Closing the Artificial Photosynthesis Cycle on the Nanometer Scale

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Artificial Photosynthesis of energy dense carbon fuels is a way of storing solar energy in chemical bonds using CO_2 and water as feedstock. At the same time CO_2 is reduced to fuel at the cathode, oxygen evolves at the water oxidation site. If these reactions occur in the same compartment, it can lead to fuel/oxygen back reactions, intermediates' reactions and oxygen reacting with high potential electrons, potentially leading to materials degradation. To avert these hurdles, chemical compartmentalization is preferred. Normally, a micrometer-thick membrane is used, which adds a significant transport resistance to the already demanding overpotential of the reactions. Decreasing the membrane thickness to the smallest possible can minimize this energy loss. Shaped into a microtube, the membrane provides the required compartmentalization by separating the tube inner volume - where water is oxidized, from the tube external volume - where CO_2 is reduced. Made of a ~2 nm thick proton conducting/electron-insulating SiO_2 layer and embedded with ~2 nm long conjugated molecules that governs the electron transport, the membrane also provides the required electronic connection at the nanometer scale. An array of such microtubes constitute a low-cost and scalable route to an integrated artificial photosynthetic system for making solar fuels.

In this talk, I will present our progress towards realizing a proof of this concept.