Supporting Information

Towards efficient thick active PTB7 photovoltaic layers using diphenyl ether as a solvent additive

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Table S1 Parameters employed for the fitting of the impedance spectra by use of an equivalent circuit model.

Devices	R_1 (Ω)	CPE1-T (F/cm^2)	CPE1-P	R_2 (Ω)	C_2 (F)	τ_{avg} (μs)
Without DPE	1.07×10^{3}	4.2×10^{-9}	0.94	1.03×10^{6}	1.01×10^{-9}	4.5
DPE 2%	6.43×10^{3}	2.1×10^{-9}	0.87	9.10×10^{5}	1.17×10^{-9}	13.5
DPE 4%	1.55×10^{3}	2.4×10^{-8}	0.99	3.00×10^{5}	2.44×10^{-12}	37.1
DPE 5%	2.77×10^{3}	9.8×10^{-9}	0.98	3.06×10^{5}	3.19×10^{-12}	27.2

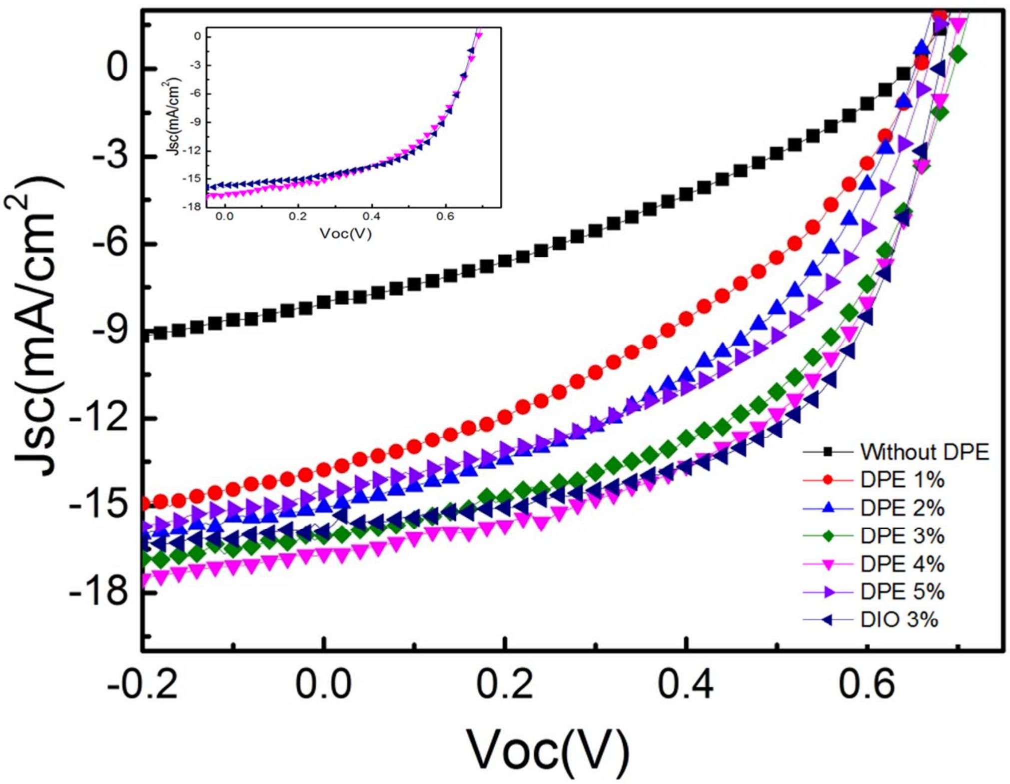

Figure S1 *J*-*V* characteristic curves of OPVs with different ratio of solvent additives; Inset: Comparison *J*-*V* characteristic of the device with DIO 3% and DPE 4%.

