INVESTIGATION OF THE R.W.G.S. REACTION IN SOECs FOR THE H_2O/CO_2 CO-ELECTROLYSIS

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ABSTRACT

High temperature co-electrolysis of steam/CO_2 mixtures using Solid Oxide Cells has been proposed as a promising technology to produce synthesis gas (H_2 + CO) which can be processed further towards synthetic hydrocarbon fuels production[1]. Therefore, SOECs represent an attractive and alternative technology to mitigate climate changes by reducing CO_2 emissions. In addition, operation at high temperatures has the advantages of (i) efficient use of electricity and heat, as well as of (ii) high reaction rates and efficiencies[2]. Co-electrolysis is a significantly more complicated process than steam electrolysis, because three reactions take place simultaneously; namely H_2O electrolysis, CO_2 electrolysis and the Reverse Water Gas Shift reaction (RWGSr)[3]. Specifically, there are discrepancies whether CO is produced via the RWGSr solely and that no electrolysis of CO_2 occurs, or if CO is produced both via the RWGSr and via electrolysis of CO_2[4]. As a result, it is crucial to quantify the degree of CO production for each reaction.
Ni/GDC is known as an effective electrode in suppressing coke formation under humidified hydrocarbon fuels. Its performance can be further improved by dispersing trace amounts of various elements (noble and/or non-noble) metals[5]. Following this approach, in the presented investigation X-Ni/GDC electrodes (where X = Au, Mo and Fe) are studied, in the form of half-electrolyte supported cells, for their performance in the RWGS through catalytic-kinetic measurements[6]. The samples were tested at open circuit potential conditions in order to elucidate their catalytic activity towards the production of CO ($\mathbf{r_{co}}$), which is one of the products of the H_2O/CO_2 co-electrolysis reaction. Physicochemical characterization is also presented, in which the samples were examined both in the form of powders and as half cells with BET, H_2-TPR, Air-TPO and TGA re-oxidation measurements in the presence of H_2O.
In brief, it was found that the rate of the produced CO ($\mathbf{r_{co}}$) increases by increasing the operating temperature and the partial pressure of H_2 in the reaction mixture. In addition, the first results revealed that Fe and Mo modification enhances the catalytic production of CO, since the 2wt.% Fe-Ni/GDC and 3wt.% Mo-Ni/GDC electrodes were proved to perform better compared to the other samples, in the whole studied temperature range (800-900 °C), reaching the thermodynamic equilibrium. Furthermore, carbon formation was not detected. The electrocatalytic investigation on full electrolyte-supported cells is currently in progress.

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