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Combination of bioanode and biocathode for the conversion of wastes into biocommodities using microbial electrosynthesis

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Combination of bioanode and biocathode for the conversion of wastes into biocommodities using microbial electrosynthesis

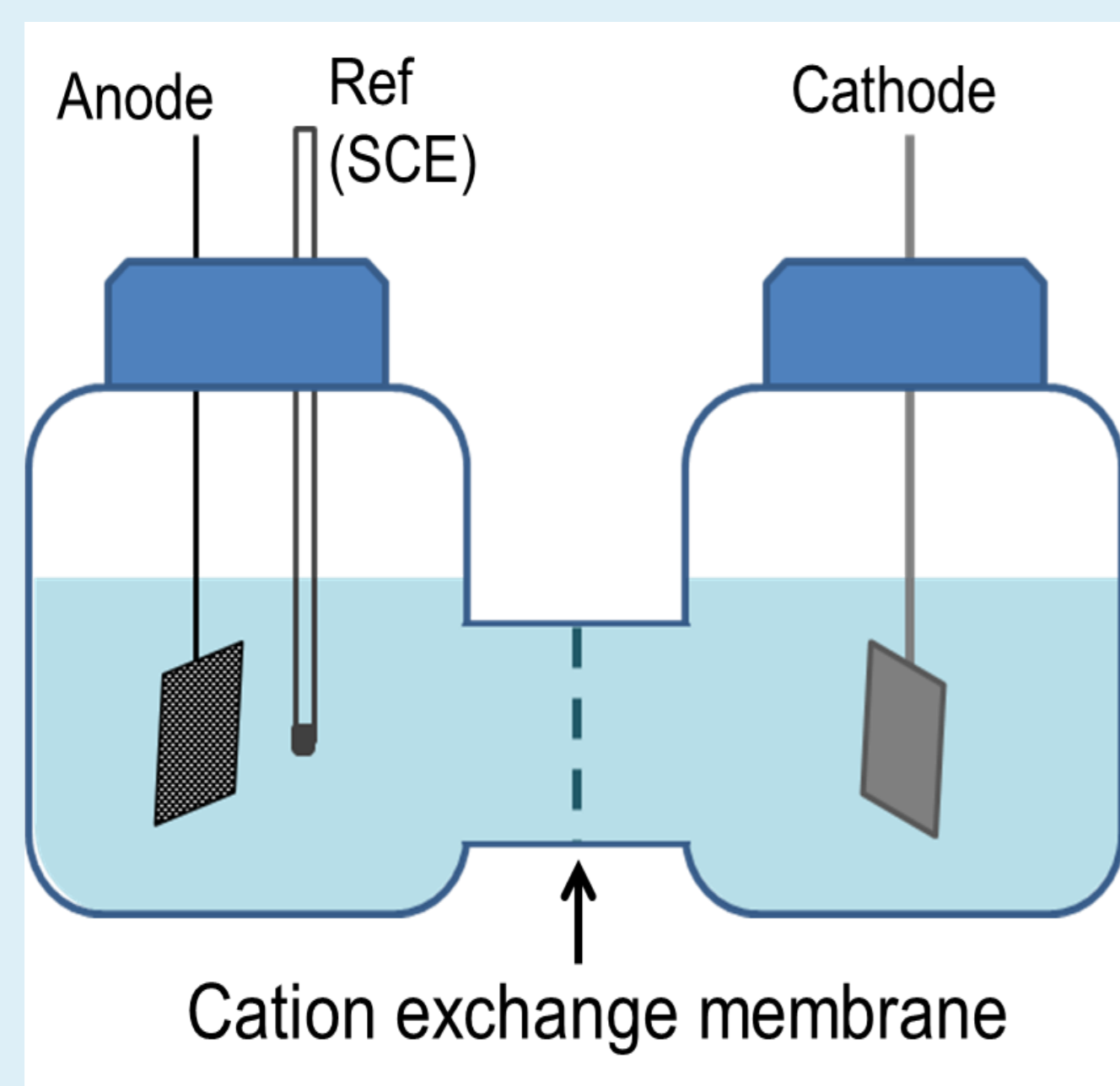
A. Bridier¹, E. Desmond-Le Quemener¹, L. Rouillac¹, C. Madigou¹, E. Blanchet², B. Erable², A. Bergel², A. Carmona³, E. Trably³, N. Bernet³, L. Aissani⁴, L. Giard⁴, L. Renvoise⁵, A. Bize¹, L. Mazeas¹, T. Bouchez¹

