XXX TRANSFRONTIER MEETING ON SENSORS AND BIOSENSORS (TMSB2026)

BOOK OF ABSTRACTS

UPVD, Perpignan | 17 - 18 September 2026

Hosting Institution:

Université de Perpignan Via Domitia
Institut Universitaire de Technologie
77 Chemin de la Passio Vella
66 100 Perpignan

Organising committee:

Thierry Noguer
Georges Istamboulie
Carole Blanchard
Gaëlle Catanante
Marta Meneghello

Benvinguts al TMSB 2026!

Dear colleagues,
We are very proud and honored to welcome you to the 30th edition of the Transfrontier Meeting on Sensors and Biosensors (TMSB 2026).
TMSB was created in 1996 at the initiative of Profs. Salvador Alegret (Universitat Autònoma de Barcelona), Jean-Louis Marty (Université de Perpignan) and Maurice Comtat (Université Paul Sabatier), with the aim of bringing together researchers from the Euroregion (Catalonia, Occitanie) working in the field of sensors and biosensors. Since then, TMSB has become an annual meeting which is hosted alternately by research groups located on each side of the border, as listed below:

1 - Barcelona, 15-16 July 1996
2 - Céret, 18-19 September 1997
3 - Peníscola, 17-18 September 1998
4 - Montpelhièr, 16-17 September 1999
5 - Vic, 21-22 September 2000
6 - Tolosa, 20-21 September 2001
7 - Barcelona, 19-20 September 2002
8 - Céret, 18-19 September 2003
9 - Tarragona, 16-17 September 2004
10 - Albi, 15-16 September 2005
11 - Girona, 14-15 September 2006
12 - Céret, 27-28 September 2007
13 - Andorra-la-Vella, 18-19 September 2008
14 - Banyuls-de-la-Marenda, 24-25 Sept. 2009
15 - Sant Carles de la Ràpita, 16-17 Sept. 2010
16 - Tolosa, 29-30 September 2011
17 - Tarragona, 20-21 September 2012
18 - Alès, 19-20, September 2013
19 - Barcelona, 25-26 September 2014
20 - Perpinya, 1-2 October 2015
21 - Barcelona, 29-30 September 2016
22 - Montpelhièr, 21-22 September 2017
23 - Barcelona, 19-20 September 2018
24 - Perpinya, 26-27 September 2019
25 - La Ràpita (online), 30 Sept 2021
26 - Barcelona, 29-30 September 2022
27 - Banyuls-de-la-Marenda, 28-29 Sept 2023
28 - La Ràpita, 26-27 September2024
29 - Tarragona, 18-19 September 2025
30 - Perpinya, 17-18 September 2026

This year, we are delighted to organise the 30th edition of the Transfrontier Meeting at the Université de Perpignan Via Domitia, on the premises of the University Institute of Technology.

As already mentioned, TMSB is intended to be a place of exchange in a relaxed and friendly atmosphere, and as usual priority will be given to doctoral students and young researchers to present their results in oral and poster communications.

We sincerely hope that this meeting will lead to fruitful exchanges and will help to foster new collaborations on both sides of the Pyrenees and far beyond!

Thierry Noguer,

on behalf of the organising committee

Aknowledgements

The organising committee extends their sincere thanks to the University of Perpignan Via Domitia (UPVD) and Catalan Society of Biology (SCB) for their kind support, as well as the University Institute of Technology for hosting this event in their facilities.

Scientific and Social Program

Thursday 17th September		
13:00 -14:00	**Registration and poster installation**	
14:00 - 14:10	**Opening (Amphithéâtre A, IUT Perpignan)**	
	Oral communications. **Chair: Thierry Noguer (UPVD)**	
14:10 - 14:50	Keynote lecture 1: **Ana-Maria Gurban (ICECHIM, Bucharest, Romania)** Integrated Opto-Electrochemical (Bio)sensing with Advanced Hybrid Nanomaterials: from Fundamental Design to Real Solutions for Health, Food and Environmental Monitoring	KL 1
15:00- 15:15	**Anaixis del Valle (UAB)** Portable electrochemical genosensing of IFN-γ mRNA in HLA-DR$^+$ extracellular vesicles for decentralized immune monitoring	OC 1
15:20 - 15:35	**Laia Garrido-Carretero (UAB)** Optimizing potentiometric sensing strips: paving the way for at-home monitoring of hereditary metabolic diseases	OC 2
15:40 - 15:55	**Jaume Reverté (IRTA)** Automated patch clamp as functional biosensing technology for marine toxins: from cellular responses to food safety decision	OC 3
16:00 - 17:00	**Coffee break and Poster session (Room C13)**	
	Oral presentations. **Chair: Carole Blanchard (UPVD)**	
17:00 -17:40	Keynote lecture 2: **Yanxia Hou-Broutin (CEA, Grenoble)** Biomimetic Optoelectronic Nose for Analysis of Odors	KL 2
17:50 - 18:05	**Rosanna Rossi (UAB)** Plasma biosensor based on brain-derived exosomes for early Alzheimer's disease detection and risk-stratification of dementia patients. Preliminary results from SENS4AD project	OC 4
18:10 - 18:25	**Alessandra Cutillo-Foraster (UAB)** Studying the spectroelectrochemical behaviour of Ce(III)/Ce(IV) system by UV-vis in normal reflection mode	OC 5
18:30 - 18:45	**Núria Barrera Gutiérrez (IMB-CNM, Barcelona)** Validation of an ISFET-based multisensor system for macronutrients monitoring in horticultural applications	OC 6
20:00	**Gala Dinner - Restaurant le Mas Chabry (Perpignan)**	

