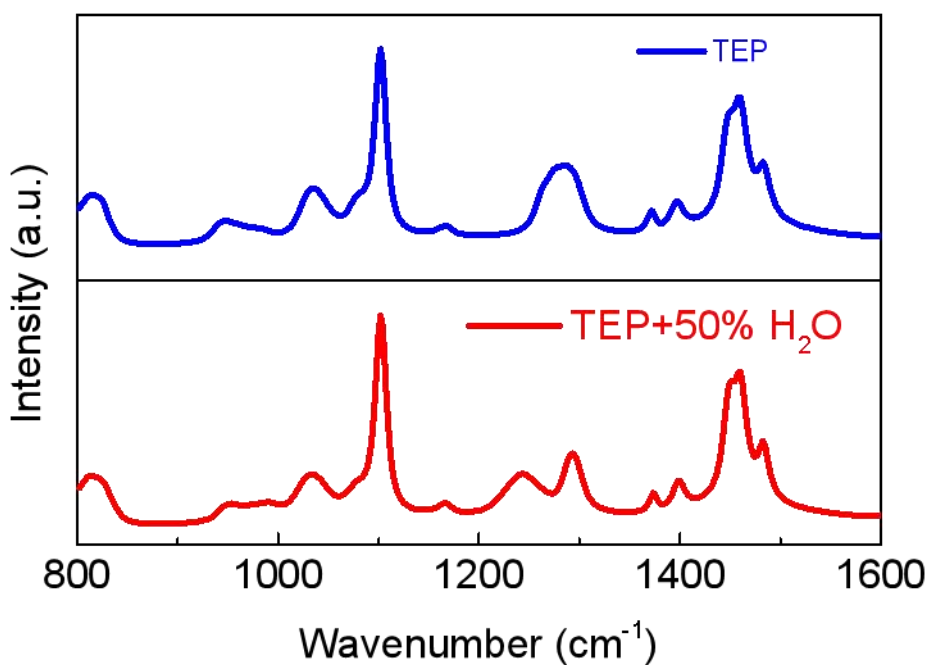

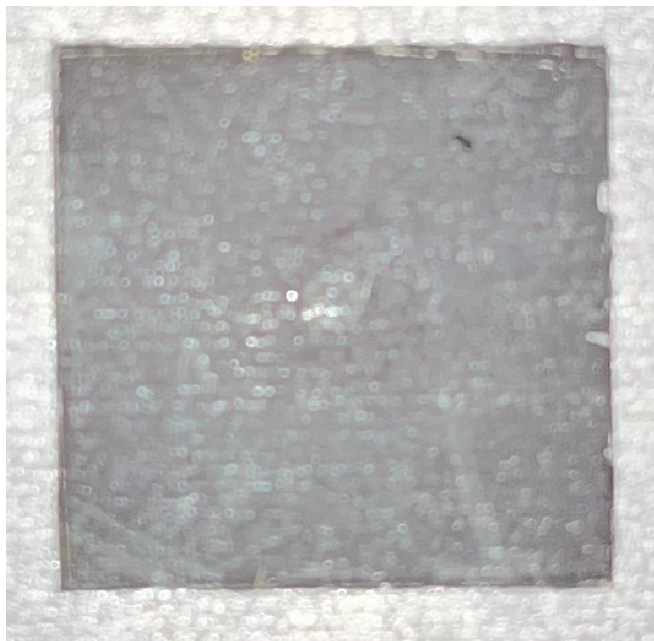**Figure S2** The full Raman spectra of pure TEP and TEP+50% H_2O

Figure S3 The photograph of perovskite films in the air with high relative humidity (RH=70~80%). The films are prepared without substrate preheating technology, and then annealed at 150 ℃ for 10 min.
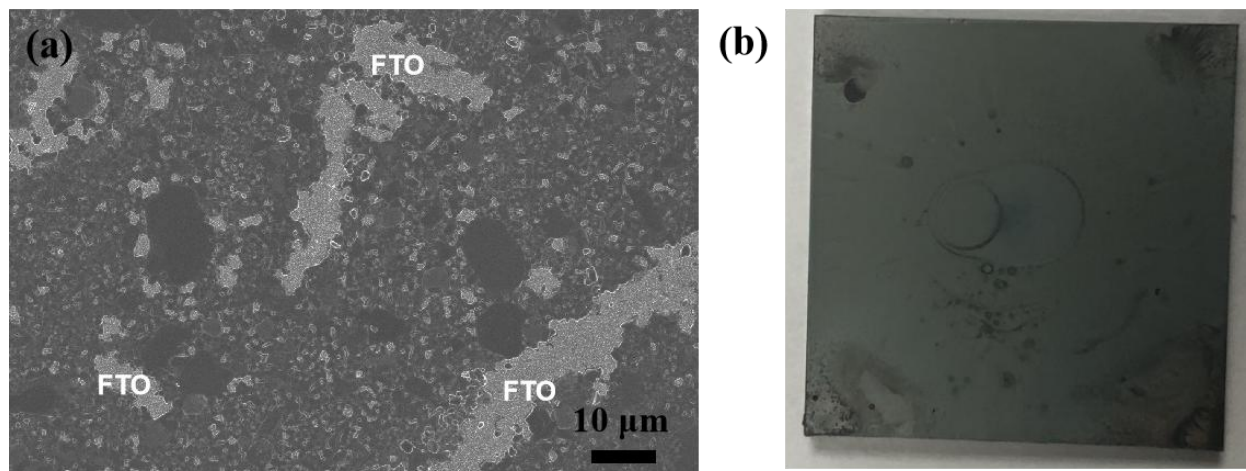