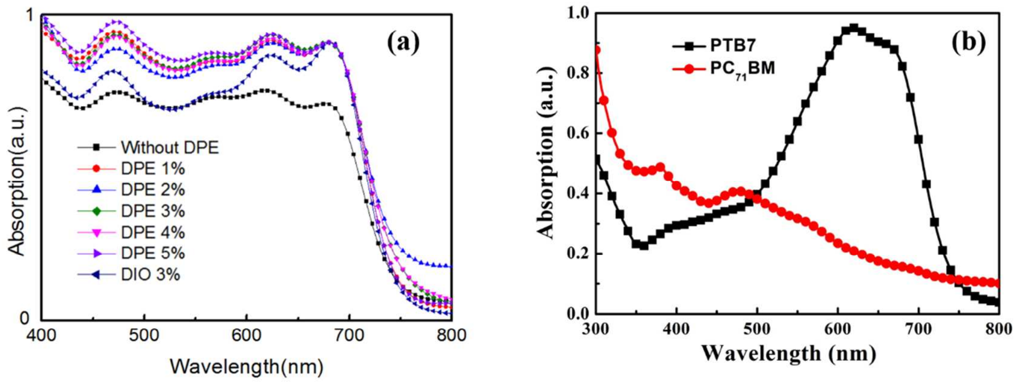

Figure S2 UV-Vis absorption spectra of (a) the PTB7:$PC_{71}BM$ BHJ film with different solvent additive ratio and (b) the pure PTB7 and PCBM film.

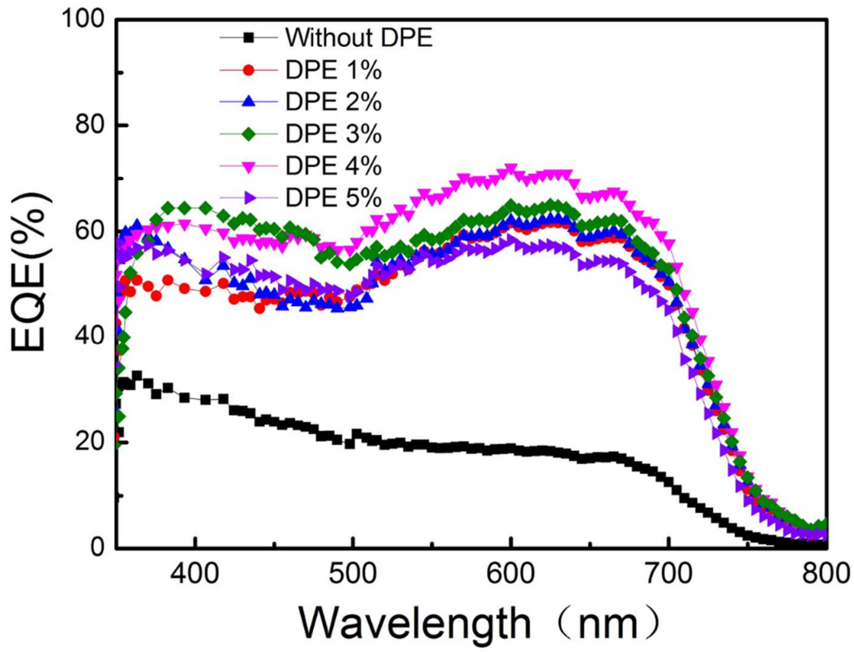

Figure S3 External Quantum Efficiency (EQE) of device with variety ratio of DPE.