Friday 18th September		
	Oral presentations. **Chair: Mònica Campàs (IRTA)**	
9:00 - 9:40	Keynote lecture 3: **Derrick Butler (IES, CNRS, Montpellier)** Cantilever-based MEAs for simultaneous recordings of electrophysiological and mechanical signals of contractile organoids	KL 3
9:50 - 10:05	**Ainhoa Chaves Horrillo (UPVD)** Electrochemical sensors monitoring of PFAS solar decontamination in Wastewater	OC 7
10:10 - 10:25	**Nuan Zhang (IMB-CNM, Barcelona)** Sustainable functionalized forestry residues for manufacturing electrochemical sensors toward water pollution monitoring	OC 8
10:30 – 11:15	**Coffee break and Poster session (Room C13)**	
11:15 – 11:30	**Claudio Roscini (ICN2, Barcelona)** Waxes-based fluorescent thermal sensors	OC 9
11:30 – 11:45	**Haroon Muhammad Ali (UAB)** Determining acetylcholinesterase activity with functionalized carbon dots synthesized in microreactors	OC 10
12:00 - 12:45	Closure remarks, TMSB2026 Awards, & Group Photo	
13:00	**Closure lunch – La table du Mas (Perpignan)**	

Abstracts

Keynote lectures and oral presentations

Integrated Opto-Electrochemical (Bio)sensing with Advanced Hybrid Nanomaterials: from Fundamental Design to Real Solutions for Health, Food and Environmental Monitoring

Ana-Maria Gurban[1 *], Lucian-Gabriel Zamfir[1], [(†)]Raluca Ianchiș[1], Petru Epure[2], Ioana Cătălina Gîfu[1], Iuliana Răut[1], Mariana Constantin[1], Cristina Firincă[1], Maria-Luiza Jecu[1], Mihaela Doni[1,*]

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The incresing need for safety in healthcare, water resources, and the food supply chain represents a major public health challenge, requiring portable, affordable tools capable of rapid, accurate, real-time and on-site monitoring. Recent advances in nanotechnology have opened new directions for versatile optoelectrochemical biosensing platforms addressing these challenges across clinical diagnostics, food quality control, and environmental monitoring [1].

This lecture presents a series of innovative biosensing platforms built on carbon-based nanostructures, including fullerenol, single and multi-walled carbon nanotubes (SWCNTs/MWCNTs), and MXene, often combined with metallic nanoparticles and the redox mediator Prussian blue. These nanomaterials enable stable, sensitive bioreceptor immobilization and enhanced electron-transfer properties, translating into robust analytical performance across diverse matrices.

Applications for the developed biosensing platforms span the sensitive aptasensor-based detection of antibiotic residues (tetracycline, penicillin) in meat products, the monitoring of food and environmental contaminants such as aflatoxin M1, nitrite, and biogenic amines, and a wearable multiplex patch enabling noninvasive, simultaneous detection of glucose, lactate, hydrogen peroxide, and cortisol in sweat [2,3].

Together, the developed opto-electrochemical platforms illustrate how nanotechnology can be translated into practical, field-deployable tools for the sensitive detection of clinically relevant biomarkers, food contaminants, and environmental pollutants. Such integrated platforms hold strong potential to accelerate the implementation of advance personalized medicine, strengthen food security strategies, and support environmental sustainability.

References

[1] J. Wang, *Electroanalysis,* 2005, **17**, 2005, 7-14, doi.org/10.1002/elan.2004.03113

[2] Gurban A.-M., et al., *Chemosensors*, 2023, **11(4)**, 224, doi.org/10.3390/chemosensors11040224

[3] Zamfir L-G, et al., *Food Control*, 2025, **172**, 111161, doi.org/10.1016/j.foodcont.2025.111161

Acknowledgements: This work was supported by the Ministry of Research, Innovation and Digitization, through projects M-ERANET-318/2022 (FULSENS-GEL), within PNCDI III, PN 23.06.01.01-AQUAMAT, PN-III-P2-2.1-PED2021-1942 (AMI-FOOD), and PN-IV-P7-7.1-PED-2024-1277 (SafeBioChain).

Portable Electrochemical Genosensing of IFN-γ mRNA in HLA-DR$^+$ Extracellular Vesicles for Decentralized Immune Monitoring

