Solar to Chemical Energy Conversion

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If renewable power sources such as solar and wind could be used to produce chemical precursors and/or fuels, it would provide an alternative to mankind's currently unsustainable use of fossil fuels and slow the rate of CO_2 emission into the atmosphere. Analogous to photovoltaics, driving the thermodynamically uphill redox reactions required for net solar to chemical energy conversion necessitates both efficient generation of electrons and holes and directional charge transport. Examples of engineered structures which steer electrons and holes to drive the electrochemistry of water splitting reaction will be discussed [5].

Developing devices which will use sunlight to convert carbon dioxide to hydrocarbons, analogous to photosynthesis, is considerably more challenging. Producing products selectively requires management of multi-electron transfer reactions (e.g. 12 in the case of ethylene and ethanol), and potential losses in all parts of the system including the cathode, anode, electrolyte, and membrane must be minimized. It will be shown that optimized coupling of photovoltaics to electrolysis cells can be used to convert CO_2 to C-C coupled products such as ethylene and ethanol with an overall energy conversion efficiency of over 5%, 10x that of natural photosynthesis.

Charge selective contacts can be used to steer direct photo-generated carriers to catalytic sites that perform CO_2 reduction in an integrated photocathode. When this concept is implemented with a Si absorber, current densities (>30 mA cm^{-2}) and photovoltages (>600 mV) similar to those of PV devices can be achieved. By coupling photocathodes to series-connected semi-transparent halide perovskite solar cells, we have demonstrated stand-alone, "no-bias," CO_2 reduction with a 1.5% conversion efficiency to hydrocarbons and oxygenates.

Biography: *Joel W. Ager III is a Staff Scientist in the Materials Sciences Division of Lawrence Berkeley National Laboratory and an Adjunct Full Professor in the Materials Science and Engineering Department, UC Berkeley. His research interests include the fundamental electronic and transport properties of semiconducting materials, discovery of new photoelectrochemical and electrochemical catalysts for solar to chemical energy conversion, and the development of new types of transparent conductors.*