Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.


**Supporting Information**

**For**

# Random D-$A_1$-D-$A_2$ Terpolymer Based on Benzodithiophene, Thiadiazole[3,4-*e*]isoindole-5,7-dione and Thieno[3,4-*c*]pyrrole-4,6-dione for Efficient Polymer Solar Cells

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**Figure S1.** Cyclic voltammetry of **P1**

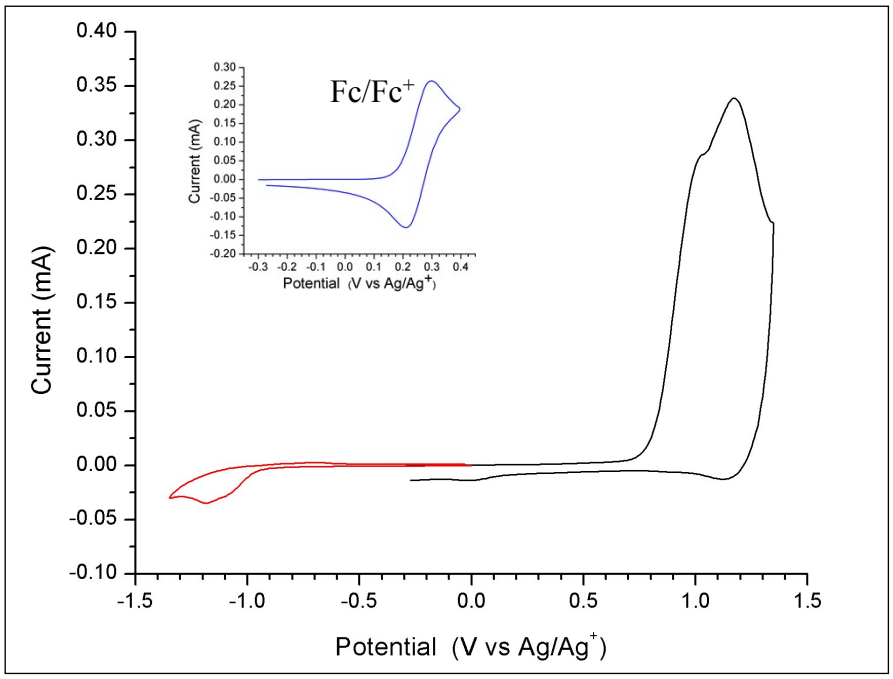



**Figure S2.** Cyclic voltammetry of **P2**

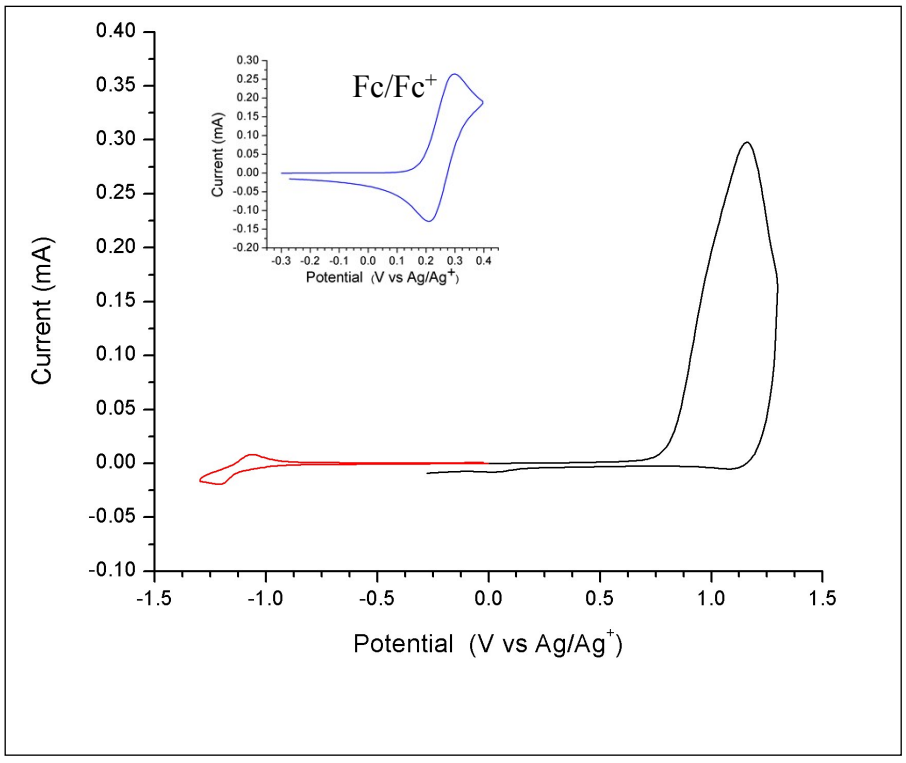


**Figure S3.** Cyclic voltammetry of **P3**

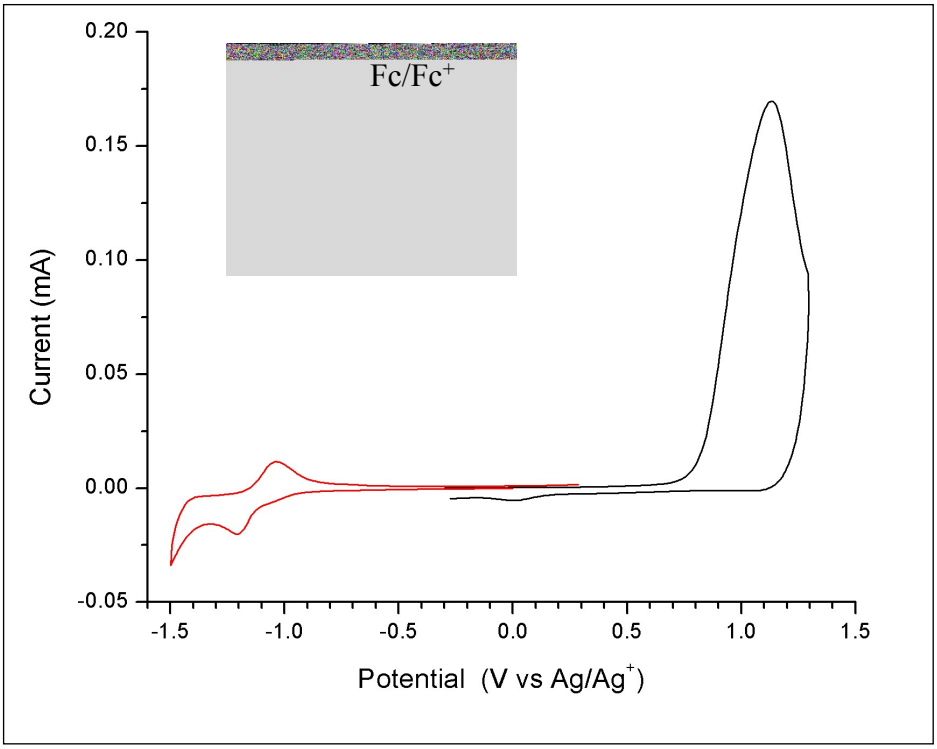



