Ben-Gurion University of the Negev
Blaustein Institutes for Desert Research
The Swiss Institute for Dryland Environmental and Energy Research
Alexandre Yersin Department of Solar Energy and Environmental Physics

Core-Shell Micro-Tube Array for Closing the Artificial Photosynthesis Cycle on a Nanometer Scale

Eran Edri
Department of Chemical Engineering
Ben-Gurion University of the Negev

Abstract:

Artificial photosynthesis is a way of storing solar energy in chemical bonds. Except that the key chemical reactions involved in artificial photosynthesis of carbon fuels are chemically incompatible. In order to prevent species crossover and destructive reactions, the oxygen evolution reaction sites (anode) needs to be separated from the CO_2 reduction sites (cathode) by a membrane. Usually, a sub-millimeter thick membrane separates the anode and cathode, preventing reduced carbon species from being oxidized at the anode, and oxygen from reacting at the cathode. However, sub-millimeter thick membranes introduce a significant transport resistance to the already demanding overpotential of the reactions. Decreasing the membrane thickness to the smallest possible - the nanometer scale - will diminish these transport losses. We propose a design that electronically and protonically closes the photosynthetic cycle on the nanometer scale with spatially and chemically separated reaction environments. Our design consists of a centimeter-squared array of tubes, each of micron-scale diameter and with a few nanometer thick walls. The inner layer of the tube-wall is made of an earth-abundant water oxidation catalyst. The outer layer of the tube is a composite organic-inorganic membrane layer (~2 nm) decorated externally with photocatalysts for CO_2 reduction. This design forms a separation between the oxygen evolution reaction sites (inner tube volume) and the CO_2 reduction sites (outer tube volume). The ultra-thin membrane is made of dense phase amorphous silica enclosing embedded conjugated molecules, which provides the required electronic connection between reduction and oxidation sites. At the same time, the dense phase silica is gas impermeable and can be made proton conductive by chemical doping.

I will describe the combination of fabrication and synthetic methods we used to form and study the centimeter-squared array of tubes and intermediate steps we took to study the functionality.

Date & Location:

Tuesday, June 16, 2020, 11:00
Lecture room, Physics Building (ground floor)