Challenges and Opportunities in Solar-Driven Carbon Dioxide Reduction

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The scalable production of liquid transportation fuels and commodity chemicals by sustainable reduction of carbon dioxide could reduce dependence on fossil fuels. Heightened concerns about the effects of atmospheric release of greenhouse gases on the global climate has spurred interest in developing technologies to capture and constructively utilize CO_2 from both point source emitters and from the atmosphere. While plants have developed exquisitely complex photosynthetic pathways to produce their food from sunlight, CO_2, and water, synthetic systems capable of photo-driven reduction of CO_2 are still in the proof-of-concept stage. These devices are typically comprised of: a photoabsorber to harvest light energy from the sun, a cathode where CO_2 is reduced to the desired product, an anode where water is oxidized to O_2, an electrolyte, and a membrane capable of permitting ion transport while preventing crossover of oxidation and reduction products. Fundamental work remains to be done on all of these components. This presentation will address current challenges facing sustainable reduction of CO_2 to useful products, including CO_2 capture and concentration, catalyst efficiency and selectivity, light absorber activity and stability, membrane conductivity and selectivity, and integration of these components into efficient prototype devices. Finally, early life-cycle assessments of photocatalytic CO_2 reduction systems will be discussed.