Electronic Supplementary Material (ESI) for Nanoscale.

Synergistic effect of processing solvent and additive for the production of efficient all-polymer solar cells

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Experimental Section

Materials and Reagents:

Patterned ITO glass substrates (Rs ≤ 15Ω sq^{-1}) were purchased from Shenzhen huayulianhe Technology Co.. Photoactive donor J71 was bought from Solar mer Materials Inc. (China). Acceptor N2200 (M_n of 75.6 kg/mol, PDI of 1.75) and PEDOT:PSS were obtained from Shanghai vzchem. All the available solvents reagents were used as received without any further purification unless otherwise specified.

Device Fabrication:

The regular all-PSCs were fabricated using the device configuration of ITO/PEDOT:PSS/active layer/AZO/Al. Patterned ITO substrates were sequentially ultrasonicated in detergent, deionized water, acetone, and isopropanol, and then were treated with O_2-plasma for 8 min. PEDOT:PSS (Baytron, Clevious 4083) was spin-coated onto the ITO surface at 4000 rpm for 60 s, followed by annealing at 150 °C for 10 min in air. Photoactive blends of J71:N2200 with a fixed D:A ratio of 2:1 were dissolved in CB or CF with the total concentration of 15 mg /mL or 10 mg/mL, respectively. Then the blends solutions with varied amount of DIO additive were deposited onto the PEDOT:PSS layer and then annealed at 100 °C for 10 min. The thickness of photoactive layers spin-coated from all of the solvent/additive systems were around 100-110 nm by controlling the blends concentration and spinning condition. Then the AZO solution (8 mg/mL in TFE) was spin-coated onto the active layer at 4000 rpm for 60 s, followed by deposition of Al (100 nm) top electrode in an evaporation chamber under high vacuum (< 2×10^{-4} Pa). The effective device area was defined to be ≈0.09 cm^2 controlled with a shadow mask.

Characterizations and Measurements:

UV-vis absorption spectra were performed on a GS54T UV-vis-NIR absorption spectrophotometer. The thickness of the active layer was determined by a surface profiler

(Veeco, Dektak 150). Tapping-mode atomic force microscopy (AFM) images were conducted by using a scanning probe microscope (Dimension 3100 V, Veeco). Transmission electron microscopy (TEM) images of blend films were tested by FEI Tecnai F20 TEM. The *J*-*V* characteristics were measured with a Keithley 2400 source meter by using a So13A solar simulator (Newport Inc.) with an AM 1.5G irradiation intensity (100 mW cm^{-2}). The EQE measurements were performed with a Newport quantum efficiency measurement system (ORIEL IQE 200TM) with a lock-in amplifier in ambient atmosphere. The light intensity at each wavelength was calibrated with a standard Si/Ge solar cell. And the apparent hole/ electron mobility (μ) was calculated with the Mott-Gurney law, given by equation: $J = 9\varepsilon_0\varepsilon_r\mu V^2/(8L^3)$, where J stands for the current density, ε_0 is the permittivity of free space, ε_r is the relative permittivity of the medium, μ is the mobility of hole or electron, V is the effective voltage, and L is the thickness of the active layer. The hole and electron mobility can be calculated from the slope of the $J^{0.5}$-V curves.

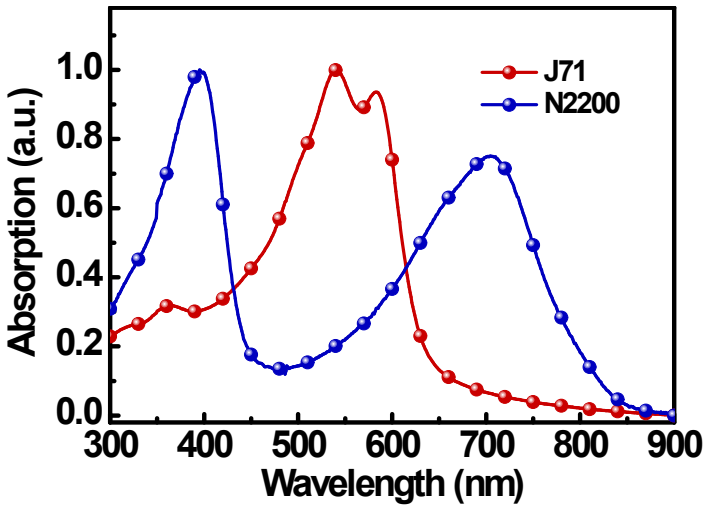

Fig. S1 Normalized absorption spectra of J71 and N2200 solid films.

