

Comparative study of light and thermal induced degradation for both fullerene and non-fullerene based organic solar cells

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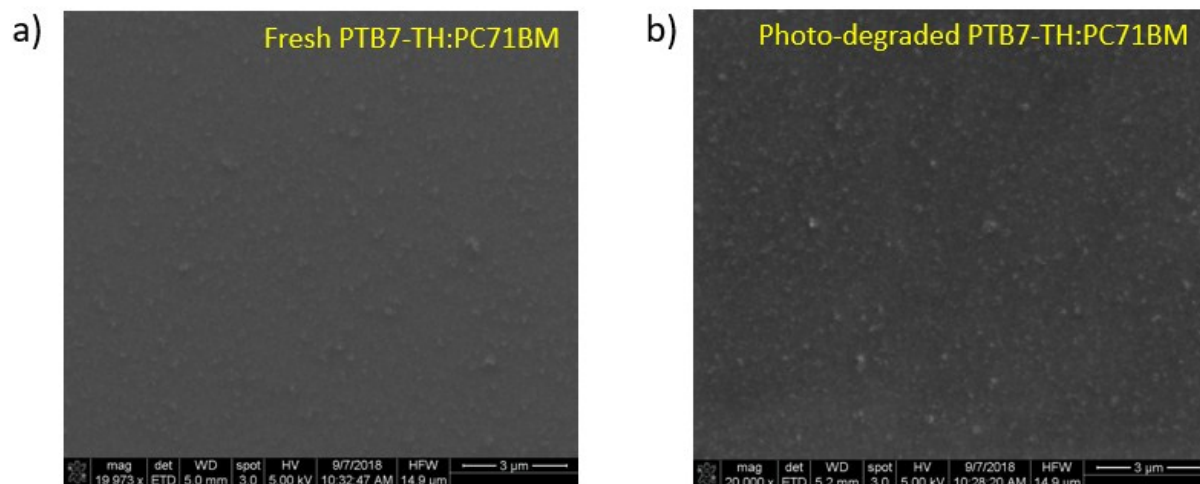
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Support information



