

Electronic Supplementary Information

Efficiency Enhancement of Organic Photovoltaics by Introducing High-Mobility Curved Small-Molecule Semiconductors as Additives

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Figures

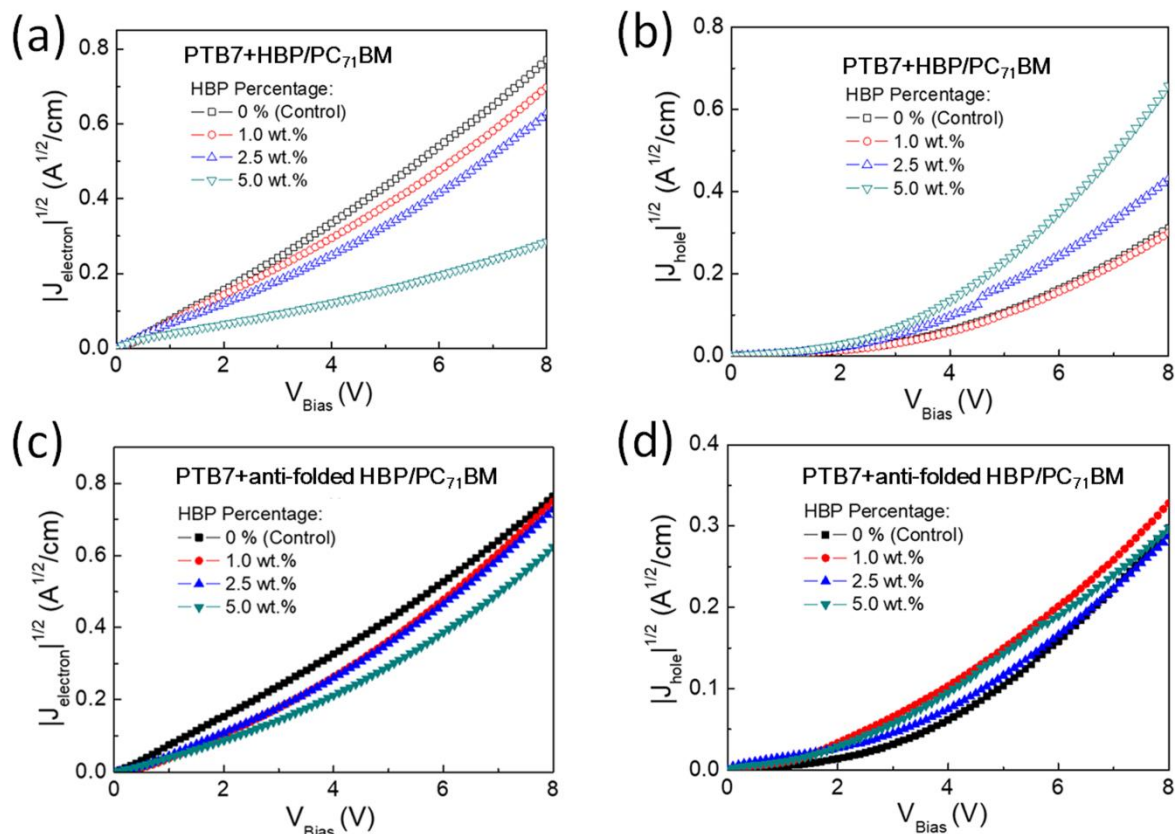


Figure S1. Square root of electron current densities versus bias voltage of the ITO/PEDOT:PSS/PTB7+HBP/PC₇₁BM/Au devices with (a) different HBP percentage or (b) twisted & anti HBP percentage; Square root of hole current densities versus bias voltage of the ITO/ZnO/PTB7+HBP/PC₇₁BM/Al devices with (c) different HBP percentage or (d) different twisted & anti HBP percentage.

