Electrochemical and Molecular Approaches for Artificial Photosynthesis

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The ultimate goal of artificial photosynthesis research is to develop methods to produce carbon-based gaseous and liquid fuels such as carbon monoxide, methane, and methanol from carbon dioxide and water using solar energy as the energy source. In particular for the methods to be commercially viable the overall costs for the production processes should be low enough so that the processes can compete with the current fossil fuel based processes. The fastest and the most feasible approach would be to combine solar cells and electrochemistry. In other words to electrochemically reduce CO_2 to CO, CH_4, C_2H_4, and alcohols such as methanol, ethanol, propanol, and others using the electricity produced by solar cells. For this, to be economically feasible, two electrode systems should be used, the electrochemical reaction should be stable for months, and the electrical energy to chemical energy conversion efficiency (ECCE) should be over high (>70%). Our recent results arising from our efforts to address the above issues will be presented. Another simplest strategy to commercialize artificial photosynthesis is to develop artificial molecular enzymes which can carry out artificial photosynthesis by merely dissolving them into the water pool placed under the sunlight. To make this strategy to be feasible the effective molecular water oxidation catalysts and CO_2 reduction catalysts should be developed and the molecular system consisting of a water oxidation catalyst, a photopump (photosensitizer), and a CO_2 reduction catalyst should be developed. Our recent efforts to address this issue will also be presented.