Electrochemical hydrogen pump/compressor – gas diffusion electrodes, membrane electrode assemblies, cell performance and back diffusion effects

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The electrochemical hydrogen pump/compressor (EHP/EHC) offers numerous advantages over mechanical compressors, such as superior energy efficiency, stationary mechanical components, and the ability to operate at high pressures without pre-treatment of the supplied reactant. However, a key challenge lies in the membrane electrode assembly (MEA), which determines the electrochemical conversion rates and differential pressure between gas diffusion electrodes, affecting overall energy efficiency. This work presents a newly developed laboratory prototype of the electrochemical hydrogen pump/compressor (EHP/C), operating with the proton-conductive membrane Nafion 117 at a differential pressure of up to 10 bar and commercially available gas diffusion electrodes with 0.38 mg/cm² Pt-based catalyst loading and an average thickness of 250 µm.

The initial laboratory tests demonstrate that the design of the developed device and the architecture of the electrodes ensure high efficiency of both hydrogen oxidation reaction (HOR) and hydrogen evolution reaction (HER), with a cell energy efficiency of 85%. Additionally, the device exhibits the capability to operate with an identical rate of gas compression at different input hydrogen pressures. The differential pressure of the cell was set at 10 bar, while the current density varied from 0.6 to 1.6 A cm^{-2} at temperatures ranging from 20 to 60 °C, respectively. Back diffusion pressure was also characterized under different operating conditions. The hydrogen gas crossover reached values of 3.85 mA cm^{-2} at 80 °C and an absolute humidity of 11.7 g kg^{-1}.

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