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# CW-Photocurrent measurements of conjugated polymers and fullerenes blended into a conventional polymer matrix

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## Abstract

In this work we present efficiency data of solar cells based on mixtures from soluble alkoxy PPV, a highly soluble fullerene derivative (PCBM) and three different conventional, non conjugated polymers, polystyrene (PS), polyvinylcarbazole (PVK) and polyvinylbenzenechlorid (PVBC). We studied the I/V characteristics of devices with various amounts of conventional polymer. Energy conversion efficiency $\eta_e$ and carrier collection efficiencies $\eta_c$ are calculated for these three composite devices and compared with the data for a pure conjugated polymer / fullerene device. We find that addition of up to 10% of conventional polymer to the electroactive composite is possible without lowering the efficiency of the device.

*Keywords*: Solar Cells, Poly (phenylene vinylene) and Derivatives, Fullerenes and Derivatives, Photoconductivity, Metal / Semiconductor Interfaces

## 1. Introduction

Interpenetrating networks of organic donors and acceptors, sandwiched between two electrodes with different workfunctions have been proposed recently as a novel concept for photovoltaic devices. Devices have been demonstrated where the donor was a strongly luminescent alkoxy PPV and the acceptor either a substituted fullerene [1] or a cyano PPV [2]. These devices are based on the ultrafast photoinduced electron transfer with long-lived charge separation [3] in the conjugated polymer/ fullerene system which offers a photoinduced charge generation efficiency near unity. Under the influence of the built in electric field due to the different workfunctions of the electrodes, charges are separated selectively and collected at the proper electrodes. Holes are transported via the donor network to the high work function electrode (typical ITO or Au), and electrons are transported via the acceptor network to the low work function electrode (typical Al, Mg, or Ca). The performance of photovoltaic devices based upon the interpenetrating network is strongly related to the morphology of the composite. Investigations on fullerenes $C_{60}$ and PVK blends suggest that the efficiency of photoinduced charge separation between these two components depends critically on the distance between the donor and acceptor [4]. Recently it has been shown [5], that the incorporation of conjugated polymer / fullerene compounds into a conventional host polymer is proper way to tune the morphology of the network as well as the intermolecular distances between the single components.

In this work we investigate the I/V and efficiency characteristics of photovoltaic devices based on MDMO-PPV (poly( 2 – methoxy – 5 - (3',7'-dimethyloctyloxy)- 1, 4 - phenylene vinylene)) and PCBM (1-(3-methoxycarbonyl)-propyl-1-phenyl-(6,6)$C_{61}$) blended into different host polymers like PVK, PS or PVBC.

## 2. Experimental

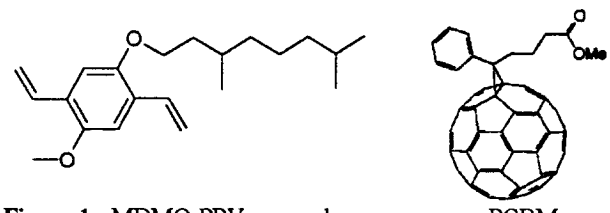

**Figure 1:** MDMO-PPV and PCBM

The chemical structure of the MDMO-PPV and PCBM is shown in Fig. 1. Optical quality films with weight ratios of PCBM : MDMO-PPV of 3:1 are possible. In the composites with conventional polymers the concentration of the electroactive components was kept at 3:1, while the conventional polymer was added adequately.


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### 3. Results

Fig. 2 presents I/V curves for devices with PVK as host polymer, while I/V data for devices with PVBC as host polymer are shown in Fig. 3

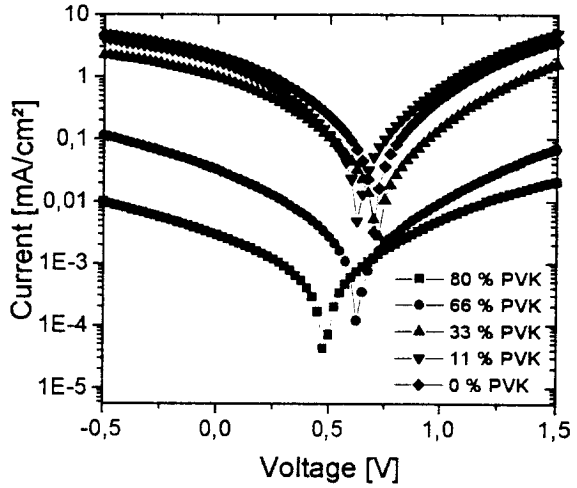


**Figure 2:** I/V curve of ITO / MDMO-PPV – PCBM – PVK / Al device with PVK concentrations as indicated in the Figure. Illumination was provided with 40 mW/cm$^2$ from a defocused Ar Laser at 488 nm.

