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Designing Electrochemical Solar Fuels to Operate in Variable Conditions

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Electrochemical solar fuels reactors are a promising technology towards decarbonizing the chemicals manufacturing industry. This technology involves the co-design of an electrocatalyst and photovoltaic into a single device for chemicals generations that is directly powered by solar irradiation. However, the outdoor operation of these devices exposes them to harsh environmental conditions which differ on various diurnal (i.e., throughout the day) time scales. Broadly, these time scales can be split into three categories: over multiple diurnal cycles (days), a single diurnal cycle (hours), and short-term meteorological fluctuations (seconds/minutes). Each time scale imposes unique design principles for solar fuels reactors (e.g., for activity, selectivity, and durability), which are separate from those which govern their purely electrochemical counterparts. These challenges remain a significant roadblock to the commercialization of solar fuels technology and motivate the need to explore the performance of solar fuels systems under on-sun or simulated diurnal conditions. In this presentation, I will discuss challenges which arise under diurnal operating conditions through the lens of two electrochemical reactions. Using a combination of time resolved characterization techniques and spectroscopic analysis, we have identified mechanisms of degradation of the electrode surface and electrochemical performance which occur under simulated diurnal conditions. Overall, I will present a comprehensive methodology to investigate the consequences of diurnal operation on the selectivity, activity, and durability of electrochemical solar fuels systems.

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