Supporting Information for

Fullerene-free polymer solar cell based on polythiophene derivative with an unprecedented energy loss less than 0.5 eV

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Table S1. The optimization of D/A weight ratio of the PDCBT-2F/IT-M-based PSCs

D/A	*Voc (V)*	*Jsc (mA/cm2)*	FF	PCE (%)
2:1	1.16	7.52	0.484	4.20
1.5:1	1.16	7.58	0.492	4.32
1:1	1.12	5.80	0.514	3.33

Table S2. The screening for additives of the PDCBT-2F/IT-M-based PSCs

Additive	*Voc* (V)	*Jsc* (mA/cm2)	FF	PCE (%)
Control devices	1.15	7.42	0.467	4.00
0.5% vol DPE	1.12	8.95	0.524	5.25
0.5% vol CN	1.03	7.33	0.396	2.99
0.5% vol DIO	1.1	4.3	0.394	1.86
0.5% vol NMP	1.01	6.11	0.311	1.93

Table S3. The optimization of additive feed ratio of the PDCBT-2F/IT-M-based PSCs

DPE (%)	*Voc* (V)	*Jsc* (mA/cm2)	FF	PCE (%)
Control devices	1.14	7.98	0.472	4.29
0.5	1.13	9.01	0.541	5.57
1	1.13	9.65	0.526	5.72
3	1.13	7.71	0.539	4.71

Table S4. The optimization of thermal annealing of the PDCBT-2F/IT-M-based PSCs

Annealing*	*Voc* (V)	*Jsc* (mA/cm2)	FF	PCE (%)
80	1.12	9.7	0.523	5.70
100	1.13	9.66	0.551	6.02
120	1.11	10.43	0.556	6.42
140	1.08	10.58	0.521	5.94

*the time for thermal annealing is 10 minutes for all cases.

