**Aggregation and Morphology Control Enables Multiple Cases of Polymer Solar Cells with Efficiencies >10%**

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Polymer solar cell (PSC) technology has attracted much attention due to its promise as low-cost conversion of solar energy. Despite recent progress, several limitations are holding back PSC development. For instance, current high-efficiency (>9.0%) PSCs{Liao, 2013 #103} are restricted to materials combinations that are based on limited donor polymers and only one specific fullerene acceptor, PC71BM. Furthermore, best-efficiency PSCs are mostly based on relatively thin (100 nm) active layers. Thick-film PSCs generally exhibit lower fill factors and efficiencies compared to the best thin-film PSCs. Here we report multiple cases of high-performance thick-film (300 nm) PSCs (efficiencies up to 10.8%, fill factors up to 77%) based on conventional PCBM and many non-PCBM fullerenes. Our simple aggregation control and materials design rules allowed us to develop, within a short time, three new donor polymer, six fullerenes (including C60-based fullerenes), and over ten polymer:fullerene combinations, all of which yielded higher efficiency than previous state of art devices (~9.5%). The common structural feature of the three new donor polymers, the 2-octyldodecyl (2OD) alkyl chains sitting on quaterthiophene, causes a temperature-dependent aggregation behavior that allows for the processing of the polymer solutions at moderately elevated temperature, and more importantly, controlled aggregation and strong crystallization of the polymer during the film cooling and drying process. This results in a well-controlled and near-ideal polymer:fullerene morphology (containing highly crystalline, preferentially orientated, yet small polymer domains) that is controlled by polymer aggregation during warm casting and thus insensitive to the choice of fullerenes. Following this strategy, a new record PSC efficiency of 11.5% (certified by Newport) was recently achieved in our group, which has been included as a major milestone for organic solar cells in the “best research efficiency chart” by NREL.

The second part of this presentation will describe highly efficient non-fullerene PSCs with power conversion efficiencies over 7%. There are several attractive features of our non-fullerene PSCs. 1) An exceptionally high Voc of nearly 1 V can be achieved for a PSC with an optical bandgap of 1.6 eV. 2) A new small molecule acceptor with a unique 3D structure was developed that exhibits similar morphological and electronic properties to those of PCBMs. 3) Efficient all-polymer solar cells can be achieved using a pair of crystalline polymers that can maintain their crystallinity in the polymer/polymer blend.

Reference:

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