

EFFECT OF MORPHOLOGY ON CHARGE CARRIER DYNAMICS IN MDMO-PPV:PCBM BULK HETEROJUNCTIONS

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Spin-coated blend films consisting of poly(2-methoxy-5-(3',7'-dimethyloctyloxy)-1,4-phenylene-vinylene) (MDMO-PPV) and 1-(3-methoxycarbonyl)-propyl-1-phenyl-(6,6)C₆₁ (PCBM) form a promising basis for cheap photovoltaic cells. The spin-coating solvent used is reported to have a dramatic influence on the cell performance, which varies from ~ 1 % for toluene (TOL)¹ to ~ 3% for chlorobenzene (CB).² In this work the effect of the spin-coating solvent on the photoconductivity and the morphology is investigated. For this purpose MDMO-PPV/PCBM blends with a weight fraction PCBM (W_{PCBM}) of 0.55, 0.60 and 0.75 are spin-coated from either TOL or CB and are compared by means of microwave-conductivity measurements and by tunneling electron microscopy (TEM).

The observed photoconductivity, expressed in $\eta\Sigma\mu/F_A$ (the product of efficiency per absorbed photon times the sum of the mobilities of the charge carriers), on nanosecond pulsed excitation at 500 nm of blend films with $W_{PCBM} = 0.55$ spin-coated from either solvent, is comparable (Fig. 1). Increasing the PCBM weight fraction leads to an enhancement of the photoconductivity: surprisingly, while at a W_{PCBM} of 0.60 the photoconductivity is somewhat larger for samples spin-coated from toluene, the opposite is true for samples spin-coated at a W_{PCBM} of 0.75. The TEM measurements display for blend films with a W_{PCBM} of 0.55 spin-coated from either solvent a homogeneous nanostructure without any phase separation. A higher W_{PCBM} (0.6) results in phase separation in case of films spin-coated from TOL and increasing the W_{PCBM} to 0.75 leads to phase separation for both solvents, with particles sizes of 20-50 nm and >200 nm for CB and TOL, respectively.

The increase of the photoconductivity can be related to the observed morphology in the following way. On absorption of a photon by the polymer, an exciton is created, which can diffuse to the MDMO-PPV/PCBM interface. This leads to interfacial charge separation yielding an electron on a PCBM molecule and a hole on the polymer. In the absence of phase separation, the electron is localized on a PCBM molecule and the photoconductivity is attributed to mobile positive charge carriers. On phase separation, PCBM molecules form large aggregates allowing the electron to diffuse, which enhances the photoconductivity. The details of the effect of the solvent on the film morphology and the photoconductivity will be discussed.

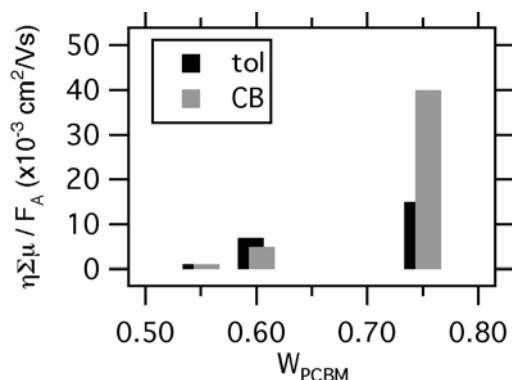


Figure 1. Observed photoconductivity for blend films prepared with indicated solvents.

1) S.E. Shaheen, C.J. Brabec, N.S. Sariciftci, F. Padinger, T. Fromherz and J.C. Hummelen, Appl. Phys. Lett. Vol. 78(6), 841 (2001).

2) C.J. Brabec, N.S. Sariciftci and J.C. Hummelen, Adv. Funct. Mater. Vol. 11(1), 15 (2001).

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