Supporting information

Enhancing photovoltaic properties of low bandgap terpolymers based on benzodithiophene and phenanthrophenazine by introducing different second acceptor units

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1. Photovoltaic properties of terpolymer based PSCs at different conditions

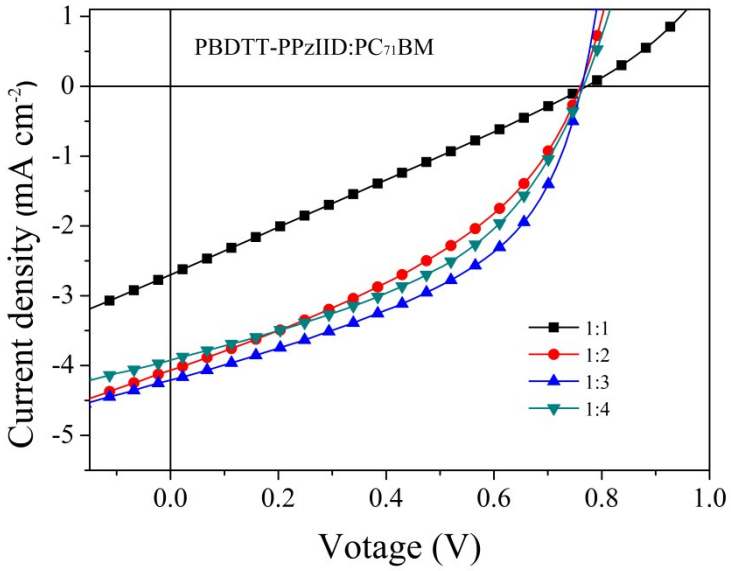

Fig. S1a *J-V* curves of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different blend ratios (*w/w*) under illumination of AM 1.5G, 100 mW/cm^2.

Table S1a Photovoltaic properties of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different blend ratios (*w/w*) under illumination of AM 1.5G, 100 mW/cm^2.

D/A Ratio	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1/1	2.67	0.76	26.3	0.54
1/2	4.05	0.75	39.4	1.19
1/3	4.19	0.76	45.5	1.45
1/4	3.91	0.76	43.9	1.31

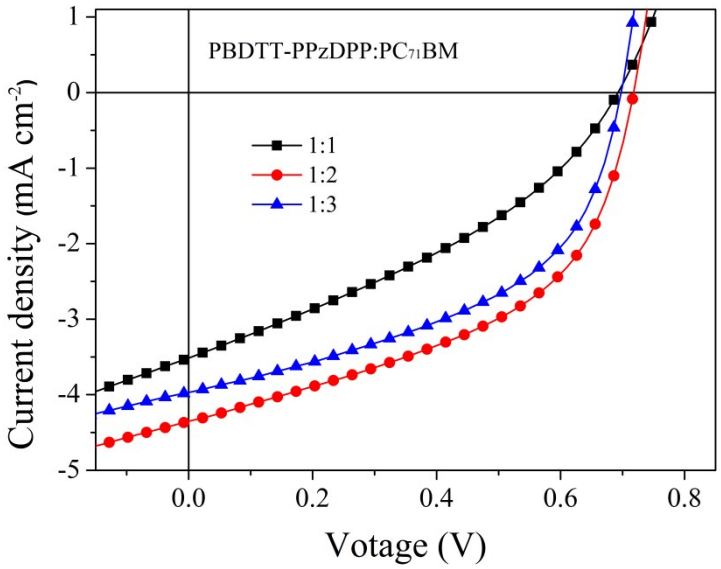

Fig. S1b *J-V* curves of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different blend ratios (*w/w*) under illumination of AM 1.5G, 100 mW/cm^2.

Table S1b Photovoltaic properties of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different blend ratios (*w/w*) under illumination of AM 1.5G, 100 mW/cm^2.

