Supporting Information for

Pyrrole-an additives for improving the efficiency and stability of perovskite solar cells

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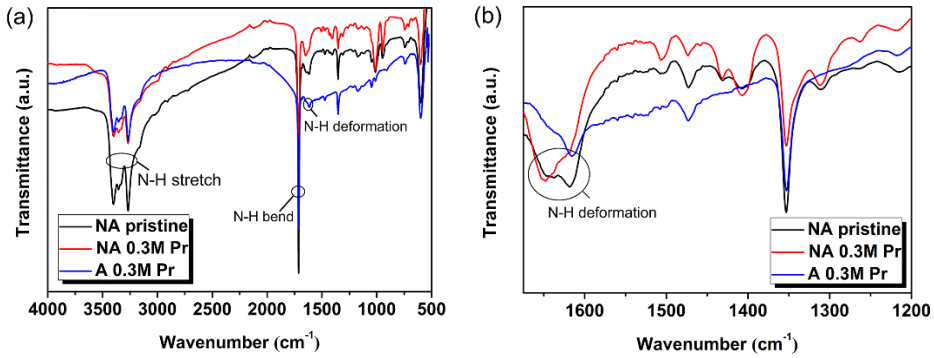

Fig. S1 (a) FTIR spectra of the unannealed pristine film, unannealed modified film (0.3 M Pr) and annealed modified film (0.3 M Pr); (b) Magnifications of FTIR spectra of the corresponding films from the wavelengths of 1200cm^{-1} to 1670 cm^{-1}.

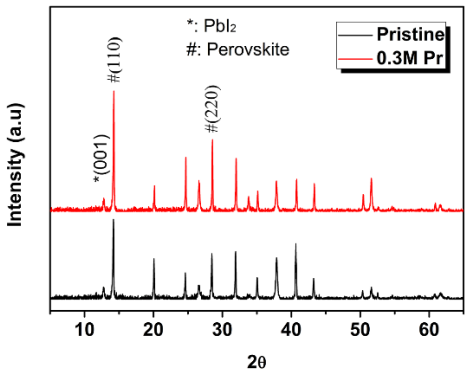

Fig. S2 XRD patterns of the films with and without pyrrole doping.

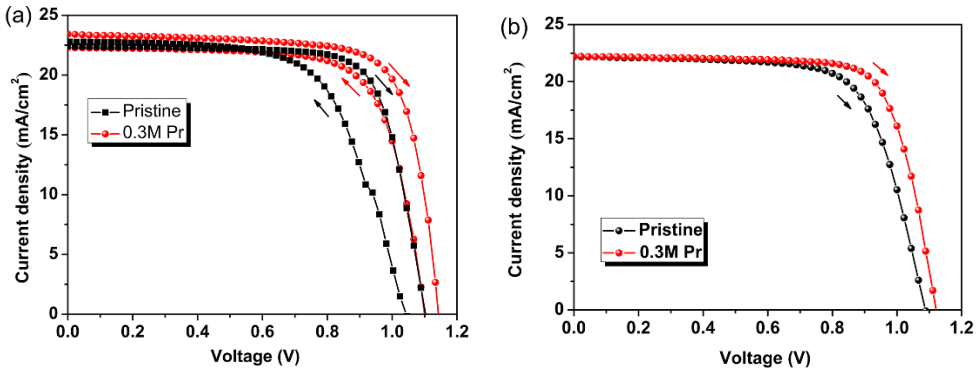

Fig. S3 (a) *J-V* curves of the devices with and without pyrrole doping under the forward bias scan and reverse bias scan (active area of the devices were defined as 0.1225 cm^2); (b) *J-V* curves (reverse scan) of the devices with and without pyrrole doping (active area of the devices were defined as 0.37 cm^2), the illustration is the Photograph of a typical device on a 2.0×2.0 cm^2 substrate.

