Consequences of solid electrolyte interphase (SEI) formation upon ageing on charge transfer processes in dye-sensitized solar cells

Miguel Flasque[(a)], Albert Nguyen VanNhien[(b)], Frédéric Sauvage[(a)]*

(a) Laboratoire de Réactivité et Chimie des Solides, Université de Picardie Jules Verne, CNRS UMR7314, 33 rue Saint Leu, 80039 Amiens Cedex
(b) Laboratoire de Glycochimie, des Antimicrobiens et des Agroressources, Université de Picardie Jules Verne, CNRS UMR7378, 33 rue Saint Leu, 80039 Amiens Cedex

*E-mail of the Corresponding Author: frederic.sauvage@u-picardie.fr

We reported for first time the formation of a solid electrolyte interphase (SEI) layer growing on sensitized-TiO_2 photo-anodes and platinum counter-electrodes when dye-sensitized solar cells (DSSCs) are subjected to an accelerated ageing protocol (e.g. heating at 85 °C in the dark for 500 hours) (Fig. 1).[1] The naked surface of TiO_2 between sensitizer molecules plays a catalytic role in the thermal degradation of the electrolyte, leading to the growth of such a SEI. The formation of this layer is responsible for the well-established tri-iodide depletion in electrolyte upon ageing. In this communication, a particular attention will be paid to the chemical characterization of this SEI based on XPS and ToF-SIMS and to the understanding of how this new interface between TiO_2 / electrolyte and sensitizer / electrolyte interfaces will impact the device operation. In short, electrochemical impedance spectroscopy study showed that the SEI induces an additional electron transfer process from the TiO_2 to the electrolyte. This is materialized by the onset of a new charge transfer semi-circle at higher frequencies, predominantly visible under bias voltage similar and above open circuit voltage. Our results emphasized on the detrimental role of the SEI formation on device performance and lifetime.[2] Additionally, ns-transient absorption spectroscopy indicates that SEI formation reduces the rate for the oxidised dye regeneration. We also show that a proportion of the photogenerated holes on the dyes are transferred to the SEI itself. Prolonged ageing duration leads to the electrode's mesoporosity network entirely clogged by the SEI; thus impeding efficient transport of the electrolyte redox couple, also responsible for a further decline in photovoltaic performances. All these results will be discussed in details giving new insights on the ageing mechanisms in dye-sensitized solar cells.

References

[1] M. Flasque, A. Nguyen Van Nhien, J. Swiatowska, A. Seyeux, C. Davoisne, F. Sauvage, ChemPhysChem 2014, 15(6), 1126-1137
[2] M. Flasque, A. Nguyen Van Nhien, D. Moia, P.R.F. Barnes, F. Sauvage, J. Phys. Chem. C 2016, 120, 18991-18998