NOVEL APPROACHES FOR THE OPTIMIZATION OF SOLAR ENERGY HARVESTING AND CONVERSION DEVICES

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Solar energy is a very promising source of renewable energy. For this reason, the scientific community is doing great efforts to improve the efficiency of photovoltaic (PV) devices and, at the same time, to reduce its costs and its environmental impact. Dye-sensitized solar cells (DSSC) represents one of the most studied PV technology, in the last 20 years, due to its low costs, facility of fabrication and efficiencies up to 13%[1]. In this respect, our research group proposed novel techniques to reduce the DSSC’s costs substituting Pt counter electrodes (CEs) with efficient low-cost materials. Cobalt sulfide (CoS) is a p-type semiconductor with a high catalytic efficiency in the oxidation/reduction of I-/I3- redox couple. CoS become very interesting for the preparation of efficient CEs for DSSCs[2]. However, most techniques proposed so far in the literature for the deposition of CoS thin films, does not consider the large-scale applicability of the processes. For this reason, we focused on ink-based techniques, compatible with both screen-printing and ink jet deposition, widespread used in films electronics fabrication. Our first attempt to the production CoS CEs consisted of a solvent-soluble organic complex (precursor) thermally converted into a thin layer of CoS nanocrystals[3]. This method was further improved by using water instead of toxic organic solvents for the ink preparation reaching energy conversion efficiencies up to 6.8%[4]. Along with the research on DSSCs, we also investigate on perovskite-based solar cells (PSCs), which have reached efficiencies up to 21% just in a few years[5]. Especially, charges extraction, trapping and recombination issues are responsible for hysteresis phenomenon in PSCs. This results in charges accumulation in the device causing efficiency and stability losses. We recently demonstrated that hysteresis can be efficiently reduced by using Nb2O5 as hole blocking layer[6]. Last, but not least important device studied in our group is the organic solar cell (OSC). This device uses the optoelectronic properties of some organic polymers for sun light harvesting and conversion. In this direction, with our collaborators of Université de Pau et des Pays de l’Adour, we proposed a novel synthesis of main-chain polyfullerenes[7]. [1] S. Mathew et al., Nat. Chem., vol. 6, no. 3, pp. 242–247, 2014. [2] J. Huo et al., Electrochim. Acta, vol. 159, pp. 166–173, Mar. 2015. [3] M. Congiu et al., Electrochim. Acta, vol. 151, pp. 517–524, 2015. [4] M. Congiu et al., Sol. Energy, vol. 122, pp. 87–96, Dec. 2015. [5] T. C. Sum et al., Energy Environ. Sci., vol. 7, no. 8, pp. 2518–2534, 2014. [6] S. L. Fernandes et al., Mater. Lett., vol. 181, pp. 103–107, 2016. [7] H. H. Ramanitra et al., Macromolecules, vol. 49, no. 5, pp. 1681–1691, 2016.