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Supporting Information for

External load-dependent degradation of P3HT:PC₆₁BM solar

cells: behavior, mechanism, and method of suppression

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Figure S1. The schematic diagram of four cells on the same substrate



Figure S2. Averaged degradation curves of inverted P3HT:PC₆₁BM cells aged at different external

load conditions.

Thin layer chromatography (TLC) was utilized to confirm the side products of the photoactive layer after light illumination. Figure S6 showed TLC results of the $PC_{61}BM$ and $P3HT:PC_{61}BM$ (1:1, w/w) films after illuminated for 50 hours. Point A and B are the light illuminated samples of $P3HT:PC_{61}BM$ blend film and pure $PC_{61}BM$ film, respectively. Point C is fresh $PC_{61}BM$ without any light illumination. As can be seen here, after light illumination, a long tailing was detected for the sample from the pure $PC_{61}BM$ film, which is not detected in the fresh $PC_{61}BM$ sample. This tailing is ascribed to the formation of $PC_{61}BM$ dimers after light illumination.^[1] The $P3HT:PC_{61}BM$ sample showed also a spot with similar Rf value of $PC_{61}BM$ dimers shown in point B. With that formation of $PC_{61}BM$ dimmers was also suggested in the $P3HT:PC_{61}BM$ blended film after light illumination.



Figure S3. TLC analysis of the product of the photoactive layer after light illumination for 40 hours. (a) without UV light; (b) under UV 254 light



Figure S4. Light intensity depended *J-V* curves of the fresh prepared and aged cells that aged at different load condition



Figure S5. The simulated dark J-V curves of inverted P3HT:PC₆₁BM cells before or aged at

different external load conditions.



Figure S6 EQE comparison of P3HT:PC₆₁BM cells before aging, aged at open circuit condition and the aged cell after thermal annealing. The right one is the normalized EQE spectra



Figure S7 Normalized EQE spectra of devices (a) and UV-vis absorption spectra of the photoactive layers (b) before and after degradation. Insertions in (b) show the decrease of absorbance over 550-750 nm, and an isobestic point around 355 nm.



Figure S8 AFM topological images of the photoactive layers before and after aging.



Figure S9. J-V curve of P3HT:PC $_{61}$ BM cells blended with piperazine (3%) as triple quencher.



Figure S10. "Burn-in" loss suppression of piperazine in PTB7-Th:PC₆₁BM cells.

Reference:

1. T. Heumueller, W. R. Mateker, A. Distler, U. F. Fritze, R. Cheacharoen, W. H. Nguyen, M. Biele, M. Salvador, M. von Delius, H.-J. Egelhaaf, M. D. McGehee and C. J. Brabec, *Energy Environ. Sci.*, 2016, **9**, 247-256.