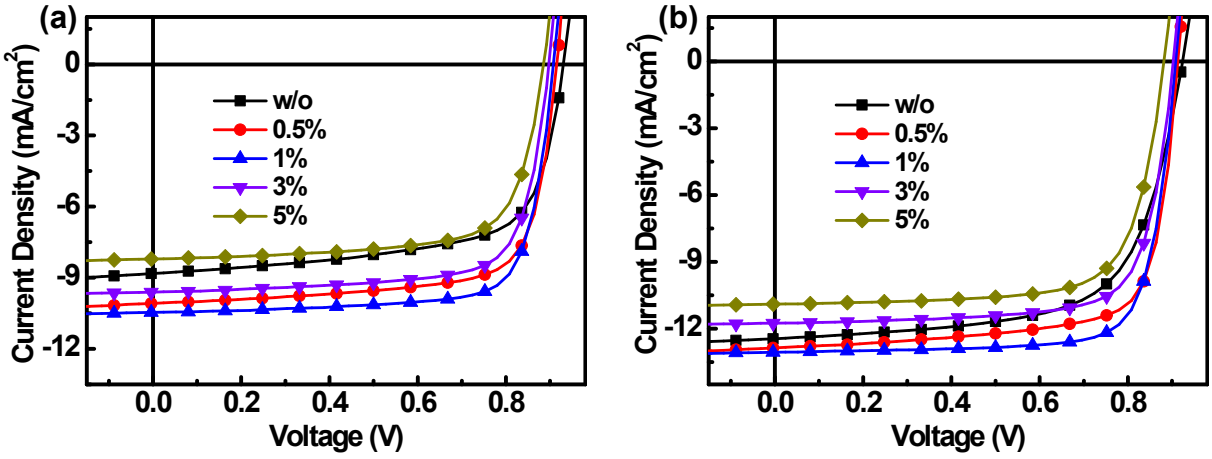

Fig. S2 *J-V* curves of J71:N2200 all-PSCs processed with (a) CB, and (b) CF based on various DIO contents (w/o, 0.5%, 1%, 3% and 5%).

Table S1 Summary of the photovoltaic performances J71:N2200 all-PSCs processed with CB, and CF based on various DIO contents (w/o, 0.5%, 1%, 3% and 5%).

Solvent	DIO (%)	V_{OC} (V)	J_{SC} (mA/cm^2)	FF (%)	PCE (%)	R_S (Ω·cm^2)
CB	w/o	0.929	8.82	66.76	5.47	8.84
	0.5	0.915	10.08	73.27	6.76	6.92
	1	0.907	10.46	76.68	7.27	5.56
	3	0.897	9.60	74.18	6.39	6.38
	5	0.885	8.21	71.63	5.21	9.03
CF	w/o	0.926	12.21	65.68	7.43	7.72
	0.5	0.914	12.86	74.30	8.73	6.99
	1	0.908	13.14	77.75	9.28	5.25
	3	0.902	11.71	74.63	7.88	6.76
	5	0.880	10.82	72.21	6.88	7.87

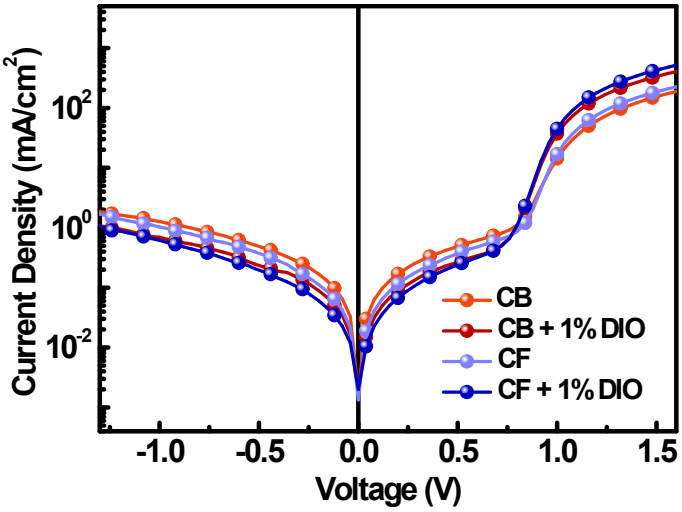

Fig. S3 Dark *J-V* curves of J71:N2200 all-PSCs processed with various treatments (CB, CB + 1% DIO, CF, CF + 1% DIO).

