Supporting information

Efficient polymer solar cells based on a new quinoxaline derivative with fluorinated phenyl side chain

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1. TGA measurement

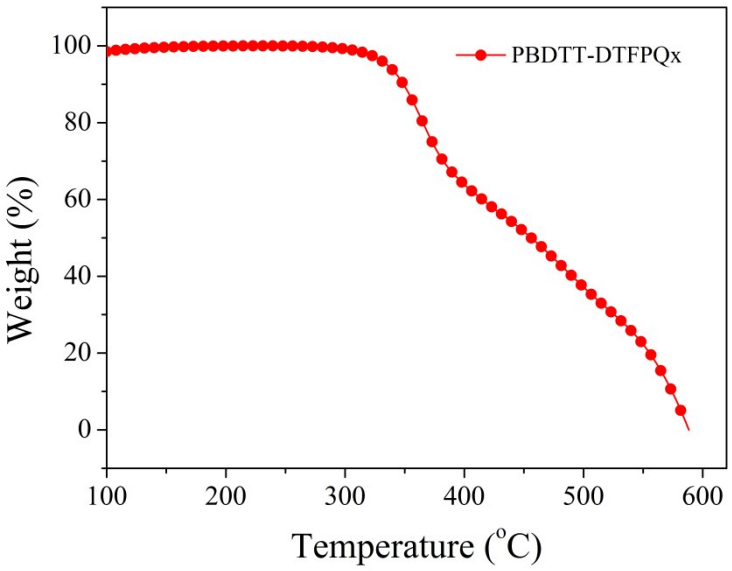


Fig. S1 TGA curve of PBDTT-DTFPQx at a scan rate of 20 ˚C/min under nitrogen atmosphere.

2. DSC measurement

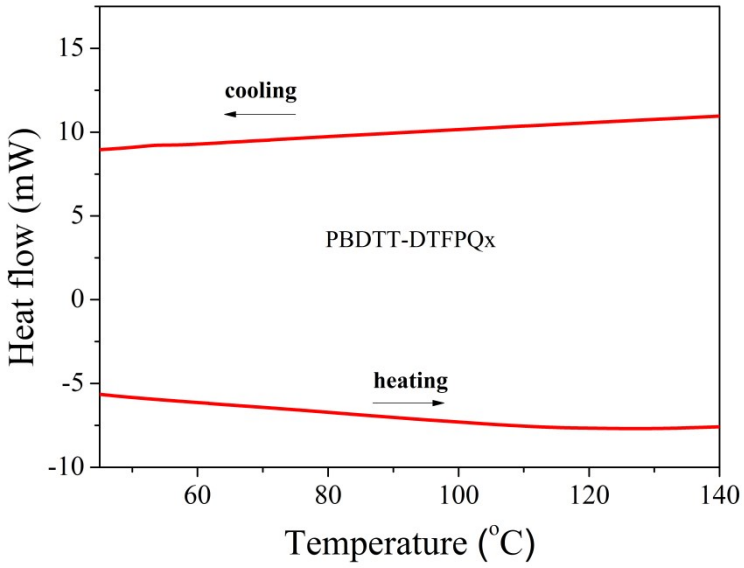


Fig. S2 DSC curves of polymers with a heating rate of 10 °C min^{-1} under N_2 atmosphere.

