## 13-18 September 2026

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amU Institut méditerranéen pour la transition environnementale Aix Marseille Université

ISE International Society of Electrochemistry

BES Bioelectrochemical Society

Société Chimique de France

dcp

# How to reach the IGESA center

## Informations pratiques

### Parkings pour l'embarquement vers l'Île de Porquerolles depuis la Tour Fondue

Plusieurs parkings payants sont disponibles à proximité immédiate de l'embarcadère.

- Parking des Îles

Convient aux séjours journée ou week-end.

- Adresse : 1852 Avenue des Arbanais, 83400 Hyères
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  - 0,20 € / 15 min de 20h à 8h
  - 21 € / 24h
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- Les tarifs varient selon la saison et la durée : Environ 16,50 € à 25 € / 24h selon la période ; tarifs dégressifs possibles pour les longues durées
- Accessible aux personnes à mobilité réduite
- Idéal pour les départs tôt le matin

- Parking Porquerolles

- Adresse : 1800 Avenue des Arbanais, 83400 Hyères
- Ouvert : 24h/24
- Accessible aux personnes à mobilité réduite
- Proximité de l'embarquement : Embarcadère à moins de 500 m
- Tarifs indicatifs : Environ 16 € à 18 € / 24h
- Proximité de l'embarquement : Embarcadère à moins de 500 m.

# Program

| | Dimanche 13/09 | Lundi 14/09 | Mardi 15/09 | Mercredi (16/09) | Jeudi (17/09) | Vendredi (18/09) |
|---|---|---|---|---|---|---|
| 8h30 | | | | 8h30-8h45 Annonce des winners | | |
| 8h45 | | 8h45-10h15 : F. Lemaitre | 8h45-10h15 : B. Erable | 8h45-10h15 : J. Vidic | 8h30-9h00 Julea Butt | 8h30-9h00 Nicolas Brun |
| 9h | | | | | Oral 4 - Dkekra | Oral 18 - Jachim |
| 9h15 | | | | | Oral 5 - Marmouget-Joyau | Oral 19 - Paul |
| 9h30 | | | | | Oral 6 - Saad | Oral 20 - Rhouati |
| 9h45 | | | | | Oral 7 - Arbault | Oral 21 - Tcholakova |
| 10h | | | | | 10h-10h30 : Pause/posters | 10h-10h30 : Pause/posters |
| 10h15 | | 10h15-10h30 : Pause | 10h15-10h30 : Pause | 10h15-10h30 : Pause | | |
| 10h30 | | 10h30-12h : B. Limoges | 10h30-12h : P. Mailley | 10h30-12h : E. Benevent | Oral 8 - Faverge | Oral 22 - Liu |
| 10h45 | | | | | Oral 9 - Hossain | Oral 23 - Zhang |
| 11h | | | | | Oral 10 - Singh | Oral 24 - Contaldo |
| 11h15 | | | | | Oral 11 - Lebègue | Conclusion du workshop |
| 11h30 | | | | | Equipmentiers (Jacomex, Metrohm, Biologic) | |
| 11h45 | | | | | | |
| 12h | | | | | | |
| 12h15 | | 12h15-13h15: Déjeuner | 12h15-13h15: Déjeuner | 12h15-13h15: Déjeuner | 12h15-13h15: Déjeuner | 12h15-13h15: Déjeuner |
| 12h30 | | | | | | |
| 12h45 | | | | | | |
| 13h00 | | | | | | |
| 13h15 | | | | | 13h15-14h30 AG | |
| 13h30 | | 13h30-14h30 : Collaborative project | 13h30-15h00 : E. Ismailova | Temps libre/Accueil congressistes | | |
| 13h45 | | | | | | |
| 14h | | | | | | |
| 14h15 | | | | | | |
| 14h30 | | 14h30-16h00 : E. Lojou | | | Temps libre | |
| 14h45 | | | | | | |
| 15h | 15h-18h | | 15h-17h30: Temps libre | | | |
| 15h15 | Accueil Participants | | | | | |
| 15h30 | | | | | | |
| 15h45 | | | | | | |
| 16h | | 16h-16h15 : Pause | | | | |
| 16h15 | | 16h15-17h45 : T. Bouchez | | | | |
| 16h30 | | | | | Oral 12 - Nicolardot | |
| 16h45 | | | | | Oral 13 - Mijajlovic | |
| 17h | | | | Introduction du workshop | Oral 14 - Scola | |
| 17h15 | | | | 17h15-17h45 Stefano Cinti | Oral 15 - Tilli | |
| 17h30 | | | | | | |
| 17h45 | | 17h45-19h00: Collaborative Project | 17h30-19h00: Collaborative Project | Oral 1 - Nguyen | Pause/posters | |
| 18h | 18h-19h15 | | | Oral 2 - Chabbert | Oral 16 - Barhoumi | |
| 18h15 | Aperitif de bienvenue | | | Oral 3 - Guessab | Oral 17 - Nicola | |
| 18h30 | | | | Flash Posters | 18h30-19h00 Benjamin Erable | |
| 18h45 | | | | | | |
| 19h | | | | | | |
| 19h15 | 19h15-20h15: Diner | 19h15-20h15: Diner | 19h15-20h15: Diner | 19h15-20h15: Diner | 19h15-20h15: Diner | |
| 19h30 | | | | | | |
| 19h45 | | | | | | |
| 20h | | | | | | |
| 20h15 | | | | | | |
| 20h30 | | | | | | |
| 20h45 | | | | | | |
| 21h00 | 21h-22h | | 21h-22h | | | |
| 22h | nformation/Teams constitution | | Rendu des projets | | | |

| | | Chairs |
|---|---|---|
| Mercredi 16 | cession 1 pm | Sophie Griveau et Camille Scola |
| Jeudi 17 | cession 2 am | Estelle Lebègue et Navendu Paul |
| | cession 3 am | Florence Lagarde et Oriane Nicolardot |
| | cession 4 pm | Ievgen Mazurenko et Harpreet Singh |
| | cession 5 pm | Stéphane Arbault et Théo Faverge |
| Vendredi 18 | cession 6 am | Umberto Contaldo et Natalia Jachim |
| | cession 7 am | Anne de Poulpiquet et Marina Tcholakova |

# ABSTRACTS

# Compagnies

BioLogic

**An extensive range of high-performance instrumentation for bioelectrochemistry:**

- Potentiostats/Galvanostats
- Scanning Electrochemical Workstations

Together with a comprehensive range of accessories, including add-on products such as RDEs/RRDEs and boosters amongst many other products.

## Cutting-edge hardware.
## Powerful, user-friendly software.

BioLogic is the world's leading designer/manufacturer of ultra-precise, ultra-accurate electrochemistry measurement instruments and accompanying, high-performance control and analysis software.

Our extensive product portfolio includes potentiostat-galvanostats, battery cyclers and scanning probe workstations for local electrochemistry (SECM, LEIS, etc.).

BioLogic's cutting-edge instruments satisfy the most demanding needs in academic and applied research, as well as industrial R&D.

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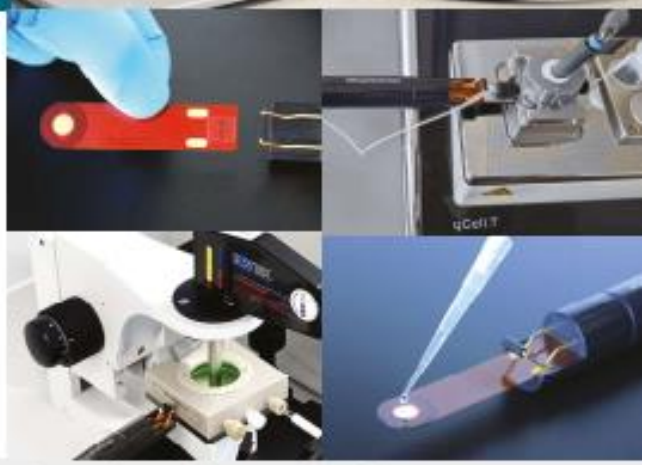
# eSorptionProbe

QCM-D probe designed for electrochemical measurements



**EQCM-D has never been easier!** The eSorptionProbe enables user-friendly EQCM-D measurements in static mode allowing direct immersion into a liquid sample or direct pipetting of small droplets onto the sensor surface without handling flow cells and pumps.

The eSorptionProbe integrates **EQCM-D seamlessly** into standard **electrochemical workflows.** When combined with Metrohm Autolab **potentiostat**, it functions as both a **mass sensor** and **working electrode** in EQCM-D experiments, operating alongside the standard reference and counter electrodes in conventional electrochemical cells. **Vertical insertion allows gas bubbles to escape freely**, minimizing interference.

## Layer-by-Layer and Dip-Coating Analysis

- Enabling **fundamental research and optimization of dip-coating processes** for layer growth, thickness, and mechanical properties of coatings
- **Direct, real-time monitoring** of layer-by-layer and dip-coated films
- **No clogging or contamination** of flow cells or tubing
- **Cavity-free, direct-immersion design** of film formation and measurement under true dip-coating conditions

## Integrated Software Workflow

- Data acquisition via **NOVA/qGraph** (automated, time-synchronized) or **INTELLO/qGraph**
- The combined datasets are visualized and analyzed in **qGraphViewer**
- Broad range of analysis tools: **calculation of layer thickness** for rigid and viscoelastic films and **data overlay** from multiple experiments
- **Easy data export** to Excel, Origin, or SigmaPlot

3T analytik

Metrohm Autolab

# Keynote Lectures

# Paper-based approaches for next-generation bioelectrochemical diagnostics

Stefano Cinti

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Despite substantial advances in sensing technologies, the development, preparation, and use of self-testing devices is still confined to specialist laboratories and users. Decentralized analytical devices will enormously impact daily lives, enabling people to analyze diverse clinical, environmental, and food samples, evaluate them and make predictions to improve quality of life, particularly in remote, resource-scarce areas. In recent years, paper-based analytical tools have attracted a great deal of attention; the well-known properties of paper, such as abundance, affordability, lightness, and biodegradability, combined with features of printed electrochemical sensors, have enabled the development of sustainable devices that drive (bio)sensors beyond the state of the art. Their blindness toward colored/turbid matrices (i.e., blood, soil), their portability, and the capacity of paper to autonomously filter/purge/react with target species make such devices powerful in establishing point-of-need tools for use by non-specialists. Depending on analytical requisites, different types of paper (filter, office) and configurations (1D, 2D, 3D) can be adopted. A wide overview regarding application ranging from nucleic acids to heavy metals, through pesticides detection will be provided, with the aim in showing the potentialities of paper-based electrochemical biosensors for improving society involvement in monitoring. In addition, a novel approach for pre-concentration is reported. The use of a disposable paper-based architectures and origami, opportunely configured, represents the first examples of horizontal and vertical pre-concentrations. It highlights the suitability of producing a novel electroanalytical platform that does not require expertise-required tasks. The talk is aimed to provide general basis regarding the development of smart electrochemical strips for multiple applications. However, it should be noted that the term “paper” is too general: chromatographic paper, office paper and nanocellulose are only some of the paper-based substrates that can be exploited.