¹ IRSTEA-HBAN, France; ² CNRS-LGC, France; ³ INRA-LBE, France; ⁴ IRSTEA-GERE, France; ⁵ Suez Environnement - CIRSEE, France.

Context: Microbial electrolysis cell

Bioelectrochemical systems such as microbial fuel cells take advantages of microorganisms to convert the chemical energy of organic waste into electricity. Recently, the discovery that BES can also be used for the synthesis of biocommodities via microbial electrosynthesis has greatly expanded the horizons for their applications. Indeed, some microbes are able to use electrons and molecules such as CO₂ to synthesize reduced products: volatile fatty acids, alcohols etc... By combining both these processes, it should thus theoretically be possible to use the electrons of organic waste to synthesize bio-based chemicals in a clean and controlled compartment. In this context, we developed a dual-chamber reactor with both biotic anode and cathode separated by a cation-exchange membrane and evaluate its ability to produce molecules of interest and the microbial population dynamics associated.

1. Electrochemical setup



Anode: poised at +0.4V v/s SHE

- Carbon cloth electrode
- Inoculum= precultivated anode
- Medium= 1L minimal medium + 600 mg/l acetate for each phase; pH ≈ 7.5.

Cathode:

- Stainless steel electrode
- Inoculum= hydrogenotrophic culture
- Medium= 1L minimal medium; pH ≈ 7.5.