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Interferon-gamma (IFN-γ) is a key cytokine of the cellular immune response, with broad clinical relevance in infection, oncology, and immunotherapy monitoring. Established assays (ELISA, RT-PCR, IGRA, ELISpot) require centralized laboratories and multistep protocols, limiting decentralized use. Extracellular vesicles (EVs) offer an alternative target: nanoscale, cell-derived particles carrying nucleic acids, recovered non-invasively from blood. Biological fluids, however, contain heterogeneous EV populations that dilute the immune-specific signal, so selective enrichment of the relevant subpopulation is a precondition for adequate sensitivity. We report a portable electrochemical genosensor targeting IFN-γ mRNA inside HLA-DR-positive EVs, enriched from activation-associated antigen-presenting cells and T lymphocytes. The platform integrates three modules: (i) HLA-DR-targeted immunomagnetic separation (IMS) of EVs; (ii) on-bead mRNA capture on poly(dT)-modified magnetic particles, reverse transcription, and double-tagging PCR that simultaneously amplifies and labels IFN-γ (biotin/fluorescein) and GAPDH (biotin/digoxigenin, a capture-and-amplification control); and (iii) amperometric readout on screen-printed carbon electrodes with a portable bipotentiostat.
Flow cytometry on PBMC-derived EVs identified HLA-DR as a suitable capture marker, preserved after immunomagnetic capture (76.1% vs. 65.0% in the bulk preparation) and coenriched with the tetraspanin CD81. Analytical calibration in PBMC and EVs reached LODs of 3.08 and 80.3 EVs μL^{-1} for GAPDH and IFN-γ, respectively, improved up to 1.7-fold by HLADR-targeted capture. Applied to pre-cleared PBMC culture supernatants (n = 8 donors), the assay resolved activation kinetics: IFN-γ was enriched over blank at day 15 (mean fold-change ≈ 11) and declined toward background by day 30, while GAPDH enrichment remained stable, confirming that the temporal change reflected transcriptional state rather than a loss of capture efficiency. Applied without pre-analytical purification to unprocessed plasma from six donors, IFN-γ was scored positive in four of six, fully concordant with an orthogonal qPCR readout (6/6; Cohen's κ = 1.000). The full workflow, from raw sample to amperometric readout, needs no ultracentrifugation or size-exclusion step and runs in ~4.5 h on portable instrumentation, supporting same-day, decentralized monitoring of defined EV subpopulations directly in unprocessed clinical matrices.

References:
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[2] Pallarès-Rusiñol, A. et al. *Anal Chem*, 2023, **95**(4), 2487–2495.

Optimizing potentiometric sensing strips: paving the way for athome monitoring of hereditary metabolic diseases

Laia Garrido-Carretero[1*], Beatriz Rebollo-Calderón[1], Antonio Calvo-López[1], Aida Ormazabal[2], Rafel Artuch[2], Julián Alonso-Chamarro[1], Mar Puyol[1]

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Hereditary metabolic diseases (HMDs) are genetic disorders that can severely affect patients' health and their quality of life, particularly due to complications involving the nervous system. To prevent these outcomes, regular biochemical monitoring is crucial, highlighting the need to move from occasional, complex hospital-based analyses to more frequent at-home testing.
In this work, we present cyclic-olefin-copolymer (COC) based potentiometric sensing strips designed for the direct or indirect determination of key HMD-related biomarkers. The strips incorporate two identical ammonium ion-selective electrodes and a gas-diffusion membrane, enabling effective isolation of the target ion from complex sample matrices. Their versatility allows the monitoring of multiple metabolic disorders by integrating enzymes capable of converting specific biomarkers into ammonium ions, thus adapting the sensing mechanism to different analytical needs.
This study focuses on four representative HMDs requiring biochemical monitoring, associated with altered levels of ammonium (NH_4^+), phenylalanine (Phe), leucine (Leu), and alanine (Ala).
We optimized the strip configuration, electrode materials, chemical composition, and analysis time for the determination of the four target species. Reliable operation within the pathological ranges of the corresponding diseases was achieved for three of the biomarkers, demonstrating their potential for future point-of-need (PON) applications. Urease was used initially as a model enzyme to validate the required enzymatic approach.
The results obtained in this investigation, together with previous work by our group [1], as well as successful autocalibration procedures with single-use potentiometric devices [2], make these strips excellent candidates for use in potentiometric point-of-need devices for at-home monitoring of HMDs, showing ease of use, low cost, and fast analysis time.

References:
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Automated Patch Clamp as Functional Biosensing Technology for Marine Toxins: From Cellular Responses to Food Safety Decisions

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The detection and characterisation of marine toxins, particularly those emerging in our waters, remains challenging, as conventional analytical methods often fail to provide the accurate and reliable information required to support food safety decisions and protect seafood consumers. Consequently, there is a need for advanced biosensing technologies capable of overcoming these limitations by providing robust, sensitive, and functionally relevant toxin detection. In this context, our group has explored the potential of automated patch clamp (APC) technology as a functional biosensing platform for the detection and characterisation of marine neurotoxins, including tetrodotoxins (TTXs), paralytic shellfish toxins (PSTs), and ciguatoxins (CTXs). By monitoring the activity of voltage-gated sodium channels (VGSCs), the APC system proved suitable for detecting VGSC-blocking neurotoxins, such as TTXs and PSTs, in both pufferfish [1,2] and shellfish [3], while also enabling the functional characterisation of their toxin analogues [3,4]. The platform is currently being adapted for the detection of other VGSC-targeting neurotoxins with different mechanisms of action, such as CTXs. A key advantage of this technology is that it detects toxins according to their biological activity rather than solely their chemical structure. As a result, it provides direct information on the toxic potential of a sample, generating functionally relevant data that can better support food safety risk assessment and decision-making.

