Carbon capture and utilization in bioelectrochemical systems: Enhancing Microbial Electrosynthesis of value-added chemicals from carbon dioxide

KID: 20230206

The rise in global temperatures due to increased CO_2 emissions is a major concern for environmentalists. CO_2 is the most prevalent greenhouse gas, accounting for over 63% of all GHG emissions. As a result, there has been a growing interest in carbon capture and utilization technologies in recent years. Microbial electrosynthesis (MES) is a promising technology for converting CO_2 into chemicals using electricity as an energy source. In a typical MES setup, water molecules are split into protons, electrons, and oxygen at the anode, while electrons and protons are combined to form hydrogen at the cathode (Fig. 1).

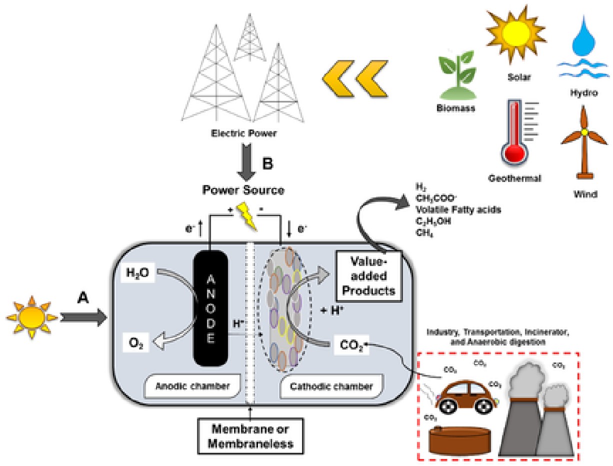

Fig. 1: Microbial Electrosynthesis power supply with (A) Direct and (B) Indirect source3

The electroactive bacteria in the cathodic chamber use hydrogen and CO_2 to produce volatile fatty acids (VFAs), such as acetate (C2), butyrate (C4), and caproate (C6). These VFAs have found application as platform chemicals in diverse industrial processes.

However, the current state of MES technology is limited by the low market value of acetate, the main product of MES. In order to make MES more scalable and economically viable, it is necessary to produce higher-value VFAs, such as butyrate and caproate.

Our research group focused on the optimization of operational conditions and parameters for the production of VFAs in serum bottles. The optimal conditions for VFA production were found to be pH 7.15, ethanol concentration 2.3 g L-1, and headspace gas pressure 1.1 atm 1. **The effect of applied voltage on chain-elongated product synthesis from CO_2 was studied at these optimal conditions in MES 2.**

The higher production rate of propionate was achieved at -1.0 V, with a rate of 0.32 g L-1 d-1. In another investigation, at the same optimal values using long-running reactor culture used and achieved caproate as a major product (1.5g L-1, at a cathode voltage of -1.0V).

Currently, an investigation on the integration of an anaerobic process with MES was started, which could help to simultaneous treatment of waste/wastewater (at the anode) and reduce the external energy requirement for cathodic reactions. In addition, the anodic effluents (liquid and gas) could be fed to the cathode for further reduced production and hydrogen purification.

Overall, the above results suggest that the optimization of operational parameters is important for the enhancement of MCFAs production in MES systems. Additionally, industrial wastewater like distillery and brewery wastewater, which contains ethanol in its effluent, could be upgraded to caproate using MES technology.

This research has the potential to make MES a more scalable and economically viable technology for the production of high-value VFAs. The findings of this study could also be used to develop new applications for MCFAs in industrial processes.

References

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[1] Mr Narnepati Krishna Chaitanya
PhD Scholar, Environmental Engineering, Department of Civil Engineering
[2] Dr Pritha Chatterjee
Assistant Professor, Department of Civil Engineering & HoD, Department of Climate Change