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## ELECTROCHEMICAL MEMBRANE REACTOR FOR OXYGEN SEPARATION AFTER CO<sub>2</sub> PLASMOLYSIS

### Introduction

Plasmolysis is an energy efficient process for converting CO<sub>2</sub> into CO and O<sub>2</sub> towards reintroducing CO<sub>2</sub> into energy and chemical cycles. The main bottleneck of this process is that CO remains mixed with O<sub>2</sub> and residual CO<sub>2</sub> [1]. Therefore, efficient gas separation and recuperation are essential for obtaining pure CO, which can be used to produce CO<sub>2</sub>-neutral fuels using water gas shift (WGS) and Fischer-Tropsch reactions. In the framework of European project KEROGREEN, we aim to overcome this obstacle and investigate a novel CO<sub>2</sub> valorisation route to produce sustainable aviation fuel synthesised from H<sub>2</sub>O and CO<sub>2</sub> powered by renewable electricity.

### Electrochemical Oxygen Separation

Our approach is to electrochemically separate O<sub>2</sub> by employing a solid oxide electrolyte cell (SOEC) as shown in Fig.1. The SOECs consist of perovskite electrode materials and yttria-stabilized zirconia based electrolyte. They exhibit remarkable properties, which can be fully utilized for gas-separation processes (downstream of plasma-reactor) in a cost-effective manner [2]. The main challenge of this concept is the optimization of the plasma electrode to exhibit (i) chemical and structural stability under CO<sub>2</sub> plasma atmosphere and (ii) poor catalytic activity for the back reaction, i.e. CO oxidation.

La/Sr-based perovskite oxygen electrode materials have been widely reported for SOEC application due to their excellent oxygen reduction reaction (ORR) activity and redox stability under operating conditions [2]. However, their catalytic activity towards CO oxidation at a high temperature as plasma electrode is yet to be explored. Thus, in present work, we examine the use of La/Sr based material as plasma exposed electrode by following a three-step approach, i.) Evaluation of the catalytic activity in powder samples in a straightforward gas stream, ii.) Electrocatalytic activity in SOECs and iii.) Performance under CO<sub>2</sub> plasmolysis conditions.

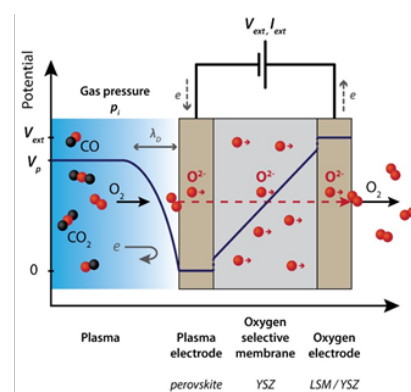


Fig.1. Electrochemical oxygen separation after plasmolysis.

## Experimental

The perovskites that were screened in our study were prepared using the spray pyrolysis technique by Cerpotech. After an extensive pre-assessment of potential materials with low CO oxidation activity [3], Zn and Ga doped lanthanum strontium titanates (LSZT, LSGT) were fabricated and subsequently compared with standard electrode materials optimized for conventional SOECs applications, i.e.  $\text{La}_{0.8}\text{Sr}_{0.2}\text{MnO}_3$  (LSM),  $\text{La}_{0.6}\text{Sr}_{0.4}\text{Co}_{0.2}\text{Fe}_{0.8}\text{O}_3$  (LSCF),  $\text{La}_{0.75}\text{Sr}_{0.25}\text{Cr}_{0.5}\text{Mn}_{0.5}\text{O}_3$  (LSCM). All samples were physicochemically characterized using SEM, XRD and BET techniques. The catalytic performance was evaluated with the temperature programmed oxidation experiments (100 to 850°C, with 5°C/min), using a fixed bed quartz reactor loaded with 200 mg of pre-sintered (at 1100°C for 2 h) material. The  $\text{CO}_2$  and CO were continuously recorded using an IR analyser.

## Results and discussion

The oxygen separation process from gas mixture (7%  $\text{CO}_2$ , 3% CO and 1.5%  $\text{O}_2$ ) will be performed using SOEC. Hence, the initial screening of materials was meant to identify the plasma exposed electrode with reduced catalytic activity towards the CO oxidation and selectivity for oxygen reduction reaction. Following, three parameters were used to quantify the catalytic performance towards the back reaction: Temperature at which 5% (ignition point) and 50% of CO conversion are achieved ( $T_{5\%}$  and  $T_{50\%}$  respectively). The CO conversion at nominal SOEC operating temperature ( $T_o=700^\circ\text{C}$ ).

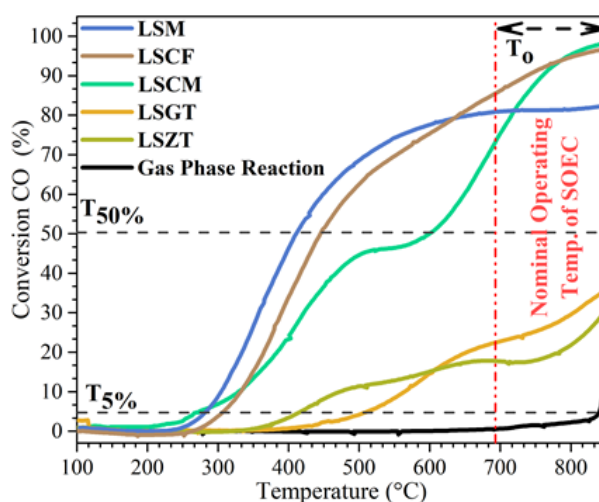


Fig.2. CO oxidation as a function of Temperature

LSGT and LSZT catalytic performance were fairly low, while LSM, LSCF and LSCM show very high activity even at low temperature (Fig. 2.). At  $T_o$ , both LSGT and LSZT shows reduced CO conversion rate of 23% and 18% respectively. The obtained results suggest that both LSGT and LSZT are suitable for plasma facing electrode in SOEC. Further electrochemical studies with LSGT and LSZT are required to identify the best candidate for the electrochemical oxygen separator in the plasma process.

## Conclusions

The KEROGREEN project could lead to a renewable way to develop sustainable fuel for the future aviation industry. In this work, we focus on developing materials with reduced catalytic activity towards the CO oxidation as well as increased ORR activity towards oxygen molecule. Among the studied materials, LSGT and LSZT are found to be the best candidates for electrochemical (SOEC) oxygen separation after  $\text{CO}_2$  plasmolysis.

## Acknowledgment

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