References:
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Biomimetic Optoelectronic Nose for Analysis of Odors

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The human olfactory system is capable of detecting and discriminating between thousands of odors with remarkable sensitivity and selectivity. It has inspired researchers to develop sensor-based technology for artificial olfaction, such as electronic noses (eNs). However, the existing eNs are often limited by sensitivity and selectivity. Indeed, the advancement of artificial olfaction poses significant scientific and technological challenges. In the last decade, we have developed innovative biomimetic optoelectronic noses based on biomolecules as sensing elements, such as peptides, and an optical detection system, surface plasmon resonance imaging (SPRi) for the analysis of odors in gas phase. The device is highly versatile for the analysis of large chemical families of odorants, offering good sensitivity, selectivity and stability with potential applications in various fields.

Plasma biosensor based on brain-derived exosomes for early Alzheimer's disease detection and risk-stratification of dementia patients. Preliminary results from SENS4AD project

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Blood-based biomarkers, particularly brain-derived exosomes (BDEs), have emerged as a promising alternative for early Alzheimer's disease (AD) detection, since they carry AD-related molecules and can be isolated non-invasively. We developed a magneto immunoassay to isolate BDEs using magnetic particles functionalized with an anti-neuroligin-3 (NLGN3) antibody, while the AD-related marker β-secretase (BACE-1) was detected on the captured exosomes [1]. Then, we prepared and analyzed a total of 42 pooled plasma samples from 1586 patients with different syndromic diagnoses, such as AD (N=10), Amnesic Mild Cognitive Impairment (AMCI, N=15), Non-Amnesic Mild Cognitive Impairment (NAMCI, N=7), Subjective Cognitive Decline (SCD, N=5) and other dementia (OD, N=5). Three additional pooled plasma samples from healthy subjects were used as negative control (CTRL-). Each pool was considered as an individual sample. Exosomes were isolated by ultracentrifugation as previously reported [1]. Three mL of plasma were used initially, and isolated exosomes were resuspended in 50 µL PBS buffer. Purified exosomes were then enriched in BDEs and analyzed with a portable device integrated with an electromagnetic reader, as previously described [1]. Results were analyzed using a one-tail unpaired t-test against the CTRL- group, with a level of statistical significance at P<0.05 and are visually reported in Figure 1.

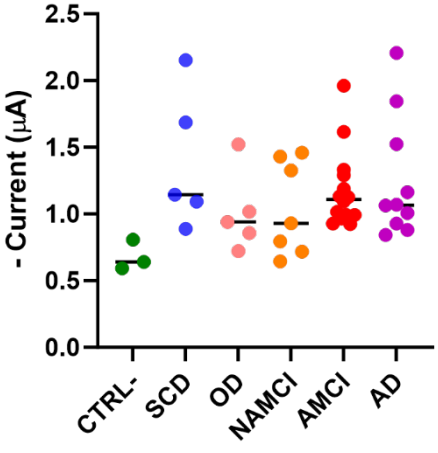

Figure 1: Preliminary results using 42 pooled plasmas from patients with different syndromic diagnostic showed that AD and AMCI samples got similar signals and both statistically significantly higher than CTRL- (respectively P=0,0303* and P=0,0059*). NAMCI and OD samples got signals not statistically significantly different than CTRL- (respectively P=0,0639 and P=0,0642). Interestingly, SCD behaved more similarly to AD and AMCI groups than to CTRL-, getting significantly higher signals (P=0,0312*).

These preliminary results support the potential of our method to identify disease-associated signals across dementia-risk groups, highlighting molecular similarities between SCD, AMCI and AD. However, validation in individual samples is still required and currently in progress.

References:
[1] Rossi R et al. *Biosens Bioelectron*, 2025, 292, 118061.

Studying the spectroelectrochemical behaviour of Ce(III)/Ce(IV) system by UV-vis in normal reflection mode

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UV-vis spectroelectrochemistry (SEC) in normal reflection mode enables the *in situ* investigation of optically and electrochemically active compounds by measuring the changes in the UV-vis spectrum during an electrochemical process. More specifically, the study is conducted using chronoamperometry, an electrochemical technique in which a constant potential is applied for a specific time, and the changes in the UV-vis spectrum are recorded simultaneously. This dual approach provides an electrochemical and optical response in a single experiment. In addition,

SEC in normal-reflection mode is suitable for reduced-volume analysis, typically below 100 µL, while maintaining analytical performance. In a previous work, UV-vis SEC in normal reflection mode was used as an analytical tool to study the system Fe(II)/Fe(III)-*o*-phenanthroline (OP) [1,2,3].

In this work, the viability of investigating the system Ce(III)/Ce(IV) was demonstrated, without the need to add a reagent to form a colored complex, by UV-vis SEC in normal reflection mode, due to the fact that the system exhibits both electrochemical and optical responses. In this regard, it was observed that in a solution containing Ce(IV), when a reduction potential is applied, the absorbance decreases between 340 and 350 nm due to the disappearance of the yellow color of the cation. In contrast, the opposite behavior is registered for a solution containing Ce(III), in which the absorbance increases positively due to the appearance of the yellow color of the Ce(IV)-ion. Based on these results, an analytical study was conducted to determine the analytical parameters (limit of quantification (LOQ), limit of detection (LOD), linear range and sensitivity) of the system Ce(III)/Ce(IV). Furthermore, a second study was carried out, taking advantage of the strong oxidizing power of Ce(IV), to evaluate the antioxidant capacity of ascorbic acid and gallic acid.

