Abstract #2287, 224th ECS Meeting, © 2013 The Electrochemical Society

A Technical and Operational Perspective on the DOE Energy Innovation Hub in Fuels from Sunlight, the Joint Center for Artificial Photosynthesis

Professor Nathan. S. Lewis
California Institute of Technology
Division of Chemistry and Chemical Engineering
Beckman Institute and Kavli Nanoscience Institute

Abstract.

The design of highly efficient, non-biological, molecular-level energy conversion "machines" that generate fuels directly from sunlight, water, and carbon dioxide is both a formidable challenge and an opportunity that, if realized, could have a revolutionary impact on our energy system. Basic research has already provided enormous advances in our understanding of the subtle and complex photochemistry behind the natural photosynthetic system, and in the use of inorganic photo-catalytic methods to split water or reduce carbon dioxide–key steps in photosynthesis. Yet we still lack sufficient knowledge to design solar fuel generation systems with the required efficiency, scalability, and sustainability to be economically viable.

In the DOE Energy Innovation Hub, the Joint Center for Artificial Photosynthesis, we are developing an artificial photosynthetic system that will only utilize sunlight and water as the inputs and will produce hydrogen and oxygen as the outputs. We are taking a modular, parallel development approach in which the three distinct primary components-the photoanode, the photocathode, and the product-separating but ion-conducting membrane-are fabricated and optimized separately before assembly into a complete water-splitting system. The design principles incorporate two separate, photosensitive semiconductor/liquid junctions that will collectively generate the 1.7-1.9 V at open circuit necessary to support both the oxidation of H_2O (or OH^-) and the reduction of H^+ (or H_2O). The photoanode and photocathode will consist of rod-like semiconductor components, with attached heterogeneous multi-electron transfer catalysts, which are needed to drive the oxidation or reduction reactions at low overpotentials. This talk will discuss a feasible and functional prototype and blueprint for an artificial photosynthetic system, composed of only inexpensive, earth-abundant materials, that is simultaneously efficient, durable, scalably manufacturable, and readily upgradeable, including both the operational and technical scope of the JCAP Hub, as well as technical results towards this goal that has recently been developed at Caltech.