The end of Pt counter-electrodes: Transparent graphene-based cathodes for iodine and cobalt-based liquid-junction (electrolytes in) DSCs

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Abstract

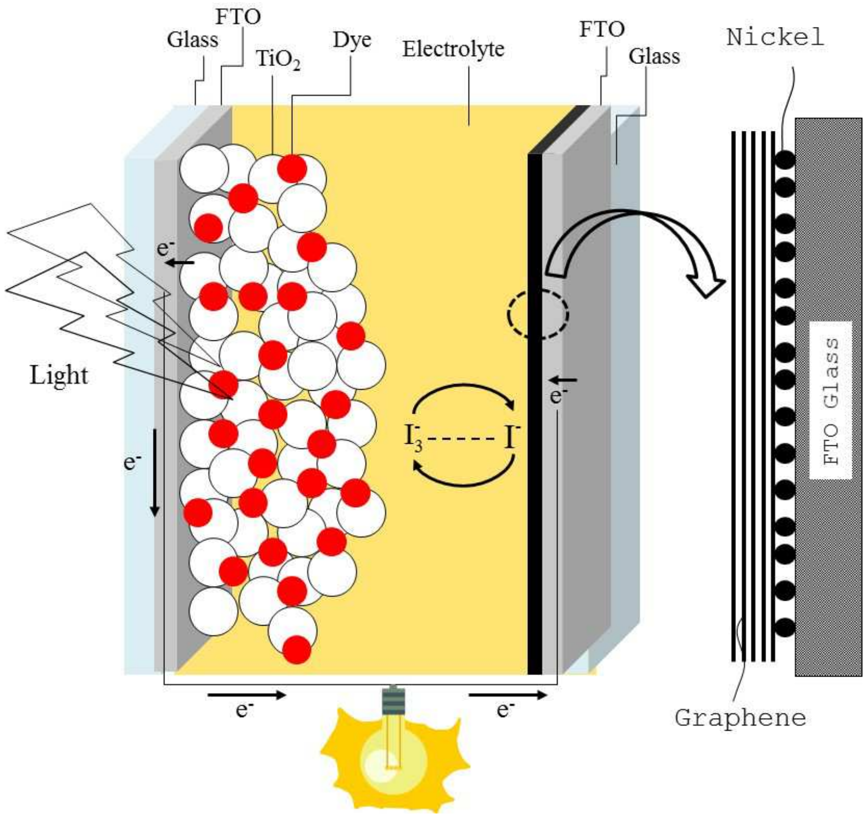
Dye-sensitized solar cells (DSCs) are a promising technology among the so-called third generation of photovoltaic cells, based on the idea of using nanotechnology and fairly abundant/environmentally friendly raw materials for lowering production costs and increase sustainability. The DSCs technology is now emerging due to its superior performance under more demanding atmospheric conditions and semi-transparency properties. [1] Nevertheless, to turn DSCs a truly cost-competitive alternative to conventional photovoltaic devices in the energy market it is necessary new cost-effective materials. Amongst them it is the replacement of the catalyst material used for the photoelectrochemical reaction that takes place at the counter-electrode side of DSCs. To date, there was no other material capable of matching both the electrocatalytic activity for the I_3^-/I^- redox couple (the most used electrolyte system), and the high optical transparency of the traditionally used Pt electrode. Although transparency is not mandatory for a DSC, it is highly appreciated as it increases the product value by enabling its use in building integrated applications (BIPV), as well as in other solutions such as tandem cells.

Here we present the first graphene-based CE capable of replacing Pt (yielding simultaneously high efficiency and transparency) for iodine-based electrolyte systems in liquid-junctions DSCs. When nickel nanoparticles are placed between a FTO substrate and oxidized graphene platelets, they are capable of restoring electronic double bonds along the platelets as well as improving ohmic resistance between the catalytic material and the FTO layer (Figure 1). Both materials and processes should enable the fabrication of a cheaper DSC.

