A promising approach in sustainable chemical production

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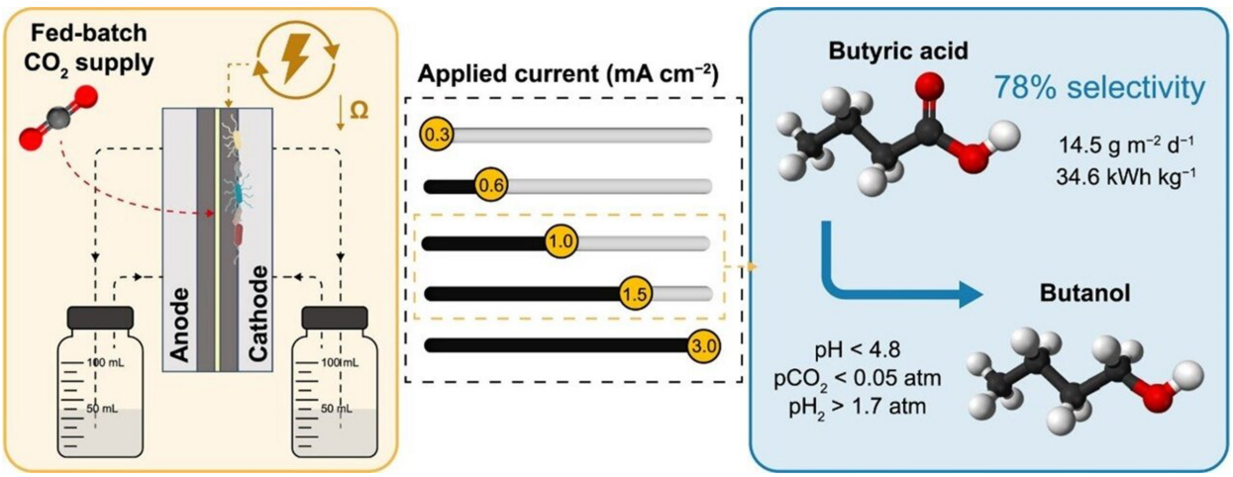

Graphical abstract. Credit: Environmental Science and Ecotechnology

Carbon capture and utilization (CCU) technologies are crucial for addressing climate change while ensuring economic viability. MES has emerged as a promising approach for CO_2 reduction to biofuels and platform chemicals. However, the industrial adoption of MES has been hindered by low-value products like acetate or methane and high electric power demand.

In a new study published in the journal *Environmental Science and Ecotechnology*, researchers from University of Girona conducted a study that focused on electrically efficient MES cells with low ohmic resistance (15.7 mΩ m^2). Through a fed-batch mode, alternating high CO_2 and hydrogen (H_2) availability, they successfully promoted the production of acetic acid and ethanol.

Chain elongation resulted in the selective (78% on a carbon basis) production of butyric acid, a valuable chemical used in pharmaceuticals, farming, perfumes, and the chemical industry. At an applied current of 1.0 or 1.5 mA cm^{-2}, the study achieved an impressive average production rate of 14.5 g m^{-2} d^{-1} of butyric acid. The key player in the chain elongation process was identified as Megasphaera sp.

Inoculating a second cell with the enriched community replicated the butyric acid production rate, but with an 82% reduction in the lag phase. Butyric acid was successfully upgraded to butanol, a valuable biofuel compatible with existing gasoline infrastructure and used as a precursor in pharmaceutical and chemical industries for acrylate and methacrylate production. Solventogenic butanol production was triggered at a pH below 4.8 by interrupting CO_2 supply and maintaining specific pH and hydrogen partial pressure conditions.

The MES cell design proved highly efficient, with average cell voltages of 2.6–2.8 V and an electric energy requirement of 34.6 kWh_{el} kg^{-1} of butyric acid produced. Despite some limitations due to O_2 and H_2 crossover through the membrane, the study identified optimal operating conditions for energy-efficient butyric acid production from CO_2.

In conclusion, this study showcases the potential of bioelectrochemical conversion of CO_2 to butyric acid and its subsequent upgrade to butanol in microbial electrolysis cells. The process holds promise for sustainable and economically viable production of valuable chemicals from CO_2. Further research and development are crucial to optimize the process for large-scale applications, and with continued advancements, this technology can revolutionize chemical production while mitigating climate change impact.

More information: Meritxell Romans-Casas et al, Selective butyric acid production from CO_2 and its upgrade to butanol in microbial electrosynthesis cells, *Environmental Science and Ecotechnology* (2023). DOI: 10.1016/j.ese.2023.100303

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