Photoactive Nanostructured Layers of Cross-linkable Polymers: Applications in Organic Photovoltaic Cells

A. Charas[1], J. Farinhas[1], G. Brotas[1], Q. Ferreira[1], R. Rodrigues[1], R. E. Di Paolo[2], J. Morgado[1,3]

[1] *Instituto de Telecomunicações, Instituto Superior Técnico, Lisbon, P-1049-001, Portugal, ana.charas@lx.it.pt*
[2] *Centro de Quíimica Estrutural, Departamento de Engenharia Química e Biológica, Instituto Superior Técnico, Av. Rovisco Pais, 1049-001, Lisbon, Portugal.*
[3]*Departamento de Bioengenharia, Instituto Superior Técnico, UTL, Av. Rovisco Pais, 1049-001 Lisbon, Portugal*

Several cross-linkable photo-active polymers, namely conjugated polymers of the family of poly(9,9-dialkylfluorene)s and poly(3-hexylthiophene)s, were synthesised and used to prepare insoluble and nanostructured layers on top of conducting and transparent (to visible light) surfaces (PEDOT:PSS). The cross-linking ability is endorsed by the presence of oxetane moieties as end-groups in the polymer side-chains (Figure 1) upon promoting cationic ring-opening polymerization (CROP) between oxetane units. The nanostructured layers of cross-linked polymers were prepared by: i) spin coating solutions of polymer blends containing the photo-active polymer and an assisting polymer (polystyrene), ii) then implementing CROP by UV-irradiation plus thermal annealing and iii) removing the assisting polymer by solvent dissolution [1, 2]. Phase separation between the two polymers develops during the spin coating step leading to nanostructured polymer phases whose morphologies are controlled by the blend characteristics and the spinning speed. Using this approach, we have tailored film morphologies towards those considered as the most favourable to photocurrent generation in organic photovoltaic cells (OPVs). Cells were fabricated by spin casting a soluble fullerene as the electron-acceptor component on top of the insoluble polymer nanostructured layer, this corresponding to the electron-donor component (Figure 1) and by thermally evaporating LiF and aluminium as the top electrode. We demonstrate the control of structuring dimensions of such polymer layers and their effect on the OPVs performance. Time-resolved fluorescence studies at the pico-second time scale performed at the donor/acceptor nanostructured layers are also herein presented. For comparison, cells based either on blends or planar bilayers of the same components were also fabricated and characterized.

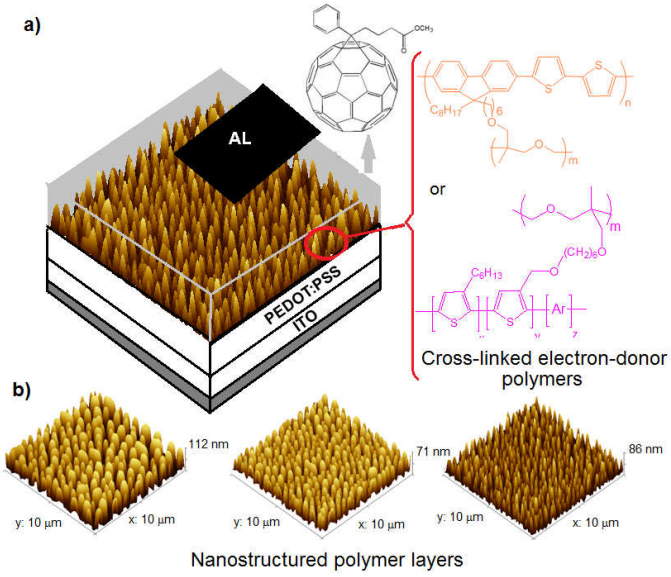

Figure 1. a) Scheme of an organic photovoltaic cell containing a nanostructured photo-active layer composed of a cross-linked electron-donating polymer and an electron-accepting fullerene. b) Nanostructured layers differing in domains sizes.

Acknowledgments: The authors thank Fundação para a Ciência e Tecnologia (FCT) for financial support (contract PTDC/CTM/111263/2009). JF (SFRH/BD/75221/2010) and GB (SFRH/BD/62130/2009) thank FCT for a PhD grant and QF (SFRH/BPD/73338/2010) and RR (SFRH/BPD/73682/2010) for post-doc grants.

[1] A. Charas, Q. Ferreira, J. Farinhas, M. Matos, S. Fonseca, H. Burrows, L. Alcácer, J. Morgado, *Macromolecules 2009, Vol. 42, 7903.*
[2] J. Farinhas, Q. Ferreira, R. E. Di Paolo, L. Alcácer, J. Morgado, A. Charas, *J. Mat. Chem. 2011, Vol. 21, 12511.*