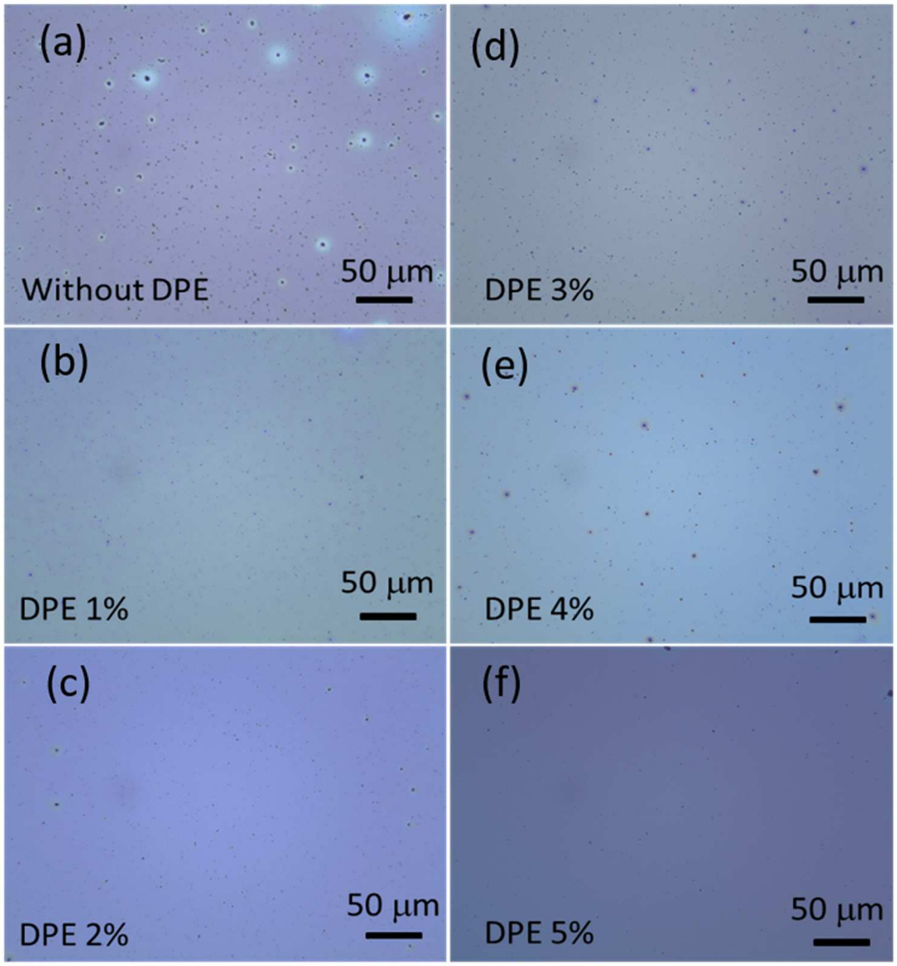

Figure S4 Metallurgical Microscope image of PTB7:$PC_{71}BM$ BHJ blend film with variety concentrations of DPE, (a) without DPE, (b) DPE 1%, (c) DPE 2%, (d) DPE 3%, (e) DPE 4% and (f) DPE 5%.

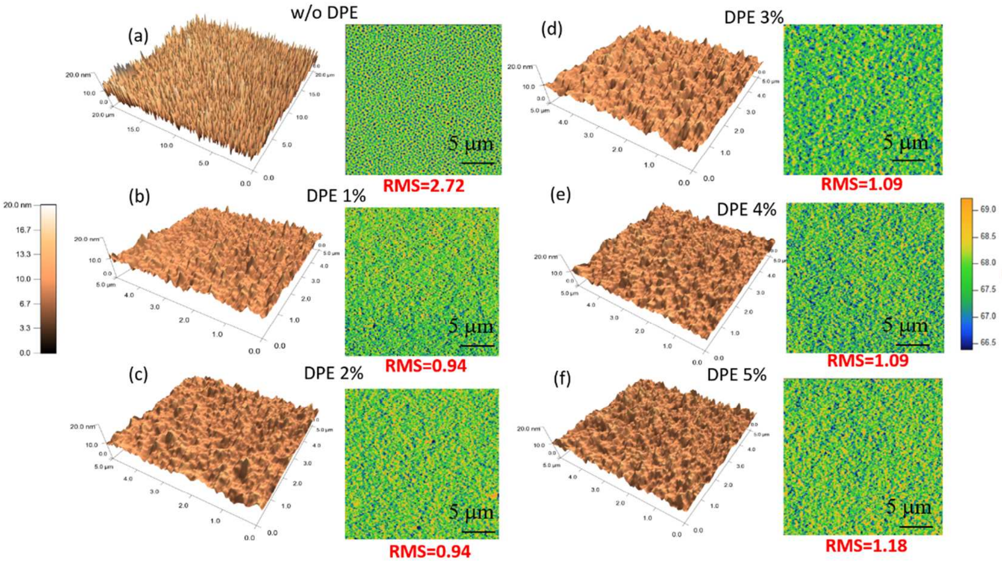

Figure S5 AFM 3D exhibitions (left) and phase image (right) of PTB7:$PC_{71}BM$ BHJ blend films with different concentrations of DPE (a) without DPE, (b) DPE 1%, (c) DPE 2%, (d) DPE 3%, (e) DPE 4% and (f) DPE 5%.

