Selective NIR-conversion in Dye-sensitized solar cells: a new generation of fully transparent and colorless photovoltaics

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Over the past 30 years, the transparent and low-cost nature of dye-sensitized solar cells (DSSCs) afforded them niche applications such as Building-Integrated PV. Consolidating the fact that the near-infrared (NIR) portion comprises ca. 40% of the total spectrum with the certainty that our eyes are not sensitive to the IR light, our work aims to develop transparent photovoltaics (TPV) by converting selectively NIR region. The theoretical PCE of a single junction selective TPV has been calculated to 20 % with an average visible transmittance (AVT) of 100 %.[1] So far, the best NIR-DSC reported achieved a PCE of 2.3% with an opaque photo-anode structure.[2] We have designed a new NIR- heptamethine dye, coded as VG20. The optimization led to the first proof-of-concept of a fully colorless and transparent DSSC with PCEs exceeding 3% and an AVT value of 68%. The discussion of our work will consider the limitations and challenges facing the NIR-DSSC. This class of dyes is known for its tendency of forming detrimental H-aggregates that can severely disrupt the function of our DSSC; as such, several approaches (dye structure, additives to the dye solution, sensitization condition) were followed. The results will be discussed based on photovoltaic output of the DSSCs associated with the steady-state absorption and transmission measurements. Shifting the absorption to the NIR region results in the narrowing of the band-gap of the dye, which may disturb the charge injection into the semiconductor, and the dye regeneration by the redox mediator. Pump-probe transient absorption spectroscopy (TAS) and intensity modulated photovoltage and photocurrent spectroscopy (IMVS/PS) gave us insights about these processes, in order to determine the limiting steps.

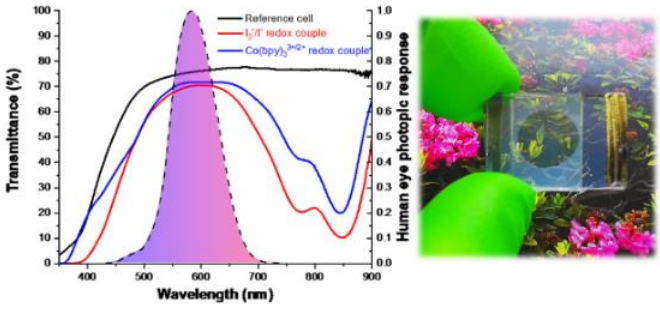

Figure 1. Transmittance spectra of full NIR-DSSCs based on VG20 dye (superimposed with the human's eye photopic response). On the right a picture of first proof-of-concept NIR-DSSC.

1. Lunt RR. *Applied Physics Letters*. 2012;101(4).

2. Ono T, Yamaguchi T, Arakawa H. *Solar Energy Materials and Solar Cells*. 2009;93(6-7):831-835.