NANOSCIENCE COLLOQUIUM

Understanding selectivity and stability challenges through microenvironment control and advanced characterization in solar fuel production

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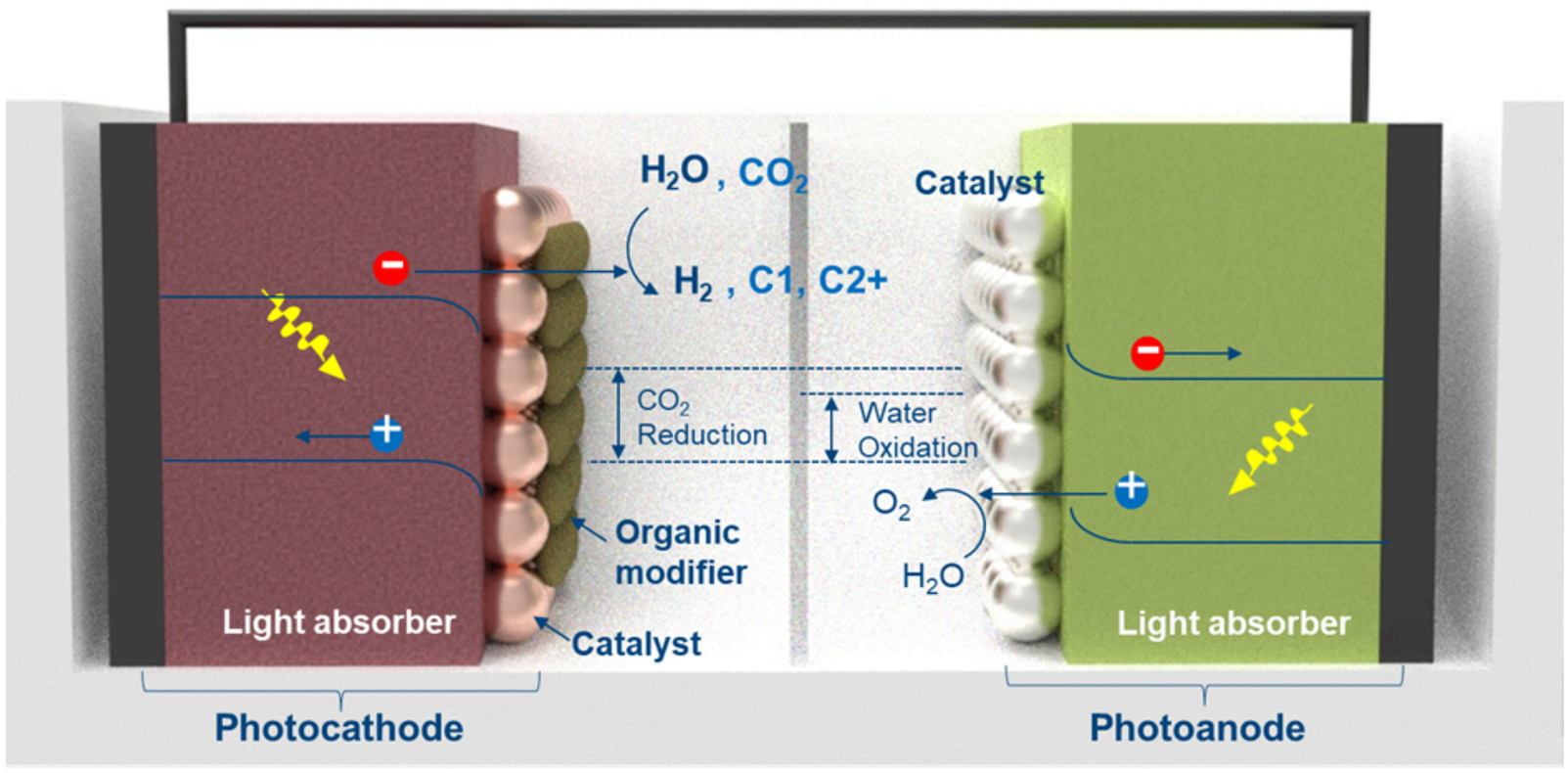
ABSTRACT: Artificial photosynthesis is a promising approach for achieving carbon-neutral energy systems. The hydrogen evolution reaction (HER) and photoelectrochemical CO_2 reduction have attracted significant attention for their potential to store solar energy in fuels and chemicals while closing the carbon cycle. However, catalyst and photoelectrode materials often suffer from instability and insufficient activity or selectivity in CO_2 reduction. Addressing these limitations requires a deep understanding of the physicochemical and structural changes that occur under operational conditions, enabled by advanced characterization techniques. In this work, we first present a suite of complementary characterization methods applicable to both catalysts and photoelectrodes. We then demonstrate how insights into the catalytic microenvironment and the parameters influencing catalytic activity can guide the development of integrated photocathodes. We explore a range of material systems, including metal oxides, silicon, and halide perovskites, and show how our bespoke design strategy for integrated systems enables the sustained production of targeted reaction products.



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