Characterisation of a 10-Layer SOC Stack under Pressurised CO_2 Electrolysis Operation

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One promising way of facing recent challenges to slow down the climate crisis or to reduce dependencies on fossil energy sources, e.g. natural gas, is using renewable methane and other e-fuels for storage and distribution via existing infrastructure. Solid oxide cell (SOC) reactors play an important role in the conversion of sustainable electric power into chemicals as they can be obtained from combined steam and CO_2 co-electrolysis for syngas production. The pressurised electrolysis operation is a key factor for increasing the system efficiency of PtX-processes, including balance-of-plant (BoP) components, electrochemical reactors and high pressure downstream processes.

In general, the yield of CO_2 electrochemical reduction at atmospheric and pressurised conditions in high temperature co-electrolysis is still controversially discussed. Previously, several SOC short stacks were thoroughly analysed in pressurised steam- and co-electrolysis operation in a test-rig environment. These experimental results indicate marginal influence of pressure on the performance of electrolyte supported cells (ESC). In contrast, electrochemical impedance spectroscopy (EIS) suggests that pressurisation of pure CO_2 electrolysis significantly reduces the fuel electrode impedance contribution, especially at lower temperatures around 700 °C [1,2].

This work aims to experimentally determine the kinetic behaviour of pure CO_2 electrolysis by varying operating conditions like pressure, temperature, reactant conversion and feed gas composition. The investigation of kinetic parameters during these experiments could complement the formerly described research. Furthermore, the kinetic expressions can be used when studying co-electrolysis operation to identify the shares of: (i) the reverse water-gas-shift (rWGS) and (ii) the CO_2 electrochemical reduction. Polarisation curves were dynamically recorded and different current densities were evaluated in steady-state operation. Additionally, EIS measurements were performed at open circuit voltage (OCV), as well as under different current densities. The kinetic parameters were estimated by curve-fitting analysis of the experimental results. The resulting expressions will be implemented in the in-house modelling framework, TEMPEST, based on [3,4] with the aim to increase the accuracy of modelling high-temperature CO_2 electrolysis and co-electrolysis systems.

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