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HYBRID TANDEM CATALYTIC CONVERSION PROCESS TOWARDS HIGHER OXYGENATE EFUELS

E-TANDEM - Deliverable report

D2.3 Report on CO_2/steam co-electrolysis

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Publishable summary

The E-TANDEM project aims to develop a lab-scale, single-step process for converting CO_2/H_2O co-electrolysis-derived syngas (e-syngas, H_2+CO) into synthetic higher alcohols through the tandem integration of olefin-selective Fischer-Tropsch synthesis (FTS) and olefin oxo-functionalization via reductive hydroformylation (RHF) at mild temperatures.

The first step in the E-TANDEM concept is co-electrolysis of CO_2 and steam on solid oxide cells (SOEC), which aims at delivering synthesis gas (syngas), a mixture composed of CO and hydrogen in the right ratio, i.e. H_2/CO ~ 2 (mol), which is used as a feed into the subsequent hybrid catalytic syngas conversion step. Additionally, aspects such as the operating pressure, and compatibility with the recycle of process water as a feed to the co-electrolyser are deemed to be central for the integration of the co-electrolysis step within the overall e-fuel production process. Finally, atom-efficiency and long-term durability (stability) are also considered central design/optimization parameters, given that, under operation conditions, the synthesis gas can undergo undesired methanation, leading to the production of methane as an undesired product, and solid carbon can be formed and deposited, potentially, which degrades the SOEC.

This report presents research findings addressing specifically studies about detailed performance as function of the input parameters such as feed composition, T, p, including degradation behavior based on electrochemical and microstructural characterization. Different SOEC versions were investigated with the aim to identify the best suitable for the E-TANDEM process.

Detailed knowledge about effect of operating parameters on performance and durability was reached. Operating windows were found where a low degradation rate can be achieved. These studies were carried out at ambient pressure. Due to the significant technical challenges for studies at higher pressure, initial results were gathered, and the effort will be continued. An additional aspect regarding system integration was investigated, specifically, if water, a major side-product from the downstream syngas catalytic conversion process steps which prospectively entrains dissolved short-chain higher alcohols, can be recycled as a reactant to the co-SOEC process. Also in this case, the developed co-electrolysis cells proved tolerant to alcohol impurities in the recycled process water, with no remarkable effects on stability.