Figure S4 (a) low magnification SEM image, (b) photograph of perovskite films prepared from the substrate temperature of 175 ℃, followed by annealing at 150 ℃ for 10 min.
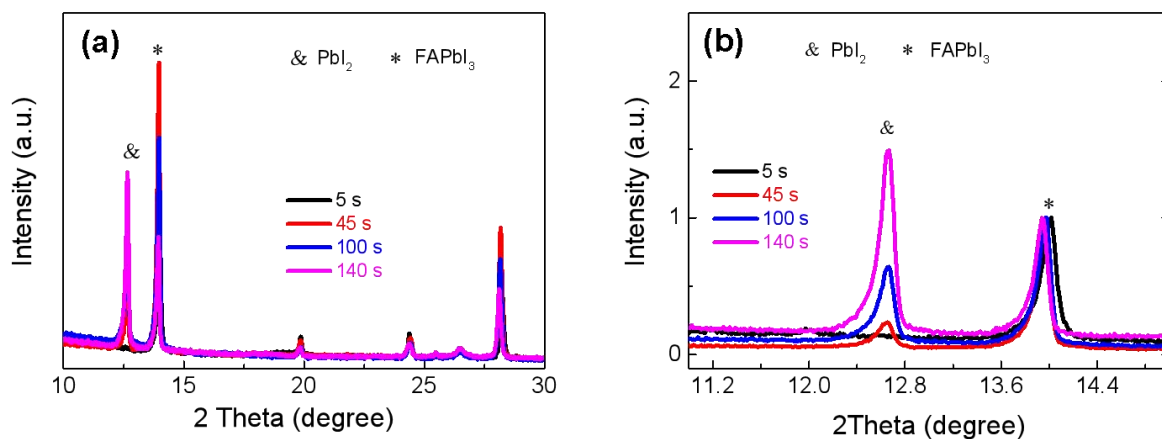
Figure S5 (a) the unnormalized XRD curves of perovskite films annealed at 300℃ for different time; (b) the normalized XRD curves of perovskite films annealed at 300℃ for different time.
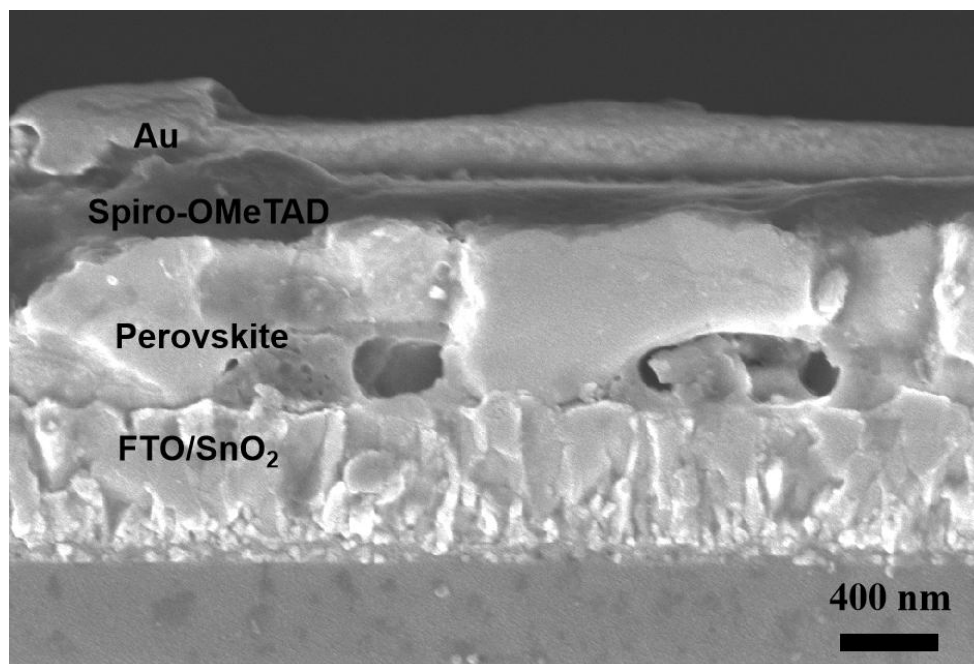