# Cytochrome Biowires: From Biology to Biotechnology?

Julea Butt

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Many environmental bacteria assemble novel biological wiring to transfer electrons generated by internal metabolism to materials, such as electrodes, that are located the cell boundary. Key to this wiring are conductive proteins with many unusual properties. This talk will consider recent advances in our understanding of these fascinating proteins and how they can inspire biotechnology.

# Toward a deeper understanding of the roles, dynamics, and controllability of extracellular polymeric substances in electroactive microbial biofilms

Benjamin Erable [1]

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Extracellular polymeric substances (EPS) are increasingly recognized as a central component governing the structure, function, and long-term stability of electroactive microbial biofilms (EABs). While electroactive microorganisms have traditionally attracted most of the attention in bioelectrochemical systems (BES), growing evidence indicates that the extracellular matrix itself plays a decisive role in shaping biofilm electroactivity and resilience. However, the mechanisms by which EPS composition evolves over time, responds to environmental conditions, and influences extracellular electron transfer remain only partially understood.

This presentation will present recent advances obtained from a systemic investigation of EAB development combining electrochemistry, confocal laser scanning microscopy, image analysis, EPS fractionation, microbial ecology, and long-term biofilm monitoring. Particular attention will be given to the temporal evolution of proteins and polysaccharides within loosely bound and tightly bound EPS fractions, and to their relationships with biofilm architecture, microbial succession, and current generation. Results reveal that EPS composition is highly dynamic during biofilm maturation and can be strongly influenced by operational parameters such as nutrient availability, substrate feeding strategy, electrode potential, and biofilm age. Protein-rich EPS fractions appear closely associated with efficient extracellular electron transfer and sustained electroactivity, whereas polysaccharides contribute predominantly to structural organization, biofilm thickness, and metabolic resilience. Recent findings further suggest that EPS may act simultaneously as a conductive network, a structural scaffold, and a transient reservoir of carbon and redox-active compounds.

Beyond providing new mechanistic insights, these observations open promising perspectives for actively steering EAB properties through process engineering. Controlling EPS production and composition may become a powerful strategy to improve current generation, stability, robustness, and scalability of bioelectrochemical technologies. The presenttaion will conclude by discussing emerging concepts and future challenges toward a predictive and controllable engineering of electroactive biofilms, where EPS are no longer viewed as passive matrix components but as key functional actors of bioelectrochemical performance.

## References

L. Martinez Ostormujof, S. Teychené, W. Achouak, S. Fochesato, M. Bakarat, I. Rodriguez-Ruiz, A. Bergel, B. Erable, Systemic analysis of the spatiotemporal changes in multi-species electroactive biofilms to clarify the gradual decline of current generation in microbial anodes, ChemElectroChem2 023, 10, e202201135. https://doi.org/10.1002/celc.202201135

H. Xu, J.-M. Fontmorin, B. Erable, Temporal evolution of extracellular polymeric substances reveals roles in facilitating electron transfer and structural organization in electroactive biofilms, Sustainable Energy Technologies and Assessments, Volume 89, 2026,104992, ISSN 2213-1388, https://doi.org/10.1016/j.seta.2026.104992.

# Implementation of formate dehydrogenases in the electrochemical conversion of carbon dioxide: a materials chemist's perspective

Q. Hanniet[1], O. Boces[1], M. Hossain[1], A. Mehdi[1], K. Sowa[2], D. Voiry[3], J. Drone[1], Nicolas Brun[1,*]

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Formate dehydrogenases (FoDHs) are emerging as key biocatalysts capable of converting carbon dioxide ($CO_2$) into formate under mild conditions. With over 800 peer-reviewed studies published since 2020, of which several dozen investigate their integration into (photo)electrochemical devices, FoDHs emerge as a promising and sustainable alternative to conventional abiotic catalysts. With this perspective, we propose to ponder the viability, sustainability and feasibility of implementing FoDH for the large-scale electrochemical carbon dioxide reduction reaction into formate. We will present an objective and performative comparison with abiotic state-of-the-art electrocatalysts and identify key metrics and quantified targets to achieve in order to measure how far the scientific community would have to go to close the gap between enzymatic and abiotic technologies.

In this context, we will explore the various aspects of this rapidly advancing field, ranging from the heterogenization of FoDHs onto electrode surfaces to the engineering of enzymatic $CO_2$ reduction electrolyzers. Finally yet importantly, we will discuss our team's recent findings, which might open new avenues for the immobilization of FoDHs and the design of **multifunctional, hybrid enzymatic electrodes.**

# Orals

# Development of a gas sensor based on organic electrochemical transistor for biomedical applications

Dieu-Linh Nguyen[1], Thi-Thu Vu[2], Benoît Piro[1,*]

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[2] *University of Science and Technology of Hanoi (USTH), Vietnam Academy of Science and Technology (VAST), 18 Hoang Quoc Viet, Cau Giay, 100000 Hanoi, Vietnam*

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The human body can generate a variety of volatile organic compounds (VOCs) from breath, body odor, sweat, and body fluids [1], [2]. Volatile organic compound profiles can reflect underlying pathological and metabolic states, with subtle variations in composition and concentration serving as potential indicators of diseases such as lung cancer, diabetes, kidney dysfunction, and inflammatory disorders [2], [3]. Hence, human VOCs are promising non-invasive biomarkers for health monitoring and early diagnosis. To enable point-of-care gas analysis, we developed an OECT-based electronic-nose array using PANI channels decorated with PdNPs and PtNPs for hydrogen and ethanol detection, respectively[4], [5].

Herein, an array of 8 side-gate transistors was fabricated by a photolithography process and gold evaporation. Then, PANI was electrodeposited via cyclic voltammetry between the source and drain terminals, forming an organic semiconducting channel. Then, catalytic nanoparticles (Pd NPs, Pt NPs) were decorated by electrochemical processes on the channel to promote gas sensing selectivity. Furthermore, a layer of acidic gel electrolyte was printed on top of each transistor by direct ink wiring method with Kelenn DMD100 ink-dispensing printer. Prior to gas sensing, a 3D printed gas chamber was placed on top of the array. The signals of gas sensing were recorded as the change in drain current versus time, while exposing gas to the system. Preliminary results with PdNPs@PANi based OECT showed a high response to exposed hydrogen gas (R% = 99%), proving that this sensor array is favorable for further investigations with other catalytic functionalizations for other gas or with more complex gas mixtures.

## References

[1] P. C. Moura, M. Raposo, and V. Vassilenko, "Breath volatile organic compounds (VOCs) as biomarkers for the diagnosis of pathological conditions: A review," *Biomed. J.*, vol. 46, no. 4, p. 100623, Aug. 2023, doi: 10.1016/j.bj.2023.100623.

[2] A. Amann *et al.*, "The human volatilome: volatile organic compounds (VOCs) in exhaled breath, skin emanations, urine, feces and saliva," *J. Breath Res.*, vol. 8, no. 3, p. 034001, Jun. 2014, doi: 10.1088/1752-7155/8/3/034001.

[3] N. Nasiri and C. Clarke, "Nanostructured Chemiresistive Gas Sensors for Medical Applications," *Sensors*, vol. 19, no. 3, p. 462, Jan. 2019, doi: 10.3390/s19030462.

[4] C. Sandaruwan, H. M. P. C. K. Herath, T. S. E. F. Karunarathne, S. P. Ratnayake, G. A. J. Amaratunga, and D. P. Dissanayake, "Polyaniline/palladium nanohybrids for moisture and hydrogen detection," *Chem. Cent. J.*, vol. 12, no. 1, p. 93, Dec. 2018, doi: 10.1186/s13065-018-0461-y.

[5] R. K. Pippara, P. S. Chauhan, A. Yadav, V. Kishnani, and A. Gupta, "Room temperature hydrogen sensing with polyaniline/SnO2/Pd nanocomposites," *Micro Nano Eng.*, vol. 12, p. 100086, Aug. 2021, doi: 10.1016/j.mne.2021.100086.

# Algal strain-dependent modulation of electrochemical dynamics in sediment microbial fuel cells

Ambre Chabbert[1,2], Abdelghani Ghanam[1], Laurent Nicolas[1], Arnaud Elger[2]

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## Context

Sediment microbial fuel cells (SMFCs) rely on electroactive bacteria to convert organic matter into electricity. Previous studies have investigated phototrophic organisms in SMFCs, mainly as algae-assisted cathodes to enhance oxygen reduction reaction and power generation [1,2]. However, the influence of different algal communities on the temporal electrical dynamics of membrane-less SMFCs under light/dark cycles remains poorly documented. This study evaluates the effect of selected algal strains on SMFC electrical behavior and performance.

**Materials and methods.** Membrane-less SMFCs were assembled with carbon felt anodes and Pt/C-functionalized air cathodes, using a 50:50 sand–potting soil mixture. Four conditions were tested in quintuplicate: control without algae ($SMFC_{NC}$), cyanobacteria *(Phormidium automnale;* $SMFC_C$), green algae (*Scenedesmus* sp.; $SMFC_{GA}$), and diatoms (*Nitzschia palea;* $SMFC_D$). Voltage was continuously monitored, while weekly electrochemical (cyclic voltammetry, polarization and power curves) and physicochemical (COD, pH, conductivity) were performed.

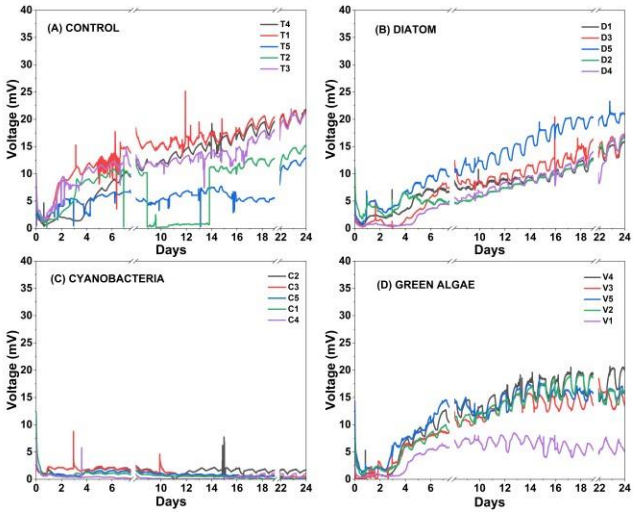


**Fig.1.** Temporal evolution of the voltage output of **(A)** control, **(B)** diatom, **(C)** cyanobacteria, and **(D)** green algae.