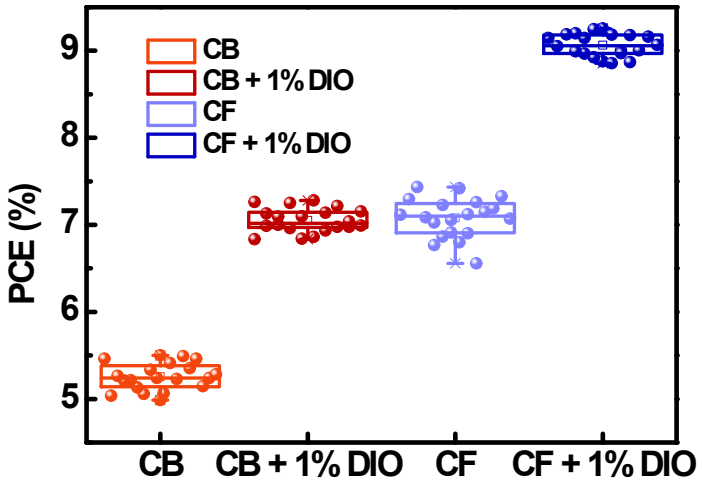

Fig. S4 The box chart of PCEs of J71:N2200 all-PSCs processed with various treatments (CB, CB + 1% DIO, CF, CF + 1% DIO).

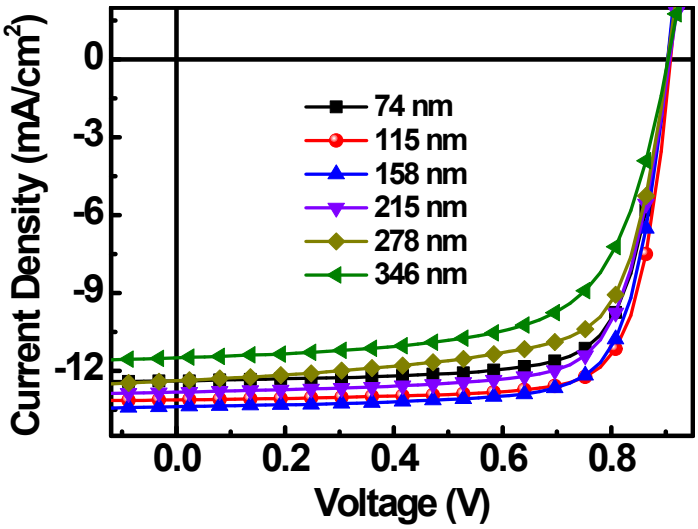

Fig. S5 *J-V* curves of J71:N2200 all-PSCs based on different active layer thickness prepared form CF + 1% DIO processing.

Table S2 Summary of photovoltaic parameters of J71:N2200 all-PSCs based on different active layer thickness prepared form CF + 1% DIO processing.

Active layer	Thickness (nm)	V_{OC} (V)	J_{SC} (mA cm^{-2})	FF (%)	PCE (%)
J71:N2200	74	0.905	12.37	75.23	8.42
	115	0.909	13.14	77.75	9.29
	158	0.905	13.38	75.84	9.18
	215	0.907	12.81	73.62	8.55
	278	0.904	12.39	68.85	7.71
	346	0.903	11.48	64.59	6.70

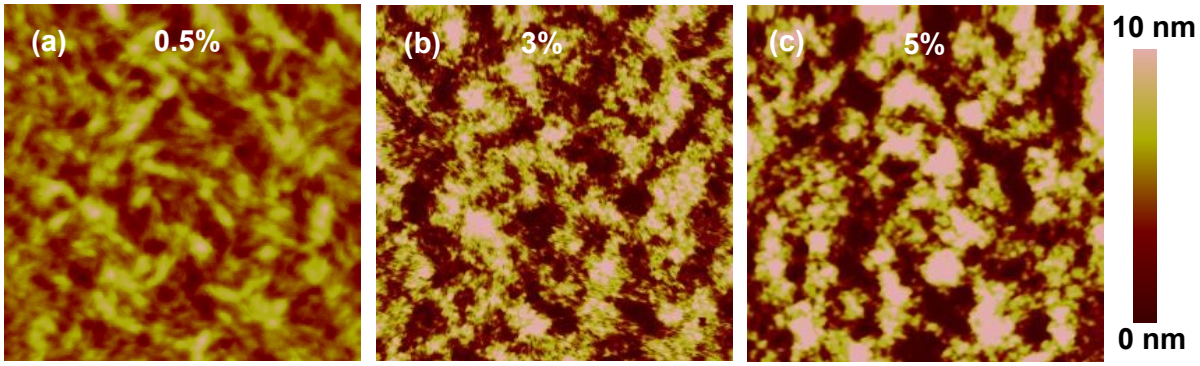

Fig. S6 AFM topography images (2 μm × 2 μm) of the J71:N2200 films processed with CB based on various DIO contents.

