SCIENTIFIC PROJECT SHORT VISIT REPORT FOR EUROPEAN SCIENCE FOUNDATION PROGRAMME

ORGANIC SOLAR CELLS USING A NOVEL ACCEPTOR (DE109)

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INTRODUCTION

Organic solar cell research has developed during the past three decades, but especially in the last decade it has attracted scientific and economic interest much more than the past.

Conjugated polymers consisting of an electronically delocalized backbone are significant technological materials that enjoy much usage in optoelectronics, such as in polymer light-emitting devices (PLEDs) and polymer solar cells (PSCs) [1–4]. In addition, PSCs are a promising alternative to conventional inorganic solar cells owing to their large area, flexible shape, low mass, ease of processing and low-cost fabrication [3,4]. The conversion of solar light into electrical power requires the generation of both electrons and holes and a potential that extracts these charges to an external circuit. To obtain efficient photon-to-charge conversion, many different PSC architectures have been developed, such as single-layer cells [5], double-layer cells [6], and bulk-hetero-junction (BHJ) blend cells [7–10]. Although having advantages of organic solar cells such as reduced costs and flexibility, these solar cells are considerably deficient than inorganic solar cells in terms of power conversion efficiencies. There are a lot of scientific research studies in order to increase the power conversion efficiencies as much as possible.

To date, the most widely investigated organic semiconductors are p-type (hole transporting) materials based on aromatic amines and thiophene materials.[12,14,15] To further advance the area of high-performance organic electronic devices, we need organic n-type semiconductors with high electron mobilities and controllable HOMO and LUMO energy levels [16-18] . For example, organic solar cells incorporating heterojunctions of p- and n-type conjugated materials show much better performance than devices based on only p type or n type material,seperately.

AIM OF VISIT

The aim of this project is to fabricate and characterize polymer based organic solar cells. In this study, we focused on a novel acceptor instead of PCBM for the photovoltaic applications. The project mainly dealed with bulk heterojunction solar cells, prepared with semiconducting polymer with MDMO-PPV and a novel acceptor called DE109 which was synthesized by Priv. Doz. Dr.Daniel Egbe and his coworkers.

EXPERIMENTAL

1.1 General Characterization of a Solar Cell

The basic parameters describing the performance of a solar cell can be deduced from a current-voltage (I-V) curve (see figure 1).

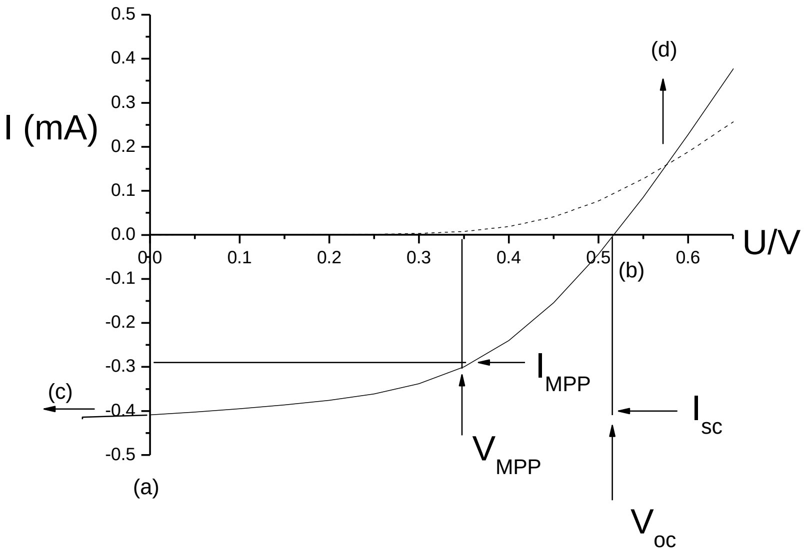


Figure 1. Current-voltage characteristics of a solar cell

In the dark, there is almost no current flowing, until the contacts start to inject heavily at forward bias for voltages larger than the open circuit voltage. (a) Short-circuit current condition where the maximum generated photocurrent flows (b) Flat band condition where the photogenerated current is balanced to zero. The fourth quadrant (between (a) and (b)) the device generates power. At maximum power point (MPP), the product of current and voltage is the largest [19].

