A current–voltage model for organic solar cells with carrier transport layers based on a combined analytical and regression approach

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Abstract

Organic solar cells (OSCs) have many potential applications due to attributes such as high mechanical flexibility, relatively low production cost, good transparency, and lightweight. Since the power conversion efficiency (PCE) of OSCs is relatively low currently, their PCE must be further improved to better exploit their potential in the future. The use of carrier transport layers (CTLs) is essential to maximize the PCE of OSCs. Therefore, a model that can accurately and reliably describe the current voltage (J-V) characteristics of OSCs with CTLs is also essential. Such a model is proposed in this paper. The proposed model is based on the semiconductor drift–diffusion transport model, which is the standard physics-based approach for modeling semiconductor devices including solar cells. In obtaining the proposed model, the approximate electric fields and the approximate boundary conditions in OSCs with CTLs are derived and then applied to the carrier continuity equations, which are then solved using a recently proposed combined analytical and regression method. The use of the recently proposed method makes the proposed model to be more accurate than analytical drift–diffusion-based J-V models and more reliable than numerical drift–diffusion-based J-V models. We verify that the proposed model works well and show that it can provide insights into how to optimize the design and improve the PCE of OSCs with CTLs. Therefore, owing to its unique quality, the proposed model can be a valuable tool for predicting and analyzing the J-V characteristics, and ultimately for improving the design and the PCE of OSCs with CTLs.

Author keywords

Blocking layer; Device physics; Metal oxides; Organic semiconductors; Photovoltaic cells; Semiconductor device modeling

Indexed keywords

Engineering controlled terms

Analytical models; Carrier transport; Conversion efficiency; Current voltage characteristics; Diffusion; Organic semiconductor materials; Organic solar cells; Organometallics; Photoelectrochemical cells; Regression analysis; Semiconductor devices

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