

## Hybrid photovoltaic devices using a carboxylated poly(3-hexyl thiophene) derivative

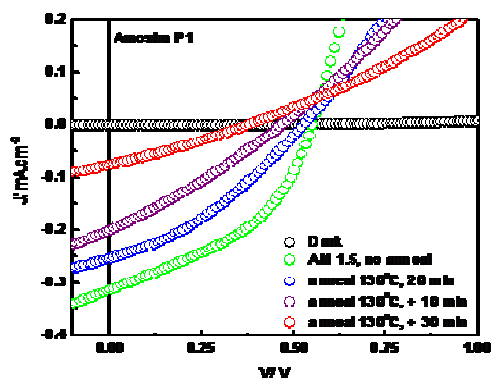
A. P. Ibaldo<sup>(1)\*</sup>, R. M. Faria<sup>(1)</sup>, H. Neugebauer<sup>(2)</sup>, N. S. Sariciftci<sup>(2)</sup>

(1) Institute of Physics of São Carlos/USP, e-mail: adrianapi@ursa.ifsc.usp.br

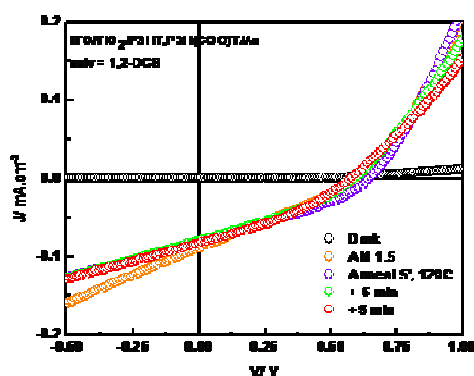
(2) Linzer Institut für Organische Solarzellen – Johannes Kepler Universität Linz

**Abstract** – In this work is proposed the utilization of a carboxylated poly(3-hexyl thiophene) in hybrid TiO<sub>2</sub>/polymer hybrid solar cells in order to study pore filling of the oxide matrix by the polymer.

Organic/inorganic nanostructured semiconductors have been applied as active materials in optoelectronic devices with a lot of emphasis on photovoltaics (PV). They exhibit several technological advantages as low cost, chemical stability and easy processing. However, the control of the film morphology in nanometric scale is its more powerful advantage, since this makes possible increasing the effective contact area of the devices [1]. In particular, TiO<sub>2</sub>/poly(3-hexyl thiophene) hybrid systems have received special attention due to promissory results obtained recently. In the present work, we propose the utilization poly(3-hexanoic acid thiophene) (P3HaT) and its blend with P3HT as polymeric layer for hybrid solar cells with the goal of a better understanding about pore filling. The devices were prepared in multilayer structure ITO/compact TiO<sub>2</sub>/porous TiO<sub>2</sub>/Polymer/Au. TiO<sub>2</sub> compact layer was prepared as described elsewhere [2]. The porous layer was obtained from commercial TiO<sub>2</sub> paste. Polymeric films were obtained by drop casting of solutions at concentrations of 1% (w/w): P3HT in 1,2-dichlorobenzene (DCB); P3HaT in aqueous solutions, and P3HaT:P3HT blends in DCB. Finally, 100 nm of Au were thermally evaporated on polymeric films. Electrical behavior of such structures was studied taking into account the influence of carboxyl groups of P3HaT chains. J-V measurements were carried out under inert environment using a Keithley 236 sourcemeter as well as a K. H. Steuernagel solar simulator under AM 1.5 conditions. The devices were annealed between 120 – 130° C before performing the electrical measurements. All photovoltaic parameters for TiO<sub>2</sub>/P3HaT junctions improved with the annealing, however, opposite effect was observed for TiO<sub>2</sub>/P3HT structures. With this last device the best results were: V<sub>oc</sub> = 550 mV; J<sub>sc</sub> = 0.31 mA.cm<sup>-2</sup>; FF = 0.424; η = 0.1% (see Fig. 1). To optimize TiO<sub>2</sub>/P3HaT PV structure we need to minimize the content of cations present in basic aqueous media during the preparation of P3HaT aqueous solutions. For TiO<sub>2</sub>/P3HaT:P3HT junctions, the best result was reached when the device was annealed for 5 minutes, as shown in Fig. 2. These results may indicate that the thermal treatment of the device may induce coiling of the P3HT chains [3], which summed to hydrophilic/hydrophobic interactions, leading on a poorer contact between the oxide and polymer. On the other hand, the distinct behaviour for P3HaT:P3HT blend may be explained by means of the interplay of heating-favoured interaction between the carboxylate groups from P3HaT and the TiO<sub>2</sub> surface and coiling of the polymeric chains. Insight about the polymer conformation may be obtained from UV/Vis and PL measurements, in which a blue shift in absorption of the annealed samples indicates a shorter conjugation length on a coiled chain. Furthermore, cross section SEM measurements provides information about polymer infiltration into the mesoporous films.



**Figure 1:** J-V characteristics for a ITO/TiO<sub>2</sub>/P3HT/Au without annealing (green) and after 130°C annealing for 20 min (blue), + 10 min (purple) and + 30 min (red)



**Figure 2:** J-V characteristics for a ITO/TiO<sub>2</sub>/P3HT:P3HaT/Au without annealing (orange) and after 120°C annealing for 5 min (purple), + 5 min (green), + 5 min (red)

### References

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- [3] C. Yang, F. P. Orfino, S. Holdcroft, *Macromolecules* **29** (1996) 6510.