The photovoltaic power conversion efficiency of a solar cell is determined by the following formula:

$$\eta_e = \frac{V_{oc} * I_{sc} * FF}{P_{in}}$$

$$FF = \frac{I_{mpp} * V_{mpp}}{I_{sc} * V_{oc}}$$

where V_{oc} is the open circuit voltage, I_{sc} is the short circuit current, FF is the fill factor and P_{in} is the incident light power density, which is standardized at 1000 W/m^2 for solar cell testing with a spectral intensity distribution matching that of the sun on the earth`s surface at an incident angle of 48.2^0, which is called the AM 1.5 spectrum [20]. I_{mpp} and V_{mpp} are the current and voltage at the maximum power point in the fourth quadrant of the current-voltage characteristics.

MATERIALS

PEDOT:PSS

PEDOT:PSS or Poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (see figure 1) is a polymer mixture of two ionomers. One component in this mixture is made up of sodium polystyrene sulfonate which is a sulfonated polystyrene. Part of the sulfonyl groups are deprotonated and carry a negative charge. The other component poly(3,4-thylenedioxythiophene) or PEDOT is a conjugated polymer and carries positive charges and is based on polythiophene. Together the charged macromolecules form a macromolecular salt [21].

It is used as a transparent, conductive polymer with high ductility in different applications. For example, AGFA coats 200 million of photographic film per year with a thin extensively stretched layer of virtually transparent and colorless PEDOT:PSS as an antistatic agent to prevent electrostatic discharges during production and normal film use, independent of humidity conditions[21].

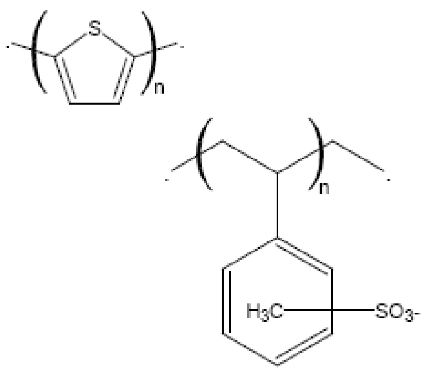
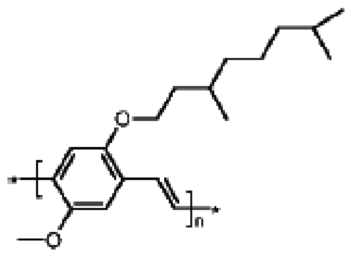


Figure 1 : Molecular composition of PEDOT:PSS

MDMO-PPV

Figure 2 shows the chemical structure of the frequently used organic semiconductor the *p*-type hole conducting donor polymers MDMO-PPV (poly[2-methoxy-5-(3,7-dimethyloctyloxy)]-1,4-phenylenevinylene) for photovoltaic applications. We used MDMO-PPV in this project.



MDMO-PPV

Figure 2: MDMO-PPV

DE109

Chemical structure of novel acceptor DE109. This material was synthesized by Priv. Doz. Dr. Daniel Egbe and his co-workers.

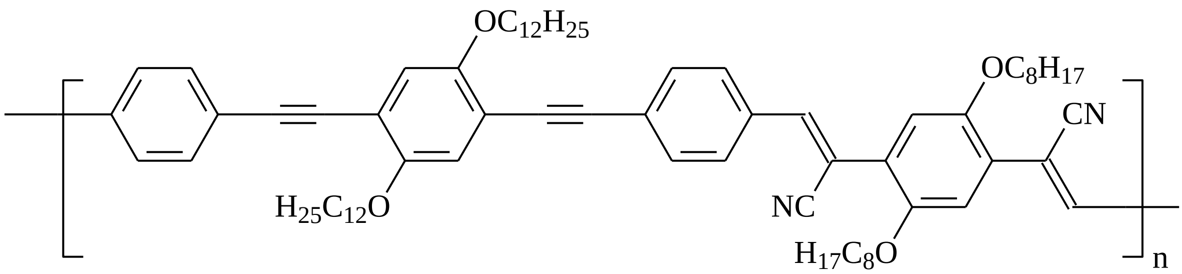


Figure 3: DE109

Fabrication and Characterization of Bulk Heterojunction Solar Cells Using DE109:

As substrates, glass sheets of 1.5x 1.5 cm2 covered with ITO, from Merck KG Darmstadt, were used with an ITO thickness of about 120 nm and sheet sheet resistance < 15 Ωcm^{-2}. The ITO Merck KG Darmstadt was used in all experiments. ITO glasses were etched with an acid mixture of HClBkonzB:HNOB3konzB:HB2BO (4.6:0.4:5) for an hour. The scotch tape was used to protect the determined area of ITO from etching. After etching, the substrate was cleaned by using acetone, ethanol, iso-propanol and finally with distilled water in an ultrasonic bath.