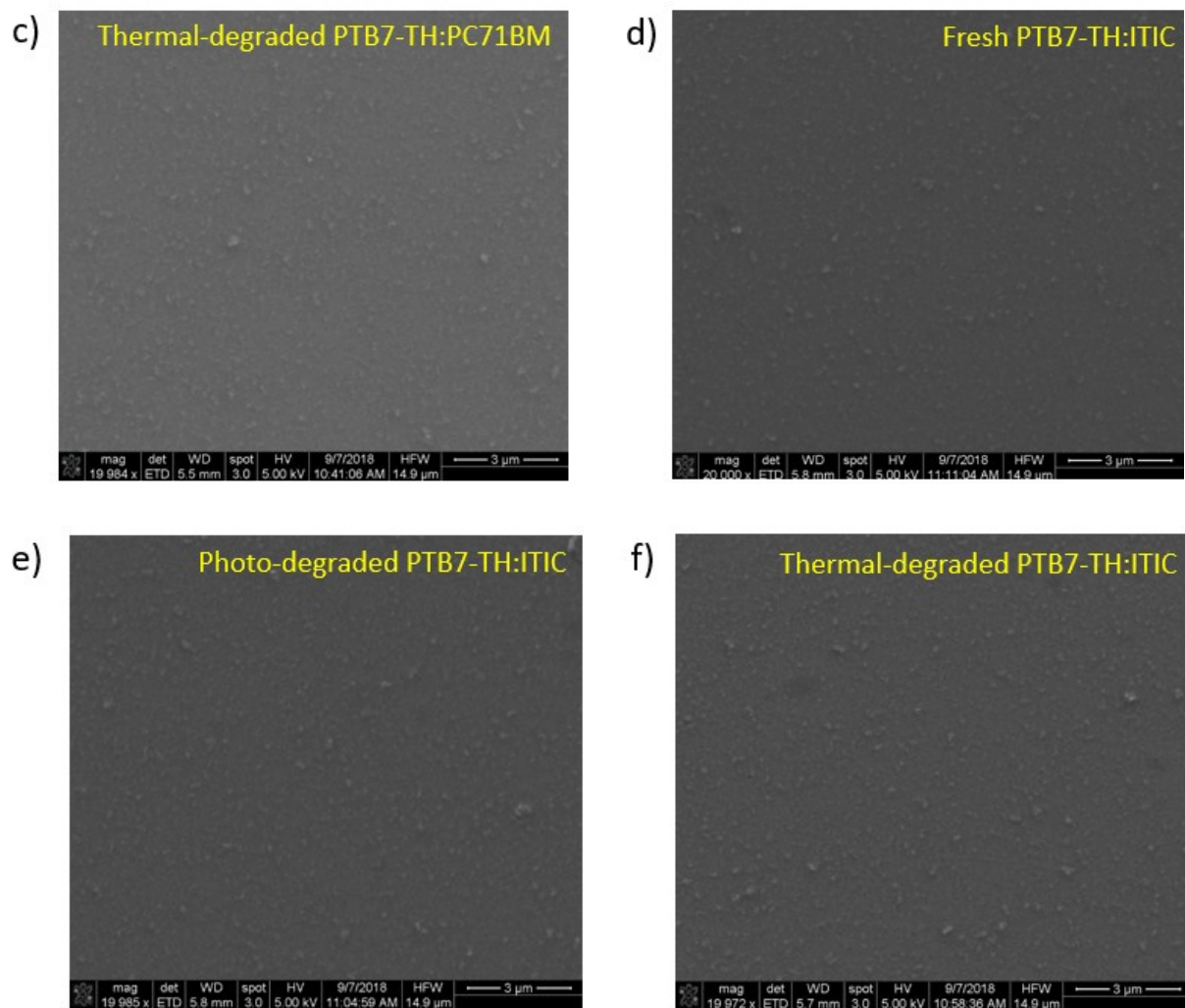


Figure S1. The SEM images of both PTB7-Th:PC₇₁BM fullerene and PTB7-Th:ITIC non-fullerene based fresh, photo-degraded and thermal-degraded blend films deposited on top of ITO/ZnO surface.

Table S1. Photovoltaic parameters for 5 hours of continuous light illumination for burn-in photo degradation test measured under one-sun test condition (AM1.5G illumination at 100 mW cm⁻²) for both PTB7-Th:PC₇₁BM fullerene and PTB7-Th:ITIC non-fullerene based devices obtained from at least 5 devices.

Degradation Time for PTB7-Th:PC₇₁BM Devices	V_{OC} (V)	J_{SC} (mA/cm²)	FF	PCE	RSH (Ω cm²)	RS (Ω cm²)
0H	0.819±0.001	14.76±0.94	0.62±0.02	7.58±0.50%	573±71	5.72±0.54
1H	0.793±0.003	14.26±0.84	0.60±0.02	6.79±0.50%	514±47	6.05±0.68
2H	0.786±0.002	13.83±0.78	0.58±0.02	6.29±0.44%	493±46	7.39±0.85
3H	0.782±0.003	13.92±0.79	0.56±0.03	6.07±0.46%	445±62	8.06±1.10
4H	0.779±0.003	13.41±0.70	0.54±0.03	5.64±0.47%	422±58	8.98±1.37
5H	0.778±0.003	13.13±0.73	0.53±0.03	5.40±0.48%	406±62	9.65±1.60
Degradation Time for PTB7-Th:ITIC Devices	V_{OC} (V)	J_{SC} (mA/cm²)	FF	PCE	RSH (Ω cm²)	RS (Ω cm²)
0H	0.831±0.001	13.46±0.19	0.60±0.01	6.72±0.15%	648 ± 51	8.25±0.54
1H	0.790±0.005	12.33±0.16	0.49±0.02	4.78±0.17%	397 ± 22	10.68±0.45
2H	0.788±0.004	11.78±0.18	0.47±0.01	4.34±0.03%	367 ± 14	12.02±0.18
3H	0.784±0.005	11.71±0.17	0.46±0.01	4.21±0.05%	345 ± 15	12.38±0.27
4H	0.782±0.007	11.31±0.15	0.45±0.01	3.99±0.09%	338 ± 12	13.27±0.32
5H	0.785±0.007	11.20±0.15	0.45±0.01	3.98±0.07%	335 ± 14	13.36±0.27