**Figure S4.** Cyclic voltammetry of **P4**

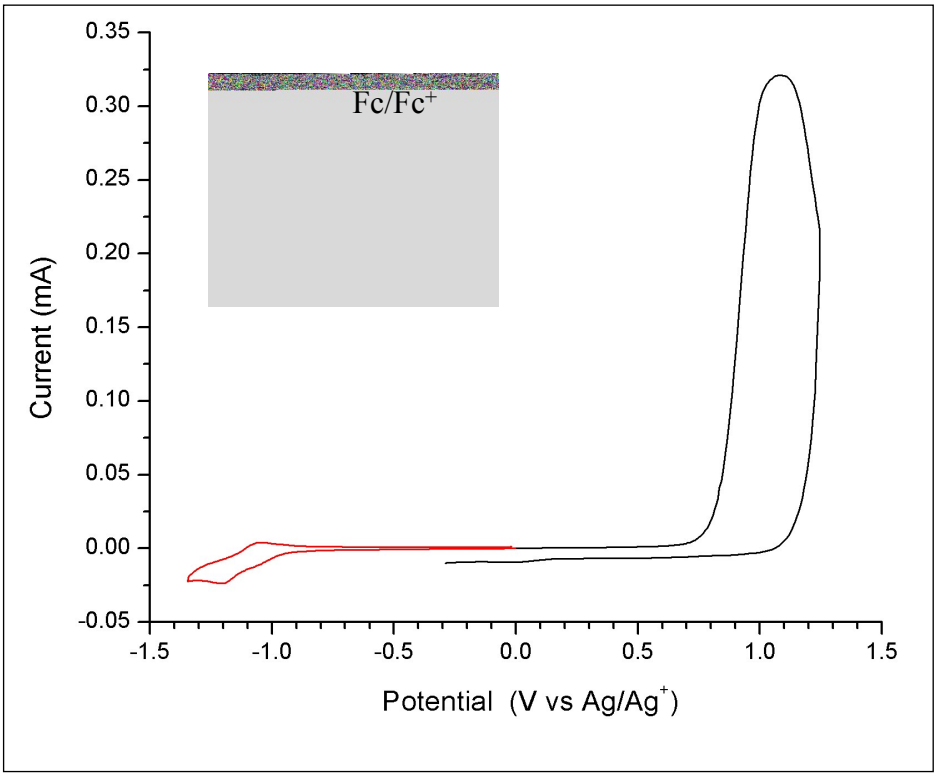


**Figure S5.** Cyclic voltammetry of **P5**

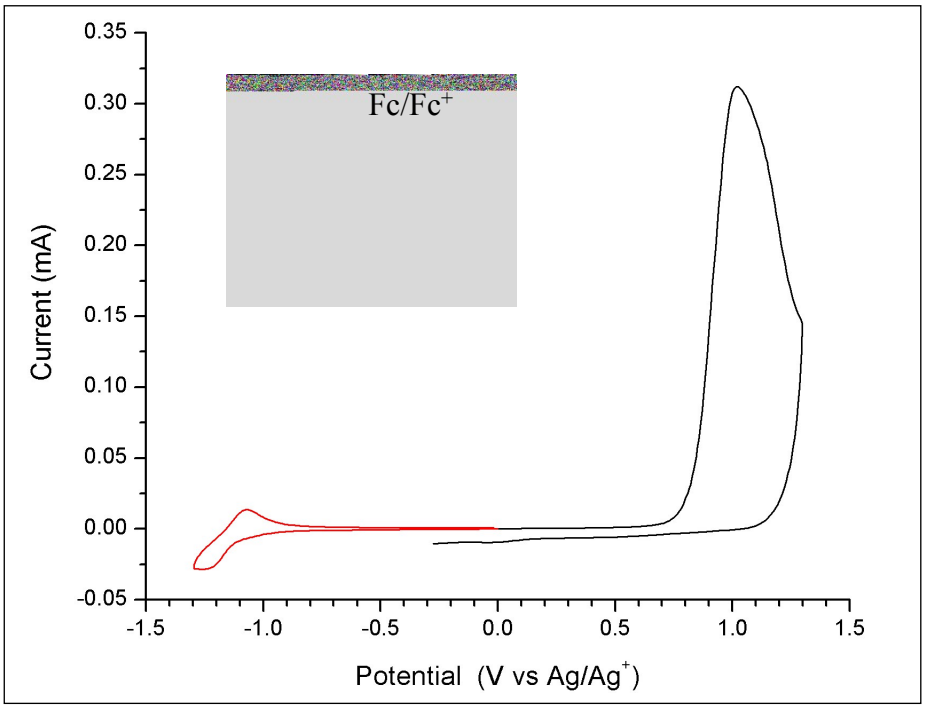



**Figure S6.** Cyclic voltammetry of **P6**

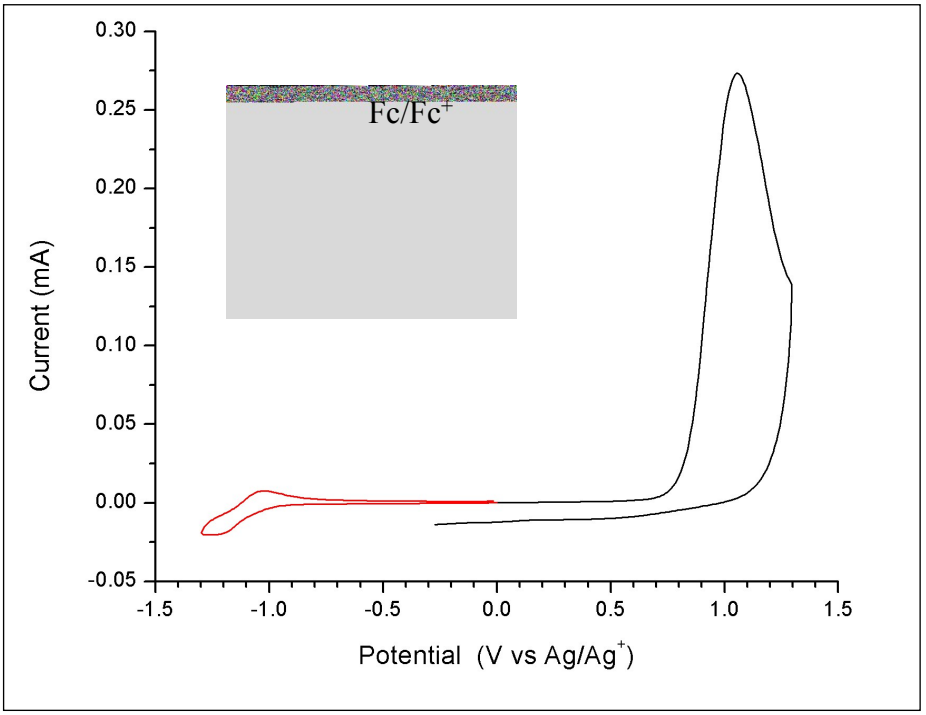


**Figure S7.** Cyclic voltammetry of **P7**

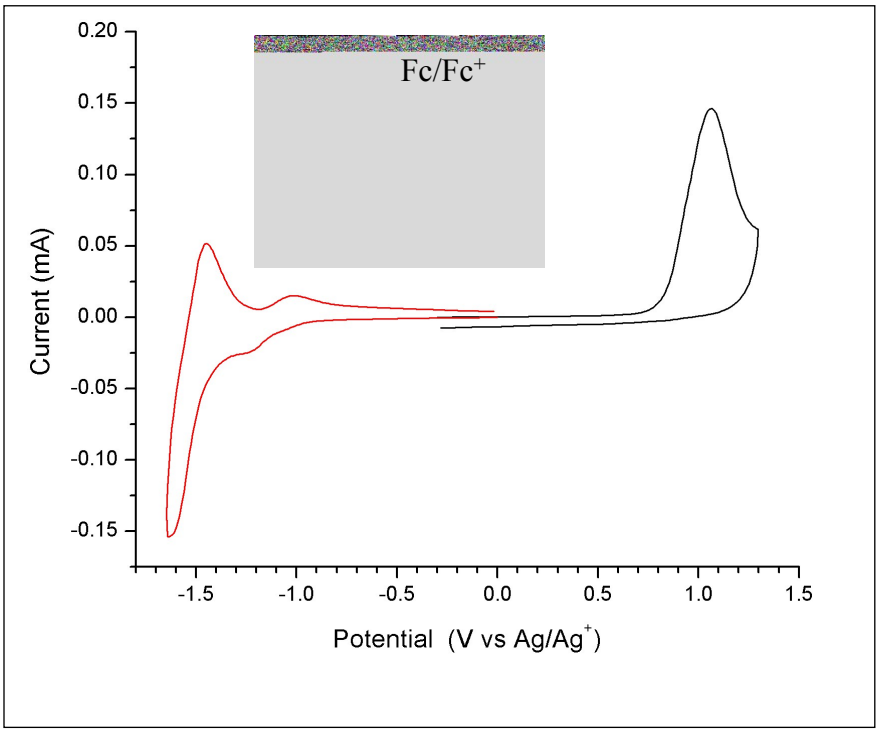