**Results and conclusion.** Distinct electrical behaviors were observed depending on the algal strain. $SMFC_{NC}$, $SMFC_D$, and $SMFC_{GA}$ progressively generated measurable voltages over time, reaching values of approximately 15–20 mV after 25 days, whereas $SMFC_C$ remained at low electrical outputs throughout the experiment (**Fig.1**). Oscillatory patterns associated with light/dark cycles were observed in all conditions, with differences in amplitude and temporal profiles depending on the algal strain. These preliminary results suggest that algal communities can influence SMFC electrochemical dynamics, likely through interactions with microbial activity and local physicochemical conditions. Further analyses, including statistical assessments, are ongoing.

## References

[1] Wang, D. B., Song, T. S., Guo, T., Zeng, Q., & Xie, J. (2014). Electricity generation from sediment microbial fuel cells with algae-assisted cathodes. *International journal of hydrogen energy*, *39*(25), 13224-13230.

[2] Abazarian, E., Gheshlaghi, R., & Mahdavi, M. A. (2020). Impact of light/dark cycle on electrical and electrochemical characteristics of algal cathode sediment microbial fuel cells. *Journal of Power Sources*, *475*, 228686.

# Characterization of bioelectrodes *in operando* by electro-chemistry & fluorescence microscopy

Assil Guessab,[1 -2] Anne de Poulpiquet,[1] Elisabeth Lojou,[1] Loïc le-Goff.[2]

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[2] *Institut Fresnel, Aix-Marseille Univ, CNRS, Centrale Marseille, UMR7249, France.*

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Enzymatic bioelectrodes play key roles in biotechnological devices for detection and energy conversion. Conventional electrochemical characterization, however, provides limited insight into near-surface composition and parameters. Fluorescence confocal laser scanning microscopy (FCLSM) enabled in-operando pH mapping of bioelectrode interfaces using pH-sensitive fluorophores [1] [2]. Although this approach revealed new information about pH near the reactive surface, it had two limitations: 1) The pH range for usage of one fluorophore in mapping is limited (~5.2 for fluorescein) and 2) **FCLSM** suffers from limited spatial and temporal resolutions.

To overcome the first limitation, we show that other fluorophores, namely **HPTS** and Lysosensor green DND189, enable successful pH mapping at the surface of both a O2-reducing bio-cathode and a H2-oxidizing bioanode over a broader range of pH (figure1) (. Moreover, we introduce here the development of a new super-resolution setup which combines Random Illumination Microscopy with Extended depth of field (**RIM-EDF**). We show that it allows faster and better-resolved imaging of the bioelectrode surface and diffusion layer.

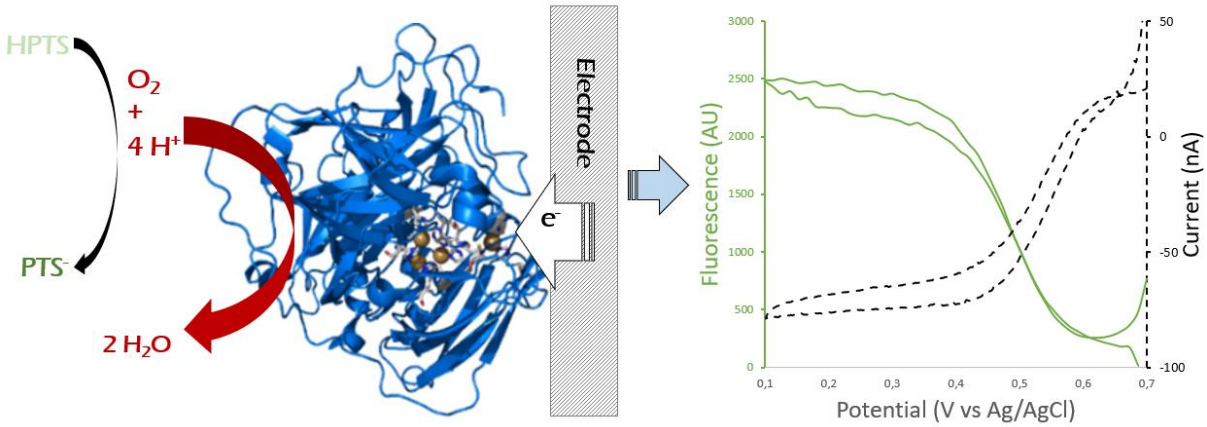


**Fig. 1:** Bio-electrode made of Enzyme (Myrothecium verrucaria bilirubin oxidase Mv-BOD) adsorbed on the surface of a graphite micro electrode (Ø = 0.3 mm). During the reaction, the enzyme exchanges $e^-$ with the electrode, $H^+$ are consumed by the reaction resulting in a pH increase which changes the state of the fluorophore **HPTS**, allowing fluorescence mapping by **FCLSM**.

## References:

[1] Tassy, B.; De Poulpiquet, A. *et al. Anal. Chem.* **2020**, *92* (10), 7249–7256.

[2] Man, H. M.;De Poulpiquet, A *et al. Anal. Chem.* **2022**, *94* (45), 15604–15612.

# Development of Stable Redox-Active Metal–Organic Framework-Modified Microelectrode Biosensors for Continuous Monitoring of Glucose and Lactate in Brain Metabolism

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*[2]Université Claude Bernard Lyon 1, CNRS UMR5292, INSERM, Centre De Recherche En Neurosciences De Lyon CRNL U1028 UMR5292, Team TIGER, F-69500 Bron, France.*
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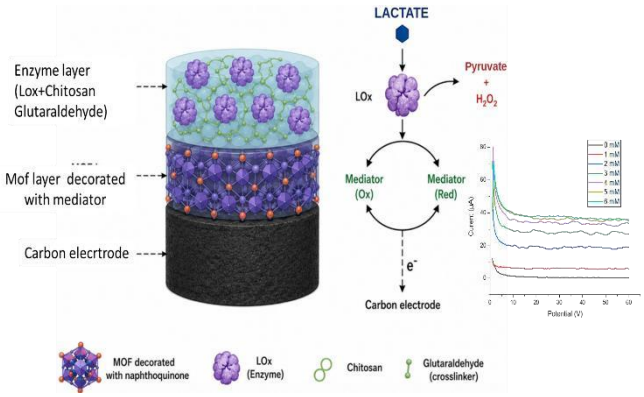
Continuous monitoring of brain energy metabolism provides a powerful strategy for early detection of neurological dysfunction and guidance of therapeutic interventions in severe brain injury [1]. Glucose and lactate are key biomarkers of cerebral metabolic activity; however, their reliable long-term monitoring in brain tissue remains challenging due to the need for stable, miniaturized, and biocompatible implantable sensing platforms [2].

Here, we report a redox-active metal– organic framework (MOF)-based enzymatic sensing platform for the continuous detection of glucose and lactate in brain metabolism monitoring applications. Several surface architectures and configurations were systematically optimized to significantly improve analytical performance, including mediator–enzyme coupling, immobilization strategies, and interface design.




The developed lactate sensor exhibits high sensitivity (9,55 $\mu A.cm^2.mM^{-1}$). Importantly, the device demonstrates excellent operational stability under continuous measurement, remaining active for up to 21 hours of uninterrupted operation. These results highlight enhanced mediator efficiency and sustained enzymatic activity enabled by the MOF-based architecture. Overall, this work establishes a robust MOF-functionalized enzymatic sensing strategy that improves mediated electron transfer and operational stability, offering strong potential for long-term continuous monitoring of brain energy metabolism in neurocritical care and other in vivo biomedical applications.

## References

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# Bioelectrochemical degradation of AMPA using Sediment Microbial Fuel Cells

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Aminomethylphosphonic acid (AMPA), the primary degradation product of glyphosate, is frequently detected in agricultural soils and aquatic systems (Ojelade et al., 2022). The current study investigates whether AMPA can serve as an electron donor in sediment microbial fuel cells (SMFCs), assessing the capacity of contaminated sediments to sustain stable bioelectrochemical activity and generate electricity under environmentally relevant conditions.

SMFCs rely on electroactive biofilms developing on an anode buried in anaerobic sediment (Hubenova et al., 2024; Nastro et al., 2019). Microorganisms oxidize substrates and transfer electrons to the anode, which then flow through an external circuit to a cathode in the oxygenated water column, where oxygen reduction occurs (Hamdan & Salam, 2023). SMFC performance is evaluated using polarization and power curves, current density, internal resistance, and temporal (including seasonal) voltage stability. The study was conducted in France (Loire-Atlantique) at two contrasting sites: a freshwater lake (LGL) and a brackish port (PDC). The systems are monitored across four seasons (Autumn 2025–Summer 2026). Measurements include voltage monitoring, electrochemical characterization, physicochemical analyses, microbial community profiling, and AMPA-spiking experiments to evaluate its impact on current production and degradation dynamics. The PDC SMFC shows more stable open-circuit voltage (OCV), improved polarization behavior, and lower internal resistance than the lake, likely due to higher conductivity reducing ohmic losses. Initial results indicate greater AMPA degradation in closed-circuit SMFCs than in controls, suggesting that enhanced removal may be linked to electroactivity. Ongoing work aims to link microbial structure with electrochemical performance, quantify the contribution of AMPA oxidation to current generation, and identify operational conditions that maximize stability. To date, the brackish port site (PDC) shows the most favorable profile for bioenergy production in contaminated sediments.

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# Morphology-Tuned Buckypaper Bioelectrodes for Next-Generation Bioelectronics

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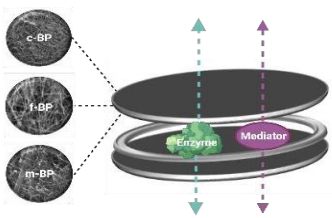
Enzymatic fuel cells (EFCs) require bioelectrodes that balance enzyme confinement, mediator accessibility, and long-term stability [1] – yet most studies focus on enzyme or mediator immobilization strategies rather than rational 3D electrode design. Here, we report hollow-cavity buckypaper (BP) bioelectrodes' design (Figure 1), where enzymes are retained in solution form within the cavity, engineered through systematic CNT morphology tuning to establish structure–function relationships governing bioanode performance [2].