D/A Ratio	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1/1	3.49	0.69	35.8	0.86
1/2	4.34	0.72	48.7	1.51
1/3	3.96	0.69	49.3	1.34

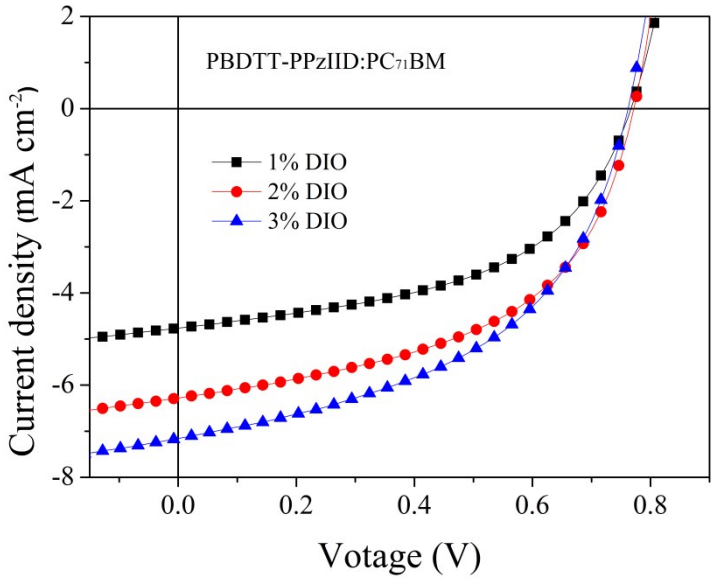

Fig. S2a *J-V* curves of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different DIO additive concentrations under illumination of AM 1.5G, 100 mW/cm^2.

Table S2a Photovoltaic properties of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different DIO additive concentrations under illumination of AM 1.5G, 100 mW/cm^2.

DIO additive concentrations	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1%	4.75	0.76	51.1	1.85
2%	6.27	0.76	52.2	2.49
3%	7.14	0.76	48.9	2.66

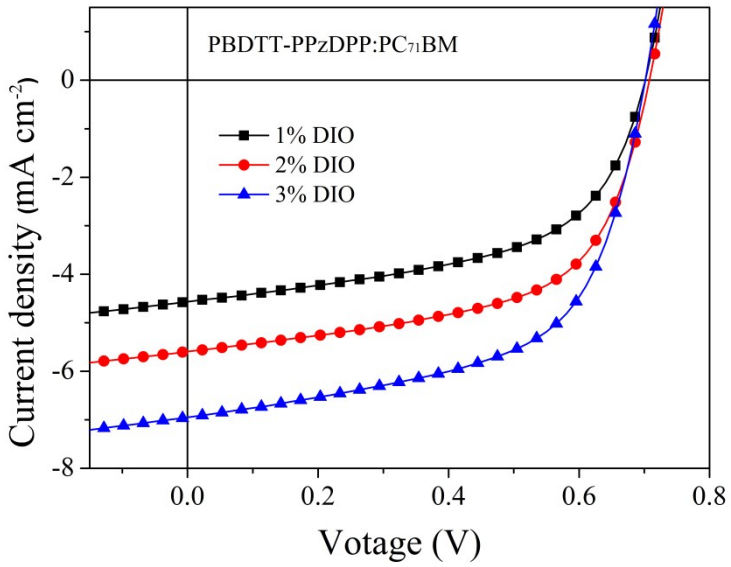

Fig. S2b *J-V* curves of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different DIO additive concentrations under illumination of AM 1.5G, 100 mW/cm^2.

Table S2b Photovoltaic properties of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different DIO additive concentrations under illumination of AM 1.5G, 100 mW/cm^2.

DIO additive concentrations	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1%	4.55	0.70	51.1	1.76
2%	5.58	0.70	59.4	2.32
3%	6.93	0.70	58.7	2.85

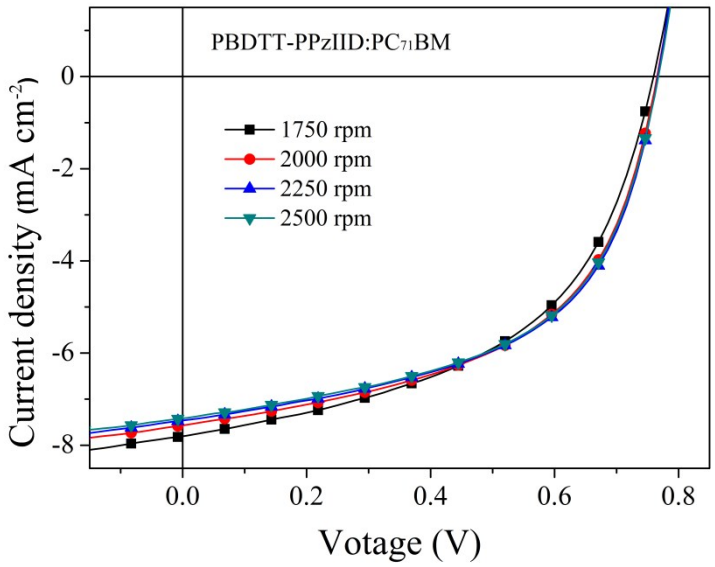

Fig. S3a *J-V* curves of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

Table S3a Photovoltaic properties of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

