Push-Pull Based Novel π-Functional Polymeric Semiconductors for Printed Flexible Electronics

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Conjugated low band gap polymeric semi-conductors are the focus of intense academic and industrial research because of their high performances both in organic field effect transistors (OFETs) and organic photovoltaics (OPVs) devices. The most common strategy for designing and synthesizing low band gap polymeric semiconductors for high performance devices is to use appropriate fused and planar aromatic donor and acceptor building blocks in the conjugated backbone. Diketopyrrolopyrrole (DPP) pigment has proven to be one of the best and suitable choices as an electron acceptor for making donor-acceptor (D-A) copolymers. Such D-A copolymers are also called as "push-pull" system due to electron donating (push) and electron accepting (pull) moieties inserted in the main chain. Solid-state packing, π-π and intermolecular interactions, energy level tuning is strongly depending on the nature of the conjugated blocks used in synthesis. Recently, our group has synthesized several DPP based π-functional low band gap polymeric semiconductors for high performance OFET and OPV applications. These materials are synthesized via different organometallic couplings routes such as Suzuki and Stille couplings in a straight forward manner using varieties of building blocks combined with either furan or thiophene flanked DPP common acceptor moiety with branched alkyl chain. Using some of the novel materials, we have achieved hole carrier mobility in the range of 2-8 cm^2/V-s, which is one of the highest values in p-channel OFETs. Additionally, our rationally designed donor-acceptor copolymer also showed highest hole (0.56 cm^2/V.s) and electron (0.58 cm^2/V.s) mobility in ambipolar OFETs. Charge transport studies of these materials are also conducted in order to understand the fundamental science behind charge transport mechanism. These materials are also used as an active component for the fabrication of organic solar cells and we could achieve high efficiencies close to 5% under simulated AM 1.5 solar irradiation of 100 mW/cm^2. Overall DPP based organic semiconductors are a promising push-pull based π-functional "Paint Materials" for future printable flexible electronic devices.