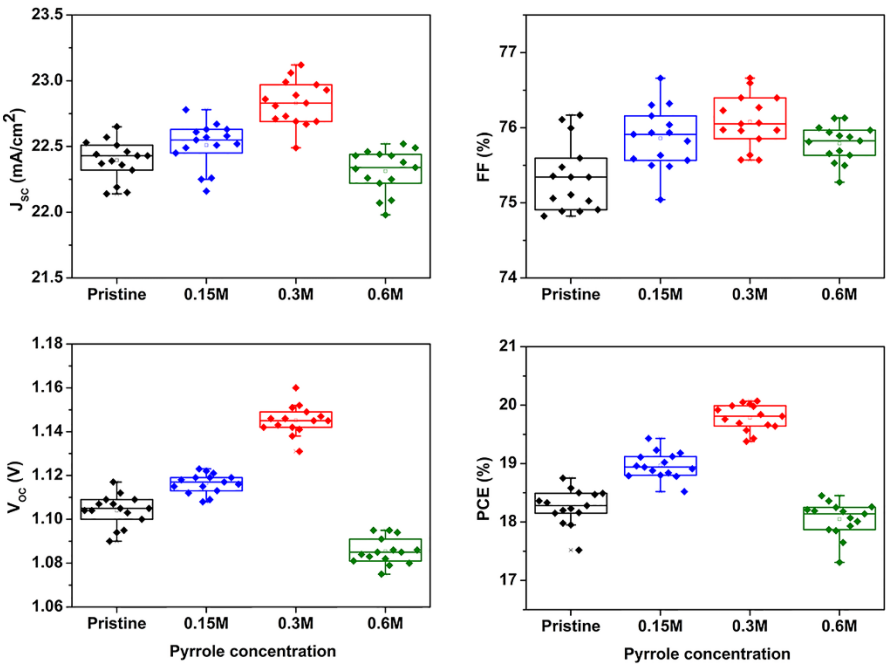

Fig. S4 Photovoltaic parameters of 15 PSCs with the pristine film and modified films (0.15 M Pr, 0.3 M Pr and 0.6 M Pr).

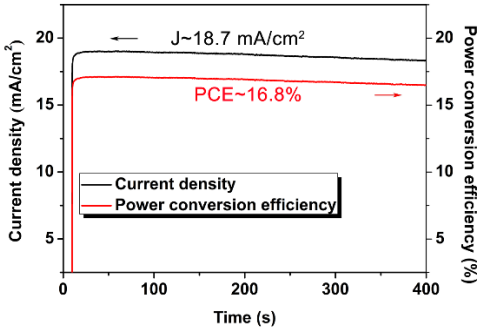

Fig. S5 Steady-state power output characteristics and the PCE of the pristine device.

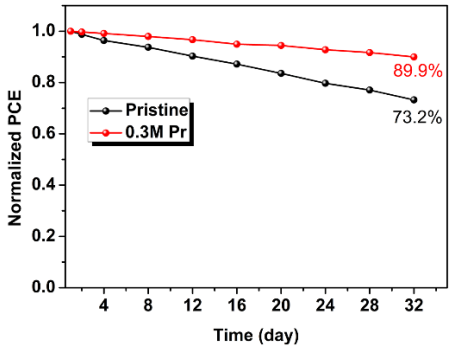

Fig. S6 Stability evaluation of the devices with and without pyrrole doping for 32 d stored in a desiccator (10 ± 5 RH%, 25 °C).

