Ørsted Lecture at DTU: Nathan S. Lewis, Caltech, USA

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Title	Ørsted Lecture at DTU: Nathan S. Lewis, Caltech, USA
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Description

”Artificial Photosynthesis: Fuel from Sunlight”

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Abstract:
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 H2O (or OH-) and the reduction of H+ (or H2O). 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. 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 the 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, thus lowering the photocurrent density at the solid/liquid junction and thereby relaxing the demands on the activity (and cost) of any electrocatalysts. A 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 to provide structural support. Interspersed patches of an ion conducting polymer will maintain charge balance between the two half-cells. The modularity of the system design approach allows each piece to be independently modified, tested, and improved, as future advances in semiconductor, polymeric, and catalytic materials are made. Hence, this work will demonstrate a feasible and functional prototype and blueprint for an artificial photosynthetic system, composed of only inexpensive, earth-abundant materials, that is simultaneously efficient, durable, manufacturably scalable, and readily upgradeable.

Dr. Nathan Lewis, George L. Argyros Professor of Chemistry, has been on the faculty at the California Institute of Technology since 1988 and has served as Professor since 1991. He has also served as the Principal Investigator of the Beckman Institute Molecular Materials Resource Center at Caltech since 1992. From 1981 to 1986, he was on the faculty at Stanford, as an assistant professor from 1981 to 1985 and as a tenured Associate Professor from 1986 to 1988. Dr. Lewis received his Ph.D in Chemistry from the Massachusetts Institute of Technology.

Dr. Lewis has been an Alfred P. Sloan Fellow, a Camille and Henry Dreyfus Teacher-Scholar, and a Presidential Young Investigator. He received the Fresenius Award in 1990, the ACS Award in Pure Chemistry in 1991, the Orton Memorial Lecture award in 2003, the Princeton Environmental Award in 2003 and the Michael Faraday Medal of the Royal Society of Electrochemistry in 2008. He is currently the Editor-in-Chief of Energy & Environmental Science. He has published over 300 papers and has supervised approximately 60 graduate students and postdoctoral associates.

His research interests include artificial photosynthesis and electronic noses.

Technical details of these research topics 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.

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