3. DFT calculation

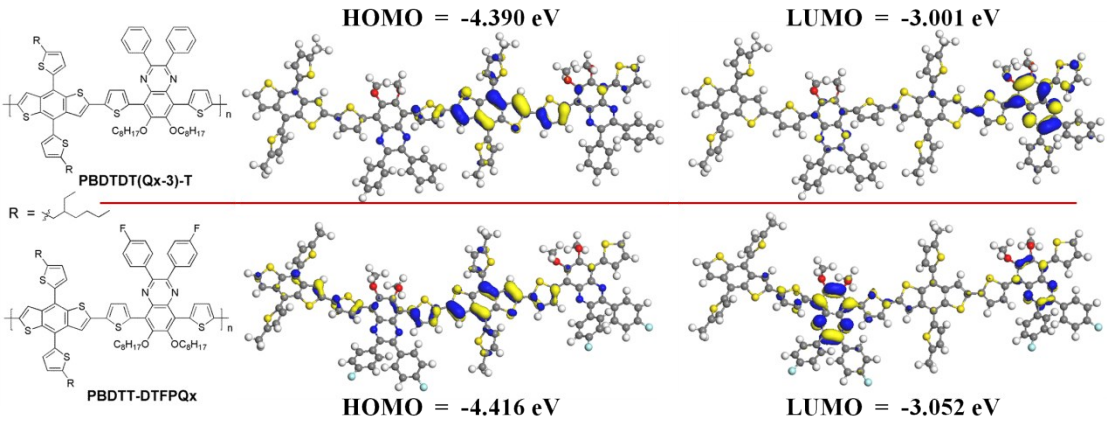


Fig. S3 The calculated HOMO and LUMO levels of non fluorinated PBDTDT(Qx-3)-T and fluorinated PBDTT-DTFPQx by Gaussian at the B3LYP/6-31G* level.

4. Photovoltaic properties of polymer-based PSCs at different conditions

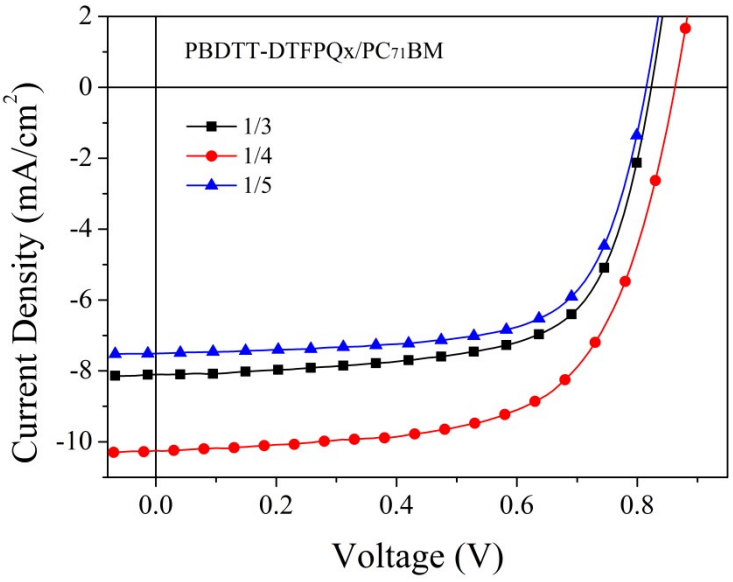


Fig. S4 *J-V* curves of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with different blend ratios (*w/w*) under illumination of AM 1.5G, 100 mW/cm^2.

Table S1 Photovoltaic properties of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with

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} (PCE_{ave}[a])/ %
1/3	8.2	0.79	70	4.5 (4.3)
1/4	10.1	0.87	65	5.8 (5.6)
1/5	7.5	0.81	68	4.2 (4.1)

[a)] The average PCE was obtained from over 10 devices.

