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Climatic response of thermally coupled solar water splitting in Antarctica

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Hydrogen is a versatile energy carrier. When produced with renewable energy by water splitting, it is a carbon neutral alternative to fossil fuels. The industrialization process of this technology is currently dominated by electrolyzers powered by solar or wind energy. For small scale applications, however, more integrated device designs for water splitting using solar energy might optimize hydrogen production due to lower balance of system costs and a smarter thermal management. Such devices offer the opportunity to thermally couple the solar cell and the electrochemical compartment. In this way, heat losses in the absorber can be turned into an efficiency boost for the device via simultaneously enhancing the catalytic performance of the water splitting reactions, cooling the absorber, and decreasing the ohmic losses.[1,2] However,integrated devices (sometimes also referred to as "*artificial leaves*"), currently suffer from a lower technology readiness level (TRL) than the completely decoupled approach.

Here, we describe our progress in designing integrated solar water splitting devices to power research stations in Antarctica as a first potentially economic competitive implementation of this technology.[3] In such remote world regions, local and small-scale hydrogen production can become both economically and environmentally favorable, since the logistics for fossil fuels are expensive and environmentally hazardous. One reason for the low TRL of integrated devices is the complex and poorly understood influence of different weather/climate conditions and changes in the solar spectra on their efficiency.[4] Therefore, we introduce an open-source Python-based model that combines solar cell physics, optical simulations, electrochemistry, as well as atmospheric and climate data as part of the "YaSoFo" environment.[5] We model and analyze the climatic response of a device based on state-of-the-art AlGaAs/Si dual-junction photoabsorbers in Antarctica. Furthermore, we present a first prototype demonstrating solar water splitting at temperatures as low as -20°C. [3]

Our work gives important insights into the chances and challenges for thermally coupled solar water splitting and lays the foundation for our goal of using these devices in remote world regions with cold climates.

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