Title
Identifying the underlying causes of ionic current rectification behavior and optical phenomena in purely protonic solar cells composed of photoacid-sensitized ion-exchange membranes

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Abstract

Electronic semiconductor diodes were developed nearly three-quarters of a century ago; one decade later Prof. John Bockris demonstrated that hydrated bipolar ion-exchange polymer membranes are ionic diodes due to the protonic semiconducting nature of water whose mobile charge carriers are hydroxides and protons. Our group seeks to further evaluate and validate the similarities in the physics between traditional semiconductors and water. We have expanded on Prof. Bockris' original discovery by sensitizing similar ionic diodes to visible-light absorption using photoacid dyes to drive release of protons as charge carriers. We have also employed pin-type doping to drive efficient charge separation, and we have fabricated membrane-electrode-assemblies (MEA) that enable direct transduction of protonic current into electronic current via reversible H2 redox chemistry. These developments result in light-driven proton pumping that can be measured using a common voltmeter.

For my presentation, I will discuss recent fundamental advances in understanding of the ionic current rectification process and dye-initiated photophysics occurring in MEAs containing pyranine as the photoacid dye. A series of MEAs were constructed by altering the pretreatment procedure of commercial ion-selective polymer membranes and varying homemade i-layer properties, namely thickness and photoacid protonation state. The effects of these variables on ionic current rectification were characterized via current-voltage measurements and quantification of the light-intensity dependence of the open-circuit photovoltage and short-circuit photocurrent. Additionally, optical and electronic phenomena such as a light-induced Stark effects will be discussed with the aid of pulsed-laser transient absorption spectroscopy data and confocal fluorescence microscopy imaging. Collectively, these data will be used to continue to improve on the Ardo Group's pioneering development of light-driven ion pumps that rely on water as a protonic semiconductor.