SYNTHESIZING CHEMICALS ON THE MOON AND MARS USING SOLID-OXIDE ELECTROLYZERS

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Researchers at the Colorado Fuel Cell Center are developing solid-oxide electrolyzers for production of chemicals on the moon and Mars. Electrolyzer technology harnesses solar-derived electricity to drive H_2O- or CO_2-splitting reactions to form H_2, O_2, and CO. These chemicals can support numerous extraterrestrial operations, including synthesis of higher-value chemicals. This talk will provide an overview of the unique electrolyzer research now underway at the Colorado Fuel Cell Center for production of high-purity, pressurized hydrogen.

Figure 1 presents an illustration of a solid-oxide electrolyzer based on novel proton-conducting ceramic materials. Protonic ceramics are unique among electrolyzer materials in their potential for generation of pure, dry hydrogen at pressure from H_2O and electricity feed stocks. Such cells are regularly fabricated at the Colorado Fuel Cell Center, with new materials being evaluated for improved performance and longer life.

These tubular devices are also being integrated into a high-pressure chamber shown in Figure 2 that enables H_2 production at pressure. Pressurized H_2 formation facilitates electrolyzer integration with other chemical processes, and reduces energy demand for H_2 storage. The vessel is rated to 150 bar at 600 ºC. Through careful reactor design, we have demonstrated pressurized electrolysis at 850 ºC and 5 bar.

At larger scales, the CFCC has a 36-kW pressurized test bed (Figure 3) now used for characterizing performance of 1000-cell, multi-stack fuel-cell and electrolyzer modules at up to 10 bar. These high-TRL assemblies are fabricated in partnership with commercial developers. This test bed is connected to Mines electrical grid, and includes extensive diagnostics for monitoring performance and operational state points. The facility is currently being used as part of a U.S. Department of Energy program for high-efficiency combined heat-and-power generation from hydrogen-blended natural gas.

This talk will feature presentation and discussion of electrolyzer research efforts in the Colorado Fuel Cell Center spanning from materials discovery to kW-scale system demonstrations.

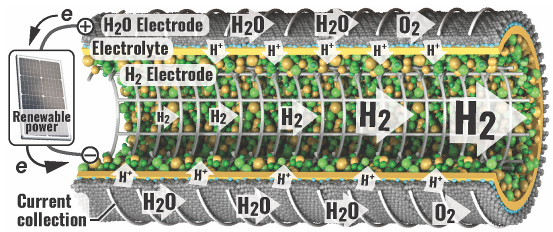

Figure 1: Illustration of a solid-oxide electrolyzer based on proton-conducting ceramic materials.

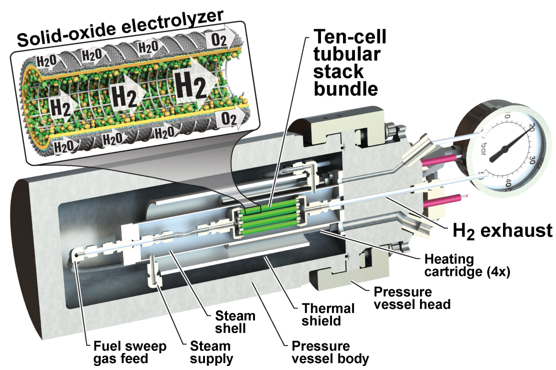

Figure 2: Design of 1-kW$_e$ electrochemical test stand for now in use at the Colorado Fuel Cell Center for characterizing performance of electrolyzer cells and stacks at 50 bar$_g$ and 800 ºC.

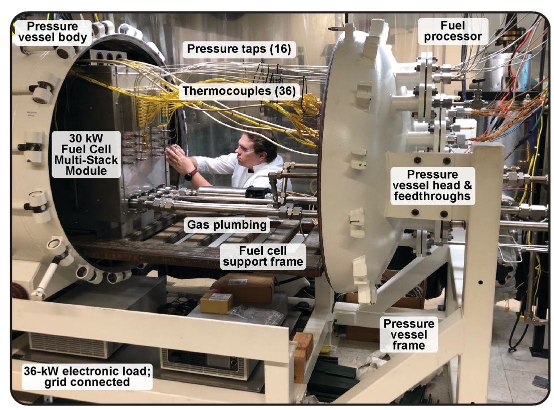

Figure 3: Photograph of 36-kW$_e$ pressurized test bed for characterizing performance of larger-scale electrolyzer stacks at up to 10 bar$_g$.