The microstructure and morphology of the different materials and the film's surface was characterized by FE-SEM, TEM, AFM and Raman analysis. TGA/DTA and XPS was used to evaluate the oxygen content. The optimization of the graphene-based counter-electrodes involved maximizing its catalytic activity (efficiency) and transparency by creating a sufficient number of active sites while ensuring enough conductivity in the

graphene platelets and a good electrical contact with the substrate [2]. This evaluation was carried out using half-cells and complete DSCs [3]. Characterization included *I-V* and EIS analysis.

The use of the graphene/Ni CE was also validated to cobalt complexes electrolytes/ porphyrin dyes systems. This was done because conventionally used Pt/iodide-triiodide/ruthenium dye systems have efficiency limitations [4]; the cobalt complexes/ porphyrin dyes systems have the potential to yield high-efficiency (> 12 %) cells, with graphene being the best suitable material to act as the catalytic layer [5-9].



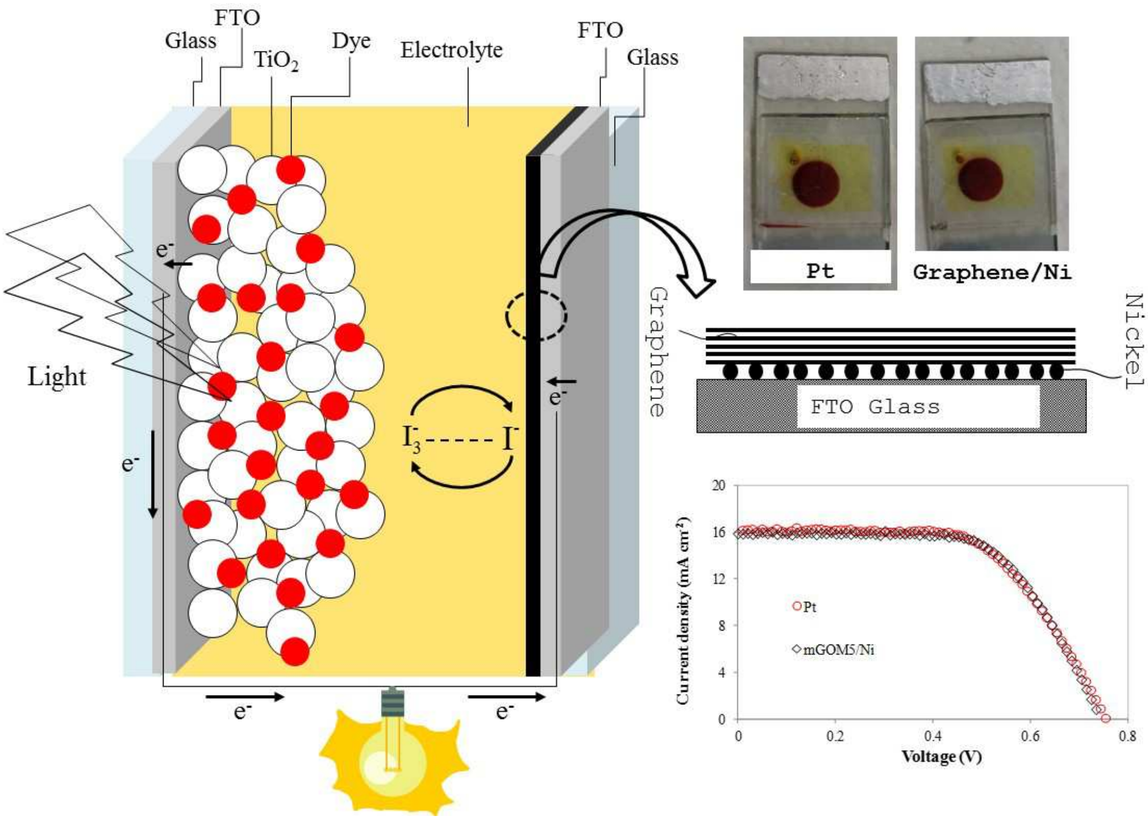


Figure Legend: Highly transparent, low cost and easily scalable CEs for DSCs, comprised of a structured graphene film over nickel nanoparticles (graphene/Ni CE), matched the energy conversion efficiencies of the reference platinum CE for liquid-junction iodine and cobalt-based electrolytes.

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