Reference electrode

- Saturated Calomel Electrode

➤ Three microbial electrolysis cells with **anode and cathode both biotic**

b. Analysis of microbial populations

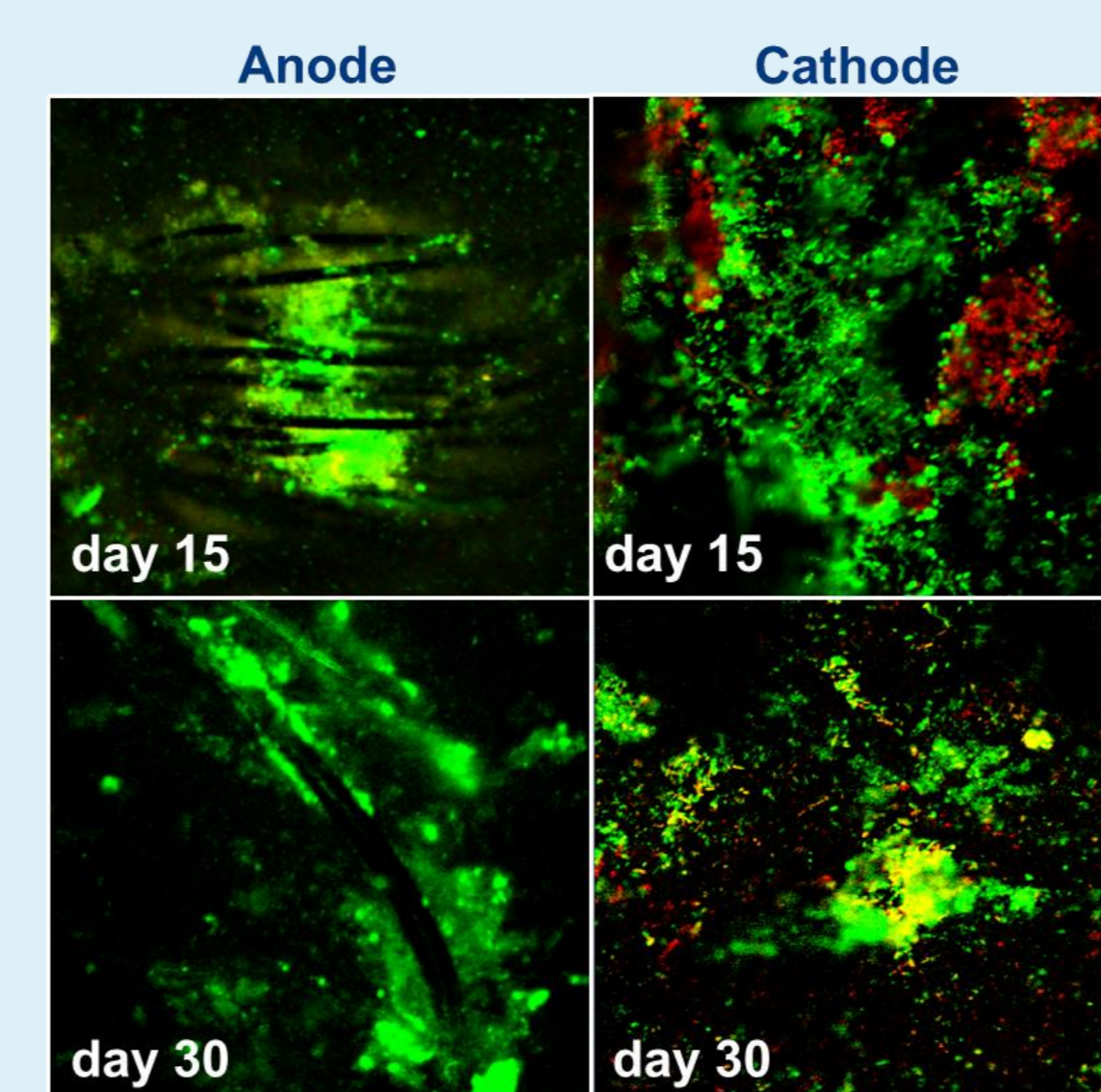


Fig.2: Visualization of biofilms on carbon cloth anode (left) and stainless steel cathode (right) using confocal microscopy and BacLight LIVE/DEAD bacterial viability staining kit (Molecular Probes Inc., Eugene, Oreg.)

