Lessons learnt with donor:acceptor photovoltaic blends applied to doped polymer systems

Natalie Stingelin

Georgia Tech

We discuss here the long-standing question of how free charges are generated in donor:acceptor blends that are used in organic solar cells. For this, we need to take into account that organic photovoltaic active layers are generally comprised of a complex phase morphology where intermixed and neat phases of the donor and acceptor material co-exist. We show that the fate of photogenerated electron-hole pairs – whether they will dissociate to free charges or geminately recombine – is determined at ultrafast times, despite the fact that their actual spatial separation can be much slower. The local arrangement of the donor and acceptor play a critical role in this phenomena as we demonstrate on a series of donor polymer:fullerenes binaries by combining 2D-NMR data with time-resolved ultra-fast spectroscopy results as well as detailed structural data. Our insights are important as similar considerations seem to apply to other organic blend systems, such as organic semiconductor:dopant blends that can lead to highly conductive systems. Indeed we will discuss how the spatial arrangement, manipulated through intercalation and co-crystal formation with dopants in analogy to the photovoltaic donor:acceptor systems, affects charge transport. We will conclude with providing a tentative picture of the complex correlation of structure and electronic landscape for the understanding of organic photovoltaic cells as well as doped, conducting “plastics” of metallic-type transport.

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