References:
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Validation of an ISFET-based multisensor system for macronutrients monitoring in horticultural applications

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This work presents a multisensor platform based on ISFET technology (**Figure a**) for the continuous monitoring of macronutrient ions in horticultural applications. Firstly, the system was trained using a fractional factorial design consisting on 27 calibration solutions and 10 test samples covering representative concentration ranges of Na^+, K^+, NH_4^+, NO_3^- and HPO_4^{2-} ions. Data was recorded using multi-channel ISFET-meters and processed using Partial Least Squares (PLS-1) multivariate regression, compensating at the same time the effect of temperature and the inherent drift of the sensors. Potassium and nitrate showed the most robust predictive models (explained variance > 80%), while sodium and ammonium achieved semiquantitative determination (variance > 40%), and phosphate yielded more limited but still trend-informative performance.

The trained probe was then deployed at the IRTA Fruitcentre (Lleida) for real-time monitoring of leachate and fertilizer solutions during three weeks (**Figure b**). The results demonstrate that the multisensor platform enables quantitative detection for most ions, identifying events such as solution changes and fertilization steps under real agricultural conditions, supporting its feasibility as an on-site nutrient monitoring tool.

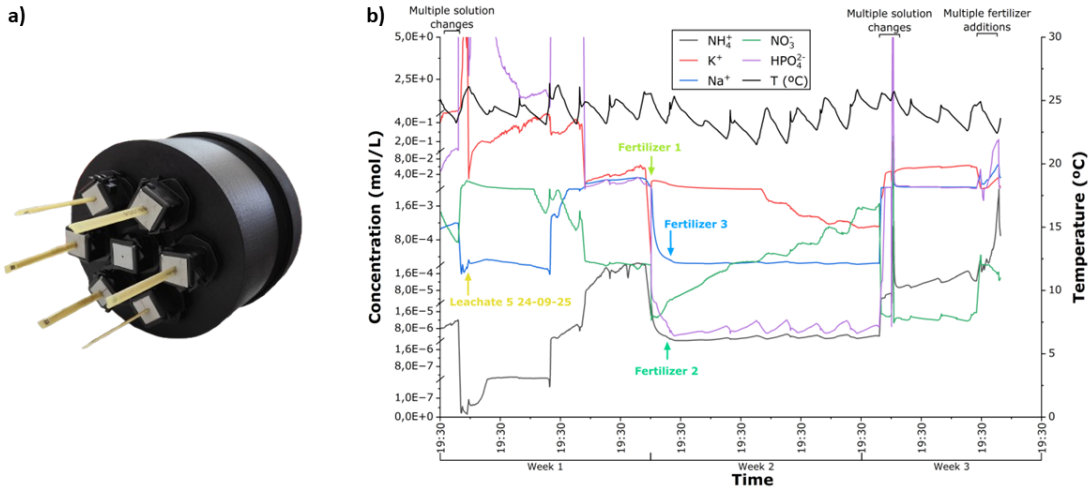

***Figure**. **a)** Multisensor probe and **b)** Recording of ion concentrations monitoring during the three-week experiment.*

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Cantilever-based MEAs for simultaneous recordings of electrophysiological and mechanical signals of contractile organoids

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This paper presents a cantilever-based Micro Electrode Arrays (MEA) device embedding microelectrodes and flexion sensors to perform simultaneous recordings of electrophysiological and mechanical signals of 3D contractile organoid, through a single acquisition system. MEAs have long been essential for investigating the electrophysiological activity of in vitro cellular models. As most MEAs were designed with planar electrodes, the emergence of more spatially complex models such as hiPSC-derived spheroids, embryonic bodies and organoids/ assembloids now presents new challenges for electrophysiological recordings [1] especially regarding the possibility to locate microelectrodes in the vicinity of active cells.

To address the challenge of placing electrodes within 3D cell clusters, we have developed a cantilever MEA technology that allows us to penetrate the tissue to within a few hundred microns of the spheroid's periphery to record electrical activity as closely as possible.

To achieve this, we use an innovative microfabrication process based on the mechanical stress relaxation of thin layers of oxides and silicon nitride, which allows us to produce cantilevers that stand vertically from structures fabricated flat using cleanroom technologies such as photolithography and plasma etching. The integration of platinum metal conductors within these cantilevers has enabled us to measure the electrical activity of brain organoids[1] mounted on an array of these cantilevers.

More recently, we have attached mechanical strain gauges to these cantilevers, which allow us to measure the deformation of the cantilevers and, in particular, the mechanical movements of the organoids embedded in a network of these cantilevers.

The has been applied to the study of cardiac organoids, where simultaneous recordings of electrophysiological and mechanical activity remain an important challenge, notably to investigate cardiac rhythm associated dysfunctions. Our device aims to address these limitations by enabling simultaneous recordings of both inner electrophysiological and mechanical signals of 3D contractile cell models through a single acquisition system, offering a more user-friendly alternative. Upon deformation resulting from mechanical displacement, the flexion of the cantilever induces a change in geometry of the resistor and thus a change in resistance value. Both mechanical and electrophysiological signals were acquired through an INTAN RHS acquisition system enabling highly temporally-resolved synchronous multichannel recordings of both modalities. With this system, we have controlled the combined electrical and mechanical activity of hiPSCderived cardiac embryonic bodies that were cultured until DIV55 and impaled on the cantileverbased-device 5 days prior to the recordings. Recordings demonstrated action potential detection across channels with amplitudes ranging from 40 to 500 µV as well as synchronized mechanical signals, with a frequency around one Hertz that are typical of heart organoids.