**Figure S8.** Cyclic voltammetry of **P8**

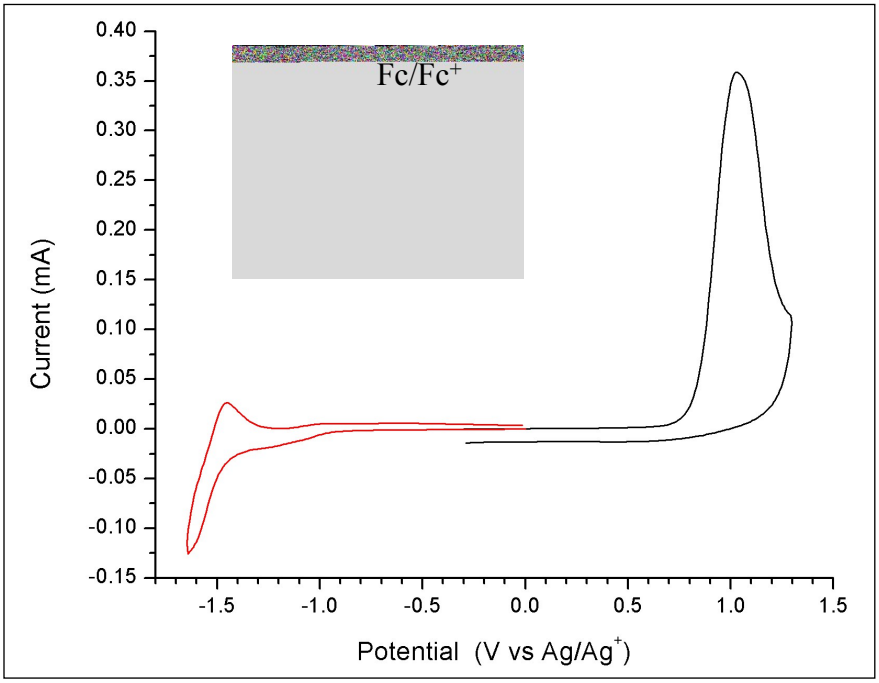


**Figure S9.** Cyclic voltammetry of **PBDTTPD**

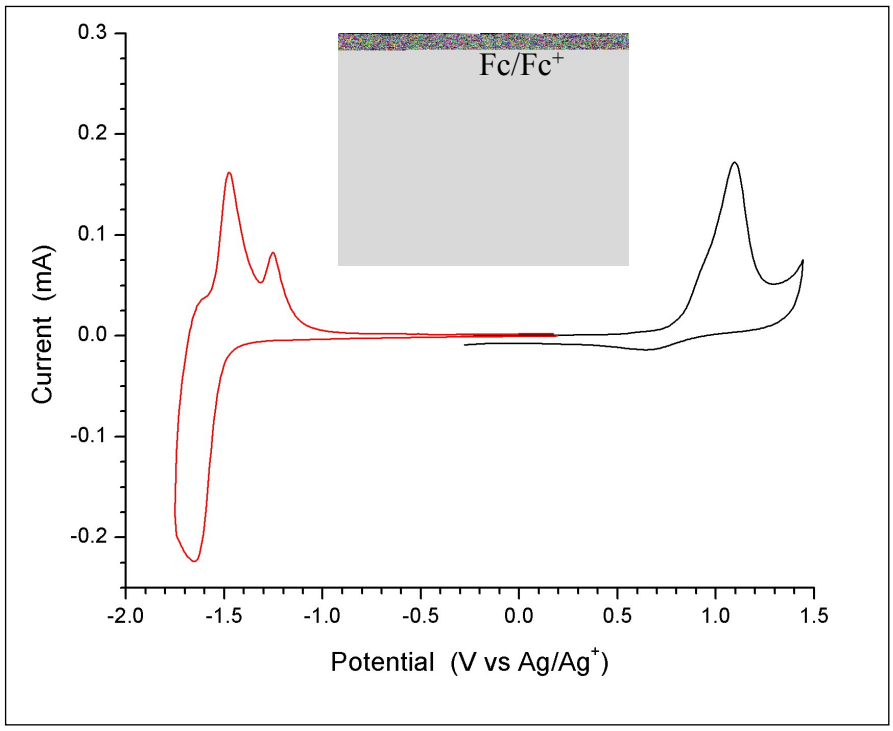


**Figure S10.** [1]H NMR Spectrum (400 MHz) in TCE at 90°C of **P1** ($\bar{M}_n$ = 30 kg/mol).

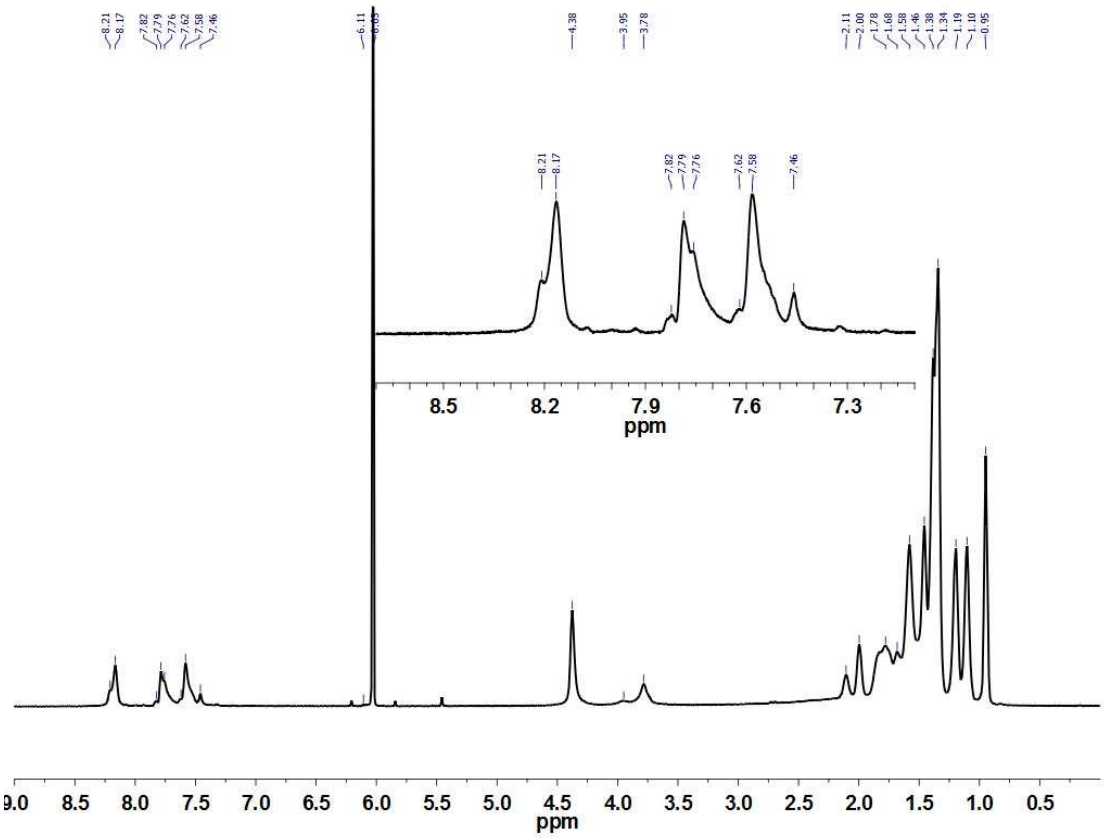