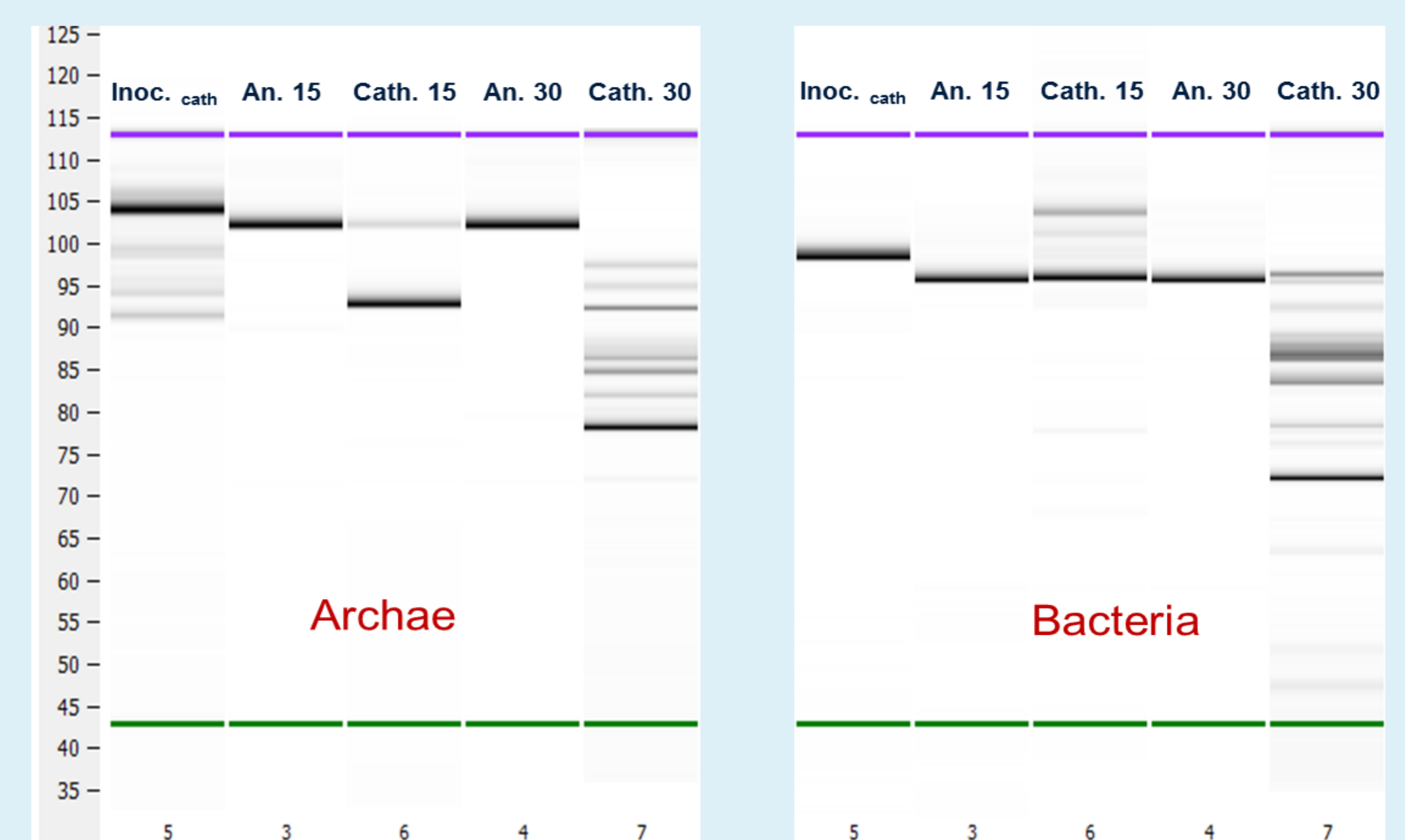


Fig.3: Archeal and bacterial fingerprinting analyses by ARISA (Automated Ribosomal Inter Spacer Analysis) of microbial communities in the anodic and cathodic compartment at different time during the experiment. *Inoc. cath*: hydrogenotrophic culture used to inoculate cathode at the beginning of the experiment (day 0), *An. 15* and *Cath. 15*: anodic and cathodic biofilm communities at day 15 (before addition of BES), *An. 30* and *Cath. 30*: anodic and cathodic biofilm communities at day 30 (after addition of BES).

- **Colonization of both electrode materials**
- **Stability of anode populations**
- **Switch of cathodic populations after BES addition**

