Low cost carbon dots sensitized solar cells

Roberto Vaz,[a] Tereza I. R. de Souza,[a] Ana B. F. Vitoreti, [a] Dmitry Aldakov,[b] Marco A. Schiavon[a]

[a] *Grupo de Pesquisa em Química de Materiais–(GPQM), Departamento de Ciências Naturais, Universidade Federal de São João del-Rei, São João del-Rei, MG, Brazil.*

[b] Univ. Grenoble Alpes, CEA, CNRS – INAC-SyMMES, F-38000 Grenoble, France

Carbon Dots (CDots) have gradually become an important class of the nanomaterials, due to their source of preparation being derived from carbonaceous materials, which are often abundant and cheap. The main reason, however, for the CDots to attract great attention of the researchers is due to their properties such as solubility, colloidal stability, and absorption and emission positions. In the literature there are reports of photoluminescence quantum yield values (Φf) reaching 80%, depending on the method of preparation and the precursor used. [2-3] In addition, CDots can be applied in sensors, photocatalysis and biomedical applications. [4]

The ability to absorb light in the wide range, their low production cost, chemical inertness and photostability make the CDots materials with great potential for application in solar cells. CDots can be used as absorbers either to replace dyes or even simultaneously with other dyes to increase the efficiency of solar cells. In this work we have demonstrated the ability of CDots, obtained by hydrothermal route from simple and cheap precursors such as coffee powder and gelatin, as TiO_2 sensitizer for application in solar cells. The results of absorption spectroscopy and the photovoltaic performance are expressed in Figure 1.

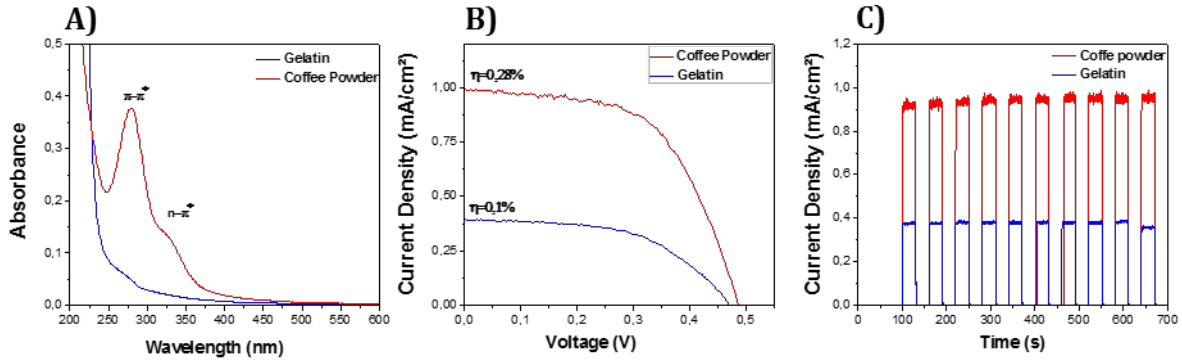

Figure 1. (A) UV-Vis Absorption spectra of CDots from coffee powder and gelatin. (B) and (C) Photovoltaic performance of the CDot sensitized solar cells.

The prepared CDots have an absorption range that extends from the ultraviolet to the visible of the electromagnetic spectrum. It is observed that the CDots derived of coffee powder exhibit higher absorption intensity and extend to longer wavelengths according to Figure 1A, which may be related to the amide groups which are observed in infrared spectroscopy analyses. Both materials have emission in the visible range, which is dependent on the excitation wavelength due to the diversity of organic groups on the surface of the CDots. These groups generate intermediate states between the HOMO and LUMO orbitals of the material, thus causing emission over a wider range of the spectrum. [5] The CDots prepared from coffee powder and gelatin presented Φf values of 1.8 and 6.8%, respectively, when referenced with quinine sulfate. CDot sensitized solar cells were prepared using the sensitized TiO_2 as photoanode, iodide/triiodide as electrolyte and Pt as counter electrodes. The energy conversion efficiency obtained was 0.28 and 0.10% for the coffee powder- and gelatin-derived CDots, respectively. We have also observed the devices were stable after at least 10 light/dark cycles using a light of 1 sun (100 $mWcm^{-2}$). These results evidenced the potential of cheap and eco-friendly CDots for use as sensitizers in solar cells, opening the possibility to increase the energy conversion efficiency by using for example a combination of dyes in cascade solar cells.

1) S. N. Baker *et al., Angew Chem Int Ed Engl*, **2010**, 49, 6726.
2) P.C. Hsu *et al., Green Chemistry*, **2012**, 14, 917.
3) Y. Zhuo *et al., Materials Letters*, **2015**, 137, 197.
4) R. Narayanan *et al., J. Mater. Chem. A.*, **2013**, 1, 3907.
5) X. Li, X. *et al., Sci Rep.*, **2014**, 4, 4976.