Understanding processes limiting the collection of photogenerated charge carriers in organic photovoltaic devices

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Organic semiconductor-based photovoltaic (OPV) devices have many advantageous properties including tailorable light absorption, low embodied energy manufacturing and cost, structural conformality, and low material toxicity. Apart from outdoor solar energy harvesting, these properties also make OPVs attractive for indoor applications which operate at considerably lower light intensities. However, owing to the low charge carrier mobilities, the competition between charge carrier extraction and recombination is an important factor limiting the performance of OPV devices, and generally depends on the light intensity. In this work, we clarify processes limiting the collection of photogenerated charge carriers in OPV devices. We investigate the light intensity and voltage dependence of the photocurrent and show how different loss mechanisms can be identified based upon their unique signatures. The theoretical framework is advanced and verified by a one-dimensional drift-diffusion device model. This work provides intriguing insights into the differences between OPV devices operating under indoor and outdoor conditions.