**Figure S11.** $^{1}$H NMR spectra (400 MHz) in TCE at 90°C of **P2-P4**.

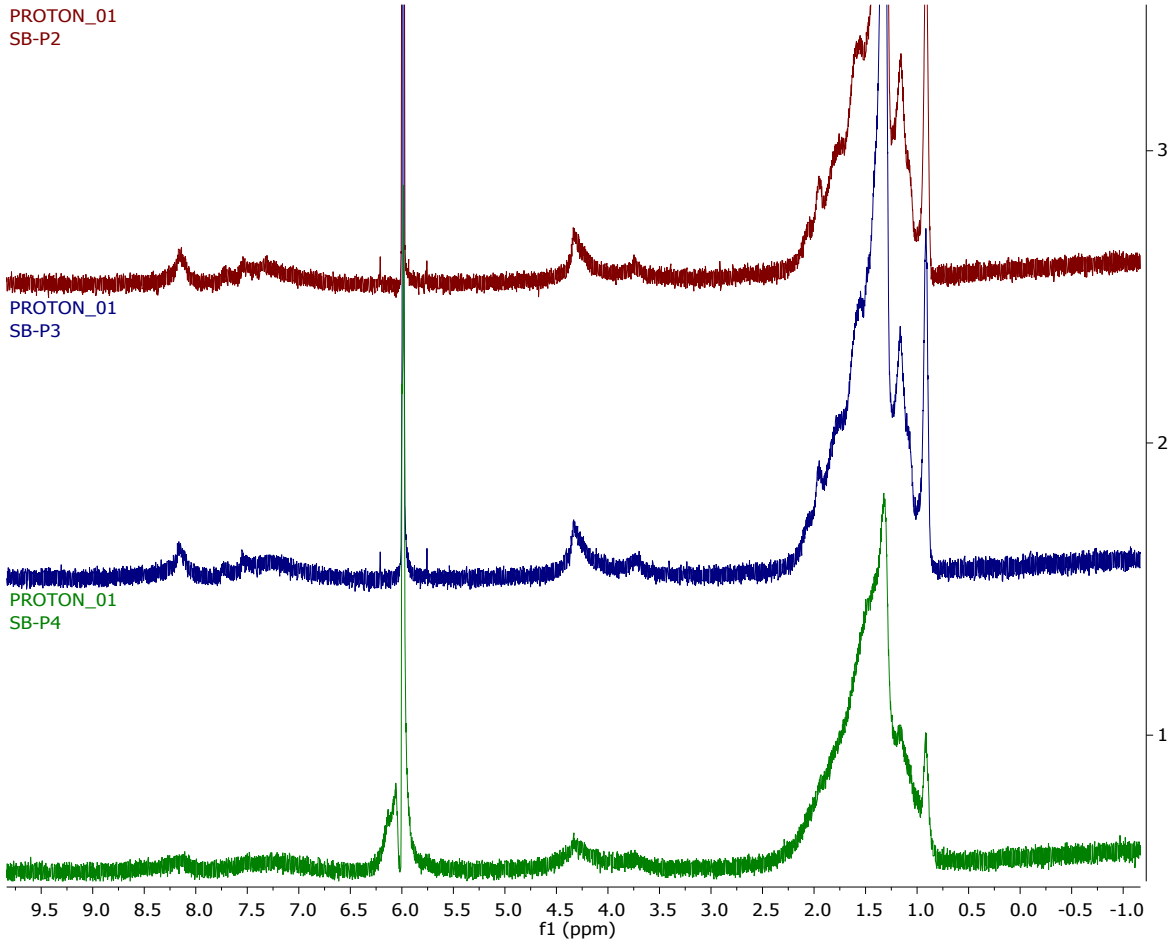


**Figure S12.** $^{1}$H NMR spectra (400 MHz) in TCE at 90°C of **P5-P7.**

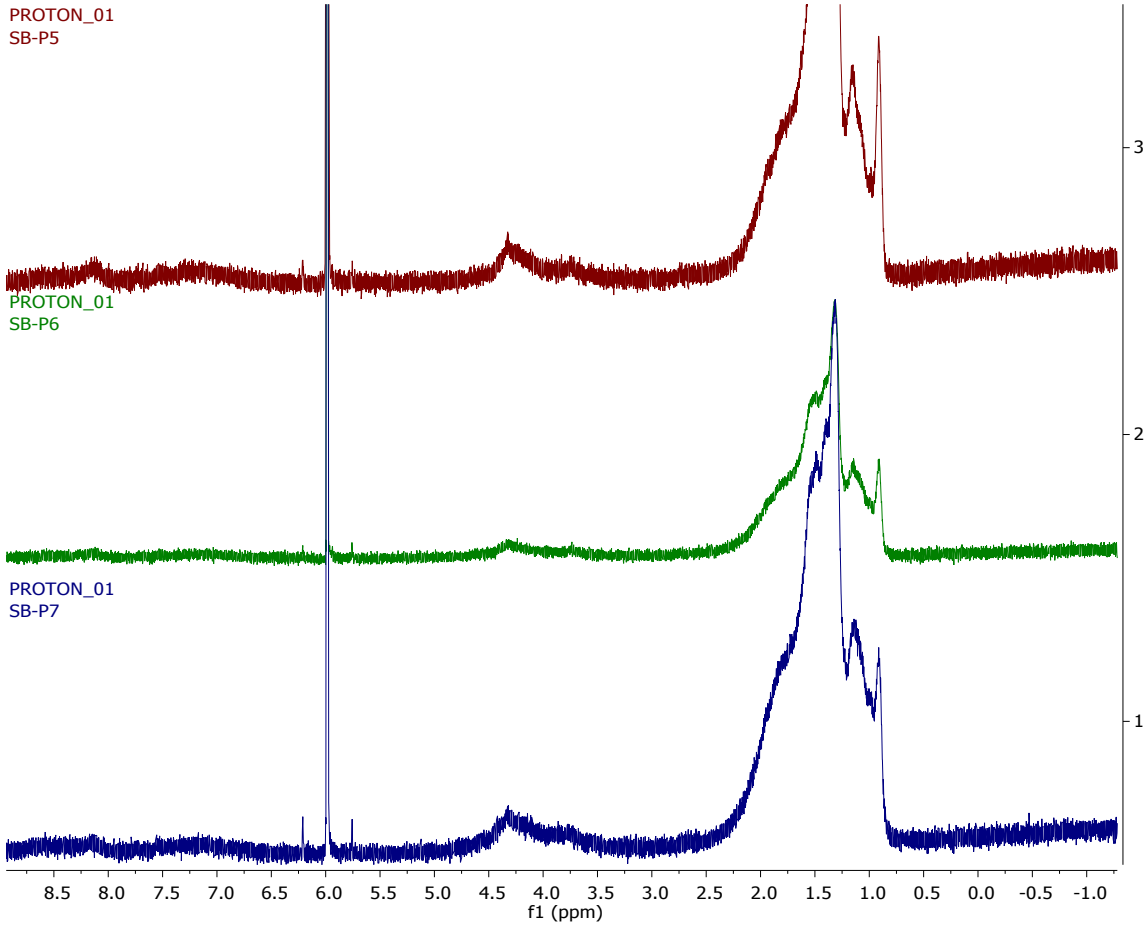
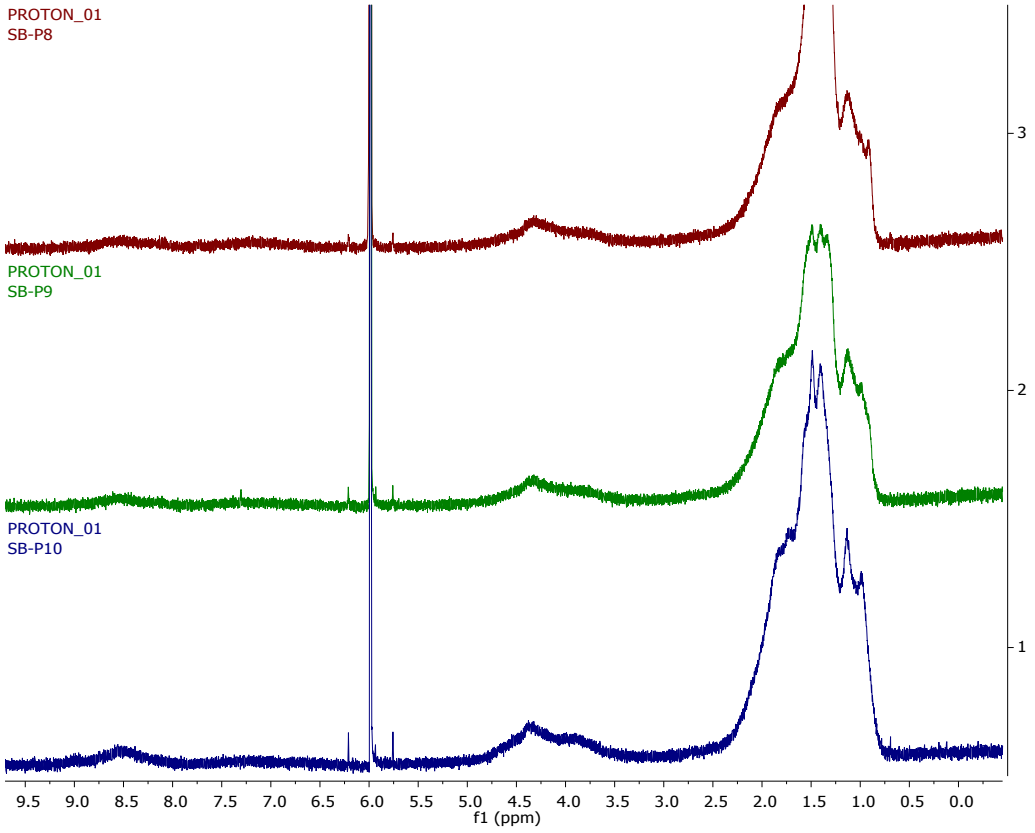