spin-coating rates/ rpm	film thickness/ nm	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1750	103	7.79	0.75	51.8	3.01
2000	96	7.55	0.76	53.7	3.09
2250	90	7.45	0.76	55.0	3.12
2500	85	7.41	0.76	54.9	3.10

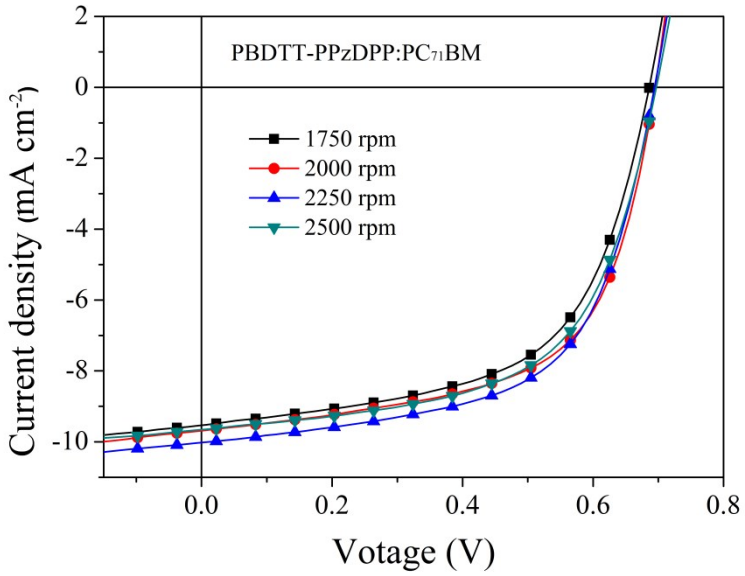

Fig. S3b *J-V* curves of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

Table S3b Photovoltaic properties of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

spin-coating rates/ rpm	film thickness/ nm	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
1750	107	9.52	0.69	58.5	3.82
2000	98	9.67	0.69	61.3	4.06
2250	93	10.0	0.69	60.9	4.18
2500	89	9.64	0.69	60.2	3.98

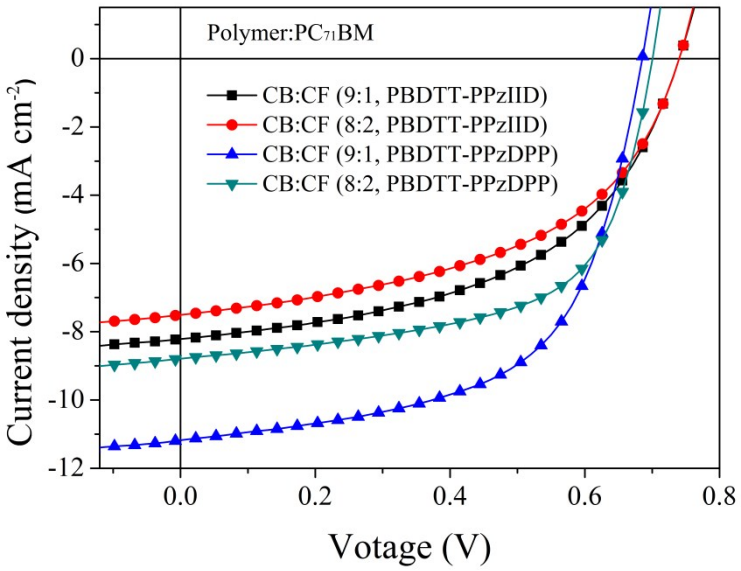

Fig. S4 *J-V* curves of the terpolymers/$PC_{71}BM$-based PSCs at different $CB/CHCl_3$ ratios under illumination of AM 1.5G, 100 mW/cm^2.

Table S4 Photovoltaic properties of the terpolymers/$PC_{71}BM$-based PSCs at different $CB/CHCl_3$ ratios under illumination of AM 1.5G, 100 mW/cm^2.