Three type of BPs were fabricated by varying CNT composition: c-BP (100% short commercial CNTs, 1.5 µm/9.5 nm), f-BP (100% long lab-made CNTs, 800 µm/60 nm) and mf50-BP (a 50% lab-made : commercial CNTs ratio). Raman spectroscopy revealed a structural gradient from defect-rich c-BP ($I_D/I_G$ = 1.58) to pristine fBP ($I_D/I_G$ = 0.36), with mf50-BP at an intermediate position ($I_D/I_G$ = 1.12). BET analysis confirmed a corresponding porosity gradient (243, 122, and 20 m²/g for c-, mf50-, and f-BP, respectively). SEM analysis showed structural difference in the BPs with c-BP having the most compact structure while f-BP having big voids and channels in it. To mimic the designed micro-cavity architectures, BPs were studied for the permeation of enzyme (flavin adenine dinucleotide-dependent glucose dehydrogenase (FAD-GDH)) in a bi-compartment cell over 15 days, and mf50-BP retained the highest fraction of FAD-GDH (~89 ± 5%), while f-BP retaining the lowest at ~71 ± 18%. Then, bilirubin oxidase (BOx), ~60 kDa-half the size of FAD-GDH, was studied for the permeation behaviour over mf50-BP, which retained ~79 ± 7%, supporting our hypothesis that the chosen CNTs-properties driven cavity architecture – dominates the enzymes' confinement efficiency. Followed, cyclic voltammetry (CV) studies of FAD-GDH/1,10-Phenanthroline-5,6-dione (PLQ) hollow cavity bioanode revealed mf50-BP with the most stable response i.e., 27% decline in current density over 70 days. Under continuous operation in chronoamperometry, all BPs decayed 30–60% over 4 hours due to substrate starvation and product inhibition inside the cavity structure. A pulsed protocol (0.2 V for 10 s / ~30 min rest) restored performance to 5-12 mA/cm² per pulse – an 8-20-fold improvement – by enabling glucose replenishment. The results indicated mf50BP as an optimal platform balancing substrate accessibility with enzyme retention. These results demonstrate CNT composition as a decisive design handle for an electrode material, affecting the immobilization of enzyme and redox mediator. Hence the stability and operational stability of the EFCs can be tuned to power bioelectronics targeting wearable sensors and IoT devices.




***Acknowledgment:*** *Authors would like to thank the National Science Centre, Poland for financial support [2023/49/B/ST4/02942], and Silesian University of Technology for support under the program 'Initiative of Excellence – Research [32/014/SDU/10-27-33].*

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# Development of Bioenergetic Artificial Cells Based on Their Spectro-Electrochemical Monitoring

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There is a rising interest in the development of synthetic-artificial cells, aimed to achieve minimal and specific biological functions to replace or supply living cells. In this context, we are developing hybrid artificial cells by encapsulating intact organelles, mitochondria, in two types of microcompartments -liposome and coacervates - and achieving bioenergetic activities inside. Giant synthetic liposomes, made up of unilamellar phospholipid membranes can mimic natural cell membranes. Coacervate droplets, produced by liquid–liquid phase separation of biocompatible polymers, are membrane-free compartments providing a crowded cystosol-like chassis [1]. GUVs (Giant Unilamellar Vesicles) and coacervates provide good structures for biological and biochemical reactions to take place in controlled micrometric environments. The main source of energy for biological processes is the hydrolysis of ATP (adenosine triphosphate), and mitochondria are the main aerobic producers of cellular ATP [2].

In this study, we managed to encapsulate mitochondria, isolated from S. cerevisiae yeasts, inside giant liposomes and coacervates during the droplet formation process. Mitochondrial activity in micro-compartments was studied by spectrophotometric and electrochemical methods [2, 3]. Epifluorescence microscopy is used to monitor the internal membrane potential, NADH content in mitochondria, while their ATP production is assessed by chemiluminescence and their oxygen consumption and quinone redox state are monitored amperometrically [2, 4]. The mitochondrial activity is modulated in real-time by adding respiratory chain substrates and inhibitors. Eventually, the control of bioenergy production is essential for driving other biomimetic processes in artificial cells, ultimately enabling the creation of complex systems such as artificial organs.

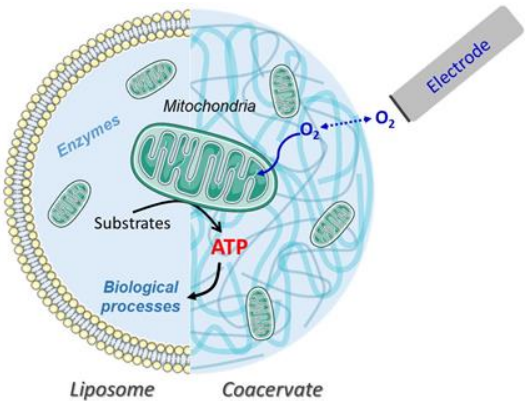


**Figure 1.** Study of bioenergetics artificial cells based on mitochondria encapsulation in micro-droplets.

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# Spectroscopic and electrochemical study of the mitochondrial respiratory chain: focus on cytochrome c under physiological and pathological conditions

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Mitochondrial dysfunction is involved in many neurodegenerative diseases, including Parkinson's disease (PD), Alzheimer's disease (AD), Huntington's disease (HD) and amyotrophic lateral sclerosis (ALS)[1,2]. In PD, the mechanisms leading to neuron's death include oxidative stress[3], mainly through the accumulation of reactive oxygenated species (ROS). As an anti-oxidant, anti-inflammatory and anti-apoptotic agent, $H_2$ appears as a promising molecule to mitigate the effect of ROS[4] and prevent mitochondrial dysfunction[5]. However, the reactional mechanism of $H_2$ on the mitochondrial respiratory chain remains unclear. We investigated the effect of $H_2$ on the peroxidase-like activity of cytochrome c, using both spectroscopic approaches and electrochemical sensing of NADH and $H_2O_2$ on modified screenprinted electrodes. Our preliminary results (Fig. 1) suggest that $H_2$ may influence the redox behavior and the peroxidase-like activity of cytochrome c, leading to variations in NADH and $H_2O_2$ consumption under hydrogen-saturated conditions. Additional studies are currently underway to determine whether such effects could influence mitochondrial function.

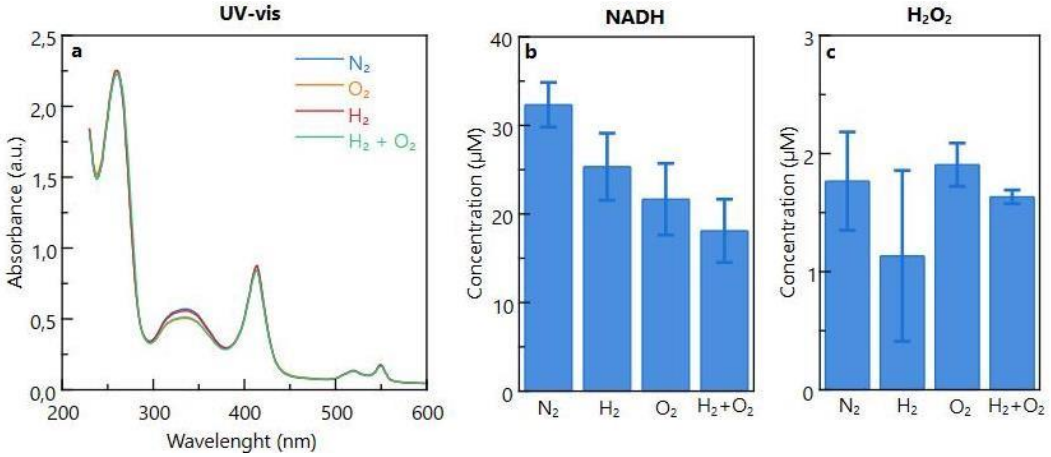


**Figure 1.** UV-vis. spectra of a solution containing 150 µM NADH, 10 µM cytochrome c and 50 µM $H_2O_2$ to determine the effect of $H_2$ and/or $O_2$ compared to $N_2$. b-c : Remaining amount of NADH and $H_2O_2$ electrochemically quantified by a modified screen printed electrode.

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# Bridging Enzymes and Materials Interface: Engineering for Efficient Mediated Bioelectrocatalytic Performance

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Enzymes are the primary means by which biology performs chemical transformations. Enzymebased bioelectrocatalytic systems offer powerful opportunities that are utilized in biosensing devices, green energy production, and sustainable chemical conversion for modern society [1]. However, their long-term performance is often limited by inefficient electrical communication between the deeply buried active sites of enzymes and support materials, as well as by instability at the enzyme-material interface. The objective of this talk is to discuss interfaceengineering strategies to bridge this gap by integrating redox mediators, porous carbon materials, bio-inspired nanostructures, and crosslinked enzyme networks. Particular attention is paid to how mediator immobilization, covalent grafting, and tailored porous carbon architectures can promote efficient electron transfer while improving bioelectrocatalytic efficiency [2, 3].

The presentation will be highlighting the design principles of oxidoreductase and formate dehydrogenase (FDH) enzymes at the material interfaces for mediated bioelectrocatalysis. Oxidoreductase-driven glucose oxidation and FDH-catalyzed $CO_2$ reduction [4] will be discussed as two representative reactions that connect applied bioelectrochemical biosensing, biofuel cells, value-added chemical synthesis, and environmental $CO_2$ mitigation. Particularly focuses on the design of enzyme-mediator-material interfaces through crosslinked redoxnetwork immobilization and porous structure confinement, where enzyme and mediator are spatially organized to promote the mediator electron collection, surface confinement, electrontransfer pathways, substrate diffusion, and enzyme-mediator kinetics. Electrochemical analysis is conducted to elucidate how rational material design can transform weak enzyme-electrode communication into efficient bioelectrocatalytic performance. These concepts provide a foundation for developing next-generation bioelectrode platforms for tackling the challenges in healthcare, renewable energy, and sustainable environmental technologies.

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# 3D-Printed Living Electrodes: A Novel Platform for Next-Generation Bioelectrochemical Systems

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Microbial electrosynthesis and bioelectrochemical systems have emerged as promising technologies for sustainable energy and chemical production. However, electron transfer at the bacteria-electrode interface remains a critical bottleneck, often limiting efficiency and scalability. Traditional electrode materials, such as carbon felt and carbon cloth, struggle with poor control over microbial attachment and electron transport, leading to suboptimal performance.

To address these challenges, we present a 3D printing of novel bio-ink formulation to fabricate living electrodes with *Shewanella oneidensis MR-1*. This platform enables optimized microbial spatial distribution and enhanced electron transfer pathways, offering a versatile and scalable solution for bioelectrochemical applications. Our work demonstrates the potential of this methodology to improve electrochemical performance in systems such as microbial electrosynthesis, paving the way for more reliable and sustainable bioelectrochemical technologies.