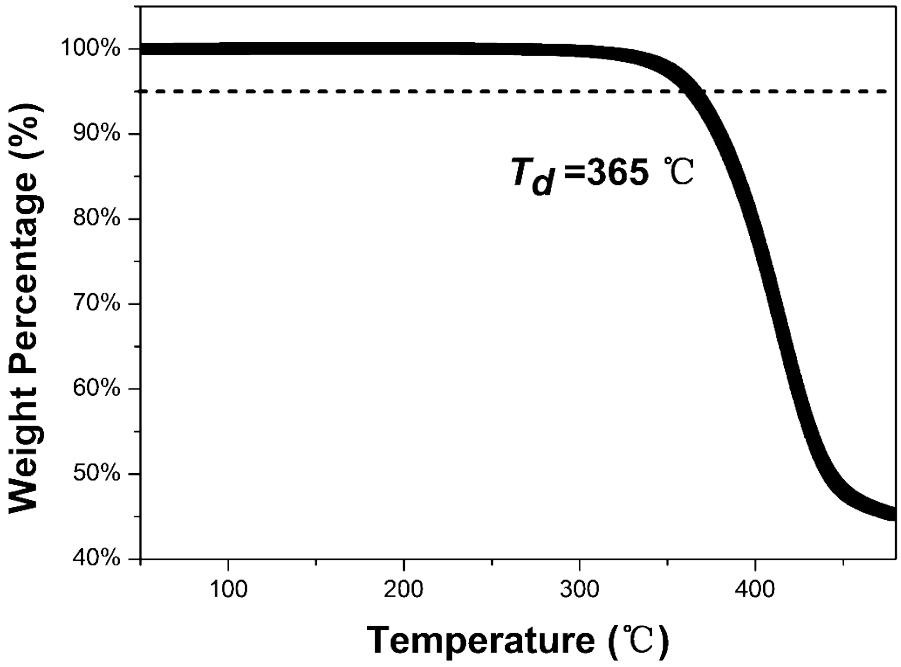

Figure S1. TGA plot of polymer PDCBT-2F

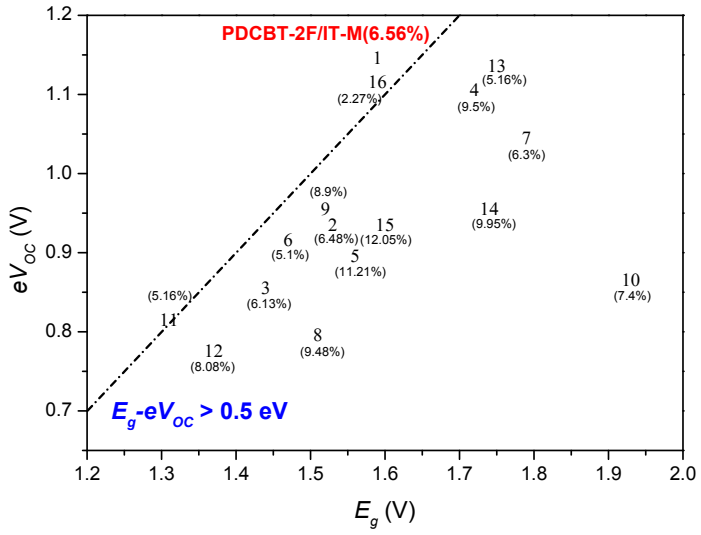

Figure S2. Distributions of E_g vs. eV_{OC} for efficient organic solar cells with low E_{loss} or high $V_{OC.}$ [1-16] The dot line refer to $E_g = eV_{OC}$ - 0.6 eV.

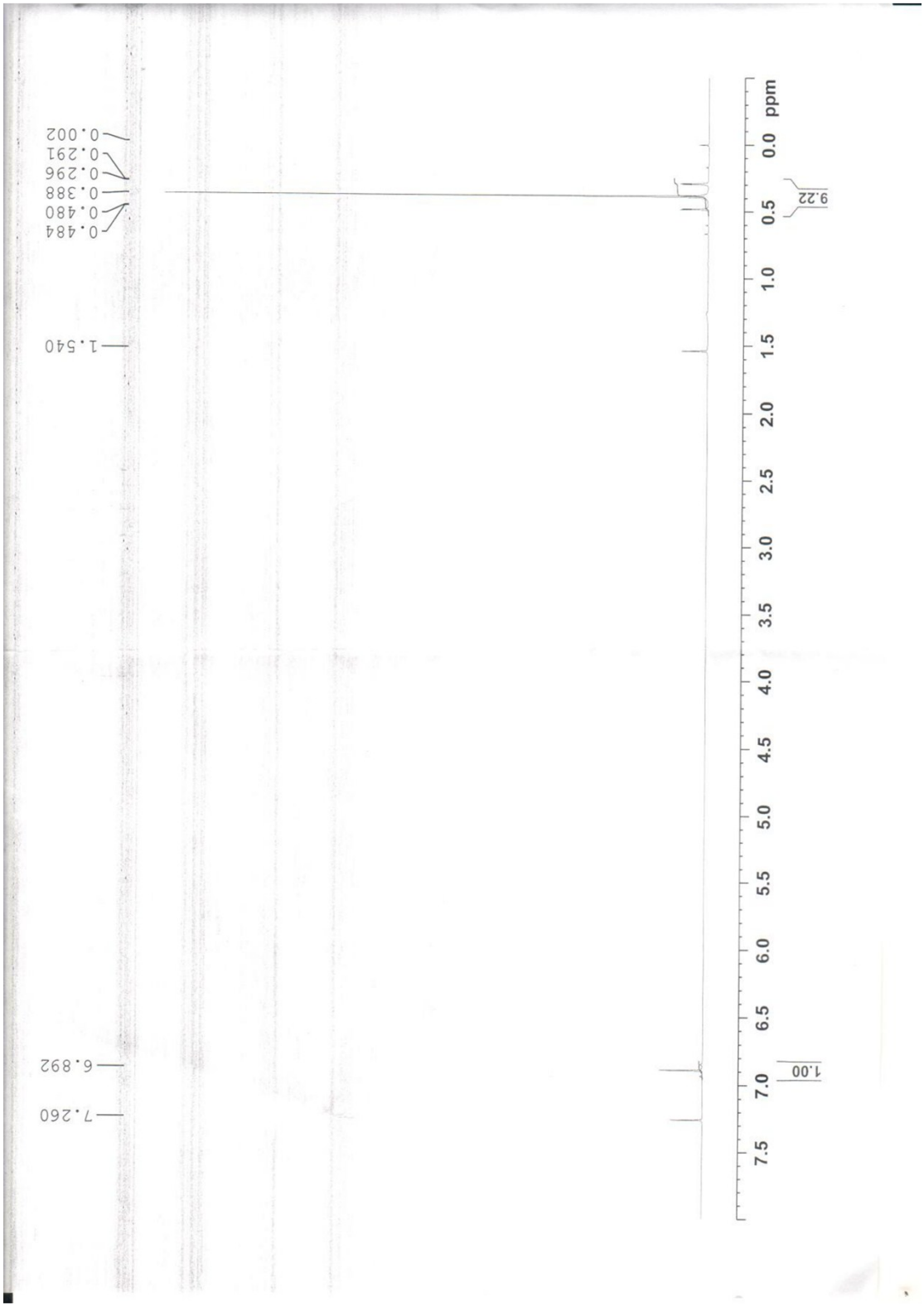

Figure S3. NMR spectra of 5,5'-bis(trimethylstannyl)-(3,3'-difluoro)-2,2'-bithiophene）

