Enhancing solar cell performance: Electrochemical reduction of titanium dioxide for energy alignment tuning

Katarina Cvetanović[1], Uroš Lačnjevac[2], Marko V. Bošković[1], Evgenija Milinković[1], Vladislav Jovanov[1], Dragomir Stanisavljev[3], Dana Vasiljević-Radović[1]

[1]*University of Belgrade – Institute of Chemistry, Technology and Metallurgy, Njegoševa 12, 11000 Belgrade, Serbia*

[2]*University of Belgrade – Institute for Multidisciplinary Research, Kneza Višeslava 1, 11030 Belgrade, Serbia*

[3]*University of Belgrade – Faculty of Physical Chemistry, Studentski trg 12-16, 11000 Belgrade, Serbia*

Metal oxides have emerged as pivotal components in advancing energy conversion and storage technologies, spanning from Li-ion batteries, electrocatalysts/photocatalysts for water splitting and CO_2 reduction, environmentally friendly dye-sensitized solar cells (DSSCs) to the latest developments in perovskite solar cells [1]. Titanium dioxide, in particular, holds a prominent position, serving as a photoanode in DSSCs and as an electron transport layer (ETL) in perovskite solar cells [2]. The high efficiency of converting solar energy to electricity depends on the spontaneous flow of charge in these systems [3]. Consequently, optimizing the energy alignment in these complex systems is crucial for achieving optimal performance [4]. One promising method for tuning the Fermi level of titanium dioxide is electrochemical reduction/oxidation [5]. The objective of this study is to investigate the most suitable electrolyte and optimal parameters for adjusting the energy levels of commercial titanium dioxide paste to best fit the energy requirements of the DSSC, which utilizes N719 dye as the sensitizer, I^-/I_3^- electrolyte, and platinum counter electrode. The electrochemical reduction of titanium dioxide will induce a shift in its Fermi level, leading to n-doping of the semiconductor. This shift is anticipated to increase the open circuit voltage of the solar cell, consequently enhancing its efficiency (Fig. 1) [6]. We will validate the reduction process through cyclic voltammetry and Mott-Schottky analysis [7]. The efficiency of this Fermi level tuning approach will be assessed by comparing the efficiency and other pertinent parameters of fabricated solar cells. By systematically investigating the impact of Fermi level adjustment on device performance, we aim to contribute to the advancement of efficient and sustainable solar energy technologies.

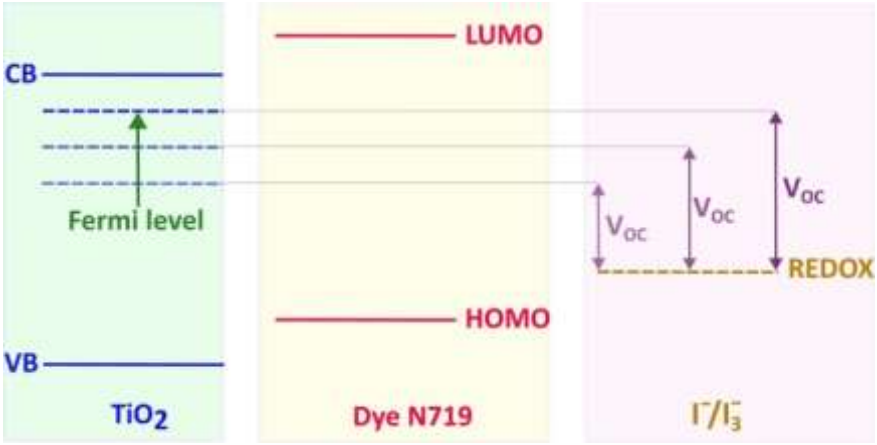

Figure 1. Schematic representation of energy level alignment in DSSC and the increase of open circuit voltage after reduction of TiO_2

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