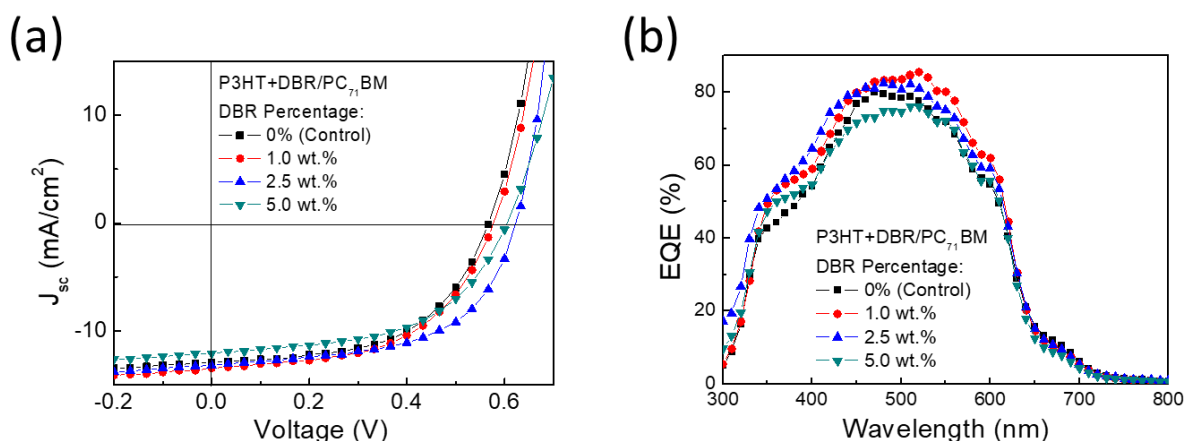


Figure S2. (a) J - V and (b) EQE curves of the OPVs based on P3HT/PC₇₁BM with different addition levels of DBR.

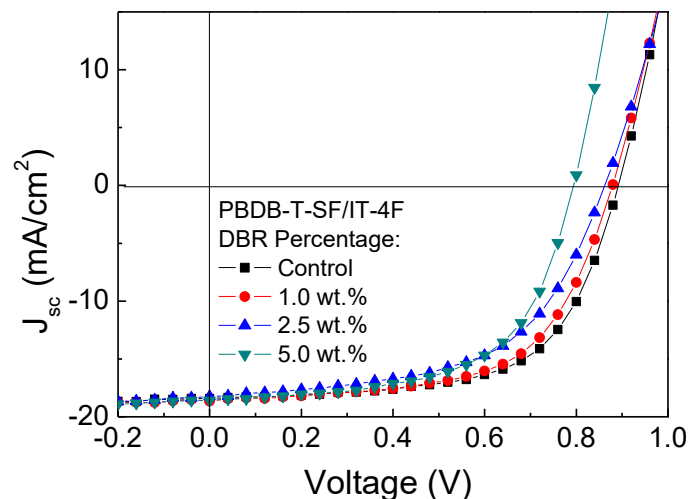


Figure S3. *J*-*V* curves of the OPVs based on PBDB-T-SF/IT-4F with different addition levels of DBR.

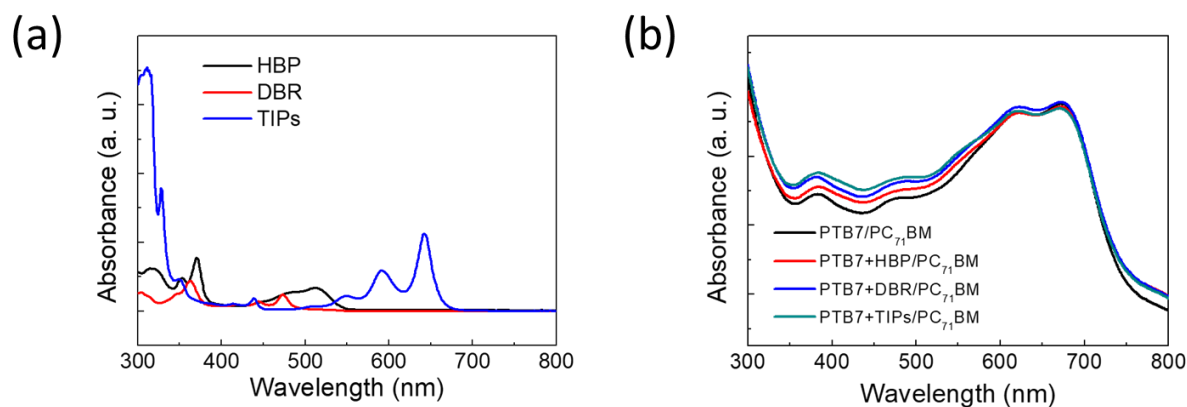


Figure S4. The UV-vis absorption spectra of (a) three additives (HBP/DBR/TIPs) in solution (5×10^{-6} M in CH_2Cl_2), and (b) blend films based on PTB7/ PC_{71}BM with different additives at the same addition level (2.5 wt. %).