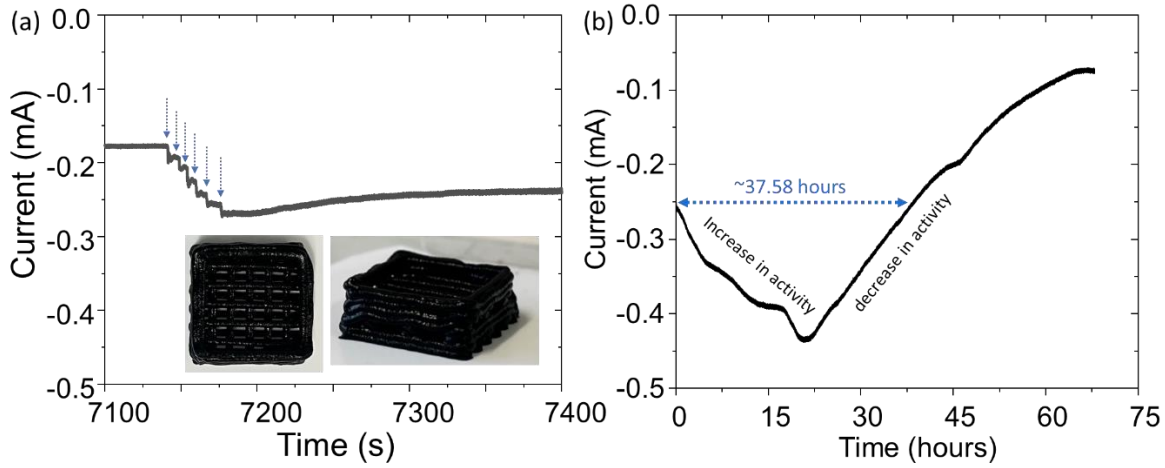


Figure 1. (a) Chronoamperometry response of 3D printed electrodes after insertion of 0.625 M sodium fumarate indicated by arrows. (b) Experiment to analyze the evolution of system with time.

# Single-impact electrochemistry of bacteria and liposomes

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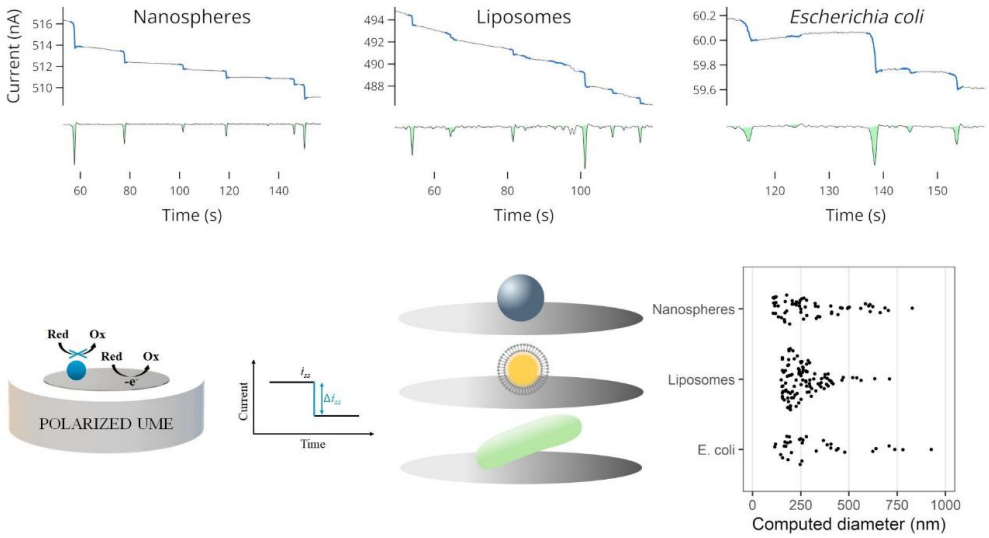
Electroanalytical chemistry greatly evolved with the continuous improvement of instrumentation sensitivity and especially with the development of the electrochemical detection of individual entities. In this context, single-entity electrochemistry, namely discrete collisions technique or nano-impacts method based on stochastic events, is a useful tool for the detection via single impacts of various micro- and nano-entities such as nanoparticles, cells, bacteria, vesicles, viruses, proteins in solution at a polarized ultramicroelectrode (UME).[1,2]. Blocking impact electrochemistry deals with single collisions of insulating (bio)entities on the ultramicroelectrode surface polarized at the redox potential of the electroactive probe in solution, involving in most cases a "current step" signal in the chronoamperometry measurement, corresponding to an impact event.[3]

In our work, we focus on single-impact electrochemistry applied to bacteria and liposomes, particularly electroactive bacteria such as *Shewanella oneidensis* and phospholipid redox liposomes with ferrocyanide species encapsulated. These two targets have interesting properties in term of release mechanism and electron transfer at a polarized ultramicroelectrode, that we investigate by single-impact electrochemistry and more recently, coupled to microscopy.




Current steps signals related to collisions of three different entities (polystyrene spheres, phospholipid liposomes and Gran-negative bacillus bacteria) in single blocking impact electrochemistry.[3]

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# Fully Integrated pH-Triggered Microbatteries for Smart Bioelectronics

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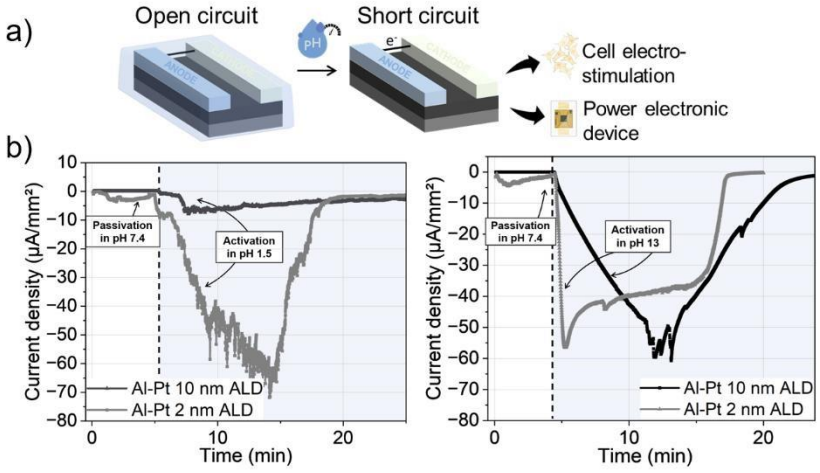
Biological systems feature dynamic chemical microenvironments characterized by pH variations that signal critical physiological or pathological processes *(e.g.*, bacterial activity, tumour acidosis or metabolic shifts). *[1][2]*

On the other hand, conventional microbatteries (MBs) are the cornerstone of autonomous bioelectronic microsystems, but lack the intelligence required for tailored adaptive actions in response to these variations. In general terms, electrochemical MBs begin operating upon contact with fluids, being unable of environmental adaptation and spaciotemporal control. Herein, a novel aluminum-platinum (Al-Pt) microbattery, engineered with an atomic layer deposited (ALD) alumina ($Al_2O_3$) layer to govern pH-triggered electrochemical activation, is introduced (**Fig. 1a**).

Results demonstrate that ALD-$Al_2O_3$-coated MBs exhibit intrinsic responsiveness to pH changes, functioning as adaptive switches, i.e., they remain fully passivated at physiological pH 7.4 and "switch on" only under acidic (pH 1.5) or alkaline conditions (pH 13) reaching current density up to 72 µA/mm² and 61 µA/mm², respectively and within seconds (**Fig. 1b**). This pH-sensitive platform functions as biocompatible self-contained, sensor-free transducer. The fast, pH-dependent activation of these microbatteries enables autonomous, rapid and localized electrochemical sensing and modulation of biological environments, with potential applications in monitoring biologically inaccessible sites, enabling localised interventions and developing bioelectrochemical interface for targeted therapies. *[3][4]*




Thus, this work highlights the potential of bioelectrochemical systems to bridge the gap between sensing and autonomous intervention in biological systems.

**Figure 1**: **(a)** Simplified scheme of the pH-triggered ALD-$Al_2O_3$-coated MBs; **(b)** Acidic (left) and alkaline (right) activation chronoamperometry at 0V for $Al_2O_3$-coated Al-Pt MBs during immersion in buffer at pH 7.4, followed by immersion to pH 1.5 or pH 13 solutions.

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# Sensitive Electrochemical Detection of Bacillus cereus Spores Using a Novel rGO@$La_2O_3$ Aptasensor

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Bacterial spore contamination poses severe risks to food safety and water quality due to the high resilience of spores against conventional disinfection methods [1]. Traditional culture-based and molecular assays are constrained by long turnaround times and the requirement for spore germination [2]. To address these challenges, this study presents a novel, label-free electrochemical aptasensor for the rapid and sensitive detection of *Bacillus cereus* spores utilizing a screen-printed carbon electrode (SPCE) modified with a reduced graphene oxide/lanthanum oxide (rGO@$La_2O_3$) nanocomposite. Phase-pure $La_2O_3$ nanoparticles, synthesized via a modified Pechini method, were uniformly anchored across wrinkled rGO sheets. The specific Apt1 aptamer was immobilized onto the modified SPCE via non-covalent $\pi$-$\pi$ stacking interactions, preserving its native biorecognition capability. The stepwise sensor fabrication was systematically validated using electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and scanning electron microscopy (SEM). Under optimized conditions, differential pulse voltammetry (DPV) demonstrated a linear response to *B. cereus* spores in the range of $1 \times 10^5$ to $5 \times 10^6$ CFU/mL with a low detection limit (LOD) of $3 \times 10^4$ CFU/mL. Furthermore, the aptasensor exhibited excellent selectivity against non-target *Bacillus subtilis* spores and common interfering ions, satisfactory reproducibility (RSD = 18%), and good storage stability, retaining 81% of its initial signal after two weeks. The practical utility of the platform was confirmed in spiked tap water samples, achieving acceptable recovery rates between 89.0% and 91.3%. This cost-effective and scalable electrode modification strategy holds great promise for *on-site* water quality monitoring and portable diagnostic applications.

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# Can Bauxite Waste be Valorised with the Help of Electroactive Bacteria?

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The aluminum industry generates millions of tons of waste every year. This waste results from the Bayer process which separates the aluminum from other undesirable components of bauxite, such as iron. This leaves non-exploited "red mud" that creates economic and environmental hazards, especially as red mud is stored in open-air areas.

