Highly efficient and stable transparent cuprous oxide photocathodes for photoelectrochemical water splitting cells

P. Dias[1], M. Mayer [2], J. Azevedo[1], L. Andrade[1], A. Mendes[1], M. Graetzel[2], S. D. Tilley[2]*

[1] Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr.Roberto Frias, 4200-465 Porto, Portugal
[2] Institut des Sciences et Ingénierie Chimiques, École Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switerland
** Presenting author*: deq11004@fe.up.pt

Solar energy is one of the most important natural sources of renewable energy. With approximately 120 PW of solar energy continuously bombarding the earth surface, it seems to be a viable alternative to overcome the current global energy demand.[1] The production of solar fuels is a promising route and, in particular, hydrogen generated via photoelectrochemical (PEC) water splitting. Numerous semiconductor materials and PEC device configurations have been investigated for several decades, since the pioneering demonstration of PEC water cleavage using a photoanode of TiO_2 by Fujishima and Honda in 1972.[2] In most cases, an external bias is necessary to generate solar hydrogen from water splitting due to non-ideal band edge alignment of the semiconductor with the electrolyte and/or insufficient charge separation (resulting in a smaller photovoltage). However, the ideal PEC cell should work without any external bias and a combination of two or more semiconductors in a tandem arrangement is an attractive solution.[3] For a stacked configuration tandem cell, the development of a transparent photoelectrode is needed since the portion of solar radiation not absorbed by the semiconductor can be transmitted and converted by the second photosystem (e.g. an n-type photoanode or a PV device), improving the efficiency of the system. The present work aims to present a highly active and stable transparent photocathode. It consists of a buried p–n junction comprising electrodeposited p-type cuprous oxide (Cu_2O) and n-type nanolayers of Al-doped zinc oxide (AZO) and TiO_2, activated with RuO_2 co-catalyst. Photocurrents of about 5 $mA \cdot cm^{-2}$ and 2 $mA \cdot cm^{-2}$ were observed for front and backside illumination at 0 V_{RHE}, respectively. Only a 10 % loss occurred after 20 hours under visible light irradiation.

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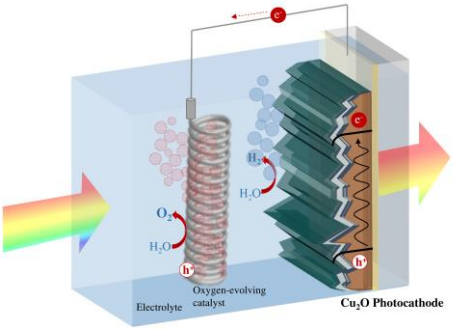

Figure 1. PEC cell based on a Cu_2O photocathode and a dark counter-electrode.