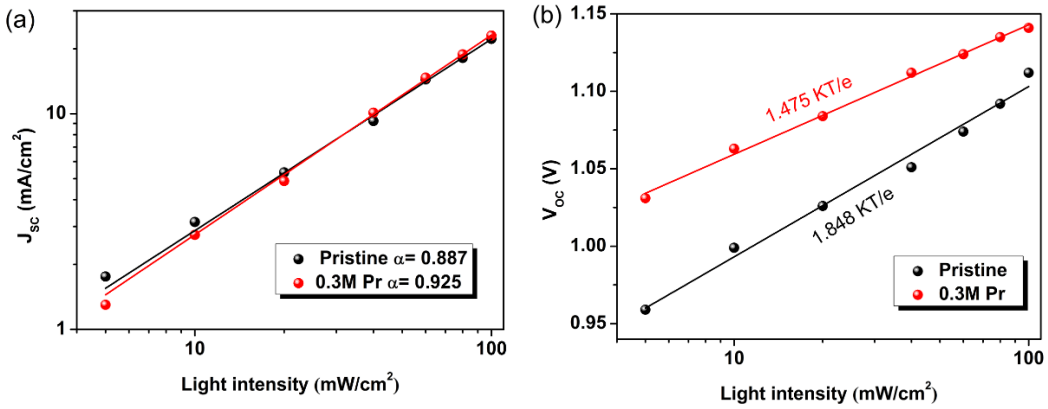

Fig. S7 Dependence of (a) J_{SC} and (b) V_{OC} on light intensity for pristine and modified devices (0.3 M Pr).

Table S1 Fitting parameters for the TRPL spectra by using bi-exponential function shown in Fig. 3c.

Sample	A_1(%)	τ_1 (ns)	A_2 (%)	τ_2 (ns)	τ_{av} (ns)
Pristine	15.79	10.810	84.21	86.741	74.750
0.15 M Pr	15.10	12.421	84.90	95.91	83.30
0.3 M Pr	10.06	9.619	89.94	96.613	87.859
0.6 M Pr	19.05	8.045	80.95	80.487	66.687

Table S2 Photovoltaic data of the PSCs with pristine modified films (0.15 M Pr, 0.3 M Pr and 0.6 M Pr).

Sample	V_{OC} (V)	J_{SC} (mA·cm^{-2})	FF	PCE (%)
Pristine	1.101	22.26	0.76	18.58
0.15 M Pr	1.116	22.48	0.77	19.23
0.3 M Pr	1.142	22.99	0.76	20.02
0.6 M Pr	1.085	22.24	0.76	18.23

Table S3 Photovoltaic data of the devices with and without pyrrole doping under different scan directions.

Sample	Scan direction	V_{OC} (V)	J_{SC} (mA·cm^{-2})	FF	PCE (%)
Pristine	Forward scan	1.044	22.79	0.64	15.17
	Reverse scan	1.103	22.41	0.75	18.48
0.3 M Pr	Forward scan	1.099	22.29	0.72	17.72
	Reverse scan	1.142	23.38	0.75	20.07

Table S4 Photovoltaic data of the devices with and without pyrrole doping under the reverse bias scan.

Sample	V_{OC} (V)	J_{SC} (mA·cm^{-2})	FF	PCE (%)
Pristine	1.049	21.91	0.73	16.87
0.3 M Pr	1.121	22.19	0.75	18.67

Table S5 Photovoltaic performance parameters of 15 devices with the pristine and modified films.

Sample	Data	V_{OC} (V)	J_{SC} (mA·cm^{-2})	FF	PCE (%)
Pristine	Champion	1.117	22.65	0.76	18.79
	Average	1.104 ± 0.012	22.39 ± 0.25	0.75 ± 0.01	18.24 ±0.61
0.15 M Pr	Champion	1.123	22.78	0.77	19.43
	Average	1.116 ± 0.007	22.51 ± 0.31	0.76 ± 0.02	18.97 ± 0.27
0.3 M Pr	Champion	1.16	23.12	0.77	20.07
	Average	1.145 ±0.014	22.82 ± 0.32	0.76 ± 0.01	19.79 ±0.35
0.6 M Pr	Champion	1.095	22.52	0.76	18.45
	Average	1.085 ± 0.01	22.31 ± 0.26	0.76 ± 0.01	18.04 ± 0.57