Optimization of organic solar cells based on star-shaped oligothiophenes

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The efficiency and stability of organic solar cells is still lower than those of inorganic solar cells. The performance of small-molecule organic solar cells (OSC) has been dramatically increased for the recent years. Oligothiophenes are among the most promising materials for small-molecule organic solar cells, e.g., OSC based on star-shaped oligothiophenes (SSO) show the efficiency up to 5.4% [1]. In this work, we optimize the performance of OSC based on SSO N(Ph(OMe)-2T-DCN-Me)$_3$ and N(Ph-2T-DCN-Et)$_3$ with a triphenylamine donor core and dicyanovinyl acceptor terminal groups (Fig. 1). These OSC have been demonstrated an efficiency of 3.9% and 3.5%, respectively [2, 3]. In the SSO OSC, the short-circuit current usually well corresponds to the film optical absorption, and the open circuit voltage agrees with a difference between the energies of the donor HOMO and the acceptor LUMO. Therefore, we assume that the efficiency of SSO OSC can be increased mainly by increasing the fill factor, which is relatively low. Possibly, the low fill factor of these samples is a result of non-optimal morphology of the active layer. To optimize the morphology of the active layer, we used various fabrication protocols including thermal and solvent-vapor annealing, high-boiling solvent additives and others. We have found that a combination of hot solution spin-coated on a hot substrate and solvent-vapor annealing results in the best performance N(Ph-2T-DCN-Et)$_3$ OSC. Impacts of all the fabrication protocols on the photovoltaic performance of SSO OSC are discussed.

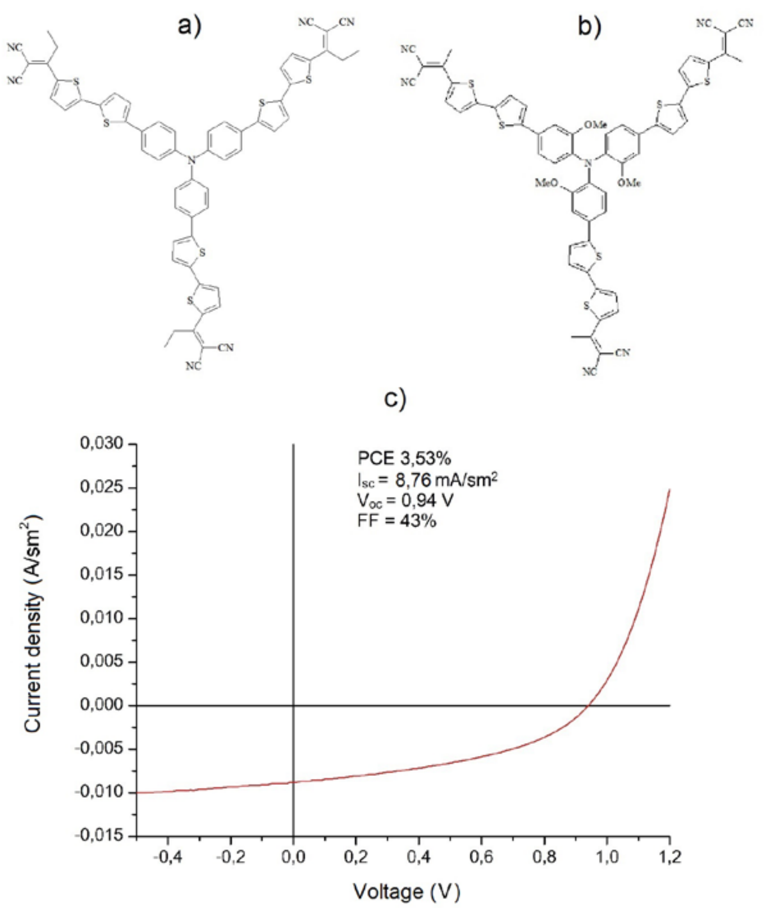

Fig. 1. (a), (b) Structural formulas of SSO N(Ph-2T-DCN-Et)$_3$ and N(Ph(OMe)-2T-DCN-Me)$_3$; (c) I/V curve for N(Ph-2T-DCN-Et)$_3$/PC$_{70}$BM solar cell.

[1] Jie Min, et al. *Advanced Energy Materials*. 2014, 1400816.

[2] Jie Min, et al. *Journal of Materials Chemistry C*. 2014, **2**, 7614.

[3] S. A. Ponomarenko, et al. *Faraday Discussions*. 2014, **174**, 1.