In this work, we investigate green routes for the extraction of iron from the bauxite red muds using electroactive bacteria. Bacteria of the genus *Geobacter* are capable of extracellular electron transfer (EET), a process whereby microorganisms export or accept electrons across the cellular membrane through exchanges with extracellular electron acceptors or donors. In our case, the well-known species *Geobacter sulfurreducens* is capable of exchanging electrons with solid extracellular electron donors such as iron(III) oxides, reducing them to iron(II) [1]. Since iron in bauxite and red muds mainly occurs as oxide forms (hematite $Fe_2^{III}O_3$ or goethite $Fe^{III}O(OH)$), a possible nanomaterial product of this reduction reaction is magnetite $Fe_3O_4$ ($Fe^{II}Fe_2^{III}O_4$). This, in principle, allows for a simple separation with a magnet.

Building on previous results in our laboratory [2,3] and current research, we present a low-cost and environmentally-friendly route to separate iron and aluminum in bauxite wastes using electroactive bacteria. First, the iron contained in red muds is rendered bioavailable to the bacteria via a reductive dissolution step, producing amorphous and/or low crystallinity iron oxyhydroxides. These iron oxyhydroxides are then susceptible to reduction and reprecipitation to biomagnetite through *exo*-electrogenic respiration. We show how this bioelectrochemical route leads to clean magnetic separation under ambient pH and temperature conditions, representing a promising route for sustainable bauxite waste valorisation and novel nanomaterial biosynthesis.

This biologically synthesised magnetite can be applied in multiple fields, including cancer treatment, as a contrast agent in MRI, and as a depollution catalyst for the electroreduction of nitrates [4].

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# Electrochemical Approaches for Selective Protein Detection Using Molecularly Imprinted Polymers: Physicochemical Optimization and Recent Advances

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The early diagnosis of proteins is essential for the treatment and monitoring of many serious diseases. Due to their portability, high sensitivity, low detection limits, and rapid response, electrochemical techniques have become powerful analytical tools for protein sensing. In particular, electrochemical measurements provide valuable information not only for protein detection, but also for understanding the interaction mechanisms between proteins and their recognition matrices. To achieve selective detection, molecularly imprinted polymers (MIPs), also known as "artificial antibodies," were developed as stable and low-cost alternatives to conventional bioreceptors [1].

In this work, electrochemical MIP-based biosensors were designed for selective protein detection using dopamine electropolymerization. Square-wave voltammetry (SWV) and cyclic voltammetry (CV) were employed to monitor surface modification, protein extraction, and rebinding processes. Two imprinting strategies were compared: bulk electropolymerization in the presence of the protein template, and surface-confined imprinting based on protein immobilization onto self-assembled monolayers prior to polymerization. The results demonstrated that surface imprinting significantly improves protein recognition, leading to stronger affinity and lower dissociation constants.

Electrochemical measurements were also used to investigate the influence of intrinsic protein properties, such as molecular weight and isoelectric point, as well as key physicochemical parameters including pH, ionic strength, and redox probes. The findings revealed that proteins can generate their own electrochemical response in PBS buffer without external mediators, while redox probes may hinder protein–cavity interactions. Optimal sensing performances were obtained at physiological conditions (pH 7.4 and ionic strength of 167 mM). In these conditions, the limit of detection was found in the order of 1 fg/mL and Kd is the order of $(8.7 \pm 5.9) \times 10^{-11}$ mg/mL [2].

The present study highlights the major role of electrochemical measurements in the design, characterization, and optimization of MIP-based biosensors, providing an effective strategy for sensitive and selective protein detection in biomedical applications.

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# Popcorn-Shaped Expanded Graphite for Electrochemical and Bioelectrochemical detection of Ethanol

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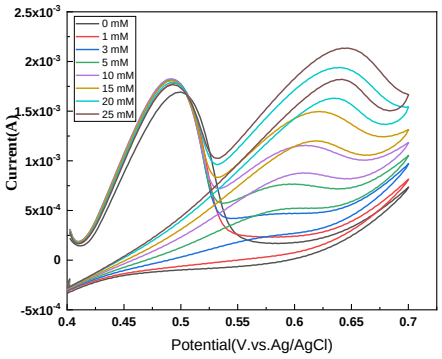
Ethanol is a key analyte in biofuel production, food processing, clinical diagnostics, and environmental monitoring, creating a strong demand for sensitive, rapid, and cost-effective sensing technologies [1]. In this work, a novel electrochemical ethanol sensor based on microwave-expanded graphite (EG) with a popcorn-like morphology was developed and evaluated [2]. The expanded graphite was deposited onto a glassy carbon electrode (GCE) and subsequently modified with electrodeposited nickel nanoparticles to enhance electrocatalytic activity. Electrochemical characterization by cyclic voltammetry and electrochemical impedance spectroscopy demonstrated improved electron-transfer properties and a significantly enlarged electroactive surface area compared with the bare electrode. The optimized Ni-EG/GCE sensor exhibited excellent analytical performance for ethanol detection, with a sensitivity of 1.71 µA. $mM^{-1}$. $cm^{-2}$ and a detection limit of 200 µM. Although the sensor showed good selectivity against uric acid, acetone, and 1-propanol, interference from glucose and ascorbic acid remained significant. Therefore, to improve the selectivity toward ethanol, an ADH-based enzymatic biosensor was developed using the expanded graphite platform.

In parallel, an enzymatic ethanol biosensor was constructed by immobilizing alcohol dehydrogenase (ADH) onto the expanded graphite "popcorn" platform. The porous and conductive structure of EG provided a favorable microenvironment for enzyme immobilization and efficient electron transfer. After optimization of ADH and $NAD^+$ concentrations, the ADH-EG/GCE biosensor achieved a detection limit of 89 µM and exhibited two linear response ranges (0.1-5 mM and 5-25 mM), with high selectivity and reproducibility [1]. These results demonstrate that popcorn-shaped expanded graphite is a promising electrode material for both non-enzymatic and enzymatic ethanol sensing, offering a versatile platform for the development of high-performance electrochemical biosensors for industrial, environmental, and biomedical applications.




Cyclic Voltammetry Responses toward Different Ethanol Concentrations

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# Development of Hydrogenase-Based Biosensor for Hydrogen

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The ongoing climate changes make our society orient towards green energy sources in order to reach a climate-neutral economy. In this context, hydrogen rapidly gains attention as it can substitute the traditionally used fossil fuels, and has a lot of possible applications in industry, transport, power and buildings sectors. However, the main disadvantage of hydrogen usage in such processes is the requirement for high security conditions, as it is a colourless, odourless, and highly flammable gas, which cannot be perceived without any highly energy-consuming sensing devices. The current $H_2$ sensors can be categorized based on the transducing principles: catalytic (pellistors), thermoconductive, resistive, electrochemical, optical, mechanical or acoustic. Each type comes with advantages and trade-offs that bring downsides. Mainly, the downsides imply selectivity issues, as they can respond to other gasses as well, response time issues, but the most common of them is the high-power consumption and high cost of production. Thus, developing an electrochemical sensor based on highly selective enzyme for $H_2$ detection turns out as an innovative concept for reliable hydrogen leak detection in enclosed spaces, such as fuel cells. One hydrogenase suitable for this purpose appears to be the *Aquifex aeolicus* membrane-bound [NiFe]-hydrogenase I (*Aa*Hase) as it has a series of qualities that allow performing in complex environments: it presents $O_2$-tolerance, CO-tolerance, and thermostability.[1] Our group published a proof-of-concept paper showing how this [NiFe]-hydrogenase can be used in building hydrogen sensing device and can serve in a bioreactor containing $H_2$-producing bacteria. The developed bioelectrode has a sensitivity of 4 μA $cm^{-2}$ per % $H_2$ and a linear range of detection between 1% and 10. This biosensor's results correlate well with gas chromatography proving its robustness.[2]

Despite the robust signal, sensitivity, linear range, and stability remain to be improved. Hereby, after having discussed the stability of the enzyme in different conditions, I will present the design of a bioelectrode based on *Aa*Hase, using different nanomaterials to enhance the obtained signal. I will compare the kinetics of $H_2$ oxidation at the electrode to homogeneous conditions looking especially at the influence of temperature. I will then evaluate the effect of salt concentrations on the enzymatic activity. I will outline the positive influence of electrolyte ionic strength on the stability of the bioelectrode. Finally, I will layout the type of interactions involved in the immobilization of *Aa*Hase on the electrode.

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# Printed OECT Biosensor with an $H_2O_2$-Responsive Nanozyme Gate for Biosensing

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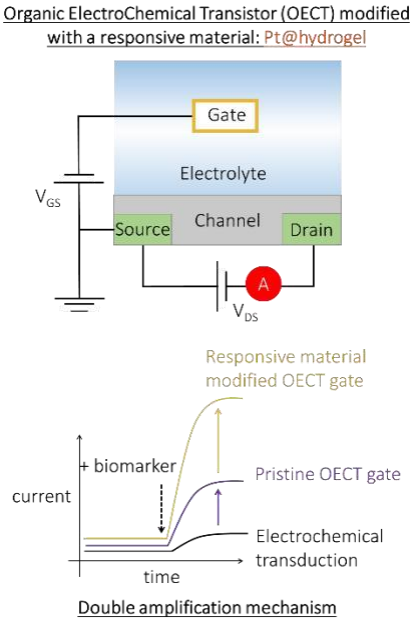
Biomarkers such as viruses, biomolecules, and hormones play a central role in monitoring physiological conditions and enabling timely medical decisions. While optical methods remain widely used in biosensing, electrochemical transduction offers distinct advantages, including compatibility with complex media and the direct generation of electronic signals suitable for automated analysis and transmission [1]. These features make electrochemical approaches particularly attractive for the development of accessible point-of-care diagnostic tools.




In this work, we introduce a fully printed organic electrochemical transistor (OECT) platform for sensitive and quantitative biosensing. The approach relies on the modification of the gate electrode with a highly selective nanocatalysts (nanozymes) for $H_2O_2$ oxidation comprising a metal core and an $H_2O_2$-responsive supramolecular shell, enabling the transduction of a biochemical event into a measurable electrical signal. Specifically, the platform targets hydrogen peroxide ($H_2O_2$) [2], a versatile electroactive reporter in biosensing, using a responsive hydrogel embedding catalytic nanomaterials that are activated upon analyte exposure.

The device architecture was optimized [3] to maximize signal amplification, leveraging both the dynamic behavior of the supramolecular system and the intrinsic transconductance of the OECT. This strategy establishes a versatile framework for the development of low-cost, printable, and highperformance biosensors with strong potential for point-of-care applications.

