SHORT COMMUNICATION

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18.69% PCE from organic solar cells

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The exquisite design and persistent development of fused-ring-acceptor-unit-based copolymer donors and Y-series nonfullerene acceptors (NFAs) have pushed the power conversion efficiencies (PCEs) for organic solar cells onto the 18% level[1–21]. Our group invented copolymer donors D18 and D18-Cl[2, 3]. D18:Y6, D18-Cl:N3 and D18:N3 solar cells have delivered outstanding PCEs of 18.22%, 18.13% and 18.56%, respectively[2–4]. Ternary solar cells based on a polymer donor, a NFA and a fullerene acceptor show great potential since they combine good light-harvesting capability of NFA and good electron-mobility of fullerene[5].

In this report, the device structure is ITO/PEDOT:PSS/D18-Cl:N3:$PC_{61}BM$ (D:A_1:A_2)/PDIN/Ag. The D : A_1 ratio was fixed at 1 : 1.4 (wt) since D18-Cl:N3 cells gave the best performance at the ratio of 1 : 1.4[3]. We adjusted $PC_{61}BM$ content from 0.1 to 0.2 to 0.3. When D : A_1 : A_2 ratio was 1 : 1.4 : 0.1, the ternary cells gave the highest PCE (Table S1). The champion cells with 0.3 vol% diphenyl ether (DPE) as the additive and an active layer thickness of 114 nm gave the highest PCE of 18.69%, with an open-circuit voltage (V_{oc}) of 0.849 V, a short-circuit current density (J_{sc}) of 28.22 mA cm^{-2} and a fill factor (FF) of 78.0% (Table S2, Table S3 and Fig. S1). The external quantum efficiency (EQE) exceeded 80% in 450–840 nm, with a maximum of 91% at 540 nm (Fig. S2). The integrated photocurrent density is 27.24 mA cm^{-2}. The best devices were also measured at the National Institute of Metrology (NIM), Beijing, and a certified PCE of 18.1% (V_{oc}, 0.854 V; J_{sc}, 27.36 mA cm^{-2}; FF, 77.3%; effective area, 2.580 mm^2) was recorded (Fig. S3). To the best of our knowledge, the 18.1% certified efficiency is the highest value reported for organic solar cells to date. Compared with the binary cells, the ternary cells show simultaneously enhanced J_{sc} and FF, suggesting the improved charge transport in the active layer. We measured hole and electron mobilities (μ_h and μ_e) by using the space charge limited current (SCLC) method (Fig. S4, Fig. S5 and Table S4). From binary to ternary blend films, μ_h didn't change much while μ_e increased from 6.32×10^{-4} to 7.42×10^{-4} $cm^2 V^{-1} s^{-1}$. Fullerene enhanced electron transport and led to more balanced charge transport (Table S4).

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Appendix A. Supplementary material

Supplementary materials to this article can be found online at https://doi.org/10.1088/1674-4926/42/6/060502.

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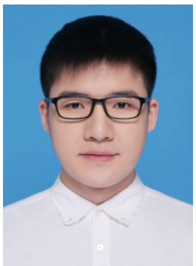

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