Photosynthetic Proteins in Devices – The Hurdle of Charge Recombination

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The integration of photosynthetic proteins in biohybrid solar cells is envisioned for the production of electricity or chemical fuels. To this end, redox hydrogels proved particularly suitable as matrices for the immobilization and electrical contacting of various photosynthetic proteins to electrodes. We tuned the redox potentials of the electron relays and the properties of the polymeric supporting matrix to enable benchmark photocurrent densities (300 $\mu A/cm^2$ for PS1[1] and up to 400 $\mu A/cm^2$ for PS2 [2]) at low overpotential [3]. In analogy to the working principle of dye sensitized solar cells, an important feature of biohybrid solar cells for conversion of light to electricity is the charge carriers needed for collection of the high-energy electron from the photosystem [4]. The main limitation in energy conversion efficiency is the recombination of this charge carrier at the photoelectrode, a process that decreases both the photocurrent and the open circuit voltage. Moreover, this charge recombination process is suspected to induce degradation of the photosynthetic protein [5]. We demonstrate that the hydrogel film properties as well as the electrode surface chemistry can be tuned to minimize the various charge recombination pathways. This concept opens up the possibility to build biohybrid photovoltaics free of semi-conductor materials.

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