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Combined Influence of Charge Carrier Density and Temperature on Open-Circuit Voltage in Bulk Heterojunction Organic Solar Cells

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Abstract : One of the key parameters in determining the power conversion efficiency (PCE) of organic solar cells (OSCs) is the open-circuit voltage, however, it is still not well understood. In order to examine the performance of OSCs, it is necessary to understand the losses associated with the open-circuit voltage and how best it can be improved. Here, an analytical expression for the open-circuit voltage of bulk heterojunction (BHJ) OSCs is derived from the charge carrier densities without considering the drift-diffusion current. The open-circuit voltage thus obtained is dependent on the donor-acceptor band gap, the energy difference between the highest occupied molecular orbital (HOMO) and the hole quasi-Fermi level of the donor material, temperature, the carrier density (electrons), the generation rate of free charge carriers and the bimolecular recombination coefficient. It is found that open-circuit voltage increases when the carrier density increases and when the temperature decreases. The calculated results are discussed in view of experimental results and agree with them reasonably well. Overall, this work proposes an alternative pathway for improving the open-circuit voltage in BHJ OSCs.

Keywords : charge carrier density, open-circuit voltage, organic solar cells, temperature
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