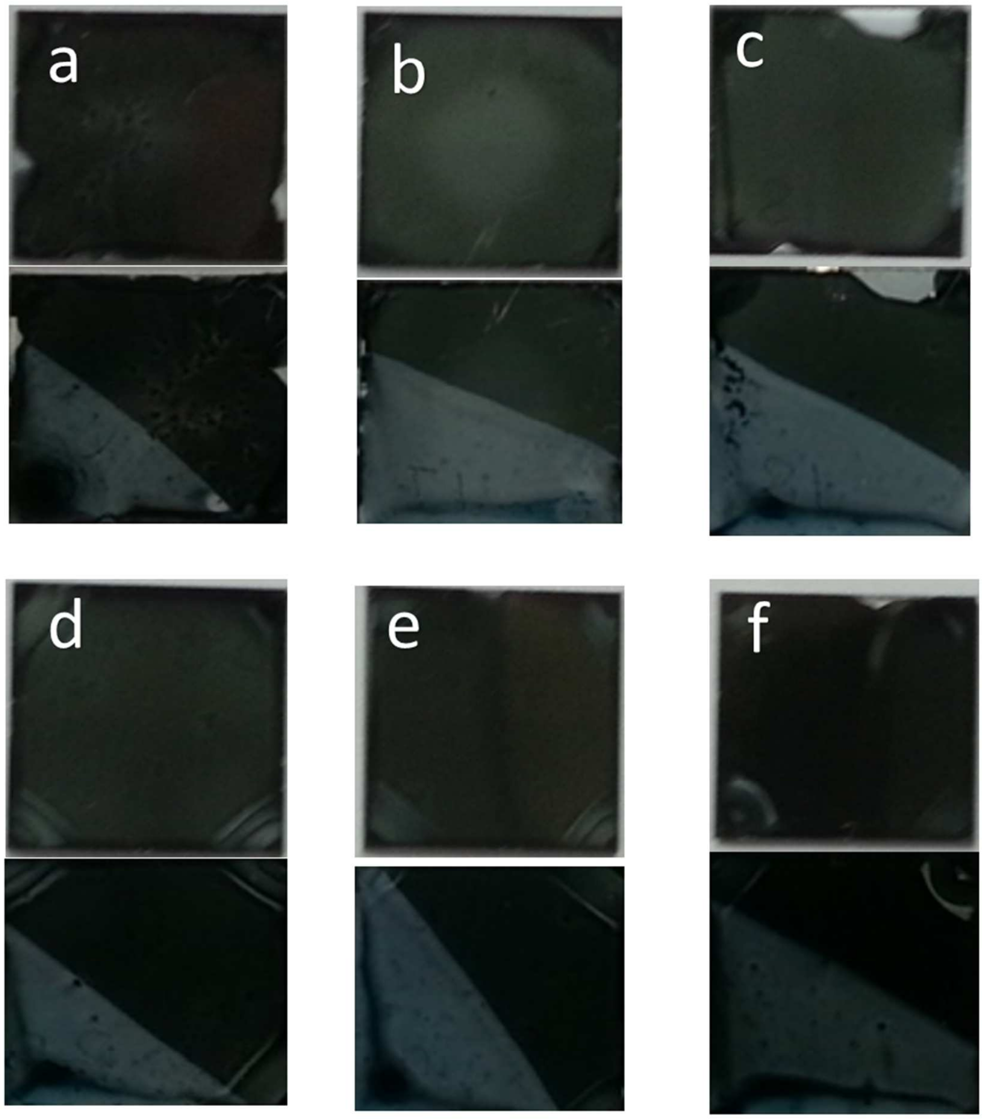

Figure S6. Image of the PTB7:$PC_{71}BM$ blend film added by different concentration of DPE (up) and the film washed by CB (down). (a) without DPE, (b) DPE 1%, (c) DPE 2%, (d) DPE 3%, (e) DPE 4% and (f) DPE 5%.

