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Material Selection for Donor Materials in Small Molecular-Based Bulk Heterojunction Organic Photovoltaic Devices

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Organic photovoltaic (OPV) devices are considered as a promising renewable energy source due to their distinct properties over the inorganic counterparts. Extensive efforts on the development of smart materials and innovative device architecture have boosted the power conversion efficiency up to 12 %. In particular, bulk heterojunction consisting of a spatially distributed donor/acceptor interface is the most efficient approach, in which almost all excitons can be effectively dissociated into free carriers to yield 100 % exciton dissociation efficiency and generate high photocurrent. However, the major challenge for achieving high power conversion efficiency is the relative poor charge carrier mobilties in the blended layer; especially the charge carrier mobilites in the blended layer are orders of magnitude lower than those of homogeneous layers. Recent demonstration on the use of a modified bulk heterojunction opens up a new avenue for improving the performance of OPV devices, in which a non-absorbing donor material at very low dopant concentration is doped into fullerene matrix to form the bulk heterojunction. Surprisingly, the doping of non-absorbing organic materials (i.e. 5 %) can dramatically improve the photovoltaic responses including short-circuit current, open-circuit voltage (V_{OC}), and fill factor, which is the highest ever reported for a cell with fullerene as the sole absorber. On the other hand, the exact mechanism for the performance improvement is not well-understood. The common energy gap law for V_{OC} cannot be applied. Here, the effects of different non-absorbing organic materials as donor on the performance of OPV devices with the modified bulk heterojunction have been systematically studied and the correlation between the physical and energetic properties of donor materials and the photovoltaic responses will be discussed.

1 E. C.-H. Kwok, D. P.-K. Tsang, M.-Y. Chan, V. W.-W. Yam, *Chem. Eur. J.*, **2013**, *19*, 2757.