Supporting Information

Enhanced performance of polymer solar cells by employing ternary cascade energy structure

Qiaoshi An,[a] Fujun Zhang,*[a] Lingliang Li,[a] Zuliang Zhuo,[a] Jian Zhang,[b] Weihua Tang,[c] Feng Teng*[a]

a. *Key Laboratory of Luminescence and Optical Information, Ministry of Education, Beijing Jiaotong University, 100044, China*
b. *State Key Laboratory of Catalysis, Dalian institute of Chemical Physics, Chinese Academy of Sciences, Dalian National Laboratory for Clean Energy, 457 Zhongshan Road, Dalian 116023, China*
c. *Key Laboratory of Soft Chemistry and Functional Materials, Ministry of Education, Nanjing University of Science and Technology, 210094, China*

PERFORMANCE OF CELLS

Here, the current density-voltage (*J-V*) characteristic curves of P3HT:ICBA cells with 150 °C annealing treatment for various time are shown in the Figure S1. The key parameters of PSCs were summarized and are listed in the Table S1. The power conversion efficiencies (PCEs) of the control cells could be regularly enhanced along with the increase of annealing treatment time. The champion PCE of the control cells achieve 3.79% with a short-circuit current (J_{sc}) of 8.63 mA/cm^2, an open circuit voltage (V_{oc}) of 0.77 V, and a fill factor (FF) of 57% after annealing 10 minutes. For a longer annealing treatment time, the performance of the control cells is slightly decreased. These results indicate that the proper annealing treatment time is about 10 minutes, which can improve the crystallinity and nanomorphology of P3HT-based films and then have a positive influence on the performance of the cells.

* Corresponding author: fjzhang@bjtu.edu.cn (Fujun), fteng@bjtu.edu.cn (Teng feng), Tel: 0086-10-51684908

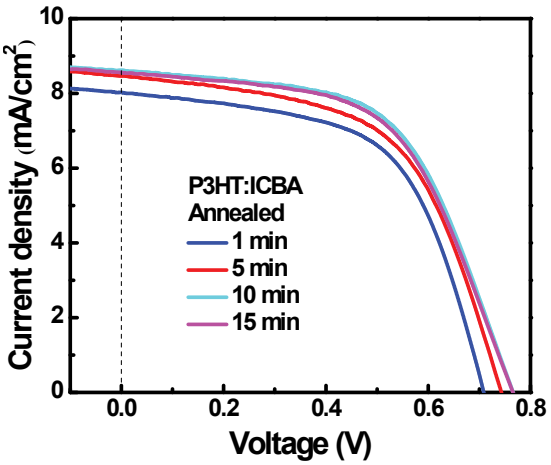

Fig. S1 Current density-voltage (*J-V*) characteristic curves of P3HT:ICBA cells with 150 °C annealing treatment for various time.

Table S1 Key photovoltaic parameters of P3HT:ICBA cells with pre-annealing treatment and post-annealing treatment.

P3HT:ICBA (1:1)	J_{sc} [mA/cm^2]	V_{oc} [V]	FF [%]	PCE[%] Best	PCE[%] Average*
Annealed (1min)	**8.03**	**0.71**	**55**	**3.32**	**3.21**
Annealed (5min)	**8.46**	**0.74**	**57**	**3.55**	**3.42**
Annealed (10min)	**8.63**	**0.77**	**57**	**3.79**	**3.65**
Annealed (15min)	**8.57**	**0.77**	**57**	**3.71**	**3.58**

*Average PCE: more than 30 annealed samples were evaluated

In order to study the influence of annealing treatment on the ternary PSCs, a series of ternary cells (3 wt% PBDTTT-C doping concentration) were annealed at 150 ℃ for various time. The *J-V* characteristic curves of P3HT:PBDTTT-C:ICBA cells (3 wt% PBDTTT-C doping concentration) with 150 °C annealing treatment for various time are shown in the Figure S2. The key parameters of PSCs were summarized and are listed in the Table S2. It should be mentioned that the ternary PSCs with only 1 minute annealing treatment arrives to the best PCE of 4.38%. However, further increasing annealing treatment time to 5 minutes, the PCE was decreased to 3.55% due to the decline of FF. The decreased performance of ternary PSCs may be the degradation of PBDTTT-C induced by the prolonged annealing treatment time.

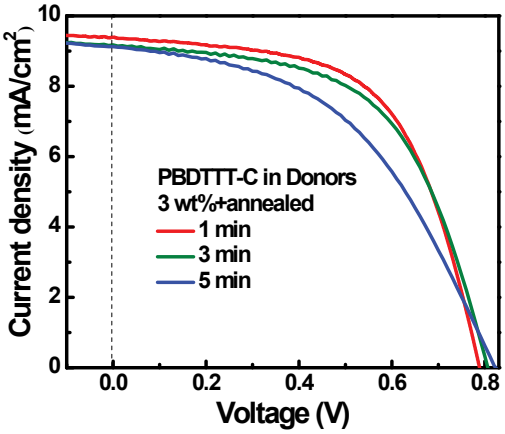

Fig. S2 *J-V* characteristic curves of P3HT:PBDTTT-C:ICBA cells with 150 °C annealing treatment for various time.

Table S2 Key photovoltaic parameters of P3HT:PBDTTT-C:ICBA cells with post-annealing treatment for various time.

PBDTTT-C in Donors [wt%]	J_{sc} [mA/cm^2]	V_{oc} [V]	FF [%]	PCE[%] Best	PCE[%] Average*
3+ annealed 1min	9.41	0.79	60	4.38	4.30
3+ annealed 3min	9.18	0.81	56	4.19	4.09
3+ annealed 5min	9.13	0.82	47	3.55	3.42

*Average PCE: more than 30 annealed samples were evaluated