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New conducting polymers containing fluorene and thiophene units and their application in organic solar cells

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Abstract – In this work, new conducting polymers containing fluorene and thiophene units were synthesized and characterized, and then employed as hole conductors in organic solar cells, in combination with a soluble fullerene derivative (electron conductor). The performance of these devices was further optimized after the addition of a third component to the polymer-fullerene mixture, as will be also discussed.

Organic solar cells are among the most promising devices for cheap solar energy conversion. These devices consist of a heterojunction of polymer-fullerene, where the most used materials are poly(3-hexylthiophene) and a soluble fullerene derivative (PCBM). In these devices, the polymeric materials are important components, acting as light absorber, electron donor and hole transporter. The fullerene acts as electron acceptor. The introduction of post-production treatment, or the addition of small alkyl thiol molecules content, the optimization of solvent conditions and device design are responsible for significant improvements in the efficiency of these devices [1,2]. Although remarkable progress has been made in device efficiency in the last few years, some factors still need to be improved. Such bottlenecks include: morphology (hard to achieve nanoscale phase separation), the mismatch with the solar spectrum (low light absorption in the infrared region), the HOMO position of the conducting polymer (which affects the open circuit voltage) and stability.

Poly(fluorene vinylene)s, which are a branch of poly(2,7-fluorene) derivatives, have similar structures to poly(p-phenylenevinylene). In these materials, the vinylene units in the polymer backbone lead the absorption spectra to broaden and the photoluminescence emission spectra to redshift in comparison with polifluorenes. The structure is rigid and has a nearly one-dimensional coplanarity, which can restrain the distortion of arylic rings, leading to high charge mobility. Thiophene and its derivatives have also been investigated as promising materials for optical devices, especially because of their narrow band gap and high stability. The incorporation of thiophene units in polyfluorene systems can change the band gap, extending the light harvesting [3]. Thus, copolymers of these materials provide opportunities to bond different contents of functional units so that the electronic and physical properties can be tuned according to the desired application.

In this work, conducting polymers with different contents of thiophene and fluorene functional units were investigated, aiming at the application in organic solar cells. The charge mobility, photophysical and electrochemical properties were investigated, and the polymers were combined with a soluble fullerene derivative (PCBM) to make bulk heterojunction photovoltaic cells. We will also discuss the effect of the addition of CdSe nanoparticles to these devices, which leads to further improvements in the performance.

References

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