Michigan State University
Science at the Edge
Engineering Seminar

September 30th, 2016
11:30 a.m.
Room1400 Biomedical and Physical Sciences Building
Refreshments served at 11:15 a.m.

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

Sunlight-Driven Hydrogen Formation by Membrane-Supported Photoelectrochemical Water Splitting

Abstract

We are developing an artificial photosynthetic system that will utilize sunlight and water as inputs and will produce hydrogen and oxygen as outputs using 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 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 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, needed to drive the oxidation or reduction reactions at low overpotentials. The high aspect-ratio semiconductor rod electrode architecture allows for the use of low cost, earth abundant materials without sacrificing energy conversion efficiency due to orthogonalization of light absorption and charge-carrier collection. Additionally, the high surface-area design of the rod-based semiconductor array electrode inherently lowers the flux of charge carriers over the rod array surface relative to the projected geometric surface of the photoelectrode, lowering the photocurrent density at the solid/liquid junction and thereby relaxing demands on the activity (and cost) of any electrocatalysts. Flexible composite polymer film will allow for electron and ion conduction between the photoanode and photocathode while simultaneously preventing mixing of the gaseous products. Separate polymeric materials will be used to make electrical contact between the anode and cathode and also provide structural support. Interspersed patches of an ion conducting polymer will maintain charge balance between the two half-cells. The modularity design approach allows each piece to be independently modified, tested, and improved, as future advances in semiconductor, polymeric, and catalytic materials are made. This work will demonstrate a feasible and functional prototype and blueprint for an artificial photosynthetic system, composed of inexpensive, earth-abundant materials while simultaneously efficient, durable, manufacturably scalable, and readily upgradeable.

Bio

Dr. Nathan S. Lewis is the George L. Argyros Professor of Chemistry at the California Institute of Technology. Professor Lewis is Principal Investigator of the Beckman Institute Molecular Materials Resource Center. His research interests include artificial photosynthesis and electronic noses. Nate continues to study ways to harness sunlight and generate chemical fuel by splitting water to generate hydrogen. He is developing the electronic nose, which consists of chemically sensitive conducting polymer film capable of detecting and quantifying a broad variety of analytes. Technical details focus on light-induced electron transfer reactions, both at surfaces and in transition metal complexes, surface chemistry and photochemistry of semiconductor/liquid interfaces, novel uses of conducting organic polymers and polymer/conductor composites, and development of sensor arrays that use pattern recognition algorithms to identify odorants, mimicking the mammalian olfaction process.

For further information please contact Prof. Richard Lunt, Department of Chemical Engineering and Materials Science at rlunt@egr.msu.edu

Persons with disabilities have the right to request and receive reasonable accommodation. Please call the Department of Chemical Engineering and Materials Science at 355-5135 at least one day prior to the seminar; requests received after this date will be met when possible.