Area: 4. Organic and Dye-Sensitized Solar Cells

REDUCTION OF PHOTON ENERGY LOSS IN POLYMER SOLAR CELLS

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A crucial issue facing polymer-based solar cells (PSCs) is how to manage the energetics of the polymer/fullerene blends to maximize short-circuit current density (J_{SC}) and open-circuit voltage (V_{OC}) at the same time and thus the power conversion efficiency (PCE). A key to resolving the issue is to reduce the relatively large photon energy loss (E_{loss}), which is defined by $E_g - eV_{OC}$, where E_g is the optical bandgap of the material.

Here, we demonstrate that the use of a newly synthesized semiconducting polymer based on naphthobisoxadiazole (PNOz4T, Figure 1a) with a narrow E_g of 1.52 eV [1] leads to high V_{OC}s of approximately 1 V and high PCEs of ~9%, when combined with $PC_{71}BM$. As a result, the E_{loss} was found to be 0.52–0.56 eV, which is much smaller than that of typical polymer systems (0.7–1.0 eV) and approaches the values for inorganic and perovskite solar cells [2]. The small E_{loss} is due to the very small energy offset that is a driving force for the photoinduced charge separation, i.e., the offset of the LUMO energy levels between PNOz4T and $PC_{71}BM$ was 0.1 eV. It is also interesting to note that PCEs of the PNOz4T system are the highest values among the PSCs having such small E_{loss}s (Figure 1b). This is ascribed to the fact that the external quantum efficiency (EQE) is high (ca. 65%) for the systems with a very small energy offset. Spectroscopic studies of the PNOz4T/$PC_{71}BM$ film revealed that the charge generation of this system is likely to be limited by the relatively large domain size of the blend film and not by the small energy offset.

These unconventional features of the present polymer system will inspire the field of PSC towards further improvement of PCEs with both high J_{SC} and V_{OC}.

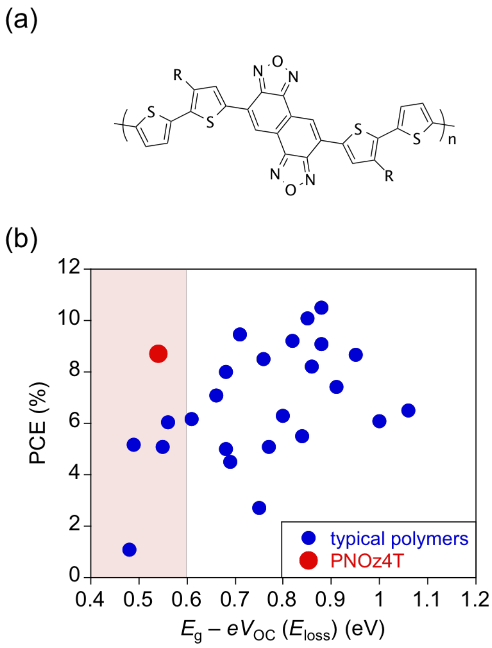

Figure 1. (a) Molecular structure of PNOz4T. (b) PCEs of polymer/fullerene-based PSCs as a function of E_{loss}.

References.

[1] K. Kawashima, I. Osaka, K. Takimiya, "Effect of Chalcogen Atom on the Properties of Naphthobischalcogenadiazole-Based π-Conjugated Polymers" *Chem. Mater.* **27**, pp. 6558 (2015).

[2] K. Kawashima, Y. Tamai, H. Ohkita, I. Osaka, K. Takimiya, "High-Efficiency Polymer Solar Cells With Small Photon Energy Loss", *Nat. Commun.*, **6**, pp. 10085 (2015).