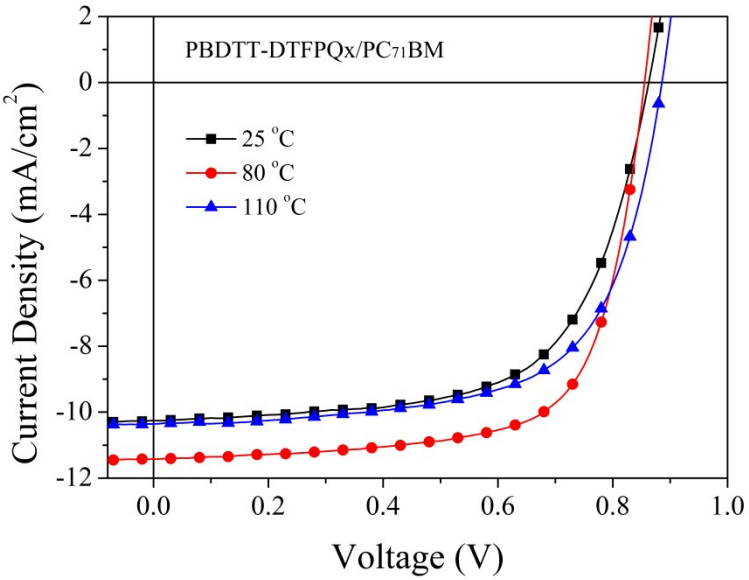


Fig. S5 *J-V* curves of the PBDTT-DTFPQx/PC_{71}BM-based PSCs with different temperature under illumination of AM 1.5G, 100 mW/cm^2.

Table S2 Photovoltaic properties of the PBDTT-DTFPQx/PC_{71}BM-based PSCs with

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} (PCE_{ave}[a])/ %
25	10.1	0.87	65	5.8 (5.6)
80	11.3	0.86	71	6.9 (6.6)
110	10.4	0.89	65	6.0 (5.8)

[a] The average PCE was obtained from over 10 devices.

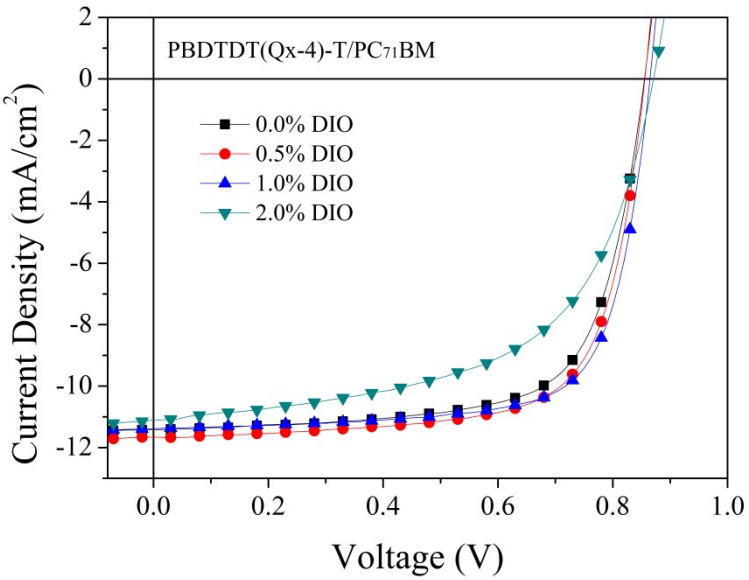


Fig. S6 *J-V* curves of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with different DIO additive concentrations under illumination of AM 1.5G, 100 mW/cm^2.

Table S3 Photovoltaic properties of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with

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} (PCE_{ave}[a])/ %
0.0%	11.3	0.86	71	6.9 (6.6)
0.5%	11.7	0.86	71	7.1 (6.8)
1.0%	11.4	0.87	73	7.2 (7.0)
2.0%	11.1	0.87	58	5.6 (5.5)

[a] The average PCE was obtained from over 10 devices.

