High-efficiency Solar-to-Hydrogen Conversion through an Integrated Concentrator Photovoltaic Electrolysis

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The photovoltaic-alkaline water (PV-AW) electrolysis system offers an appealing approach for large-scale green hydrogen generation. However, current PV-AW systems suffer from low solar-to-hydrogen (STH) conversion efficiencies (e.g. <20%) at practical current densities (e.g. >100 mA cm^{-2}), rendering the produced H_2 not economical.[1] Here, we designed and developed a highly efficient PV-AW system that mainly consists of a customized, state-of-the-art AW electrolyzer and concentrator photovoltaic (CPV) receiver. The highly efficient anodic oxygen evolving catalyst, consisting of an iron oxide/nickel (oxy)hydroxide (Fe_2O_3-NiO_xH_y) composite, enables the customized AW electrolyzer with unprecedented catalytic performance (e.g. 1 A cm^{-2} at 1.8 V, 0.37 $kgH_2/m^{-2}h^{-1}$ at 48 kWh/kgH_2). Benefiting from the superior water electrolysis performance and the efficient heat management between CPV and AW devices, the integrated CPV-AW electrolyzer system reaches a very high STH efficiency of up to 29.1% (refer to 30.3% if the lead resistance losses are excluded) at large current densities, which surpasses all previously reported PV-electrolysis systems.[2]

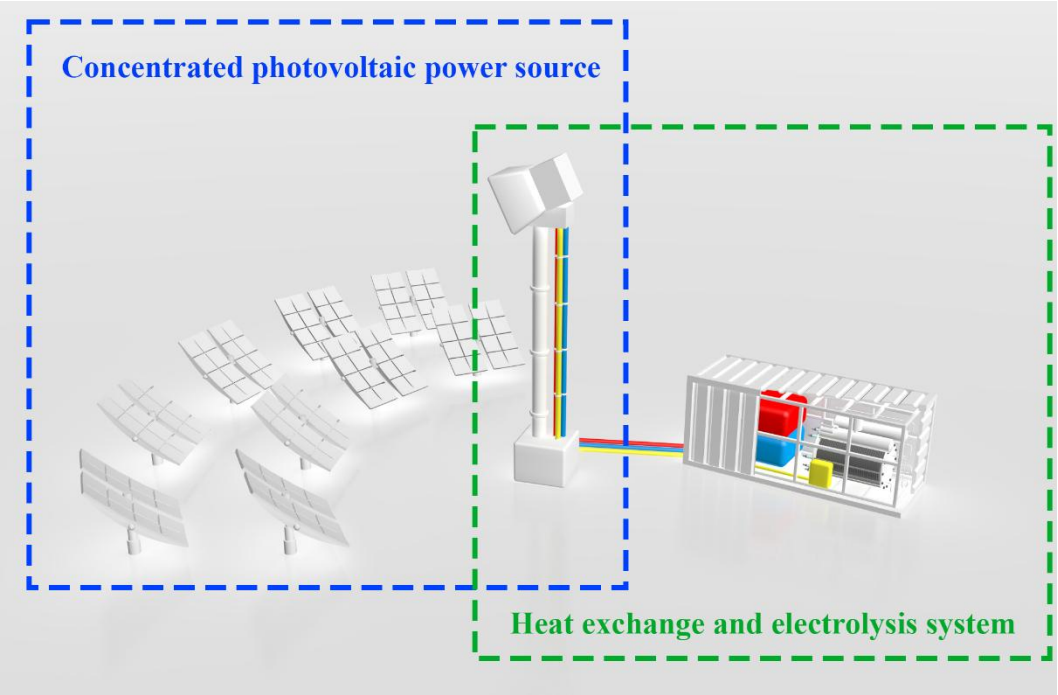

Figure 1: The schematic illustration of a scaled CPV-AW system for green hydrogen production. The photovoltaic modules in blue square represent the concentrator photovoltaic power source that provides heat and electricity for AW process, while the cargo container in green square represents the AW unit.

References

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[2] Zhang, Q., Shan, Y., Pan, J., Kumar, P., Keevers, M. J., Lasich, J., Kour, G., Daiyan, R., Perez-Wurf, I., Thomsen, L., Cheong, S., Jiang, J., Wu, K., Chiang, C., Grayson K., Green, M. A., Amal, R., Lu, X., 2025. A Photovoltaic-Electrolysis System with High Solar-to-Hydrogen Efficiency under Practical Current Densities. *Sci. Adv.*, in press.