Docket #: S13-371

Side-chain and End-chain Engineering of Organic Conjugated Polymers

Stanford researchers have developed a versatile molecular engineering approach, via random copolymerization, to gain good processability while maintaining high charge transport and photovoltaic performance for conjugated copolymers. This goal was achieved by the incorporation of tunable ratios of repeating units with short polystyrene (PS) side-chains into the copolymer. The synthetic batch-to-batch reproducibility (in terms of the molecular weight) of the polymer products was improved as a result of their higher solubility after the incorporation of PS side-chains. This approach also significantly improves the solution processability and coatability of high performance polymer semiconductors.

Due to the versatile nature of this copolymerization-based approach, it could be readily extended to other conjugated polymeric systems for varied optoelectronic applications such as polymer solar cells and field effect transistors.

Figure

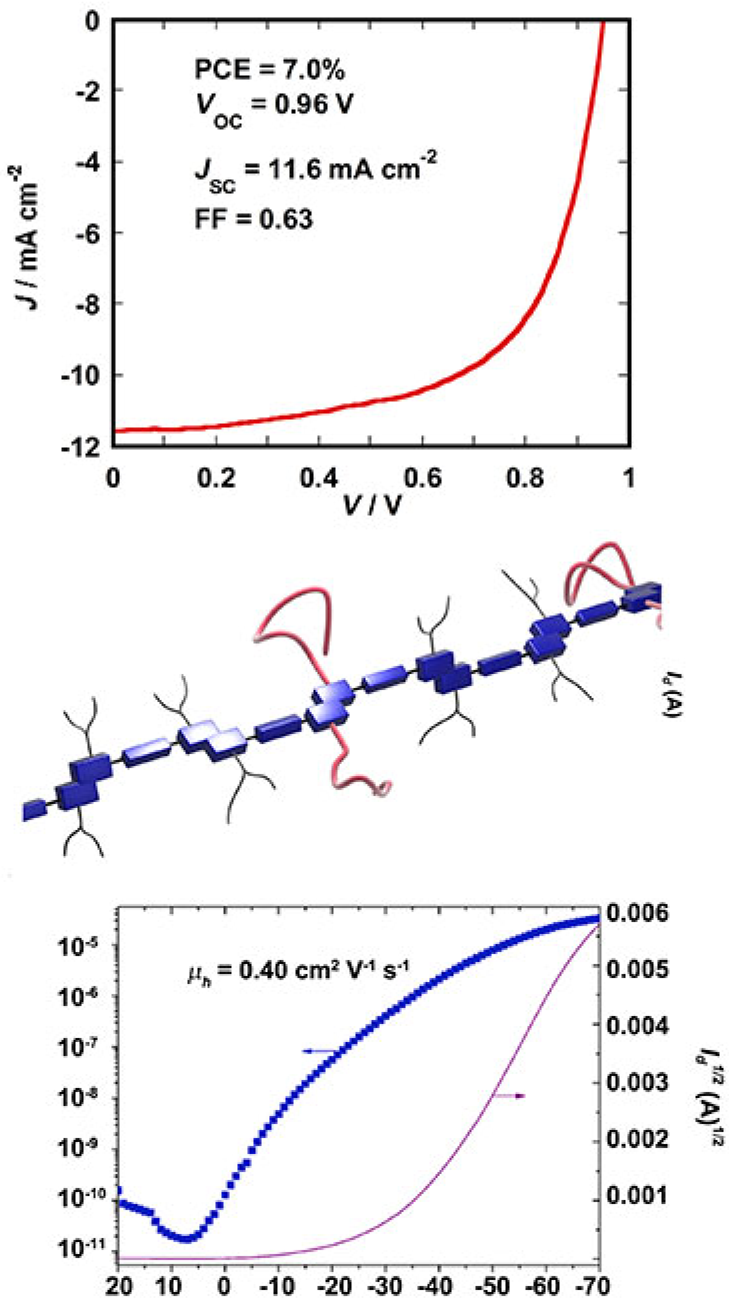

Figure description - An Example of Side-Chain Engineering

Stage of Research:

- Synthesized a series of poly(isoindigo-dithiophene) based conjugated polymers with varying amounts of low molecular weight polystyrene (PS) side-chains (Mn =1,300 g/mol) via random copolymerization.
- Observed better solubility with polymers containing the PS side-chains
- Bulk heterojunction solar cell devices fabricated with these PS-containing copolymers demonstrated significantly improved performances [maximum power

conversion efficiencies (PCE) >7% and open circuit voltages (VOC) ?0.95 V], compared to the highest reported performance (PCE = 6.3% and VOC = 0.70) based on similar isoindigo-containing polymers.

Applications

- Increases solubility of conjugate polymers without sacrificing their semiconductor properties
- Enables easy and facile purification for organic semiconductors
- Provides improved processibility for fabrication opto-electronic devices such as transistor, solar cell and organic light emitting diode.
- Enhances electronic inks stability based on organic semiconductors

Advantages

- Low cost, easy to apply
- Widely applicable in organic semiconductor, both for synthesis and purification.
- Easy to formulate the ink and stabilize the product.
- Improves device reliability
- This approach achieves a balance between the optical/electronic properties and solubility/processability of reproducible polymeric systems
    - Enhanced solubility brought by PS side-chains is beneficial for the synthesis and solution-processing
    - Fine tuned PS mole ratio gives high-performing electronic properties comparable with that of non-PS polymer
    - PS side-chains brings another dimension in tuning the phase segregation of BHJ blend films
    - Could be readily extended to other conjugated polymeric systems for varied optoelectronic applications such as polymer solar cells and field effect transistors

Publications

- Fang, Lei, et al. "Side-Chain Engineering of Isoindigo-Containing Conjugated Polymers Using Polystyrene for High-Performance Bulk Heterojunction Solar Cells." *Chemistry of Materials* (2013).

Patents

- Published Application: 20150105520

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