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# Electrode nanostructuration effect on electrocatalysis by an oxygen-tolerant [NiFe]-hydrogenase

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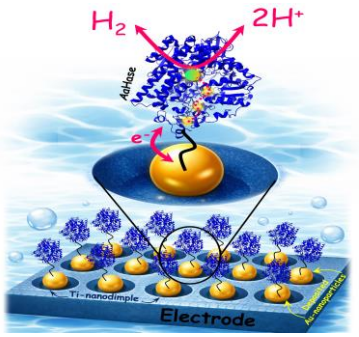
Hydrogenases are highly efficient metalloenzymes capable of catalyzing both hydrogen oxidation and hydrogen production under mild conditions, making them promising catalysts for bioelectrochemical energy conversion [1]. Among them, [NiFe]-hydrogenases exhibit high catalytic activity with a strong bias toward hydrogen oxidation over hydrogen production. In particular, the membrane-bound Ni–Fe hydrogenase I from the hyperthermophilic bacterium *Aquifex aeolicus* (*Aa*HaseI) displays high oxygen tolerance and exceptional thermostability within this enzyme class [2]. Despite these advantages, integrating [NiFe]-hydrogenases onto electrode materials to enhance electroactivity and stability, control catalytic bias, and beyond understand enzyme–electrode interactions remain the significant challenges [3,4].

Here, we report the electroenzymatic activity of *Aa*HaseI immobilized on gold nanoparticles uniformly deposited on nanostructured Ti/$TiO_2$ substrate. We will demonstrate how the nanostructured surface can significantly enhance catalytic current magnitude and stability for hydrogen oxidation compared to standard polycrystalline gold-disc electrodes. We will show that the catalytic bias can be modulated by varying the deposited AuNP size. These results highlight the potential of hydrogenase on electrode interfaces for tunable hydrogen electrocatalysis to advance the design of biohybrid electrodes for sustainable hydrogen energy technologies.

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# A COF-Based Electrochemical Aptasensor for Ultrasensitive Detection of CFTR Protein

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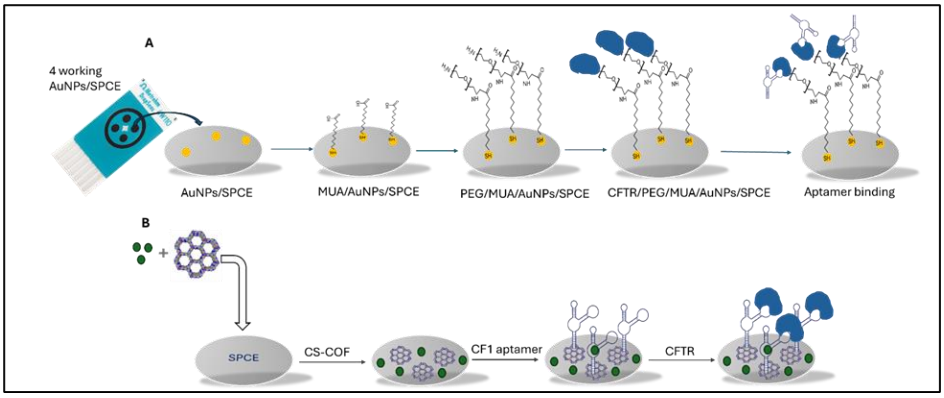
Cystic fibrosis transmembrane conductance regulator (CFTR) is a key biomarker involved in cystic fibrosis diagnosis and therapy monitoring. However, its determination remains challenging because of its low expression levels and the limitations associated with conventional immunoassays. In this work, ssDNA aptamers targeting CFTR were generated through ten rounds of SELEX and integrated into electrochemical sensing platforms. First, an electrochemical microarray composed of gold nanoparticle-modified carbon electrodes was developed to evaluate the affinity of the selected aptamers toward CFTR. Differential pulse voltammetry measurements revealed that the aptamer CF1 exhibited the highest affinity, with a dissociation constant of 7.55 nM.

Subsequently, a voltammetric aptasensor based on covalent organic frameworks (COFs) was fabricated for CFTR quantification. The COF nanostructure provided a high surface area and favorable microenvironment for aptamer immobilization, leading to enhanced electrochemical performance. Under optimized conditions, the proposed aptasensor exhibited a wide linear range from 0.01 to 500 pg/mL and a low detection limit of 0.037 pg/mL. High selectivity toward CFTR was demonstrated against interfering proteins, and successful applicability in spiked whole blood samples was achieved. These findings demonstrate the potential of combining aptamers with COF-based electrochemical platforms for the sensitive and selective detection of CFTR, opening promising perspectives for cystic fibrosis diagnostics and therapeutic monitoring.

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# Harnessing electroactive microorganisms for nitrate removal

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Driven by the need to feed a fast-growing global population, agriculture has intensified livestock production and increased the use of inorganic fertilizers. As a result, large amounts of ammonia from manure and fertilizers enter the soil, where it is converted to nitrate. When nitrate levels exceed the plant demand, the remaining nitrate moves from soils into groundwater and surface waters[1]. In Europe, around 77% of the nitrogen entering aquatic systems comes from agriculture[2]. Similarly, farms in Brittany are the dominant source of nitrate leaching into soils and water, driving eutrophication and recurrent green tides along the Breton coast. These large algal blooms disturb coastal ecosystems and put human health at risk, while also having a negative impact on tourism and local industry. Conventional denitrification approaches vary in efficiency and costs, and often require the addition of chemicals. These limitations can be alleviated by using bacterial denitrification[3,4].

This project aims to develop a bioelectrochemical system that uses electroactive bacteria to reduce nitrate in natural water streams. The system relies on selectively growing electroactive bacteria for organic matter oxidation first before switching their metabolism to nitrate reduction. Anodic biofilm growth was initially stimulated on carbon-felt electrodes by applying a constant potential (100 mV vs. Ag/AgCl) and adding acetate to the bioreactor. Using a compost-electrolyte solution as an inoculum source, it was possible to grow acetate-oxidizing electroactive biofilms for 7 to 10 days. Upon complete depletion of acetate in the bioreactor, nitrate was added as the new final electron acceptor, and the applied potential was changed to -500 mV vs. Ag/AgCl. After 10 to 20 days under nitrate-reducing conditions, these biofilms showed cathodic electroactive response.

Developing such a system that can be deployed as close as possible to the nitrogen source would enable nitrogen removal before it disperses into the environment, thereby reducing nitrate leaching into soils and aquatic systems. Moreover, using local bacterial species for the bioanode/converted biocathode would enhance system adaptability across different locations. This could help limit eutrophication and the proliferation of green algae, while improving surface and groundwater quality.

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# Fabrication and Modeling of Enzymatic Gas Diffusion Electrodes for Oxygen Reduction in Buffered Electrolyte

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Redox enzymes are widely regarded as promising alternatives to inorganic catalysts for the efficient activation of small gas molecules such as $H_2$, $O_2$, CO, and $CO_2$ under mild conditions. To realize their full potential, gas-diffusion electrodes (GDEs) enable high-density enzyme immobilization within a three-phase interface, effectively overcoming substrate solubility limits to maximize volumetric activity. However, this necessary spatial confinement creates a complex microenvironment characterized by molecular crowding and restricted substrate accessibility. Furthermore, the catalyzed redox reactions themselves can alter the microenvironment, for example, by releasing or consuming protons, thereby modifying local pH. Understanding how such changes influence enzyme activity and stability is therefore critical.[1] While optimizing the balance between architecture of the three-phase interface, enzyme stability, and activity is essential, systematic experimental testing is labor-intensive given the complex interplay of various design parameters and offers insufficient insight into the dynamic intrapore microenvironment.

To address these challenges, we employed COMSOL Multiphysics® to simulate these enzymatic GDEs, using bilirubin oxidase from *Myrothecium verrucaria* (*Mv*BOD) as a model system to quantify the impact of reaction-induced pH shifts during four-electron oxygen reduction.[2] We constructed a model that explicitly incorporates the pH-dependence of key kinetic parameters to investigate the influence of these variables on the catalytic response. Beyond enzyme kinetics, the model integrates key structural parameters, such as porosity and electrode thickness, alongside wetting properties to evaluate how they modulate the local microenvironment and dictate catalytic efficiency. Experimentally, we constructed an enzymatic GDE with a hierarchical architecture by adsorbing *Mv*BOD on a CNTs-modified carbon cloth. The simulated cyclic voltammograms were compared with experimental data obtained from the electrodes to validate the model accuracy. The specific spatial gradients revealed by this model are further corroborated by studies employing a pH-sensitive fluorescent dye and confocal fluorescence microscopy.[3] Consequently, our findings can provide guidelines for optimizing electrode structural properties and local electrolyte conditions, enabling the design of high-performance enzymatic GDEs.

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# Design of Electrochemical Aptasensors for Emerging Pollutants: Influence of Aptamer Grafting Strategy on Aptamer/Target Interaction and Sensing Performance

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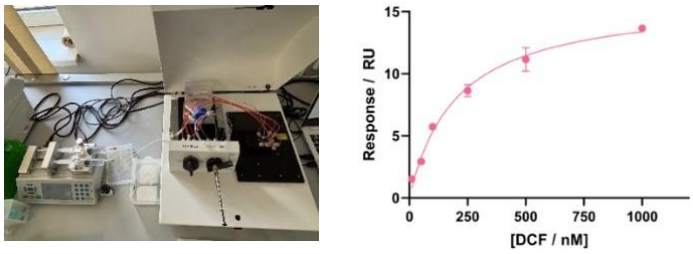
Electrochemical biosensors are particularly attractive tools for the detection of environmental pollutants, owing to their high sensitivity, selectivity, and potential for miniaturization enabling *in situ* monitoring of complex environmental matrices such as river water [1]. Among biorecognition elements, aptamers have attracted considerable attention because of their high affinity and specificity toward target analytes, their superior stability compared to antibodies, and their ease of chemical modification for surface immobilization or redox /fluorescent labeling. Yet, the rational design of high-performance aptasensors remains challenging: key bottlenecks include *(i)* achieving stable and reproducible aptamer immobilization *(ii)* controlling surface bioreceptor density, and *(iii)* preserving aptamer binding affinity after surface confinement [2]. Although numerous immobilization strategies have been proposed, only a limited number of studies have systematically investigated their impact on the apparent dissociation constant of surface-confined aptamers and on sensor selectivity in the presence of interfering compounds.

In this study, we address this gap by evaluating how the immobilization strategy influences target recognition and sensor selectivity using a dual analytical approach combining surface plasmon resonance (SPR) [3] and electrochemical impedance spectroscopy (EIS). Two immobilization strategies yielding distinct surface probe densities were compared: self-assembled monolayer formation on gold electrodes and covalent grafting within a thin hydrogel matrix. Selectivity was challenged using environmentally relevant interferents, including structural analogues of diclofenac and compounds typically present in natural waters at concentrations exceeding that of the target analyte. This systematic approach reveals the interplay between immobilization strategy, surface organization, and sensing performance, and provide design guidelines for robust aptasensor development targeting emerging pollutants.