In conclusion, with this upgraded cantilever-based MEA system, we aim to offer a solution for simultaneously capturing both the electrophysiological and mechanical activity of complex 3D human cell models, paving the way for more integrated and real-time assessments of cellular dynamics. This system could be useful for drug development and testing for cardiac pathologies for instance.

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Electrochemical sensors monitoring of PFAS solar decontamination in wastewater

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Per- and polyfluoroalkyl substances (PFAS) are highly persistent anthropogenic pollutants characterized by extremely stable carbon-fluorine bonds, rendering them virtually indestructible by conventional municipal wastewater treatment plants (WWTPs) [1]. To address this environmental crisis, the transboundary Across project aims to develop and optimize sustainable solar-based oxidation and adsorption technologies to effectively eliminate these contaminants [2]. This newly initiated doctoral research project focuses on establishing the essential analytical frameworks to monitor this treatment, bridging the gap between advanced solar engineering and real-time process control through the future development of low-cost electrochemical sensors. While high-resolution laboratory techniques like liquid chromatography-tandem mass spectrometry (LC-MS/MS) provide the ultimate quantitative validation, they are slow and incompatible with autonomous, on-site process control. Consequently, our prospective approach aims to develop disposable, low-cost screen-printed and paper-based electrochemical devices [3]. Our proposed design will employ electrodes modified by conducting polymers to record voltammetric 'fingerprints' of the wastewater matrix. As solar photocatalysis breaks down the target PFAS, the resulting change in chemical structure and the appearance of degradation products will dynamically alter the voltammetric signals, allowing indirect, real-time tracking of the depollution progress.

Currently in its initial conceptualization phase, experimental work on the sensors has not yet commenced. This presentation outlines the comprehensive roadmap of the project. The first milestone will focus on the theoretical design and selection of polymer modifiers (such as methylene blue or green) and electrode geometries. Subsequent phases will involve calibration of the sensors in spiked ultrapure water to establish limits of detection, cross-validating the responses against LC-MS/MS data generated at the University of Girona. Finally, the optimized sensors will be integrated into 3D-printed flow cells connected in derivation to the pilot-scale solar photoreactors at PROMES-CNRS in Perpignan for in situ validation.

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Sustainable Functionalized Forestry Residues for Manufacturing Electrochemical Sensors toward Water Pollution Monitoring

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Water pollution within organic and heavy metal contaminants poses a critical global crisis, driven by about 48% of wastewater being discharged untreated[1]. While screen-printed electrodes (SPE) offer cost-effective and portable analytical alternatives for water quality control, conventional plastic and ceramic substrates carry high carbon footprints and generate persistent waste[2]. Concurrently, despite massive annual timber consumption, industrial wood utilization remains under 70%, leaving abundant residues[3]. Herein, a circular bioeconomy strategy is presented to upcycle these residues into biodegradable sensing platform for water monitoring.

In this work, functional carbon-metal nanomaterials were synthesized via a one-step pyrolysis of metal-impregnated wood residues. These nanomaterials were subsequently formulated into conductive inks and directly screen-printed onto wood-board substrates, enabling a scalable fabrication yield exceeding 200 sensors per batch. The resulting Cu-modified SPE enabled accurate monitoring of chemical oxygen demand, while Bi-modified SPE allowed sensitive detection of trace heavy metal ions in wastewater.

Transforming carbon biomass into high-value electronics, provides a sustainable pathway aligned with carbon neutrality goals, while enabling a low-cost, scalable approach to producing sensor devices for environmental monitoring, and expanding the application of wood-derived materials in sustainable electronics.

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Waxes-based fluorescent thermal sensors

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Optical temperature sensing enables straightforward, sensitive, and rapid real-time temperature monitoring through spectroscopic techniques, smartphone imaging, or even direct visual observation. Owing to these advantages, optical thermometers have attracted considerable interest for a wide range of applications, including thermal energy storage, process monitoring, packaging, and biomedical diagnostics. However, their widespread adoption is still limited by several challenges, including the need for higher sensitivity, easy tuning of the operating temperature range and optical response (colour or emission wavelength), the replacement of critical raw materials such as rare-earth-based nanomaterials, and, for biomedical applications, excellent biocompatibility.

In this presentation, we introduce a versatile strategy based on phase-change material (PCM) solutions containing luminescent organic dyes for the fabrication of reversible, highly adaptable optical temperature sensors. Upon the solid-to-liquid phase transition of the PCM, changes in both the solubility of the fluorophore and the rigidity of its local environment directly modulate its photophysical properties, resulting in pronounced variations in fluorescence intensity, colour, spectrum, and lifetime. This platform enables the design of sensors with programmable temperature-triggered off–on, on–off, or colour-switching luminescent responses, while allowing straightforward tuning of both the sensing temperature and the emission spectrum.

