Evaluation of fluctuating condition reactors for e-methanol synthesis

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CO_2 hydrogenation to methanol is a promising route for addressing energy and environmental challenges, particularly by utilizing hydrogen generated from renewable energy sources [1]; however, fluctuation in hydrogen production in the electrolysis cell can affect process parameters and economy and, in the future, flexible operation conditions need to be identified, in order to evaluate dynamic start-up and stand-by conditions. In recent decades, several materials comprising Cu-, precious metal-, In-, Ga-, and Zn-based catalysts have been designed for CO_2 hydrogenation to methanol; among these, Cu-based catalysts, such as Cu-ZnO-Al_2O_3, remain at the forefront of research and industrial application due to their cost-effectiveness, tunable surface properties, and relatively mild reaction conditions [2-4], even though the addition of promoters is still a matter of debate. The coupling of a CO_2 hydrogenation reactor with a seawater-fed SOEC introduces extra process variables, such as a possible change of produced hydrogen as a function of electrolysis cell lifetime, and thus, suitable mitigation strategies might be found.

In the present work, both benchmark and home-made catalysts were used to evaluate the performance for CO_2 hydrogenation when coupled directly with a SOEC and compare them with both classical systems, thermodynamic equilibrium and available literature results. A full analysis of performances was carried out as a function of temperature in the range 373-523 K, pressure 1-20 bar, and a H_2:CO_2 ratio that has been varied in-between 1:1 and 5:1 in both diluted and concentrated conditions. Stand-by and start-up/shut-down conditions have been investigated together with the effect of gas hourly space velocity. A preliminary assessment has also been carried out in terms of suitable recycling and required purge of the entire process, and this will be exploited in detail, assessing the possible layout of a prototype setup.

Keywords: *carbon dioxide; hydrogenation; methanol synthesis*

References:

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