Bulk heterojunction solar cells based on conjugated polymer and novel acceptor were prepared. The layers this type of solar cells were described to be **ITO/MDMO-PPV/DE109/Al** .Solutions were prepared in chlorobenzene at different concentrations 1-1[6 mg MDMO-PPV and 6 mg DE109],1-2[6 mg MDMO-PPV and 12mg DE109],1-3 [6mg MDMO-PPV and 18 mg DE109]and 1-4[6 mg MDMO-PPV and 24 mg DE109]. The solutions were spun cast onto PEDOT:PSS coated substrates. And 120 nm Aluminum (Al) was evaporated as top contacts.

All current–voltage (I–V) characteristics of the PV devices were measured (using a Keithley SMU 236) under nitrogen in a dry glove box immediately after production. A Steuernagel solar simulator, simulating AM1.5 conditions, was used as the excitation source with an input power of 100 mW/cm^2 white-light illumination.

The spectrally resolved photocurrent was measured with a EG&G Instruments 7260 lock-in amplifier. The samples were illuminated with monochromatic light from a Xenon lamp.

RESULTS

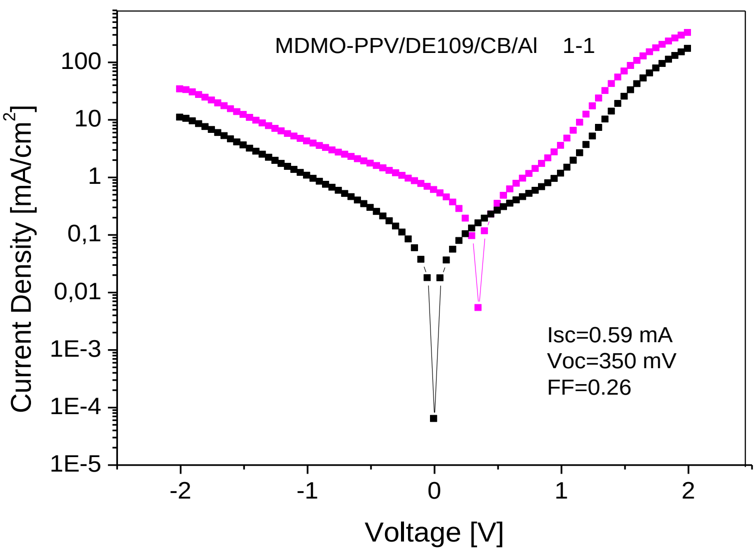


Figure (a)

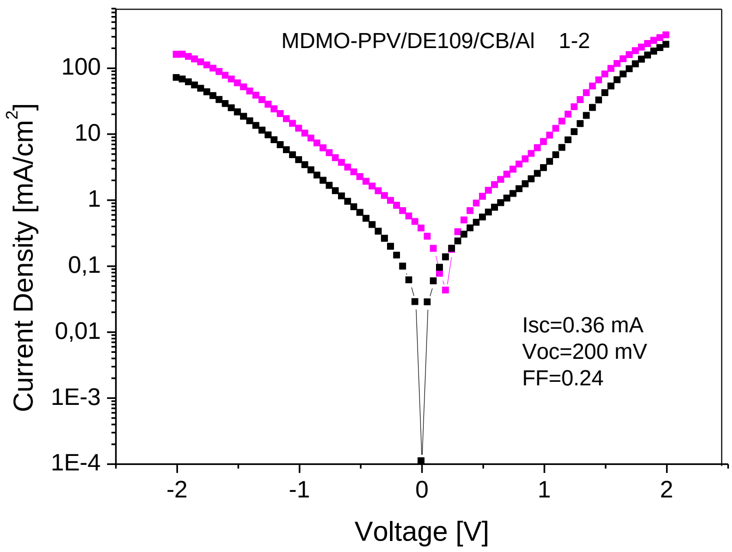


Figure (b)

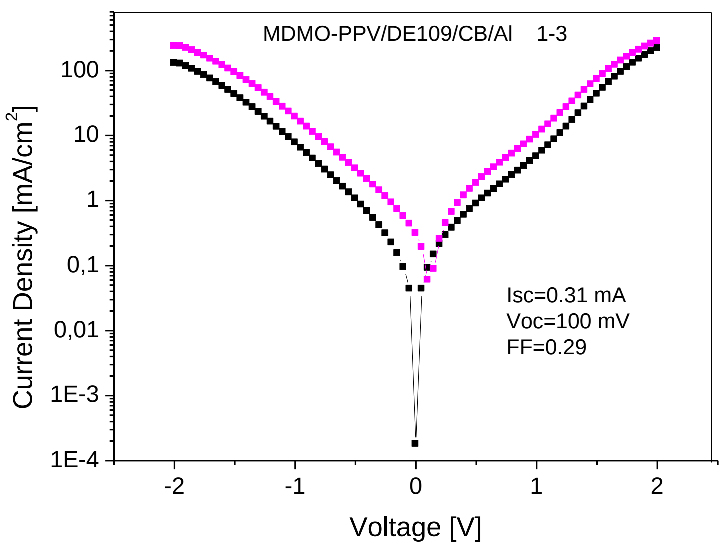


Figure (c)