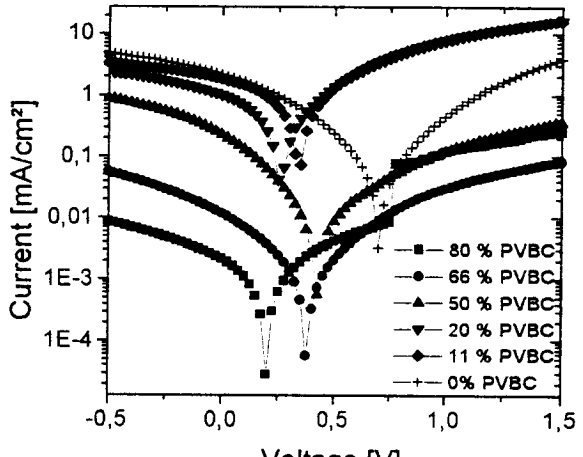


**Figure 3:** I/V curve of ITO / MDMO-PPV – PCBM – PVBC / Al device with PVBC concentrations as indicated in the Figure. Excitation was identical as for PVK devices.

Devices without host polymer show typically open circuit voltages ($V_{oc}$) around 0.7 V and short circuit currents $I_{sc}$ around 3 mA/cm$^2$ under illumination with 40 mW/cm$^2$ of 488 nm. The $I_{sc}$ and $V_{oc}$ values of the PVK blended devices (up to 30 wt.% PVK) are very similar to the pure device characteristics. At higher concentrations of PVK, $I_{sc}$ lowers steadily until the percolation threshold of PCBM in the composite is reached around 80 %. PVK. The trend of the PVBC devices is slightly different compared to the PVK cells. Generally, $V_{oc}$ of the devices is lower, which may be explained by phase separation or inhomogeneous mixing of the single components. Efficiency of the devices is more influenced at low PVBC concentrations than for PVK. Data from PS blended devices are not shown here, as their behavior is comparable to the other two host polymers. The carrier collection efficiency $\eta_c$ of a pure device is compared with a device with 50% PVK in Fig. 4. While $\eta_c$ of the pure device follows the optical absorption curve of the MDMO-PPV, the efficiency of the PVK device is more pronounced in the blue.

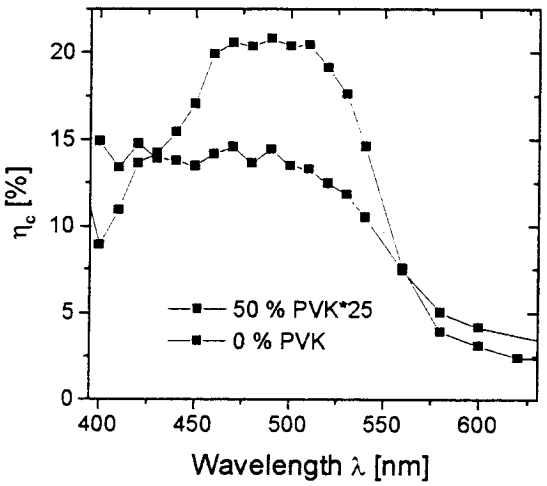


**Figure 4**: Carrier Collection Efficiency $\eta_c$ of a pure device [■] and for a device with 50% PVK [●]. Data have been calculated from spectrally resolved $I_{sc}$ data after reference [6].

### 4. Conclusion

Addition of small amounts of conventional polymers (~11 wt%) for improving film formation properties does not alter carrier conversion efficiencies. For PVK as host material, even higher concentrations are possible without altering the device performance.

### 5. Acknowledgement

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