

Factors influencing photocurrent generation in organic bulk heterojunction solar cells

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Plastic solar cells made from thin films of solution processible organic semiconductors offer one route to reducing the cost of solar photovoltaic (PV) power generation. Because of the molecular nature of the materials, efficient conversion of solar photons into charge pairs requires intimate mixing of two different semiconducting materials, typically a pi-conjugated polymer, which acts as an electron donor, combined with a second molecular material which acts as electron acceptor. The efficiency of photocurrent generation in such polymer:molecule blend solar is strongly influenced both by the energy level alignment at the donor-acceptor interface and by the microstructure of the blend films. Photoinduced charge separation requires that the charge separated state competes successfully with other excited states in the system, and that the thermodynamic driving force for charge separation exceeds some threshold, which may depend upon both the specific chemical structure and the local microstructure. The optimum blend microstructure, in turn, appears to combine a high degree of order in local molecular packing (benefitting charge transport and charge separation), a large interface (for charge separation) and significant phase segregation (to minimise charge recombination). In this work, we will show how a combination of spectroscopic techniques, electrical measurements and studies of phase behaviour can be used to build up a picture of the microstructure in a polymer: fullerene blend film, and so to rationalise the conditions for photocurrent generation. Finally, we demonstrate that the optimum blend composition for photocurrent generation can be related in a rational way to the phase behaviour of the binary system and in particular to the self-organising tendency of the component materials.