**Figure S13.** $^{1}$H NMR spectra (400 MHz) in TCE at 90°C of **P8-P10.**



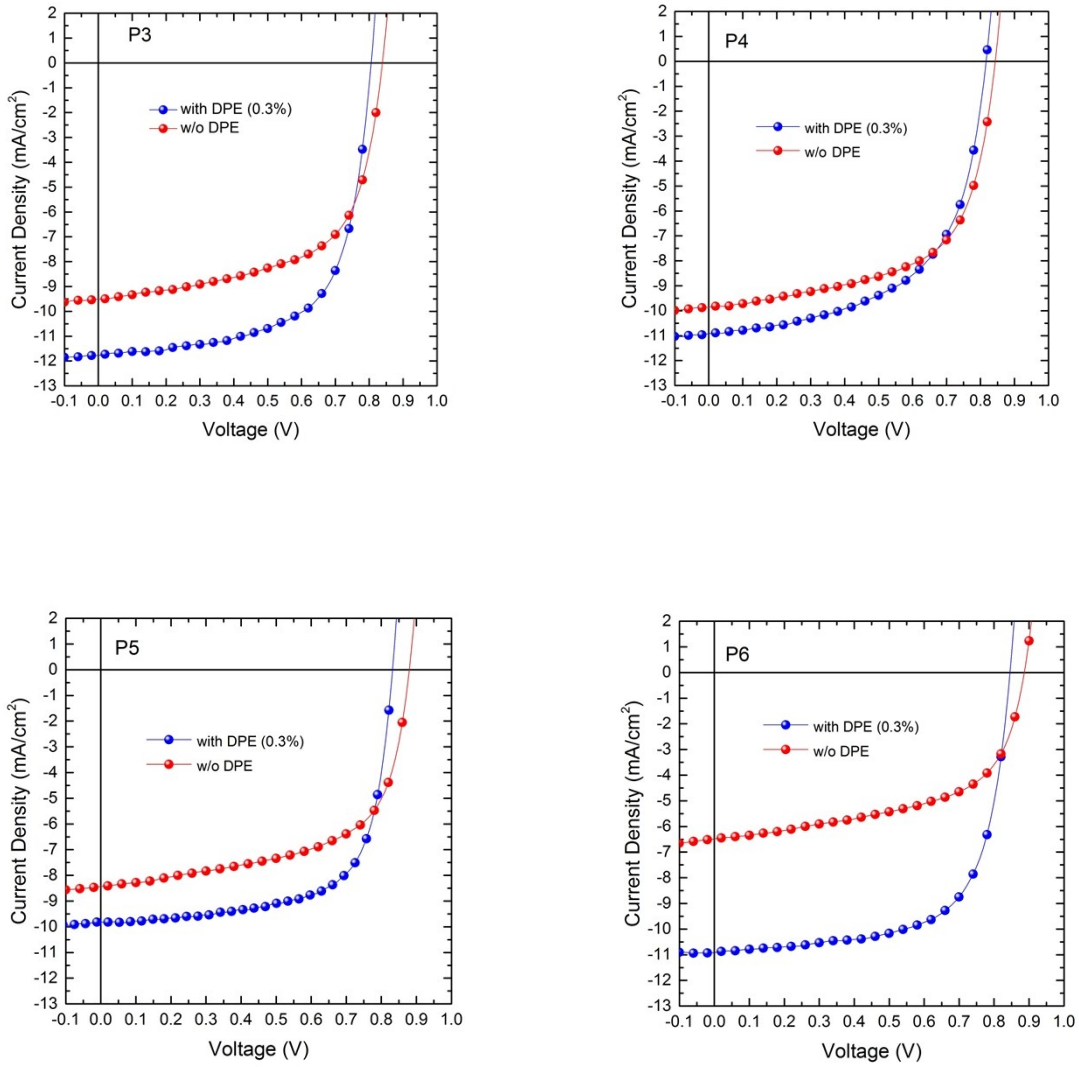



**Figure S14.** *J-V* curves of polymer solar cells with DPE and w/o DPE for **P3-P6**.

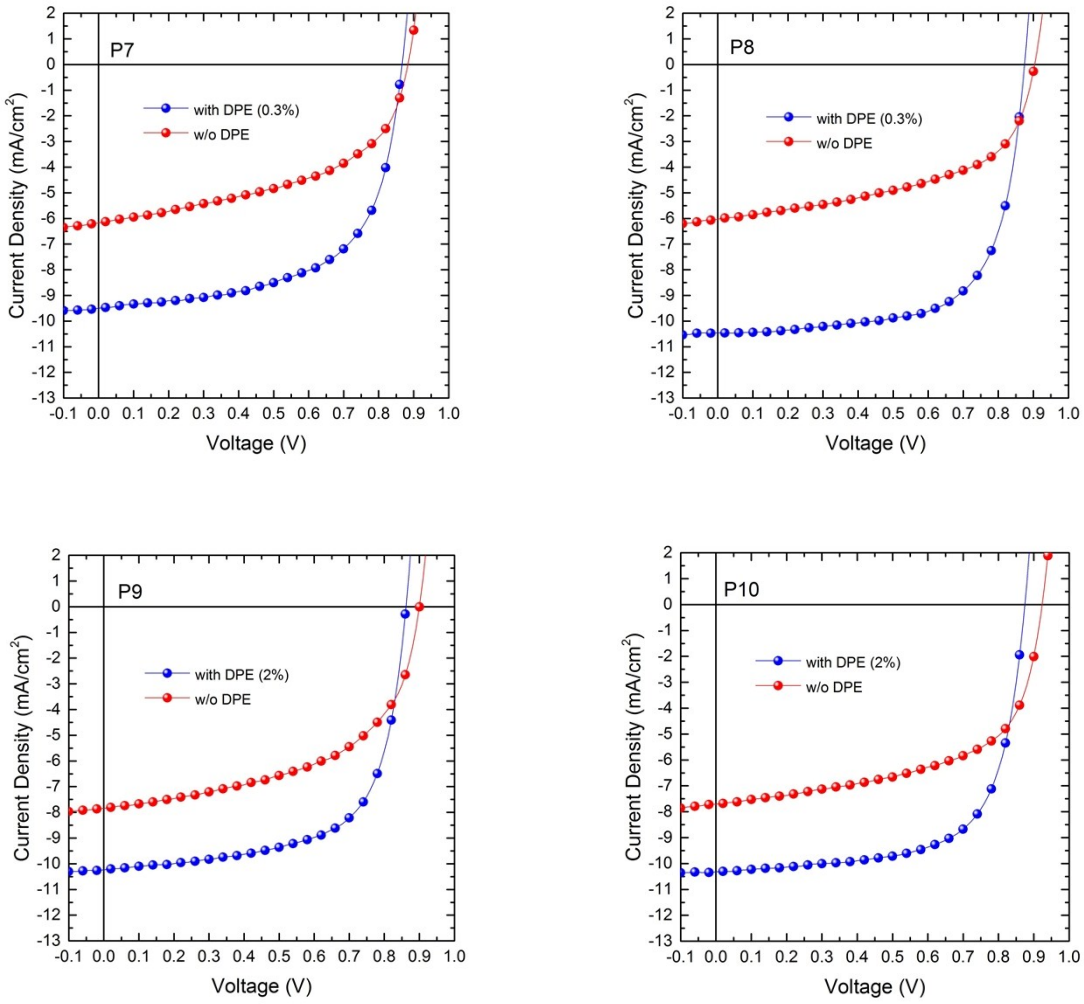



**Figure S15.** *J-V* curves of polymer solar cells with DPE and w/o DPE for **P7-P10**

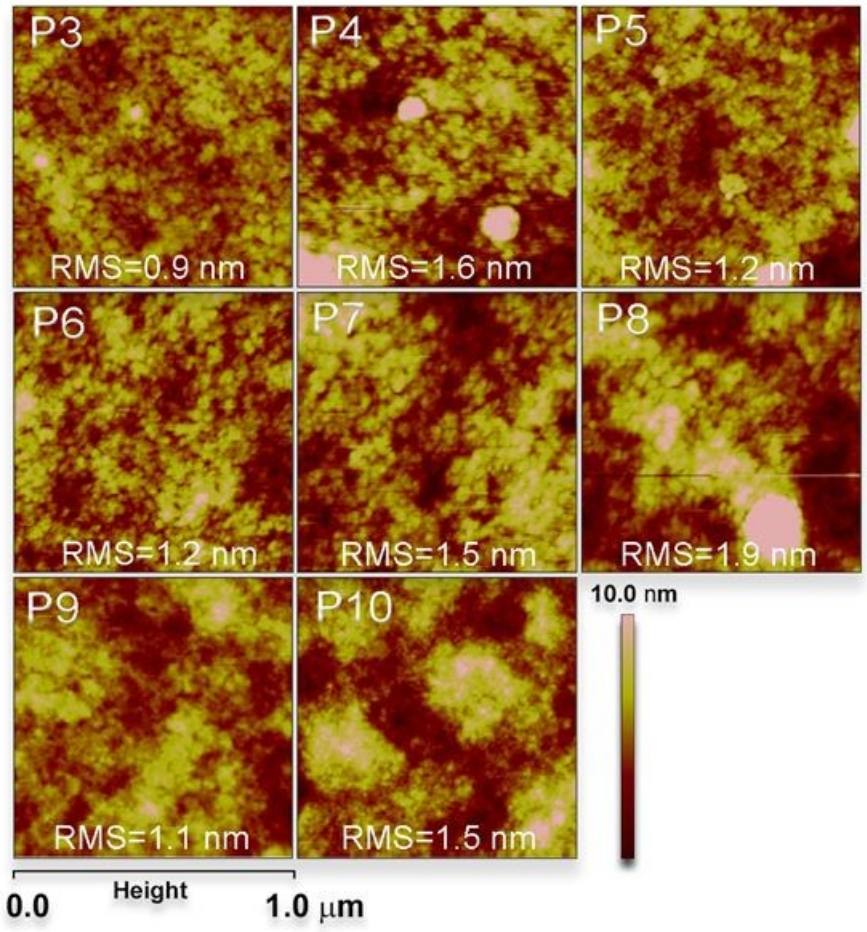



**Figure S16**. Topographic AFM images (1*1 $\mu m^2$) of **P3** to **P10** with $PC_{61}BM$ blend films.

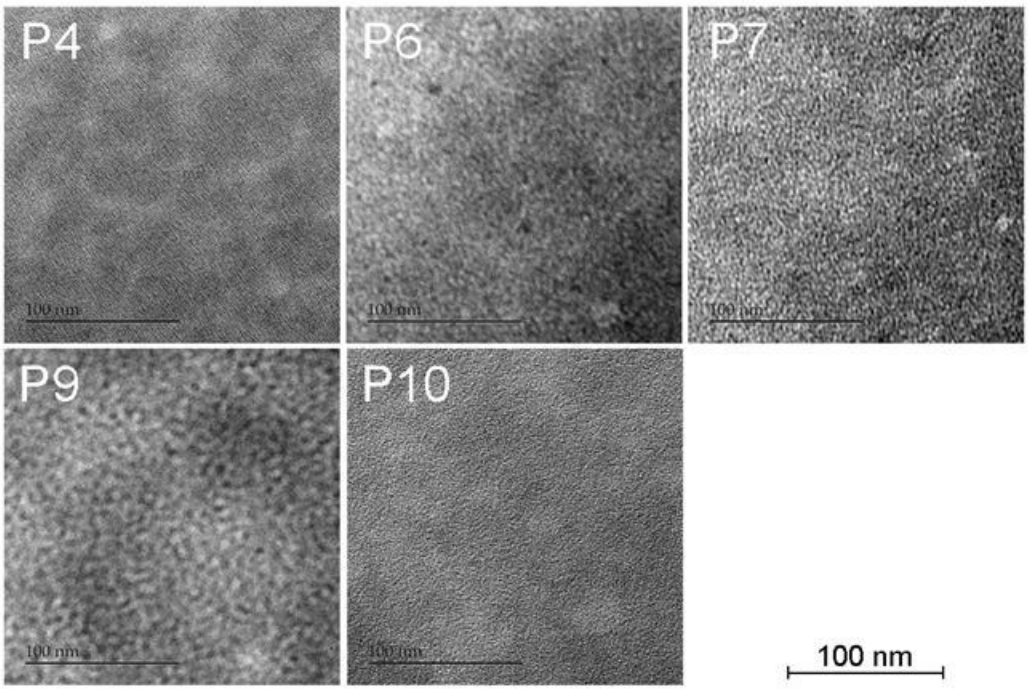



**Figure S17**. TEM images of **P4, P6, P7, P9**, and **P10** with $PC_{61}BM$ blend films.

**Table 1.** Effect of additive and PCBM on solar cell performances for **P1**.

| **P1** (12mg/cc ODCB 1:3 PCBM) | **DPE** | **PCBM** | **$J_{sc}$** | **$V_{oc}$** | **FF** | **PCE** |
|---|---|---|---|---|---|---|
| | % | | mA/cm$^2$ | V | | % |
