Sequential Series Tandem Dye-Sensitized Solar Cells (SST-DSCs): 4.7 Volts from a Single Illuminated Area

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Sequential series tandem dye-sensitized solar cells (SST-DSCs), which are mechanically stacked single illuminated area DSC devices wired in series, are reported to have the highest photovoltages obtained from a single illuminated area DSC. The use of multiple photoactive films under one area within the SST-DSC framework is made possible by fine tuning the thickness of TiO_2 in each device and judicious dye selection to allow for excellent light distribution among the films, termed as "photon management". Photovoltages (V_{oc}) ranging from 1.9-4.7 V are observed for SST-DSCs fabricated from 2-5 stacked subcells constructed with metal-free organic dyes and cobalt redox shuttles. In SST-DSCs photon management approach allows for incorporation of materials designed to use the maximal potential energy of photons in each region of the solar spectrum. Importantly, SST-DSCs were observed to maintain high V_{oc} under low-light conditions, rendering these systems very attractive for indoor applications. Furthermore, a SST-DSC was found to have a solar-to-fuel conversion efficiency of 2% (2.7% including H_2 production) for the reduction of CO_2 to CO with IrO_2 and Au_2O_3 electrocatalysts, without an external bias. Additionally, efforts to tune the absorption further into the NIR region based DSC dye designs will be discussed with materials performing at high efficiencies until ~900 nm with novel organic sensitizers based on underutilized dye design concepts.