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Origin of Non-Radiative Voltage Losses in Fullerene-Based Organic Solar Cells JOHANNES BENDUHN, IAP, TU Dresden, Germany, KRISTOFER TVINGSTEDT, University of Würzburg, Germany, FORTUNATO PIERSIMONI, University of Potsdam, Germany, SASCHA ULLBRICH, IAP, TU Dresden, Germany, DIETER NEHER, University of Potsdam, Germany, DONATO SPOLTORE, KOEN VANDEWAL, IAP, TU Dresden, Germany — The open-circuit voltage of organic solar cells (OSCs) is low as compared to the optical gap of the absorber molecules, indicating high energy losses per absorbed photon. These voltage losses arise only partly due to necessity of an electron transfer event to dissociate the excitons. A large part of these voltage losses is due to recombination of photogenerated charge carriers, including inevitable radiative recombination. In this work, we study the non-radiative recombination losses and we find that they increase when the energy difference between charge transfer (CT) state and ground state decreases. This behavior is in agreement with the energy gap law for non-radiative transitions, which implies that internal conversion from CT state to ground state is facilitated by skeletal molecular vibrations. This intrinsic loss mechanism, which until now has not been thoroughly considered for OSCs, is different in its nature as compared to the commonly considered inorganic photovoltaic loss mechanisms of defect, surface, and Auger recombination. As a consequence, the theoretical upper limit for the power conversion efficiency of a single junction OSC reduces by 25% as compared to the Shockley-Queisser limit for an optimal optical gap of the main absorber between (1.45-1.65) eV.

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