| | w/o | $C_{60}$ | 11.21 | 0.81 | 0.64 | 5.8 |
| | 1% | $C_{60}$ | 11.50 | 0.79 | 0.66 | 6.0 |
| | 0.3% | $C_{70}$ | 12.61 | 0.78 | 0.65 | 6.4 |

Thickness: 80-90 nm

**Table 2.** Effect of additive and PCBM on solar cell performances for **P2**.

| **P2** (10mg/cc ODCB 1:2 PCBM) | **DPE** | **PCBM** | **$J_{sc}$** | **$V_{oc}$** | **FF** | **PCE** |
|---|---|---|---|---|---|---|
| | % | | mA/cm$^2$ | V | | % |
| | w/o | $C_{60}$ | 9.67 | 0.84 | 0.65 | 5.3 |
| | 0.3% | $C_{60}$ | 12.87 | 0.79 | 0.66 | 6.7 |
| | 0.3% | $C_{70}$ | 13.86 | 0.81 | 0.65 | 7.3 |

Thickness: 80-90 nm

**Table 3.** Effect of additive on solar cell performances for **P3-P10**.

| | **DPE %** | **$J_{sc}$** | **$V_{oc}$** | **FF** | **PCE** |
|---|---|---|---|---|---|
| **P3** (10mg/cc ODCB 1:2 $PC_{60}BM$) | | mA/cm$^2$ | V | | % |
| | w/o | 9.41 | 0.84 | 0.62 | 4.9 |
| | 0.3% | 11.83 | 0.81 | 0.64 | 6.2 |
| **P4** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 9.93 | 0.84 | 0.61 | 5.1 |
| | 0.3% | 10.83 | 0.82 | 0.59 | 5.2 |
| **P5** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 8.43 | 0.88 | 0.61 | 4.5 |
| | 0.3% | 9.69 | 0.83 | 0.70 | 5.6 |
| **P6** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 6.46 | 0.89 | 0.57 | 3.3 |
| | 0.3% | 11.00 | 0.85 | 0.65 | 6.1 |
| **P7** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 6.14 | 0.88 | 0.51 | 2.8 |
| | 0.3% | 9.48 | 0.87 | 0.61 | 5.1 |
| **P8** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 6.10 | 0.90 | 0.53 | 2.9 |
| | 0.3% | 10.47 | 0.88 | 0.68 | 6.2 |
| **P9** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 7.86 | 0.90 | 0.55 | 3.9 |
| | 2% | 10.23 | 0.86 | 0.65 | 5.8 |
| **P10** (10mg/cc ODCB 1:2 $PC_{60}BM$) | w/o | 7.69 | 0.92 | 0.59 | 4.2 |
| | 2% | 10.27 | 0.87 | 0.68 | 6.1 |

Thickness: 80-90 nm