Illustrative determination of the affinity of surface confined aptasensor for diclofenac using SPR

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# A conserved Copper-Binding site in Multicopper Oxidases regulates the metalation of CueO from *Escherichia coli*.

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CueOs are multicopper oxidases (MCOs) involved in key biological processes related to copper homeostasis.[1] Their physiological function is the catalytic oxidation of toxic cuprous ions ($Cu^+$) to cupric ions ($Cu^{2+}$), coupled with the reduction of $O_2$ to water.[2,3] In addition to the copper sites belonging to the classical electron transfer chain of MCOs, from Cu-T1 to the trinuclear cluster (TNC), a Cu8-site was previously identified in *Ec*CueO crystal structures, located in close proximity to TNC.[4,5] One conserved ligand of the Cu8-site is the amino acid $H_{145}$, in both $Cu^+$ and $Cu^{2+}$ redox states. By designing and characterizing the $H_{145}S$ variant, this work demonstrates for the first time the pivotal role of $H_{145}$ in the functional maturation/metalation of *Ec*CueO active sites under conditions of low $Cu^{2+}/Cu^+$ availability. Moreover, we show that $H_{145}$ is part of a conserved HxHxH motif in CueOs, and more generally in bacterial MCOs, suggesting a common copper-binding Cu8-site for metalation *in vivo*. The absence of this conserved motif in certain MCOs, or the presence of additional His/Met-rich or His-rich insertions, appears to be linked to cellular copper availability and highlights the adaptability of MCOs. Beyond this fundamental understanding of MCO metalation mechanism, this works paves the way for application in medicine and environmental copper detection.

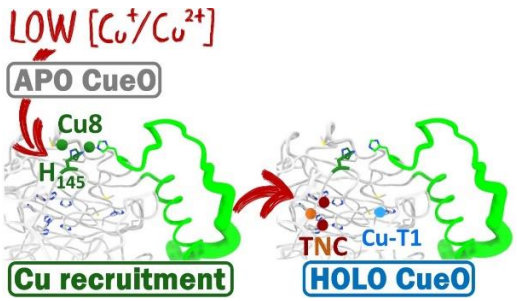


**Figure:** In environments where the availability of $Cu^+/Cu^{2+}$ is limited, the presence of $H_{145}$ residue is crucial for the recruitment of cofactors to the Cu8-site and for ensuring the rapid metalation of APO CueO to HOLO CueO.

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# Posters

# Wearable electrochemical biosensors for real-time sweat glucose and lactate monitoring in powerlifting

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Continuous monitoring of biomarkers is gaining strong interest for personalized medicine and sports physiology because it enables the capture of transient metabolic responses during exercise and recovery [1-2]. Sweat is an attractive alternative biofluid to blood and interstitial fluid because it is compatible with non-invasive and wearable sensing platforms [3]. Among the most relevant sweat biomarkers, glucose and lactate are of particular interest for tracking substrate availability, exercise intensity, and metabolic adaptation [4-5].

In this work, we developed enzymatic electrochemical biosensors [6] for longitudinal monitoring of sweat glucose and lactate during powerlifting training sessions. The aim was to investigate whether sweat biomarker dynamics could reflect changes in training load, recovery, and return-to-play status.

Preliminary results suggest that lactate clearance evolves over the training period in a consistent manner with changes in exercise status and recovery. In addition, peak lactate values during load progression were associated with lifting intensity, suggesting a relationship between metabolic response and training demand. In parallel, glucose monitoring was included as a complementary target to capture changes in energetic substrate availability during effort and recovery. Finally, blood and sweat lactate profiles showed similar overall trends in the first kinetic phase, supporting the relevance of sweat-based monitoring, while also emphasizing the need for further work on later time points and individualized interpretation.

These findings support the potential of next-generation wearable electrochemical biosensors for continuous, non-invasive assessment of metabolic responses during strength training.

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# Lytic Polysaccharides MonoOxygenases, copper enzymes for the valorization of recalcitrant polysaccharides

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The increased dependence on oil has led research to new ways to produce chemicals and fuel. Biomass is one attractive option to limit the petroleum dependence. Cellulose and chitin are both polysaccharides from biomass that are recalcitrant to depolymerization which still limits their valorization. In this context, LPMOs (Lytic Polysaccharide MonoOxygenases) have attracted attention. LPMOs are copper-dependent enzymes that catalyze the hydroxylation of a C-H bond at the glycosidic linkage, in the presence of dioxygen or hydrogen peroxide as co-substrate, further leading to chain cleavage. These enzymes possess a unique active mononuclear copper site including a specific coordination motif, named “histidine brace”, which consists of two histidines with one interacted in a bidentate fashion with the copper ion [1]. In the team, we focus on studying the interaction between the enzyme, the copper ion and the substrate to better understand the mechanism of these enzymes and improve the efficiency of biopolymer degradation. To do so, we will study bacterial chitin-active LMPOs and various mutants of the coppers’ second coordination spheres, using spectroscopic methods, activity assays and electrochemical approaches. We will also evaluate the impact of experimental parameters such as pH on the structural and functional properties of the enzyme.

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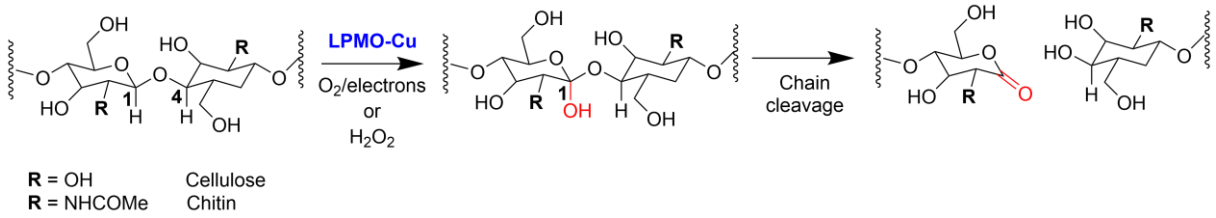
**Figure 1** : Reaction of LPMO on his natural substract

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# Dielectrophoretic Electrochemical Biosensor for the quantification of insulin in blood

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Accurate insulin quantification is essential for effective diabetes management because it provides real-time insight into insulin dynamics, enabling more precise control of glucose homeostasis and helping to reduce the risk of long-term consequences. Although conventional insulin measurement methods and delivery systems have improved glycemic control, accurate dosing remains challenging, highlighting the need for point-of-care (POC) devices.

In this project, we propose integrating a biosensor with dielectrophoresis (DEP) to overcome key limitations of conventional approaches, which often require multiple washing steps to mitigate bioreceptor cross-reactivity and non-specific adsorption. Such procedures are poorly suited to POC applications that demand rapid, simple, and reliable operation. We hypothesize that incorporating DEP into the sensing platform will address these challenges by actively concentrating insulin molecules near the sensing electrodes, enabling detection in the picomolar (pM) range. This local enrichment is expected to enhance sensitivity, improve selectivity, and increase measurement stability, enabling more reliable real-time insulin monitoring.

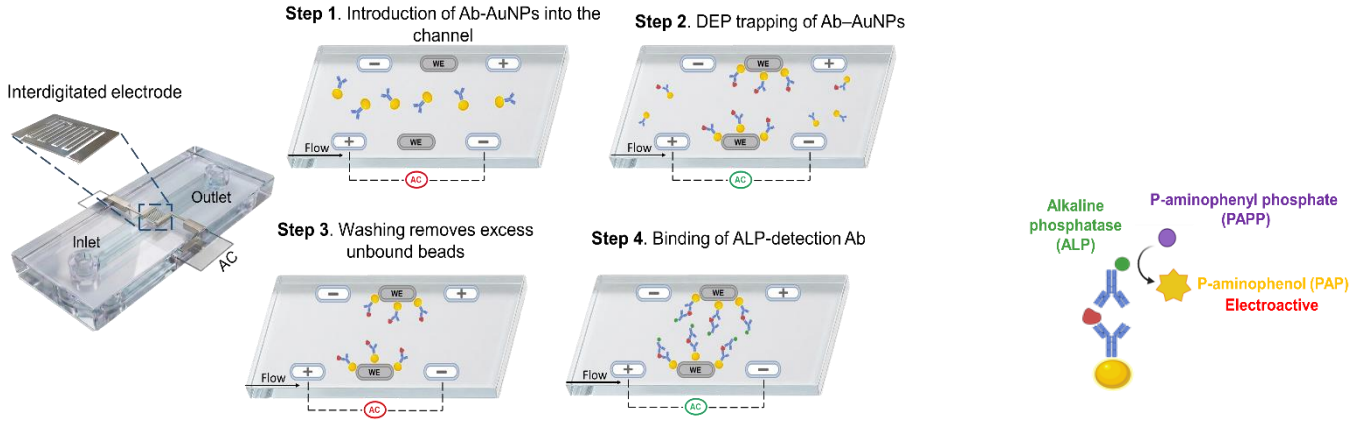


**Figure 1.** Schematic of the microfluidic device to measure insulin via DEP

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# Exploring NADH electrocatalysts for β-hydroxybutyrate biosensing at multiwalled carbon nanotube bucky paper transducers

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Electrochemical sensing of β-hydroxybutyrate (BHB), a ketone that is indicative of the onset of the potentially fatal complication, diabetic ketoacidosis, is of significant clinical importance in diabetic healthcare. This work focuses on the development of an enzymatic electrochemical biosensor based on β-hydroxybutyrate dehydrogenase (BHB-DH) which catalyses the reversible oxidation of BHB to acetoacetate in the presence of the cofactor couple: $NAD^+$/NADH.

$$\beta\text{-hydroxybutyrate (BHB)} + NAD^+ \leftrightarrow \text{acetoacetate} + NADH$$

A major limitation in such systems in the inefficient electrochemical oxidation of NADH at conventional electrode surfaces which is kinetically unfavorable, highly irreversible and typically requires a large overpotential (~1 V on bare electrode). Electrode fouling by $NAD^+$ dimers forming on the surface is also a common difficulty faced in these systems. To address these challenges, this work presents the use of phenolic redox mediators to facilitate efficient $NAD^+$ regeneration and lower the redox potential by exploiting their conjugated structures and redox-active centres. Several antioxidant compounds are evaluated and compared with respect to their electrochemical behaviour and catalytic capability to enhance mediator-substrate interactions and ability to improve electron transfer kinetics. Their enzyme compatibility for BHB-DH was also assessed to ensure preservation of enzymatic activity on the electrode. These mediators were integrated onto carbon-based transducers incorporating carbon nanotube structures which provide high surface area, advanced conductivity and favourable electrocatalytic properties. This work aims to identify mediator-electrode combinations that enhance sensitivity, reduce overpotential and improve stability of BHB biosensors, contributing to the development of point of care ketone monitoring devices.

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