Table S2. Photovoltaic parameters for 5 hours of continuous 85 °C heating for burn-in thermal degradation test measured under one-sun test condition (AM1.5G illumination at 100 mW cm⁻² for both PTB7-Th:PC₇₁BM fullerene and PTB7-Th:ITIC non-fullerene based devices obtained from at least 5 devices.

Degradation Time for PTB7-Th:PC₇₁BM Devices	V_{OC} (V)	J_{sc} (mA/cm²)	FF	PCE	RSH (Ω cm²)	RS (Ω cm²)
0H	0.821 ± 0.004	14.48 ± 0.71	0.61 ± 0.01	7.25 ± 0.24%	522 ± 50	5.98 ± 0.25
1H	0.818 ± 0.010	11.80 ± 0.84	0.47 ± 0.04	4.58 ± 0.49%	251 ± 45	9.46 ± 1.30
2H	0.821 ± 0.005	11.98 ± 0.87	0.49 ± 0.02	4.85 ± 0.44%	271 ± 18	9.07 ± 0.84
3H	0.801 ± 0.009	12.42 ± 0.90	0.50 ± 0.04	4.95 ± 0.57%	275 ± 27	8.94 ± 1.37
4H	0.812 ± 0.005	12.34 ± 0.96	0.51 ± 0.02	5.14 ± 0.53%	303 ± 20	9.02 ± 1.23
5H	0.800 ± 0.005	12.44 ± 0.94	0.52 ± 0.02	5.22 ± 0.50%	325 ± 17	8.50 ± 1.01
Degradation Time for PTB7-Th:ITIC Devices	V_{OC} (V)	J_{sc} (mA/cm²)	FF	PCE	RSH (Ω cm²)	RS (Ω cm²)
0H	0.831 ± 0.002	13.75 ± 0.49	0.60 ± 0.00	6.84 ± 0.30%	666±13	8.47 ± 0.32
1H	0.831 ± 0.003	9.70 ± 0.41	0.55 ± 0.01	4.41 ± 0.29%	342±39	9.21 ± 0.41
2H	0.829 ± 0.002	9.71 ± 0.36	0.53 ± 0.01	4.30 ± 0.24%	299±17	9.89 ± 0.43
3H	0.814 ± 0.004	9.90 ± 0.32	0.53 ± 0.01	4.30 ± 0.20%	280±20	8.96 ± 0.37
4H	0.815 ± 0.005	9.88 ± 0.30	0.53 ± 0.01	4.26 ± 0.19%	274±24	9.65 ± 0.54
5H	0.812 ± 0.005	10.02 ± 0.27	0.53 ± 0.01	4.30 ± 0.17%	280±25	9.84 ± 0.55

Table S3. Parameters including effective voltage V_{eff} , Series resistance R_s and voltage loss term B that used to calculate the carrier recombination resistance for both PTB7-Th:PC₇₁BM fullerene and PTB7-Th:ITIC non-fulleren based fresh, photo-degraded and thermal-degraded devices. (V_{eff} is extracted from the Figure 9 that equals to the voltage value for the minimum differential diode ideality factor and R_s is measured by EIS characterisaiton under the dark condion)

Devices	V_{eff} (V)	R_s ($\Omega \text{ cm}^2$)	B (V)
Fresh PTB7-Th:PC71BM	0.752	0.91	0.013
Photo-degraded PTB7-Th:PC71BM	0.681	0.93	0.012
Thermal-degraded PTB7-Th:PC71BM	0.772	1.08	0.013
Fresh PTB7-Th:ITIC	0.691	1.10	0.015
Photo-degraded PTB7-Th:ITIC	0.772	0.83	0.009
Thermal-degraded PTB7-Th:ITIC	0.722	1.02	0.010