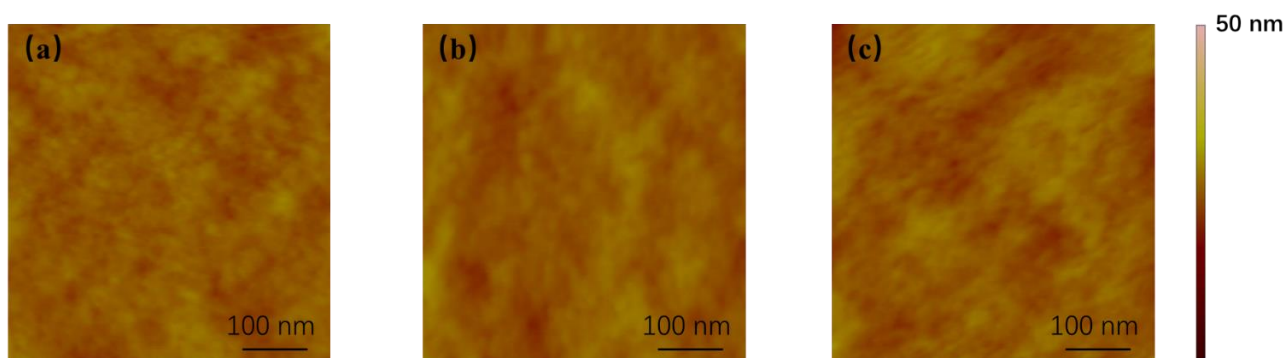


Figure S5. AFM images of the surface morphologies of (a) pristine PTB7/ PC_{71}BM blend film, PTB7/ PC_{71}BM blend film with addition of 2.5 wt.% (b) HBP or (c) DBR.

Tables:

Table S1. Summary of photovoltaic performance of devices based on PTB7/PC₇₁BM with HBP as additive.

Addition level of HBP in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	J _{sc} integrated from EQE (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.724	15.50	14.65	69.5	7.80±0.06	/
	Best	0.742	17.84	16.91	70.0	9.26	18.7
1.0 wt. %	Average	0.730	17.83	/	70.2	9.14±0.07	17.2±0.9
	Best	0.742	17.84	16.91	70.0	9.26	18.7
2.5 wt. %	Average	0.746	18.86	/	67.8	9.54±0.07	22.3±0.9
	Best	0.754	18.77	17.67	68.0	9.63	23.5
5.0 wt. %	Average	0.739	16.37	/	70.6	8.54±0.09	9.5±1.2
	Best	0.745	16.53	15.61	70.5	8.68	11.3

Table S2. Summary of the photovoltaic performance of devices based on PTB7/PC₇₁BM with twisted & anti HBP as additive.

Addition level of <u>twisted & anti HBP</u> in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.726	15.76	67.0	7.67±0.14	/
	Best	0.742	14.49	68.6	7.36	-4.0
1.0 wt. %	Average	0.731	14.36	69.5	7.30±0.05	-4.8±0.7
	Best	0.742	14.49	68.6	7.36	-4.0
2.5 wt. %	Average	0.735	13.57	68.4	6.82±0.02	-11.1±0.3
	Best	0.748	13.62	67.1	6.85	-10.7
5.0 wt. %	Average	0.737	13.43	63.0	6.24±0.01	-18.6±0.1
	Best	0.730	13.49	63.5	6.25	-18.5

Table S3. Summary of the photovoltaic performance of devices based on PBDTTT-EFT/PC₇₁BM with HBP as additive.

Addition level of HBP in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	J _{sc} integrated from EQE (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.779	17.25	16.97	67.2	9.03±0.07	/
1.0 wt.%	Average	0.784	18.57	/	68.1	9.91±0.10	9.7±1.1
	Best	0.795	18.51	17.89	68.4	10.07	11.5
2.5 wt.%	Average	0.796	17.96	/	67.2	9.61±0.10	6.4±1.1
	Best	0.801	18.04	17.48	67.5	9.75	8.0
5.0 wt.%	Average	0.794	16.36	/	67.6	8.78±0.14	-2.8±1.6
	Best	0.800	16.67	16.67	67.6	9.02	-0.1

Table S4. Summary of the photovoltaic performance of devices based on PTB7/PC₇₁BM with DBR as additive.

Addition level of DBR in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	J _{sc} integrated from EQE (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.722	15.37	15.18	69.6	7.72±0.03	/
1.0 wt.%	Average	0.731	16.55	/	65.9	7.97±0.03	3.2±0.4
	Best	0.739	16.31	15.50	66.5	8.01	3.8
2.5 wt.%	Average	0.745	17.03	/	68.0	8.63±0.05	11.8±0.6
	Best	0.751	16.92	16.02	68.5	8.70	12.7
5.0 wt.%	Average	0.732	15.16	/	69.2	7.68±0.08	-0.5±1.0
	Best	0.742	15.01	14.23	69.9	7.78	0.8

Table S5. Summary of the photovoltaic performance of OPVs based on PBDTTT-EFT/PC₇₁BM with DBR as additive.

