

Development of Conjugated DBA Type Block Copolymers For Photovoltaics

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ABSTRACT

Polymer or ‘plastic’ thin film solar cells have great potential to offer cost effective solutions for clean and renewable solar energy conversions. However, the power conversion efficiencies of current polymer based solar cells are still less than 6%. Compared to inorganic photovoltaics, there are at least three severe losses in organic photovoltaics, namely the ‘photon loss’, the ‘exciton loss’ and ‘carrier loss’. To minimize those losses, organic materials must be optimized in both spatial and energetic regimes. In energy regime, for instance, the photon and carrier losses could be minimized by tuning the frontier orbital levels of both donors and acceptors. To minimize exciton and carrier transport losses, optimizations at spatial regime must be done. Spatial optimization mainly involves controlling the donor and acceptor phase size to be within the average exciton diffusion length of photo induced exciton. Also, both electrons and holes need their own uninterrupted transportation paths toward the respective electrodes. That is why a Bicontinuous Ordered Nano Structures (BONS) are most desired. To achieve BONS, a series of -DBAB- and DBA type block copolymers and their ‘tertiary’ supra-molecular nano structures (where D is a conjugated donor block, A is a conjugated acceptor block, and B is a non conjugated and flexible bridge chain) have been designed, synthesized, characterized, and preliminarily examined for photovoltaic applications. For instance, in comparison to a corresponding donor/acceptor (D/A) simple blend, the -DBAB- block copolymer exhibited much better photovoltaic performances (V_{oc} increased from 0.14 volt to 1.10 volt, and J_{sc} increased from 0.017 mA/cm² to 0.058 mA/cm²). In materials energy levels and electron transfer dynamic regime, the photo induced exciton dissociation appears most efficient when the corresponding donor/acceptor frontier orbital offset is equal to the exciton binding energy (which is the sum of the exciton dissociation reorganization energy and the columbic binding energy).