2. Results

a. Electronic balance and chemical analyses

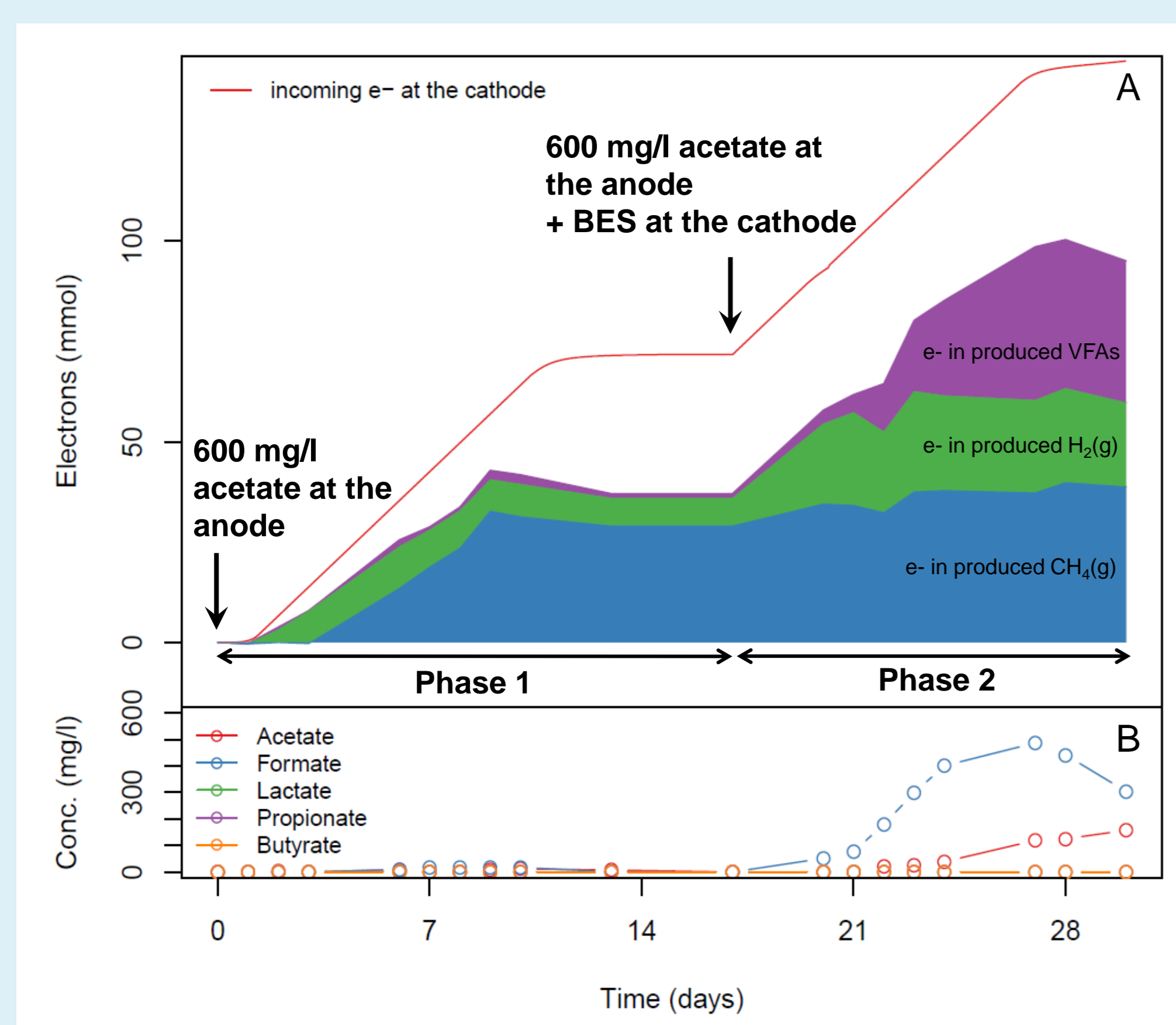


Fig.1: (A) electronic balance for the cathode of one of the experiments. The red curve indicates the quantity of electrons measured in the circuit. Both gas and dissolved species were analyzed in the cathodic compartment. Electron equivalent quantities of total VFAs, H₂(g) and CH₄(g) are shown on the graph in purple, green and blue respectively. During the first phase of the experiment the main product synthesized at the cathode is methane. In the second phase, after addition of methanogenic inhibitor 2-Bromo-ethane sulfonate (BES) in the cathodic compartment, VFAs are mainly produced. (B) details of VFAs Measured in the cathodic bulk. Formate is the main product until day 27, then acetate starts to be produced.

- **Maximum current intensity of 5 A/m²**
- **At the anode: ~85% coulombic efficiency**
- **At the cathode: ~70% coulombic efficiency**
- **Production of CH₄ and H₂ during the first phase.**
- **inhibition of methanogenesis and production of formate and acetate after BES addition (max rate of 11 g acetate/m²/d)**
- **Evidence for synthesis of caprylate (C8) (GC-MS)**

Conclusion

In conclusion, this work constitutes a first step toward the utilization of MES systems for the conversion of organic wastes into biofuels and chemicals using coupled bioanode and biocathodes. Results pointed out the detrimental role of the competition with methanogenesis in the functioning of such processes and thus underline the importance of cathodic inoculum optimization to overcome such limitations.

Contacts :

Théodore Bouchez ; theodore.bouchez@irstea.fr
Arnaud Bridier ; arnaud.bridier@irstea.fr
Elie Desmond-Le Quémener ; elie.desmond@irstea.fr

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