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Biopolymers and Biochemicals Production from Biogenic CO_2 Using a Novel Hybrid Fermentation System in the SEMPRE-BIO Project

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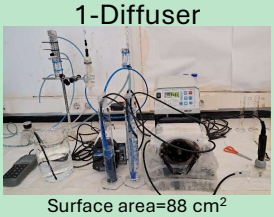
Introduction

The **SEMPRE-BIO** project aims to develop sustainable bioprocesses that contribute to a circular bioeconomy by utilizing renewable resources and minimizing waste. A key focus is the conversion of biogenic CO_2 into **value-added products** such as **biopolymers** and **organic acids** using innovative microbial fermentation systems.

Methodology

Three configurations were evaluated as an **intensive mass transfer units** (IMTU) with potential to be coupled with the fermentation system in SEMPRE-BIO.

1-Diffuser

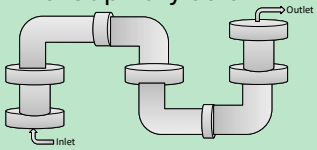


Surface area=88 cm²

2-Trickling filter

28.5 cm (height)/7 cm (diameter)

3-Capillary column



Constructed using 3D printer and owned by the University of Girona

The transfer efficiency for each of the 3 **IMTU** was evaluated at lab-scale through the determination of the volumetric mass transfer coefficient (**KLa**). The influence of the aeration flow (0.015 to 0.25 L/min) and the liquid flow (2 to 4.7 L/h) were studied.

KLa was calculated according to Equation 1.

$$KLa = \frac{F_L \cdot DO_{ss}}{V_b \cdot (DO_{sat} - DO_{ss})} \quad [1]$$

where KLa is the mass transfer coefficient (1/h), FL is the liquid flow (L/h), DOss is the concentration of dissolved oxygen in stationary state (mg/L), DOsat is the concentration of dissolved oxygen in the saturation (mg/L) and Vb is the volume liquid in the IMTU (L).

Results

The **capillary column** showed the highest oxygen transfer efficiency (**K_La up to 817 h^{-1}**), while the trickling filter consistently had the lowest (K_La below 85 h^{-1}). Despite its high efficiency, the capillary column may not be suitable for pilot-scale integration due to its susceptibility to **clogging** from biomass, given its narrow 1-mm channels. Therefore, although it offers superior transfer for poorly soluble gases like H_2, practical constraints limit its applicability. In contrast, the **diffuser** achieved a stable and adequate **K_La** (**~200 h^{-1}** under 3.5 L/h liquid flow and 0.25 L/min aeration), aligning with literature values and offering a more feasible solution for integration in hybrid fermenters aimed at **biopolymer production** from CO_2 in biogas plants.

- Production of **PHA** and **succinic acid** using a 50 L **hybrid fermenter**.
- Valorization of **biogenic CO_2**.
- Valorization of **digestate** from cow manure.

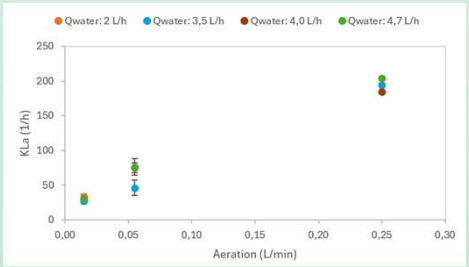


Figure 1: Experimental comparison of the mass transfer coefficient (K_La) obtained with the diffuser.

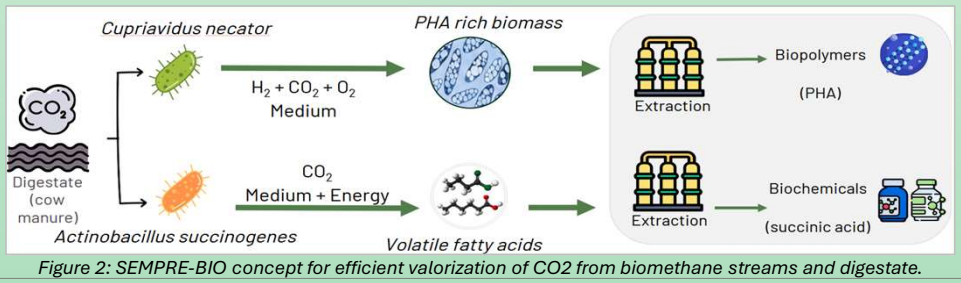


Figure 2: SEMPRE-BIO concept for efficient valorization of CO2 from biomethane streams and digestate.

Figure 3: Hybrid fermentation system for biopolymers and biochemicals production from biogenic CO2.

Acknowledgements

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SEMPRE-BIO