Enhanced power-conversion efficiency in organic solar cells incorporating polymeric compatibilizers

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Organic Solar Cells (OSCs) have attracted considerable interest because of their flexibility, lightness, and potential for low-cost and simplicity of the manufacturing processes. Devices based on the P3HT:PCBM thin film heterojunctions are among the most studied, providing power conversion efficiency (PCE) of 3-6% and 0.1-3.1% in bulk (BHJ) and planar (PHJ) heterojunctions, respectively (1,2). Although encouraging progress has been made, performances are not yet suitable for large-scale implementation. Many effort has been spent on the development of low band-gap polymers, fullerene derivatives, and additives for obtaining improved performance and controlled morphology of the heterojunctions (3-4). However, the development of most semiconducting polymers or copolymers involves complicated multistep synthetic procedures that affect the yield and the cost of final materials. In the present work, three polymers based on polythiophene and C_{60} units have been designed, easily synthesized, characterized, and employed as compatibilizers in P3HT:PCBM devices.

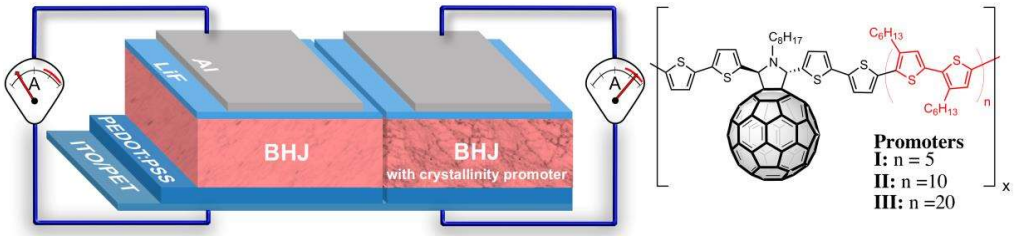

Figure 2 Schematic representation of devices with and without compatibilizer (left) and its chemical structure (right).

The effect of the thienyl spacer length between C_{60} monomers on optoelectronic properties, morphology, and structure of heterojunction has been examined using several techniques (NMR, FTIR, XPS, DSC and AFM). We observed that small quantities of these systems can play a critical role in tuning the device morphology by enhancing crystallinity along with charge transport of the thin film heterojunction. In addition, a good matching in the energy levels was observed, so that the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO) levels of these systems form a cascade energy band structure. What above allows for up to a 3-fold enhancement of PCE by adding small amount (about 2%) of compatibilizer. By our approach, we obtained the highest short-circuit current density (~ 16 mA/cm^2) and PCE (~ 4.5%) values ever reported for P3HT:PCBM solar cells on plastic/flexible substrates, thus giving new perspectives to applications of flexible photovoltaics.

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