Addition level of DBR in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	J _{sc} integrated from EQE (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.769	17.64	16.07	67.0	9.09±0.05	/
1.0 wt. %	Average	0.778	18.37	/	67.9	9.70±0.07	6.7±0.8
	Best	0.777	18.42	17.49	68.2	9.76	7.4
2.5 wt. %	Average	0.786	19.58	/	67.8	10.43±0.10	14.7±1.1
	Best	0.791	19.72	18.74	68.1	10.62	16.8
5.0 wt. %	Average	0.778	18.28	/	65.6	9.33±0.04	2.6±0.4
	Best	0.788	18.01	17.11	66.2	9.39	3.3

Table S6. Summary of the photovoltaic performance of OPVs based on PBDTTT-EFT+DBR/PC₇₁BM with different addition levels (solution volume percentage) of Au@Ag NCs in PEDOT:PSS.

Addition level of Au@Ag NCs in PEDOT:PSS layer		V _{oc} (V)	J _{sc} (mA/cm ²)	J _{sc} integrated from EQE (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.792	18.93	17.89	68.5	10.27±0.09	/
1.0 wt. %	Average	0.796	19.32	/	70.0	10.76±0.07	4.8±0.7
	Best	0.795	19.40	18.30	70.3	10.85	5.6
5.0 wt. %	Average	0.796	20.29	/	70.7	11.42±0.13	11.2±1.3
	Best	0.798	20.73	19.58	70.7	11.69	13.8
10 wt. %	Average	0.800	18.94	/	69.0	10.46±0.05	1.9±0.5
	Best	0.799	19.27	18.21	68.3	10.52	2.4

Table S7. Summary of the photovoltaic performance of devices based on PTB7/PC₇₁BM with TIPs-Pentacene as additive.

Addition level of TIPs-Pentacene in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.724	15.50	69.5	7.80±0.06	/
1.0 wt. %	Average	0.748	16.80	66.5	8.42±0.12	7.9±1.5
	Best	0.754	16.80	68.3	8.60	10.3
5.0 wt. %	Average	0.745	15.73	67.4	7.90±0.08	1.3±1.0
	Best	0.751	15.77	68.5	7.99	2.4
10 wt. %	Average	0.753	15.15	67.8	7.73±0.04	-0.9±0.5
	Best	0.757	15.05	67.9	7.77	-0.4

Table S8. Summary of the photovoltaic performance of OPVs based on PBDTTT-EFT/PC₇₁BM with TIPs-Pentacene as additive.

Addition level of TIPs-Pentacene in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.785	17.71	63.4	8.82±0.08	/
1.0 wt. %	Average	0.790	18.09	63.4	9.06±0.06	2.7±0.7
	Best	0.796	18.04	63.5	9.12	3.4
2.5 wt. %	Average	0.792	17.86	61.2	8.66±0.03	-1.8±0.3
	Best	0.796	17.98	60.7	8.69	-1.5
5.0 wt. %	Average	0.800	17.22	60.9	8.39±0.18	-4.9±2.0
	Best	0.806	17.30	61.2	8.53	-3.3

Table S9. Summary of the photovoltaic performance of OPVs based on P3HT/PC₇₁BM with DBR additive.

Addition level of DBR in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.567	12.86	55.0	4.01	/
1.0 wt. %	Average	0.567	13.30	55.2	4.16±0.01	3.74±0.25
	Best	0.567	13.43	54.8	4.17	3.99
2.5 wt. %	Average	0.617	13.21	55.3	4.51±0.13	12.47±3.24
	Best	0.633	13.20	55.5	4.64	15.71
5.0 wt. %	Average	0.600	12.04	54.1	3.91±0.02	-2.49±0.50
	Best	0.600	12.08	54.0	3.92	-2.24

Table S10. Summary of the photovoltaic performance of OPVs based on PBDB-T-SF/IT-4F with DBR additive.

Addition level of DBR in active layer		V _{oc} (V)	J _{sc} (mA/cm ²)	FF (%)	PCE (%)	Relative PCE Enhancement (%)
Control	Average	0.886	18.44	62.7	10.25±0.08	/
1.0 wt. %	Average	0.879	18.60	60.4	9.87±0.02	-3.7±0.2
	Best	0.878	18.64	60.3	9.89	-3.5
2.5 wt. %	Average	0.871	18.25	55.7	8.86±0.02	-13.5±0.2
	Best	0.861	18.25	55.3	8.88	-13.4
5.0 wt. %	Average	0.797	18.60	59.3	8.79±0.03	-14.2±0.3
	Best	0.794	18.59	59.3	8.81	-14.0