Furthermore, these materials can be readily miniaturized into micro- and nanostructures, enabling applications as printable dynamic security inks, high-temperature optical sensors, and highly sensitive biocompatible nanothermometers. In particular, we demonstrate that both fluorescence spectral shifts and lifetime variations can be exploited for accurate temperature mapping, including real-time intracellular thermometry in living cells.[1,2]

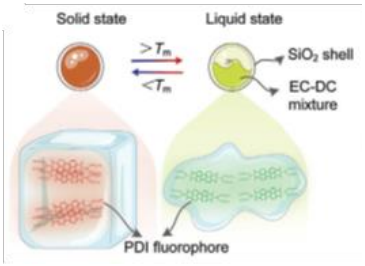

Figure 1*: Schematics of the mechanism for the luminescence variation of organic dyes (e.g., perylene diimide, PDI) during solid-to-liquid transition of phase change materials (PCM, in this case eicosane-docosane mixture, EC-DC).*

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Determining acetylcholinesterase activity with functionalized carbon dots synthesized in Microreactors.

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Acetylcholinesterase (AChE) is a key enzyme that maintains the levels of acetylcholine by catalyzing the hydrolysis reaction of acetylcholine to choline and its inhibition strategy is clinically relevant in neurodegenerative disorders such as Alzheimer's disease [1]. Therefore, it is significantly important to evaluate the activity of AChE and its inhibitors. In this regard, developing rapid, sensitive and miniaturized platforms for biomedical research and therapeutics is needed.

In this work, Cu^{2+} selective fluorescent Carbon Dots (CDs) are synthesized in Low temperature Co-fired Ceramics (LTCC) microreactors under continuous flow conditions [2]. The synthesis of CDs in this integrated microfluidic platform not only enables their scalable production but also facilitates the detection of biomarkers and bioactive compounds by allowing rapid and low-volume POC assays. The synthesized CDs are used to establish a modified sensitive fluorescence-based sensing strategy by studying their fluorescence quenching and recovery behavior [3]. Initially, Cu^{2+} forms a nonfluorescent CD-Cu^{2+} complex and quenches the CD fluorescence. When AChE and its substrate Acetylthiocholine (ATCh) are added to the system, thiocholine generated by their enzymatic hydrolysis recovers CD fluorescence by interacting with Cu^{2+}.

The final aim of this study is to implement this sensing chemistry into polymer-based microfluidic platform enabling precise fluid control, reduced reagent consumption and shorter assay times within a structured microfluidic channel network.

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Abstracts

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P3	**Antonio Calvo-López (UAB)** Hydrodynamic characterization studies focused on medium renewal in microfluidic platforms applied to in vitro fertilization processes
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P15	**Juan Carlos Porras (UAB)** Rapid and accessible molecular detection of group B Streptococcus for maternal–neonatal health
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Treat-and-Sense: An Integrated Biosensing and Bioremediation System for Removal and Biodegrading Antibiotics from Surface Waters

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Antibiotic residues in aquatic environments drive antimicrobial resistance and pose ecotoxicological risks, yet conventional wastewater treatment remains inadequate for their efficient removal and real-time monitoring. This study presents an integrated system that combines highly sensitive electrochemical aptasensors, polysaccharide-based functional hydrogels, and microalga-bacteria consortia for the detection, uuptake and biodegradation of tetracycline (TC) in aquatic surface systems.

The proposed system integrates a real-time monitoring module for drug residues in surface waters in Romania with a remediation strategy based on natural biopolymers and biological degradation. Electrochemical aptasensors targeting tetracycline were developed by functionalizing commercial carbon screen-printed electrodes (SPEs) with innovative 2D based nanomaterials, including fullerenol (FL) and MXene, and specific aptamers. Sensor performance was evaluated using electrochemical impedance spectroscopy (EIS), square-wave voltammetry (SWV), and differential pulse voltammetry (DPV).

Biodegradation experiments employed a consortium of *Chlorella vulgaris* (AICB 329) and *Bacillus subtilis* (ATCC 6051) cultivated in wastewater containing 5% TC and 1% inoculum. Antibiotic concentrations and microbial growth were monitored spectrophotometrically over 7 days, while biomass modifications were characterized by SEM and FTIR analyses. Additionally, functional hydrogels based on natural polysaccharides (e.g. chitosan, alginate, and agarose) reinforced with mineral clays (montmorillonites and laponite) were investigated as antibiotic capture materials. The algae–bacteria consortium removed up to 80% of the target antibiotics through a synergistic mechanism involving initial adsorption followed by biodegradation. Extracellular polymeric matrix (EPS) preserved cell integrity and promoted antibiotic uptake, with FTIR analysis confirming antibiotic-EPS interaction through characteristic band shifts associated with polysaccharide, carboxylate, and phospholipid groups, and the appearance of new peaks in the treated samples. The hydrogels achieved removal efficiencies exceeding 85% under optimized pH and dosage conditions, following pseudo-second-order kinetics indicative of chemisorption. The developed aptasensors exhibited high analytical performances, with Apt-FL-Glu/SPE achieving a sensitivity of 299.4 Ω dec^{-1} (0.05–45 nM, LOD 0.01 nM) and Apt-MXene-AuNP/SPE reaching 390.35 Ω dec^{-1} (3 nM–15 μM, LOD 8.6 nM).

By integrating real-time sensing, passive antibiotic capture, and biological degradation within a single platform, the proposed approach represents a promising step toward intelligent, sustainable and autonomous management of antibiotic-contaminated surface waters.

