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P167 Optimization of photoelectrode features in Cobalt (II/III) based electrolyte DSCs

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Dye-sensitized solar cells (DSSCs) have been considered an effective alternative to conventional p-n junction devices. Their low production cost, ability to harvest diffuse light and versatile applications, makes them a very interesting PV technology[1-3]. However, for the DSSC technology become a competitive alternative, higher efficiencies are required. Up to now the major drawback in increasing the DSSCs efficiency has been the excessive loss of voltage during the dye-regeneration reaction; the use of iodine/triiodide redox electrolyte limits the open-circuit potential to 0.8V[5]. With the current state-of-art sensitizers, such as N719, and high surface area TiO_2, I^-/I_3^- electrolytes achieve an efficiency maximum of 11.1%[6]. However, by replacing I^-/I_3^- by cobalt based redox couples new opportunities for higher efficiency DSSCs have been unlocked. The best DSSCsresult achieved so far is 12.3%, accomplished by the complementary use porphyrin dyes with $Co^{(II/III)}$ electrolytes[7]. These have emerged as the future electrolytes for liquid state DSSC[7-13]. In comparison to I^-/I_3^-, $Co^{(II/III)}$ complexes possess higher reduction potentials, originating V_{oc} close to 1V; they also have several advantages such as non-corrosiveness and negligible visible absorption[7]. Even though the remarkable 12.3% world record, higher efficiency is desired to commercialize the DSSC technology[14]. The drawbacks hampering the efficiency in $Co^{(II/III)}$ devices are mass-transfer limitations due to electrolyte's high viscosity and very fast electron recombination with the $Co^{(II/III)}$ species[12]. In fact in these devices, the photoanode's thickness and porosity was found to be crucial in their performance[13]. In this work we use phenomenological modeling to optimize the photoelectrode thickness, considering the slower $Co^{(II/III)}$ ionic diffusion coefficient ($1.4x10^{-6}$ vs $5x10^{-6}$ $cm^2 \cdot s^{-1}$ found in I^-/I_3^-)[15]. It is shown that a photoanode with higher electronic mobility should allow increasing its optimal thickness in current $Co^{(II/III)}$ DSSCs. New photoanode architecture is proposed, that tackles the shortcomings of cobalt-based electrolytes. Our approach uses high surface area particles with enhanced electron mobility due to the exposed (001) facets of TiO_2 crystals. By increasing the crystals size in (001) direction it is possible to create high electrical conductivity material capable of adsorbing large amounts of dye; these unique structures show higher electron diffusion with lower recombination rates even in the presence of $Co^{(II/III)}$. This works shows that careful optimization of the TiO_2 crystal features is a promising route for increasing the thickness of photoanodes without increasing recombination and mass transfer resistance; and thus opening a new route for a higher efficient DSSC.

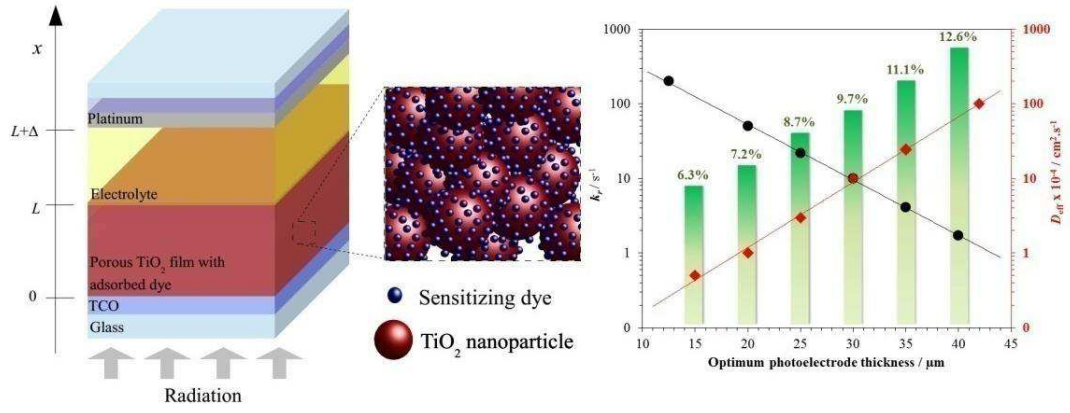

Figure 1 Figure 1. Influence of recombination and transport are crucial in optimizing the photoelectrodes thickness

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