Figure S6 The cross-sectional SEM image of a PSC, whose light harvest layer of perovskite film is annealed at 150 ℃ for 10 min in the air with high relative humidity of 70~80%.
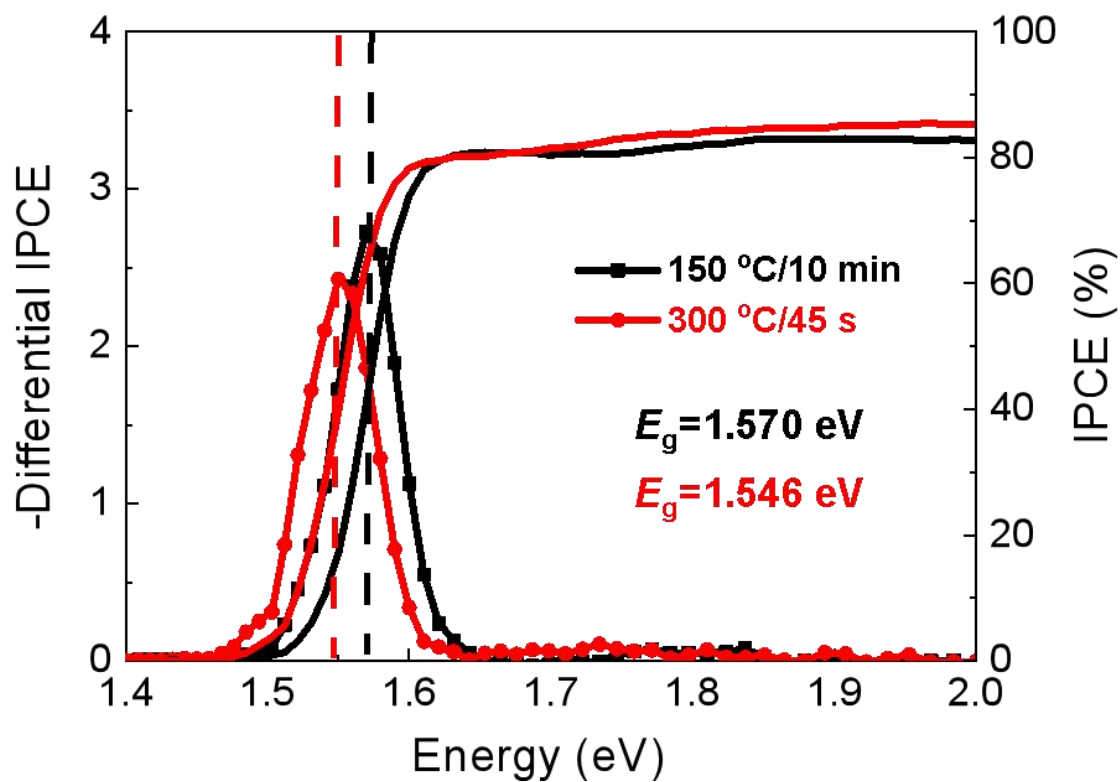
Figure S7 Calculation of the bandgap (E_g) of perovskite films from IPCE spectra. The E_g can be calculated by the maximum differential value of IPCE.

Table S1 The fitting results of TRPL spectra.

Samples	τ_1 (ns)	τ_2 (ns)	A_1 (%)	A_2 (%)	τ_{ave} (ns)
150 ℃/10 min	100.00	443.10	3.52	96.48	443.19
300 ℃/45s	163.39	715.17	21.40	78.60	682.86

$$\tau_{ave} = \left(A_1\tau_1^2 + A_2\tau_2^2\right)/\left(A_1\tau_1 + A_2\tau_2\right)$$

Table S2 The photovoltaic parameters of champion PSCs annealed at different method.

Samples	V_{oc} (V)	J_{sc} (mA cm^{-2})	FF	PCE (%)	HI index
150 ℃/10 min- RS	0.955	22.67	0.740	16.02	
150 ℃/10 min- FS	0.939	22.66	0.682	14.52	9.36%
300 ℃/45s- RS	1.105	23.46	0.766	19.86	
300 ℃/45s- FS	1.112	23.45	0.745	19.41	2.27%

$$HI=(PCE_{RS}-PCE_{FS})/PCE_{RS}$$