Single material solution-processed organic solar cells based on star-shaped D-π-A oligomers with efficient charge generation and high open circuit voltage

Artur L. Mannanov (1,2), Alexander N. Solodukhin (2), Yuriy N. Luponosov (2), Sergei A. Ponomarenko (2,3), and Dmitry Yu. Paraschuk (1,2)

(1) Faculty of Physics and International Laser Center, Lomonosov Moscow State University
(2) Enikolopov Institute of Synthetic Polymer Materials, RAS
(3) Faculty of Chemistry, Lomonosov Moscow State University
al.mannanov@physics.msu.ru

The performance of small-molecule organic solar cells (OSC) has been dramatically increased for the recent years. Soluble small conjugated molecules combine the advantage of a well-defined chemical structure, ease of synthesis and purification, reproducibility, and straightforward analysis of structure-property relationships. Donor-acceptor oligomers are promising materials for small-molecule organic solar cells, e.g., bulk heterojunction OSC based on star-shaped oligomers (SSO) with a triphenylamine donor core and dicyanovinyl acceptor terminal groups show the efficiency up to 5.4% [1]. It was recently shown that efficient exciton-to-charge conversion occurs in SSO films even without external acceptor [2]. This is beneficial for the operation of both bulk heterojunction OSC and single material OSC. These results stimulate further studies of such SSO molecules as a material of the active layer of highly efficient OSC. In this work, we study charge generation in single material OSCs based on N(Ph-nT-DCV-R)$_3$ (see Fig. 1). Charge generation and photovoltaic properties were investigated in solution-processed OSC in the structure: glass/ITO/PEDOT:PSS/N(Ph-nT-DCV-R)$_3$/cathode (Ca/Al or PEIE-C_{60}/Ag). These single material OSC demonstrate the external quantum efficiency up to 18.3%, high open circuit voltage exceeding 1.1 V, as well as power conversion efficiency up to 0.95% and shelf-life stability without encapsulation. Charge generation mechanism and recombination losses are discussed.

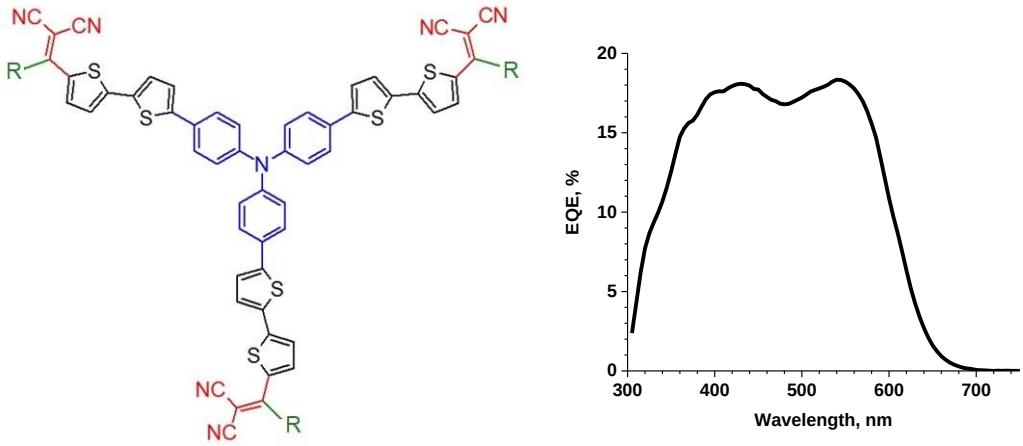

Fig. 1. Structural formula of SSO and EQE spectra for N(Ph-2T-DCV-Et)$_3$ solar cell.

This work was supported by Russian Science Foundation (grant 14-13-01380) and performed in the framework of leading science school NSh-5698.2018.3.

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

[2] Oleg V. Kozlov, et al. *Advanced Optical Materials*. 2017, 1700024