Development of Organic Semiconductors for Applications in Optoelectronic Devices

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Abstract

Organic semiconductors have been a subject of intense research in both academia and industry over the past two decades due to their wide varieties of technological applications, such as organic light-emitting diodes (OLEDs), organic field-effect transistors (OFETs), organic photovoltaics (OPVs), and chemical and biological sensing. First, I will briefly introduce our previous work on the development of deep blue OLEDs and high-efficiency red electrophosphorescent devices based on osmium(II) complexes. Then, I will present our recent effort in the development of low-bandgap conjugated materials for solution-processed bulk-heterojunction (BHJ) organic solar cells. By copolymerizing dithienosilole with thienopyrrole-4,6-dione (PDTSTPD), we demonstrated for the first time that a low bandgap (1.73 eV) and a deep HOMO energy level (5.57 eV) can be simultaneously obtained from a semiconducting polymer. Based on this polymer, a power conversion efficiency of 8.1 % has been achieved on the photovoltaic devices with an active area of 1.0 cm^2. We also worked on inverted organic solar cells due to their much better stability. We developed annealing-free ZnO nanocrystals as an electron extraction layer in inverted solar cells. A certified power conversion efficiency as high as 7.1% has been achieved on the inverted devices. We also synthesized new fullerene derivatives. Preliminary results showed that these fullerene derivatives exhibited better performance than widely used $PC_{71}BM$ when blended with poly(N-heptadecanyl-2,7-carbazole-alt-5,5-(4',7'-di-2-thienyl-2',1',3'-benzothiadiazole (PCDTBT) as the active layer. We investigated the organic solar cell stability as well. It was found that both the device structure and the inherent properties of organic semiconductors have significant impacts on the ultimate device stability.