Bio-electroCO_2recycling into C4-C6 products through a two-step process

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HIGHLIGHTS:

- A two-step carbon recycle platform is intended.
- 0.448 Kg $C_{(C4-C6)}$ were produced per kg of CO_2.
- Here, we postulate the limiting step is the bioelectrochemical one.

BACKGROUND:

Microbial Electrochemical Technologies (METs) is an emerging technology field where SCFAs are produced from CO_2 and electricity (Rabaey i Rozendal, 2010; Schievano et al., 2016). Recent studies establish ethanol is the most added-value product that can economically and sustainably be produced through METs (Christodoulou et al., 2017). Despite SCFA are valuable themselves, they can be elongated *via* chain elongation, to more valuable products as MCFAs (Lonkar et al., 2016). MCFAs are preferable due to their higher combustion energy and broad industrial applications as animal feeds or pharmaceuticals (Angenent et al., 2016). However, they are barely produced through METs excepts few examples at long-term operation (Jourdin et al., 2018; Vassilev et al., 2019). In this study, a two-step system for the conversion of CO_2 into C4-C6 commodity chemicals is proposed (Figure 1). The first step consisted in the bio-electroCO_2recycling into acetate and ethanol. These products were employed as substrates to perform chain elongation process to commodity chemicals (C4 and C6 compounds).

RESULTS & DISCUSSION:

MET platform aimed at reaching the broth requirements for the following up process (fermenter). The cathode potential of several bioelectrochemical systems (BES) were poised at -0.8 V *vs.* SHE to ensure H_2-bio-hydrogen-mediated production of commodity chemicals from carbon dioxide (Puig et al., 2017). Initially optical density (OD) was poor and a brief adaptation period was needed, then, after 30 days of operation productions of acetate and ethanol were achieved and 1:1 ratio was achieved (Blasco-Gómez et al., 2019).

The second step consisted in several 120mL batch fermenters in triplicate (Table 1). High hydrogen partial pressure (pH_2) in the reactor was required for the growth of the cultures and perform chain elongation. Hydrogen produced in first step can be recycled. pH was controlled and restored if

necessary, in each fermenter. Both tests were performed in batch, incubated at 25 ± 1 ºC and kept in the dark.

Table 1. Tests performed in the second step of the process.

Test	CO2:H2	Ethanol/Acetate ratio	pH
1	20:80	1:1	7
2	20:80	1:1	5.5

In test 1, it took a short adaptation period, 15 days until chain elongation started and less than 20 days to get C6 production. Butyrate and caproate concentrations were 33.88 ± 4.02 and 44.99 ± 0.41 mM C and production rates were 7.88 and 11.76 mM C d^{-1}, respectively (Figure 1). While in test 2 both, activity and productions were much lower (Figure 1).

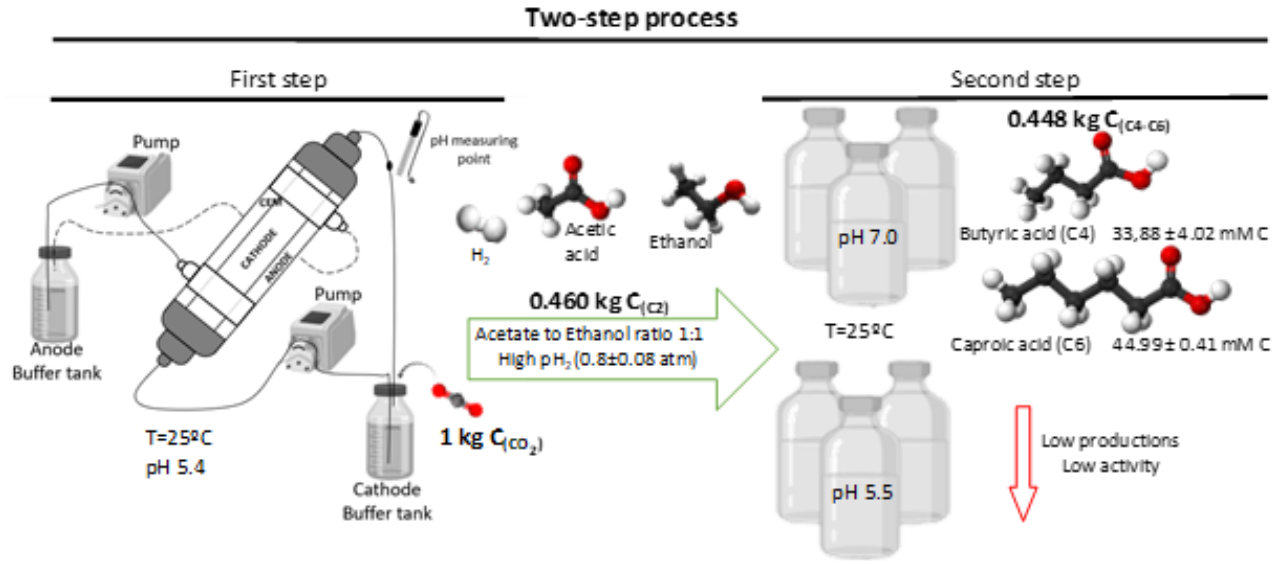

Figure 1. Schematic representation of the bio-electroCO_2recycling platform. CEM: Cation Exchange Membrane.

CONCLUSION:

This study presents a bio-electroCO_2recycling platform to produce butyrate and caproate from carbon dioxide. Optimal conditions were high pH_2, pH around 7 and the more ethanol availability, the more elongation and product selectivity. First step is the limiting one due to its low carbon use, compared to the second one. Although results are promising, further research is needed since it requires greater production rates and more valuable products (e.g. octanoic acid).

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