Terpolymers	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
PBDTT-PPzIID [a]	8.20	0.73	51.3	3.08
PBDTT-PPzIID [b]	7.49	0.73	50.6	2.77
PBDTT-PPzDPP [a]	11.2	0.67	60.2	4.51
PBDTT-PPzDPP [b]	8.77	0.69	62.6	3.79

[a] $CB/CHCl_3$ ratio is 9/1; [b] $CB/CHCl_3$ ratio is 8/2.

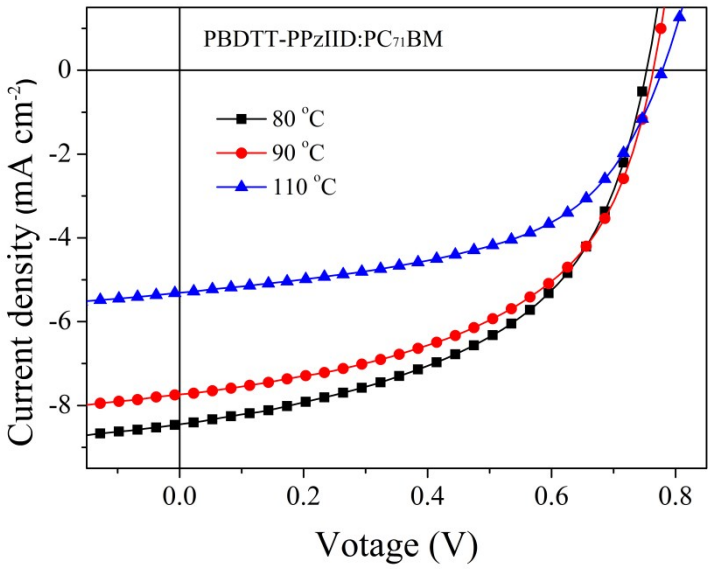

Fig. S5a *J-V* curves of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different temperature under illumination of AM 1.5G, 100 mW/cm^2.

Table S5a Photovoltaic properties of the PBDTT-PPzIID/$PC_{71}BM$-based PSCs at different temperature under illumination of AM 1.5G, 100 mW/cm^2.

Temperature/ °C	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
80	8.43	0.75	51.5	3.24
90	7.73	0.76	52.0	3.06
100	5.30	0.78	53.3	2.19

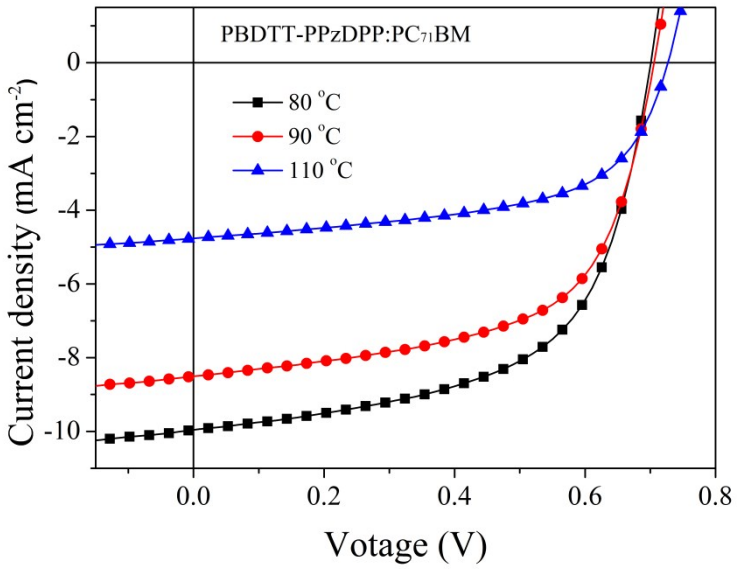

Fig. S5b *J-V* curves of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different temperature under illumination of AM 1.5G, 100 mW/cm^2.

Table S5b Photovoltaic properties of the PBDTT-PPzDPP/$PC_{71}BM$-based PSCs at different temperature under illumination of AM 1.5G, 100 mW/cm^2.

Temperature/ °C	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max}/ %
80	9.94	0.69	60.5	4.12
90	8.49	0.70	60.6	3.61
100	4.75	0.72	58.8	2.00