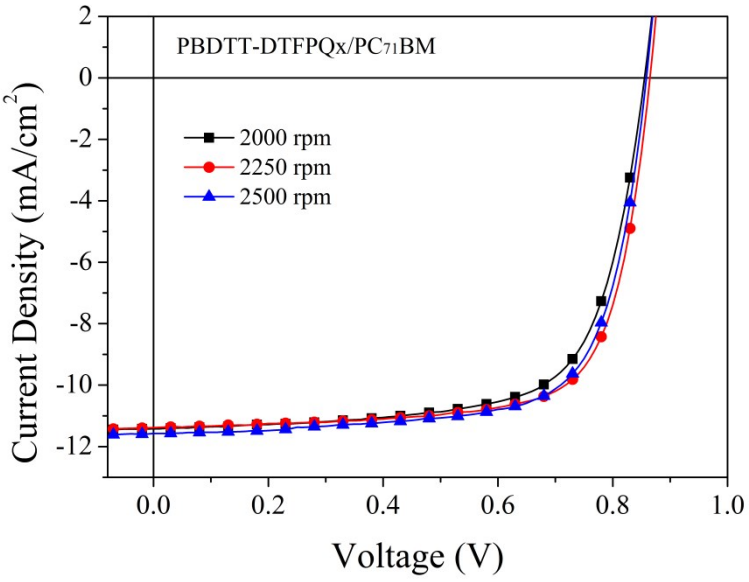


Fig. S7 *J-V* curves of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

Table S4 Photovoltaic properties of the PBDTT-DTFPQx/$PC_{71}BM$-based PSCs with

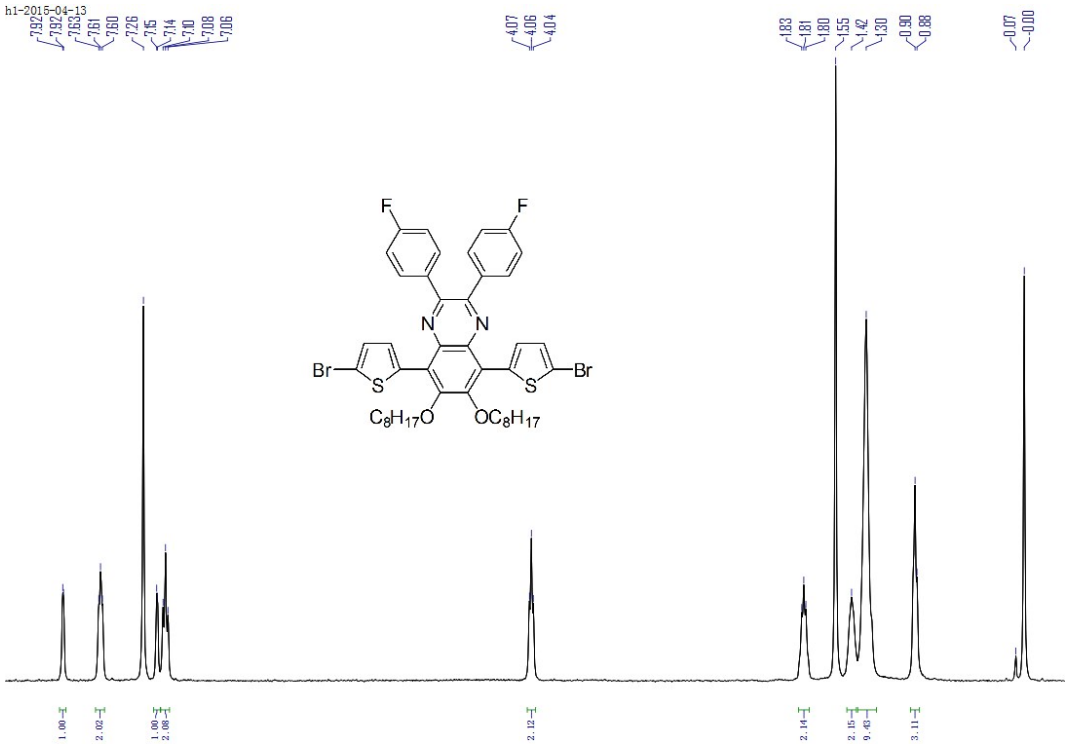
different spin-coating rates under illumination of AM 1.5G, 100 mW/cm^2.

spin-coating rates/ rpm	J_{sc}/ mA cm^{-2}	V_{oc}/ V	*FF*/ %	PCE_{max} (PCE_{ave}[a])/ %
2000	11.3	0.86	71	7.0 (6.7)
2250	11.4	0.87	73	7.2 (7.0)
2500	11.5	0.86	72	7.1 (6.9)