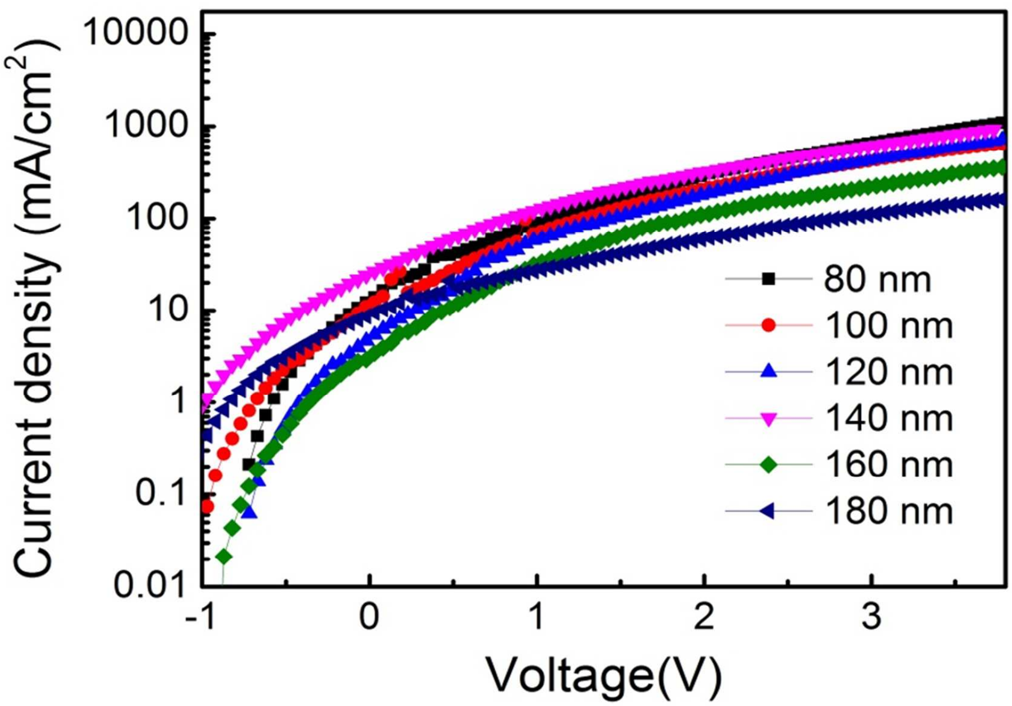

Figure S7. *J-V* characteristics of hole-only devices with a configuration of ITO/MoO_3 (15 nm)/PTB7 : $PC_{71}BM$ (x nm) /MoO_3 (15 nm)/Ag (100 nm) based on 4% DPE

J_{ph} Calculation

To investigate the effect of DPE on device performance, photocurrent density (J_{ph}) of OPVs is examined. J_{ph} is defined by $J_{ph}=J_{light} - J_{dark}$, where J_{light} and J_{dark} represent the experimental current density measured in illumination and dark conditions, respectively.[1] J_{ph} can be analyzed using Equation as the analytical solution as suggested Sokel and Hughes.[2]

$$J_{\mathrm{ph}} = eGL\left[\frac{\exp(eV/kT)+1}{\exp(eV/kT)-1} - \frac{2kT}{eV}\right]$$

where *e* is the element charge, *G* is the charge carrier generation rate, and *L* is the thickness of the active layer. *k* is the Boltzmann constant, and *T* is the room temperature. *G* is described by a relation of $G(T, E)=G_{max}P(T, E)$, where G_{max} represents the total number of photogenerated charge transfer (CT), and *P(T, E)* is the probability for CT dissociation at the donor-acceptor interface.[3]

We tabulate J_{ph} of the thin PTB7:PC_{71}BM devices with DPE additive in Table 1. OPV based on DPE 4% shows the highest J_{ph}, indicating a large number of generation of CT states as well as high CT separation efficiency.[4-6]

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