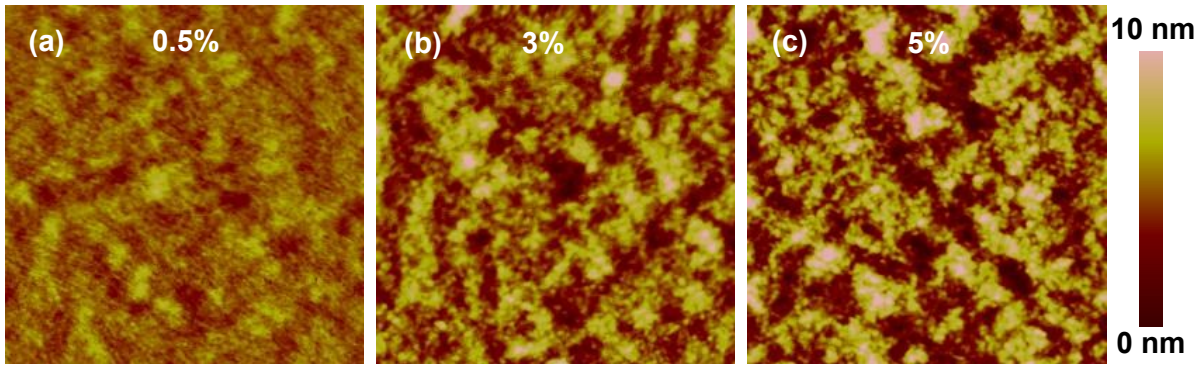

Fig. S7 AFM topography images (2 μm × 2 μm) of the J71:N2200 films processed with CF based on various DIO contents.

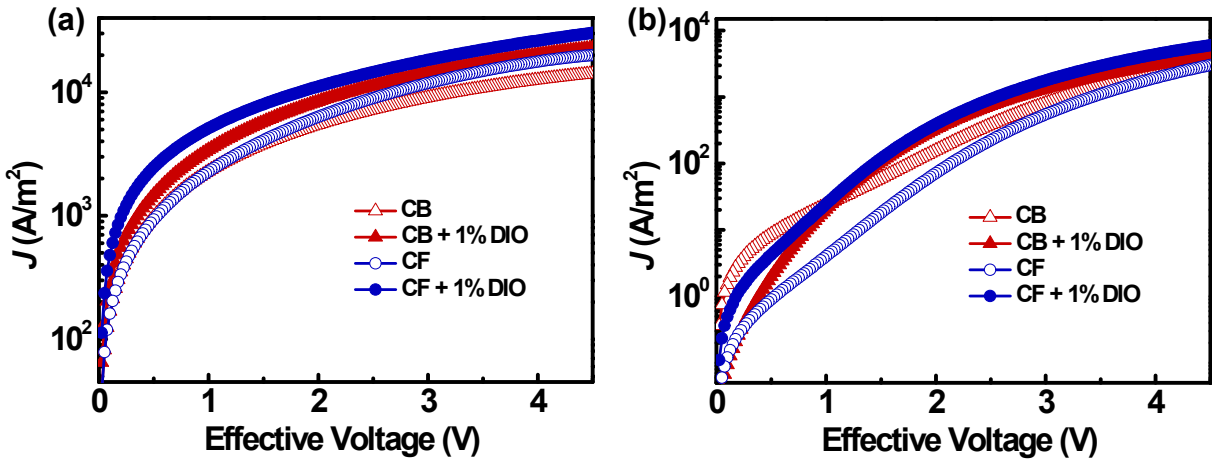

Fig. S8 *J–V* characteristics of (a) hole-only and (b) electron-only devices based on various treatments (CB, CB + 1% DIO, CF, CF + 1% DIO).

Table S3 Hole and electron mobilities of J71:N2200 devices processed with various treatments (CB, CB + 1% DIO, CF, CF + 1% DIO).

Solvent & Additive	μ_h ((cm^2 /(V s)))	μ_e ((cm^2 /(V s)))	μ_h /μ_e
CB	0.81×10^{-4}	0.39×10^{-4}	2.08
CB + 1% DIO	1.40×10^{-4}	1.18×10^{-4}	1.19
CF	1.59×10^{-4}	0.96×10^{-4}	1.66
CF + 1% DIO	2.03×10^{-4}	1.85×10^{-4}	1.09