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New Catalyst for HER and CO_2 Hydrogenation for Solar Fuel Production

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Hydrogen is the simplest solar fuel to produce and while platinum and other noble metals are efficient catalysts for photoelectrochemical hydrogen evolution, earth-abundant alternatives are needed for large-scale use. We have shown that bio-inspired molecular clusters based on transition metal sulfides mimics nature's enzymes for hydrogen evolution when deposited on various supports [1, 2]. When these catalysts are deposited on p-type Si they can harvest the red part of the solar spectrum and potentially be coupled to CO2 hydrogenation [3-5]. Such a system could constitute the cathode part of a tandem dream device where the red part of the spectrum is utilized for solar fuel evolution, while the blue part is reserved for the more difficult oxygen evolution. Recently we have found that this system can be improved considerably using a np-Si systems [6] as recently described by the Nate Lewis group [7]. Hereby it is possible to achieve photoelectrochemical H_2 production at +0.33 V vs. RHE using a porous, amorphous MoS_x catalyst. To stabilize Si during catalyst deposition and the subsequent hydrogen evolution reaction (HER), a corrosion protective layer is shown to be indispensable. At 200mV positive of RHE the cell produce an incident photon to current efficiency (IPCE) of 50%. This work represents a substantial reduction in H_2 evolution overpotential for non-Pt Si-photocathode operated in acidic solution. Further improvement in corrosion protection using several 100 nm of TiO_2 [8] will be demonstrated and coupling to CO_2 hydrogenation will discussed if time allows.

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