

Tuning of polymer aggregation and optimization of the active layer morphology of all-polymer solar cells incorporating rylene-based acceptor polymers

Naphthalene-diimide (NDI) or perylene-diimide (PDI) containing copolymers are promising alternatives for replacing fullerenes as the electron-accepting phase in organic solar cells. Within the previous funding period, we were able to raise the power conversion efficiencies of mixtures of NDI/PDI-based copolymers and regio-regular poly(3-hexylthiophene) (P3HT) to 1.4 %, which is among the highest reported values for polymer-polymer blends. We found a surprising anticorrelation between the degree of chain aggregation and the photovoltaic device performance. It was proposed that the NDI- and PDI units in these strictly-alternating copolymers exhibit a strong tendency to aggregate, which promotes long range phase separation and unfavorable nanomorphologies.

The proposed work aims at the further understanding and optimization of the morphology and photovoltaic performance of polymer-polymer solar cells comprising rylene-based copolymers. For this reason, the degree of chain aggregation in the blend layers will be chemically tuned by synthesizing copolymers containing repeat units of different length. Further on, novel “low band gap” electron-accepting copolymers based on thieno[3,4-c]pyrrole-4,6-dione and diketopyrrolopyrrole units will be synthesized and tested. Detailed studies of the chain aggregation and layer morphology will guide us towards a more efficient photo-to-electron conversion in these blends. To improve the open circuit voltage of the blend cells comprising NDI- and PDI-based polymers, anionic thiophene-based conjugated polyelectrolytes (CPEs) will be synthesized and applied as electron extraction layers. We, finally, plan detailed studies on optimized cells to explore the nanoscale blend morphology and to identify the physical processes limiting the overall photovoltaic performance of these blends.