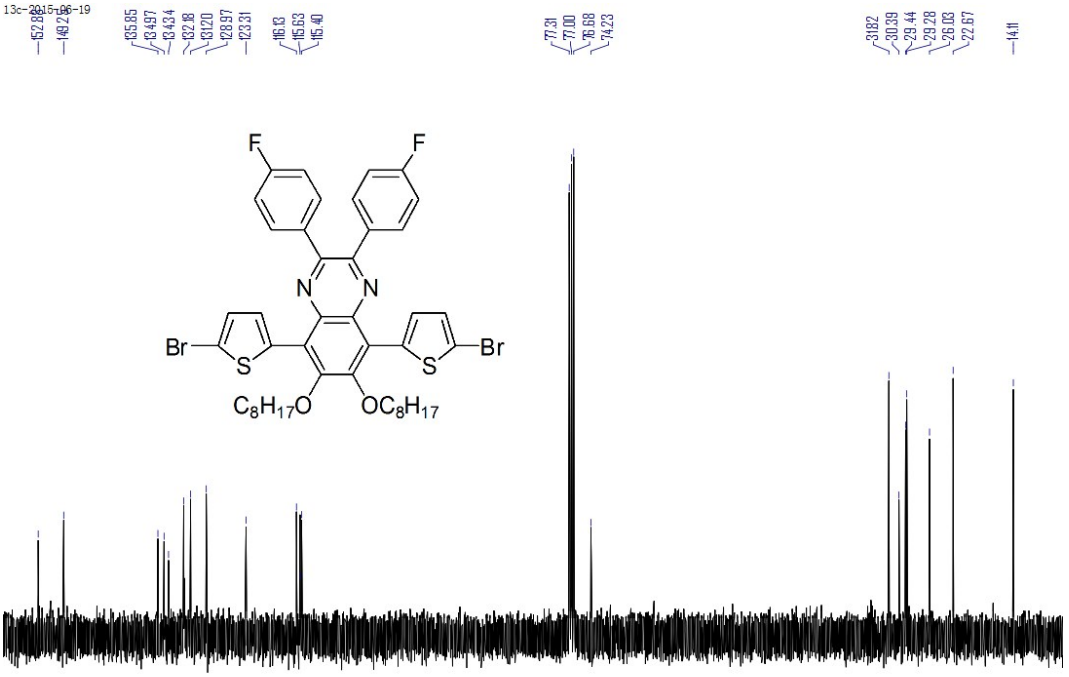
[a)] The average PCE was obtained from over 10 devices.