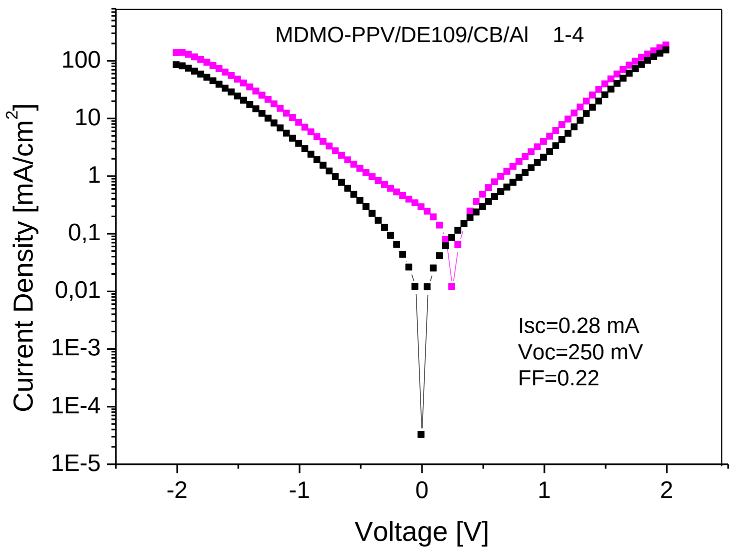


Figure (d)

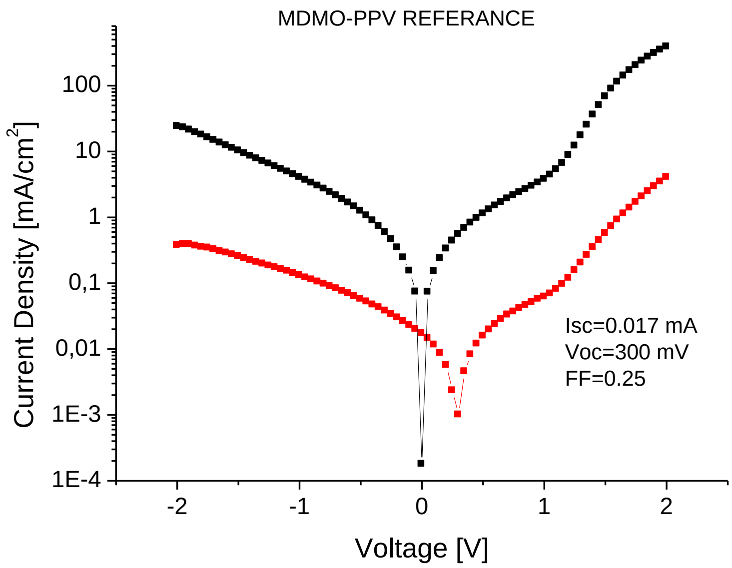


Figure (e)

Figure(a),Figure(b),Figure(c),Figure(d)shows the photovoltaic characterization of the **ITO/MDMO-PPV/DE109/Al** solar cells at different concentrations 1-1,1-2,1-3, and 1-4, respectively. Figure(e) shows reference result. At 1-1 (Figure (a) concentration solar cells showed the highest performance.

CONCLUSION

We investigated bulk heterojunction organic solar cells using MDMO-PPV and novel acceptor(DE109). To investigate the effect of novel acceptor on the performance of bulk heterojunction solar cells we prepared solar cells comprising of ITO/PEDOT/MDMO-PPV /DE109(novel acceptor)/Al. As a reference cell, a solar cell consisting of only MDMO-PPV in clorobenzen was also prepared . Organic solar cells consisting of MDMO-PPV and novel acceptor (DE109) showed better photovoltaic performance as compared to solar cells consisting of bare MDMO-PPV.

We will continue to collaborate with the host institute, Priv. Doz. Dr. Daniel Egbe and his co-workers. Future collaboration includes photophysical characterization, mobility measurements, morphology characterization and further devices with new materials.

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