An Autonomous Solar-to-Chemical Energy Conversion System

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Solar photoelectrochemistry has been a topic of research for decades and cost effective production of useful chemicals and fuels using sunlight could provide a reduction in fossil hydrocarbon use.[1-6] To date, efficient photoelectrochemical systems based on compound semiconductors have extremely short working lifetimes due to corrosion in the electrolyte. For such devices to be economical and environmentally sustainable, they need to be simultaneously efficient, inexpensive to manufacture on large scales, and stable for extended periods of operation. Here, we report a novel molecular level design and synthesis strategy for successfully stabilizing efficient semiconductor photovoltaic junctions for solar fuel production by making use of nanoporous anodic aluminum oxide (AAO) as a synthesis template and protective coating. We show that these nanostructured photoelectrochemically active heterostructures (PAH) based on efficient compound semiconductors including sulfides and selenides freely suspended in highly corrosive acidic hydrogen halide solutions produced hydrogen at a stable rate for more than 24 hours with a relatively high solar-to-hydrogen energy conversion efficiency without any external wiring or support.

The entire fabrication process of layer-by-layer template-directed electrochemical synthesis of the functional heterostructures (semiconductors and electrocatalysts) in porous anodic aluminum oxide membranes is amenable to scalable manufacturing, and inexpensive to build, install, and operate. An absolute necessity if solar fuels are to compete in commercial energy markets. The AAO is a functional component of the final device and serves to chemically and electrically isolate each unit to avoid photo-corrosion of the high efficiency semiconductors. In summary, we report a different engineering and photophysical approach to efficient solar-to-chemical conversion in a practical device structure that might point towards cost-effective use of solar energy.

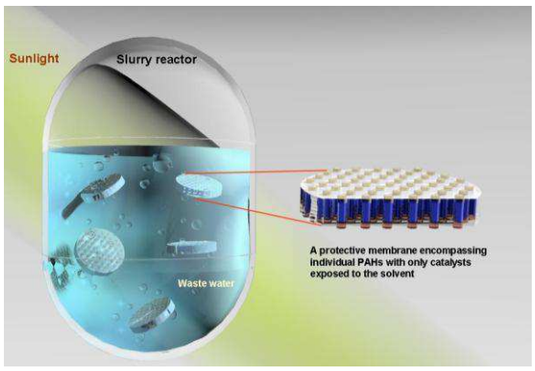

Figure 1: Artistic representation of a freely floating PAH structure suspended in a slurry reactor

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