**Electroreduction of CO2 paired with lactic acid production. Towards an economically feasible system.**

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**Highlights**

* Co-production of two added value products, carbon monoxide and lactic acid.
* Reduction of 35% in energy consumption.
* 7 fold increase in product value.
* Combined faradaic efficiencies up to 160 %.

**1. Introduction**

The electrochemical conversion of carbon dioxide presents a significant opportunity to create valuable chemicals or fuels1. However, the process is not implemented in the industry due to the high energy needed to overcome the high overpotentials of the reaction2-3. The electrochemical reduction of CO2 can be made economically more interesting by pairing to a compatible reaction where a valuable product is formed. With this approach, two valuable product are formed with the same energy usage. This study proves a paired electrochemical process where carbon dioxide is reduced to carbon monoxide and 1,2-propandiol is oxidized to lactic acid. With this strategy, a reduction of 35% in energy consumption during CO2 reduction, and a 7 fold increase in product value per unit of energy used was achieved.

**2. Methods**

The electrochemical measurements were performed in a flow cell with a 200 mL reservoir of anolyte and catholyte which were recirculated at 25 l/h. Different currents (15, 30 50 mA/cm2) were applied by the use of a potentiostat connected to a 10 cm2 gold plate cathode and a 10 cm2 carbon felt anode. A 0.5 M KHCO3 solution where pure CO2 was bubbled through was used as a catholyte, and a 0.5 M KHCO3/ 0.5 M K2CO3 solution which contained 20 mM ACT-TEMPO as a mediator and 20 mM 1,2-propanediol (PDO) as a reactant was used as anolyte. The gaseous products were analyzed by gas chromatography and the liquid products were analyzed by high performance liquid chromatography.

**3. Results and discussion**

During electrochemical reduction of CO2 paired with 1,2-propanediol oxidation performed at 15 mA/cm2 a faradaic efficiency of 80% of carbon monoxide and a faradaic efficiency of 80 % to lactic acid was observed, making a combined 160 % total faradaic efficiency. During the paired reaction, a cell voltage of 2.6 V was measured, while during the non-paired reaction (oxygen formation as counter reaction) a cell voltage of 4 V was measured. The decrease of 1.4 V in the cell voltage lead to an reduction in the cost per ton of CO formed when the reaction is performed in a paired manner. In addition, if the counter reaction is based upon oxygen evolution reaction (non-paired) instead of lactic acid production (paired), only one valuable product is formed. The combined value of carbon monoxide and lactic acid makes the paired reaction economically more beneficial per unit of energy used. Figure 1 shows the value of products formed in € per kWh and the cost in € per ton of CO formed for a) the paired reaction and b) the non-paired reaction.

A)

B)

Figure 1. Techno economic comparison of the a) paired and b) non-paired electrolysis in terms of cost per ton of CO formed (pink line) and in terms of the value of the products formed (blue bars). The green boxes indicate the cell potential at which the reactions take place.

**4. Conclusions**

We have demonstrated that pairing CO2 reduction to an electrochemical reaction which produce an added value chemical, a significant increase in product value can be achieved. In addition, if the cell potential needed to drive the reactions is reduced, an important decrease in energy usage can be accomplished. This strategy allows to move towards an economically viable electrochemical CO2 conversion.

**References**

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