**Climate change mitigation: A techno-economic assessment of the formic acid production by electrochemical reduction of CO2**

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**Highlights**

* Formic acid production by electro-reduction of CO2 was techno-economically assessed.
* The conventional fabrication process was used as a benchmark.
* Several sensitivity analyses evaluated the profitability of the CO2 utilization plant.
* Results showed the benefits of the electrification of the chemical industry with FA.

**1. Introduction**

Turning the European Union (EU) into a resource-efficient, green, and competitive low-carbon economy is the key priority to meet the EU long-term goals by 2050 against climate change. The efforts require cutting-edge technological innovations to reduce our traditional fossil-dependent processes in order to curb the greenhouse gas emissions and the current consumption of natural resources in an economic way. This paper presents a techno-economical and resource saving assessment of an alternative based on the carbon dioxide (CO2) utilization for the production of formic acid (FA) by electrochemical reduction (ER). The economic feasibility analysis of the plant includes the calculation of key performance indicators (KPIs) as the net present value (NPV) and the benefit/cost ratio (B/C). Several sensitivity analyses will evaluate the profitability of the CO2 utilization plant for the production of FA by CO2 ER. The study can help at pushing further the necessary developments towards a successful implementation of the CO2 ER technology for the production of FA on a large scale.

**2. Methods**

A mathematical model built by the authors in a previous work [1] is used in the present study to obtain the life cycle inventory (LCI) of a hypothetical ER of CO2 plan that produces 12,000 ton of FA per year. The system boundaries include the utilization plant itself (Figure 1) involving three main units: i) the ER of CO2 in the ER cell, ii) the distillation of the azeotropic mixture FA/water to the desired purity (85% wt.), and iii) the compression of by-products H2 and O2 to the liquid forms. The ER process is included in the model as a black box unit. It was modelled using three sets of parameters that create the corresponding three scenarios: (i) an ideal scenario that represents the minimum consumption of electricity and maximum Faradaic Efficiency, FE (100%); (ii) a baseline scenario that uses the current performance parameters obtained within our research group of the authors [2]; and (iii) an optimistic scenario that assumes a long-lasting cathode lifetime (capable to decrease the impact that the consumable cost has in the total cost of production) which is expected in a medium-term term. The conventional route of FA production by hydrolysis of methyl formate is used as the benchmark. Costs involved in the process are estimated using a bottom-up approach [3]. The KPIs of capital (CAPEX), operational expenditures (OPEX), net present value (NPV) and the benefit/cost ratio (B/C) are used to evaluate the economic feasibility of the plant. The reference cost of production is calculated and compared with the current FA market price c.a. 650 €·ton-1. Sensitivity analyses are completed to account for uncertainty in the main variables that influence the process performance and the impacts on techno-economic results.



**Figure 1.** System boundaries

**3. Results and discussion**

The results display the specific techno-economic parameters such as the cathode lifetime, the CO2 price, the price of electricity, the market price of FA as well as the break-even production of FA that will become the ER of CO2 plant profitable while contributing to decreasing the CO2 emissions and the resource depletion. It is demonstrated that under a CO2 market price of 100 €·kg-1, the break-even electricity market price could be between 23.5 €·MWh-1 and 29.9 €·MWh-1; these values are in agreement with the perspective of the European levelised cost of electricity of large-scale PV electricity. The results obtained have shown that the electrification of the production plants of commodities, as FA, through renewables is needed for their future competitiveness.

**4. Conclusions**

This study has shown the potential of the ER of CO2 route in the framework of climate change abatement objectives while contributing to a decrease of resources depletion. FA is shown here as an example of the benefits of the electrification of the chemical industry. The results obtained indicate that ER of CO2 route could be profitable in a mid-term horizon under proper technological developments.

**References**

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