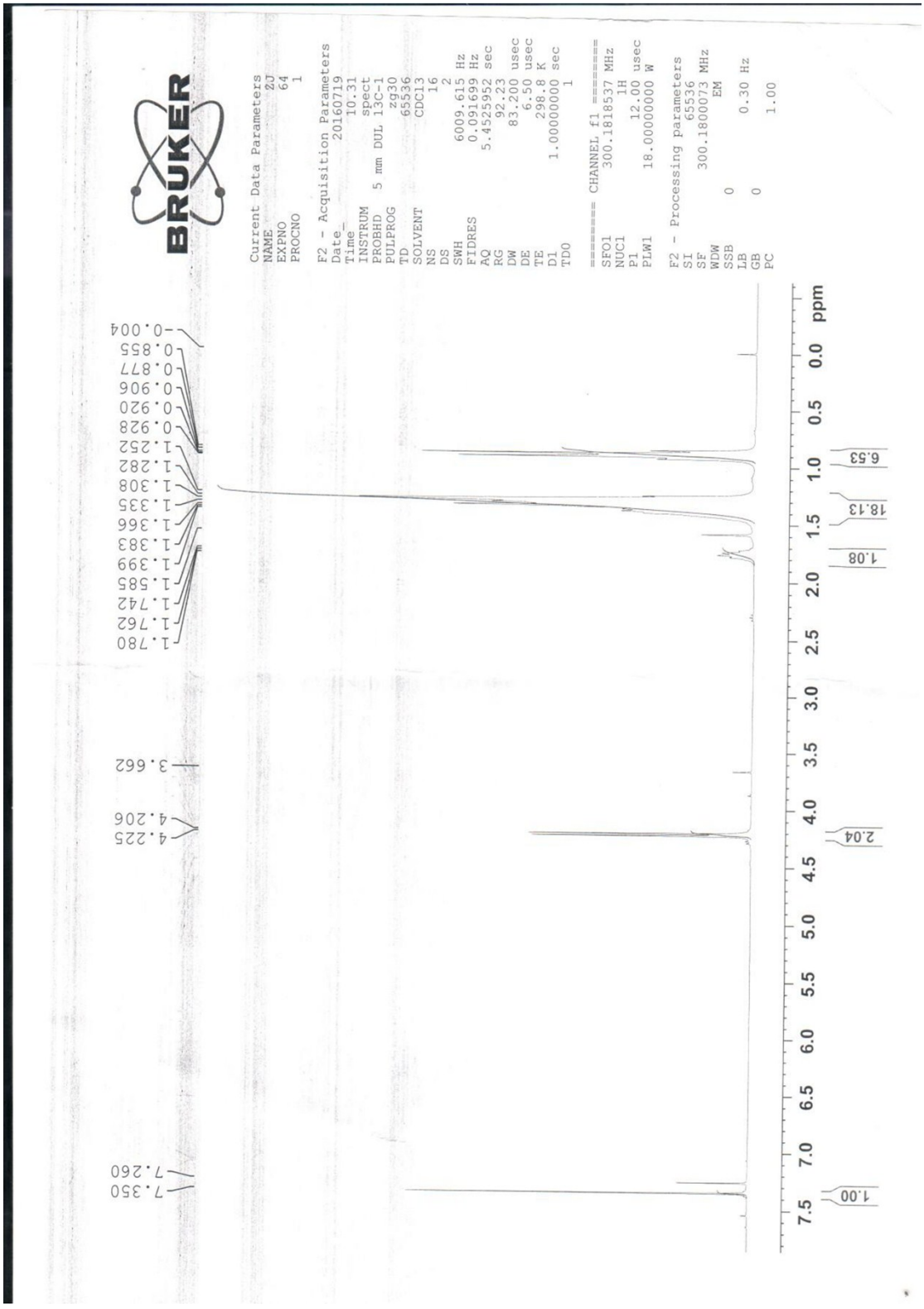

Figure S4. NMR spectra of bis (2-hexyldecyl) 5,5'-dibromo-[2,2'-bithiophene]-4,4'-dicarboxylate.

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