Fullerene-free Polymer Solar Cells with Efficiencies over 11%

Jianhui Hou, Wenchao Zhao, Zhong Zheng, and Shaoqing Zhang

Beijing National Laboratory for Molecular Sciences, State Key Laboratory of Polymer Physics and Chemistry, Institute of Chemistry, Chinese Academy of Sciences, Beijing 100190, China
E-mail: hjhzlz@iccas.ac.cn

Solution-processed bulk heterojunction (BHJ) polymer solar cells (PSCs) have exhibited great potentials for making large area and flexible solar panels through low-cost solution coating techniques. Typically, a BHJ active layer in a PSC is composed of a conjugated polymer as electron donor and an organic compound as electron acceptor. Although fullerene derivatives, especially for [6,6]-phenyl-C_{71}-butyric acid methyl ester ($PC_{71}BM$), have been predominately used in highly efficient PSCs, non-fullerene (NF) acceptors have attracted much attention due to their easily tunable molecular energy levels, excellent optical absorption properties and potentials in low-cost production. However, the power conversion efficiencies (PCEs) of the polymer:NF-acceptor-based PSCs (also known as fullerene-free PSCs) are still much lower than the state-of-art PCEs of the polymer:$PC_{71}BM$-based PSCs.

Here, we prove that the fullerene-free PSCs can yield much higher PCE than the polymer:$PC_{71}BM$-based PSCs. We found that a conjugated polymer donor named as PBDB-T can form nanoscale aggregations in solid film and the aggregations are well miscible with a NF-acceptor named as NF, and hence the phase separation morphology that is favorable for photo-induced charge generation and transport can be obtained in the PBDB:NF blend film. Comparing to the PBDB:$PC_{71}BM$ blend, the PBDB:NF blend has broader absorption spectrum and also its molecular energy level alignment can afford sufficient driving force for exciton dissociation with less thermalization energy loss. As a result, the PBDB:NF-based PSCs show outstanding PCEs up to 11.21% with excellent thermal stability, which is much better than the device based on PBDB:$PC_{71}BM$ and also reaches the state-of-art PCE in PSCs. Therefore, we anticipate that these encouraging results will give a strong push to the study of fullerene-free PSCs from the aspects of fundamental research and practical applications.

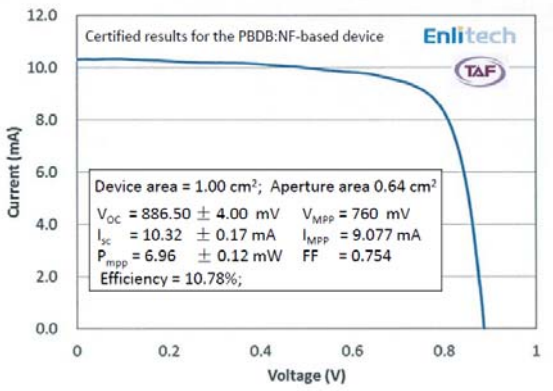

Figure 1. Photovoltaic properties of the PBDB-NF-based fullerene-free device.