5. ^{1}HNMR, ^{13}C NMR and MS data of monomer and ^{1}H NMR data of polymer

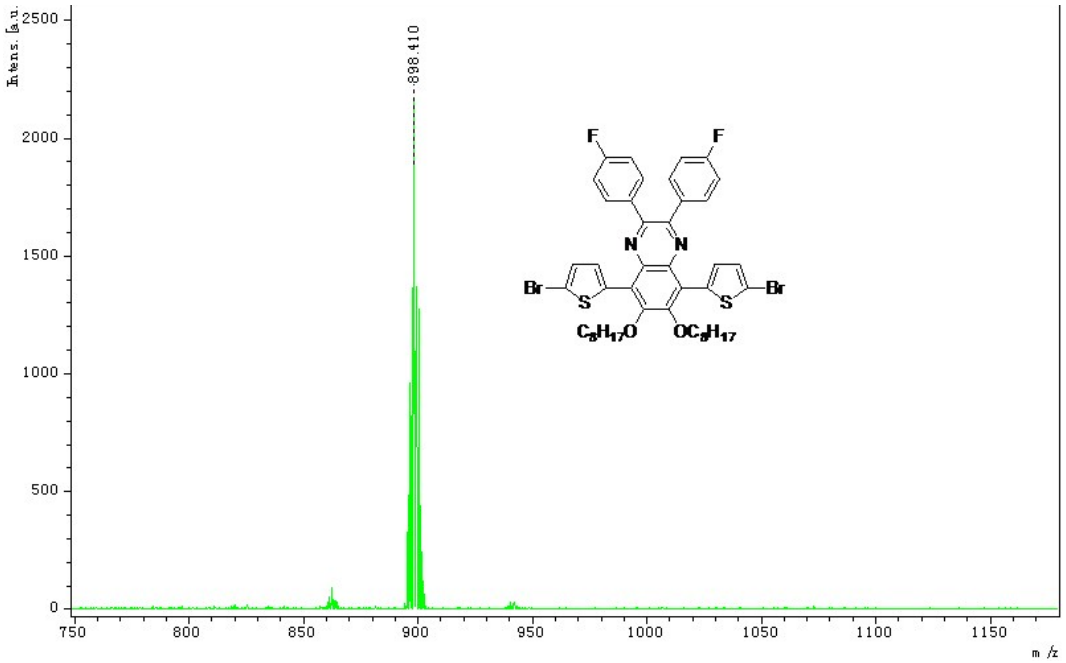
^{1}H NMR plot of **DTFPQx-Br$_2$**



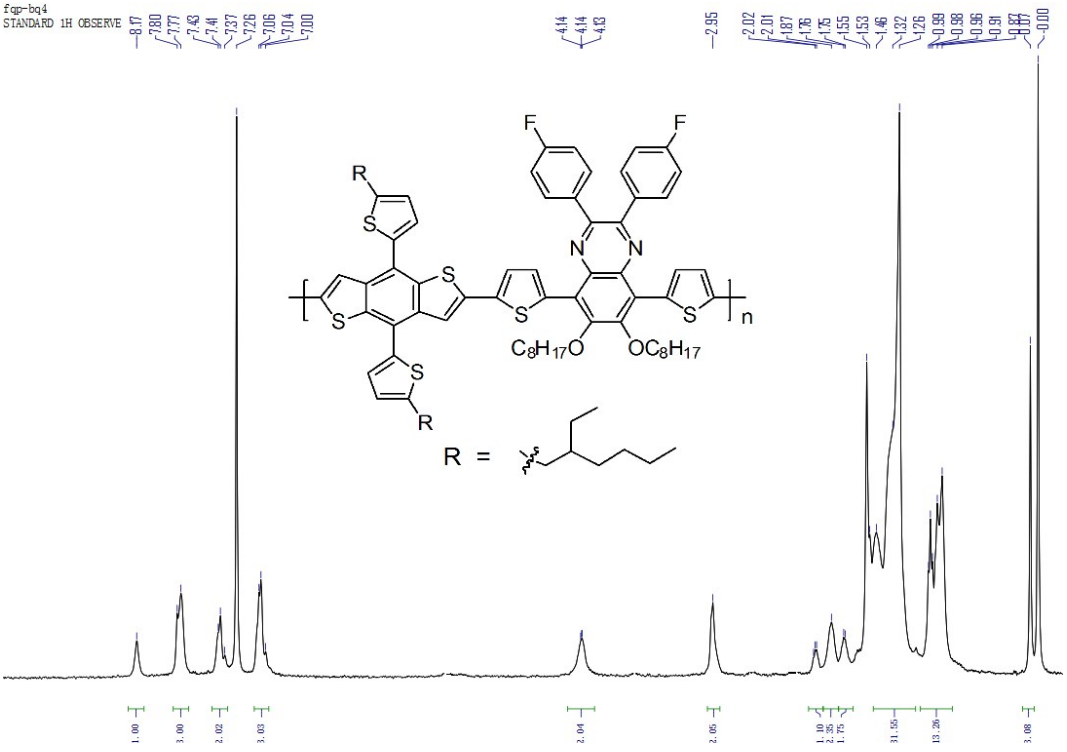
^{13}C NMR plot of **DTFPQx-Br$_2$**



MALDI-TOF plot of **DTFPQx-Br$_2$**



^{1}H NMR plot of **PBDTT-DTFPQx**


fqp-bq4
STANDARD 1H OBSERVE
8.17
7.80
7.77
7.43
7.41
7.37
7.26
7.06
7.04
7.00
4.14
4.14
4.13
2.95
2.02
2.01
1.87
1.76
1.75
1.55
1.53
1.46
1.32
1.26
0.99
0.98
0.96
0.91
0.87
0.00
F
F
R
S
N
N
S
S
S
S
n
C8H17O
OC8H17
S
R
R =
1.00
3.00
2.02
3.03
2.04
2.05
2.10
2.25
1.75
31.55
13.26
3.08