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Indene bisadduct of fullerenes as high efficiency acceptor for polymer solar cells

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Polymer solar cells (PSCs) have attracted great attention in recent years, because of their advantages of easy fabrication, low cost, light weight and flexibility. PSCs are commonly composed of a blend layer of a conjugated polymer donor and a soluble fullerene derivative acceptor sandwiched between ITO positive electrode and a low-workfunction metal negative electrode.

Poly(3-hexylthiophene) (P3HT) and [6, 6]-phenyl-C_{61}-butyric acid methyl ester (PCBM) are the most representative polymer donor and fullerene derivative acceptor respectively in the PSCs. But the power conversion efficiency (PCE) of the PSCs based on P3HT/PCBM is limited to ca. 3.5~4.0% by their low open circuit voltage (V_{oc}) (ca. 0.6 V) due to the energy level mismatch between the P3HT donor and PCBM acceptor.[1] In 2010, we reported indene-C_{60} bisadduct (ICBA)[2] and indene-C_{70} bisadduct ($IC_{70}BA$)[3] with electron-rich indene substituents (see Figure 1). The LUMO levels of ICBA and $IC_{70}BA$ are 0.17 and 0.19 eV higher than that of PCBM respectively. The PSCs with P3HT as donor and ICBM as acceptor demonstrated a high PCE of 6.48% with a high V_{oc} of 0.84 V, in comparison with the PCE of 3.88% and V_{oc} of 0.58 V for the PSC based on P3HT/PCBM under the same experimental conditions.[4]

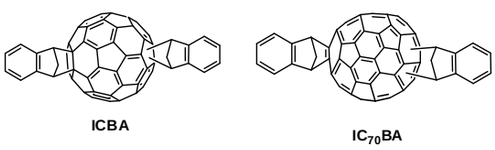

Figure 1. Molecular structures of ICBA and $IC_{70}BA$

In this presentation, I will talk about our recent progress on the applications of the new acceptors in high efficiency PSCs. We further optimized the device performance based on P3HT/$IC_{70}BA$ by using solvent additives[5,6] or by using MoO3 buffer layer on ITO[7]. By using 3 vol% high boiling point solvent additive of 1-chloronaphthalene, the PSC based on P3HT/$IC_{70}BA$ without solvent annealing demonstrated power conversion efficiency of 7.4%[6] (see Figure 2). We also applied the new acceptor in the PSCs based on the polymer donors other than P3HT, and compared their photovoltaic performance with the traditional acceptor PCBM. Several polythiophene derivatives[8,9] and some D-A copolymers[10,11] demonstrated superior photovoltaic performance when blended with ICBA.

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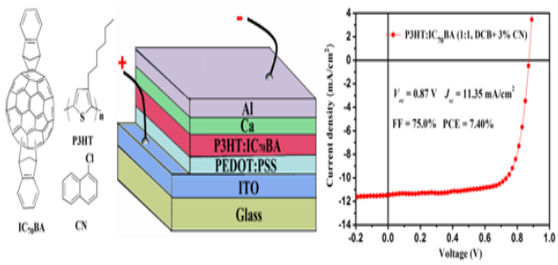

Figure 2. Device structure and J-V curve of the PSC based on P3HT/IC70BA with 3 vol.% CN additive.