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Portable Nanocomposite-Based Biosensing Approaches for NonInvasive Biomarker Detection in Sweat and Saliva

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Nanostructured electrochemical biosensors integrated on miniaturized screen-printed electrodes represent promising platforms for point-of-care diagnostics, offering rapid, low cost, sensitive, and non-invasive detection of clinical biomarkers. This work reports the development of a versatile nanocomposite-based electrochemical biosensing platform for the non-invasive detection of multiple biomarkers in sweat (H_2O_2, glucose, lactate, cortisol) and saliva (the tumor markers CEA and EGFR). Screen-printed electrodes were modified with nanocomposites based on singlewalled carbon nanotubes (SWCNTs), fullerenol (FL), amino-functionalized $Ti_3C_2T_x$ MXenes, metallic nanoparticles, and Prussian Blue, and further functionalized with enzymes, aptamers, or peptide bioreceptors tailored to each analyte. SWCNT- and FL-based nanocomposites exhibited strong electrocatalytic activity toward hydrogen peroxide, enabling selective enzymatic determination of glucose and lactate with specific sensitivities of 20.25 $mA \cdot M^{-1}cm^{-2}$ for glucose and 94.76 $mA \cdot M^{-1}cm^{-2}$, respectively. An aptamer-functionalized FL-based sensor enabled selective cortisol detection by electrochemical impedance spectroscopy, achieving a sensitivity of 53 kΩ/nM. Amino-functionalized $Ti_3C_2T_x$ MXenes provided a highly conductive interfaces for immobilizing peptide receptors targeting CEA and EGFR, enabling electrochemical detection of these cancer biomarkers in saliva. The response of ferrocenyl-labeled peptide-functionalized MXene sensors toward EGFR was evaluated by differential pulse voltammetry (DPV) and electrochemical impedance spectroscopy (EIS), confirming the feasibility of this sensing strategy. Across all platforms, the nanocomposites interfaces markedly improved electron-transfer kinetics, sensitivity, selectivity, and operational stability compared to unmodified electrodes. These results demonstrate the versatility of nanocomposite-modified electrochemical biosensors as adaptable platforms for the non-invasive determination of clinically relevant biomarkers in sweat and saliva, supporting the development of portable, point-of-care diagnostic devices.

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Hydrodynamic characterization studies focused on medium renewal in microfluidic platforms applied to in vitro fertilization processes

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In assisted reproductive technologies (ART), such as in vitro fertilization (IVF), environmental control is essential, as oocytes and embryos are sensitive to even slight variations in their surroundings. In this context, microfluidics allows for working with reduced volumes and better control of the movement and renewal of the medium within miniaturized channels and chambers. The main objective of this work is to experimentally characterize the hydrodynamics of a microfluidic device for use in IVF and compare its behavior with previous simulations performed using COMSOL software. The bicarbonate ion was used as the model analyte for this characterization, as it allows for the study of mass transport within the device through an indirect colorimetric response using a pH indicator. First, the optimization of the colorimetric system based on bromothymol blue (BTB) was performed. In this system, bicarbonate reacts in an acidic medium to generate CO_2, which diffuses through a gas-diffusion membrane reaching an acceptor solution composed of BTB and phosphate buffer. This process causes a color change in the BTB, which is monitored by absorbance measurements using a miniaturized detection system. The best results were obtained with a BTB concentration of 0.06 mM and a phosphate buffer concentration of 0.5 mM with a good linear relationship between bicarbonate concentration and absorbance signal obtained in the range of 0 - 1 mM HCO_3^-. Finally, different tests at different renewal times and flow rates allowed for the experimental mapping of the hydrodynamics of the IVF device and the medium renewal profile within the different chambers of the studied device. These results were then compared with models simulated using COMSOL, yielding comparable results. In summary, this work demonstrates that the combination of microfluidics, optical detection, and computational simulation is useful for designing and studying microfluidic platforms where mass transport and medium renewal are of vital importance, as is the case with platforms dedicated to IVF processes. The results obtained lay the foundation for moving towards more controlled microfluidic devices in assisted reproduction applications.

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A 3D-printed pH sensing platform for real-time monitoring in an ammonia recovery reactor

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In numerous chemical, biological and environmental processes, accurate real-time monitoring of key parameters is essential to ensure proper functioning. Although conventional sensors are generally reliable under laboratory conditions, they often face significant limitations when applied to real operating conditions, such as chemical reactors, increasing the demand for customized sensors. Among the available approaches, 3D printing (additive manufacturing) stands out due to its ability to transform computer-aided designs into three-dimensional objects [1]. In this study, a customized 3D-printed pH sensing platform was designed, printed, modified and implemented for real-time monitoring in an ammonia recovery biochemical reactor [2].

In the reactor investigated, ammonia was absorbed into an acidic solution for recovery. Consequently, changes in the pH of the recovery chamber directly reflect the ammonia recovery efficiency. However, due to the reactor geometry, conventional glass pH electrodes cannot be fitted into the recovery chamber. To overcome this limitation, a customized 3D-printed sensing platform (Figure 1A), consisting of five working electrodes (WEs) of varying lengths and two Ag/AgCl reference electrodes (REs), was integrated into the reactor (Figure 1B). During individual sensor characterization, the IrOx-modified WEs showed a super-Nernstian response of approximately - 77.0 mV/pH over the pH range of 2-12, together with excellent repeatability and good long-term stability. Finally, the sensing platform was employed for real-time monitoring in the reactor, remaining operational for 28 days while tracking the pH changes associated with the ammonia recovery process.

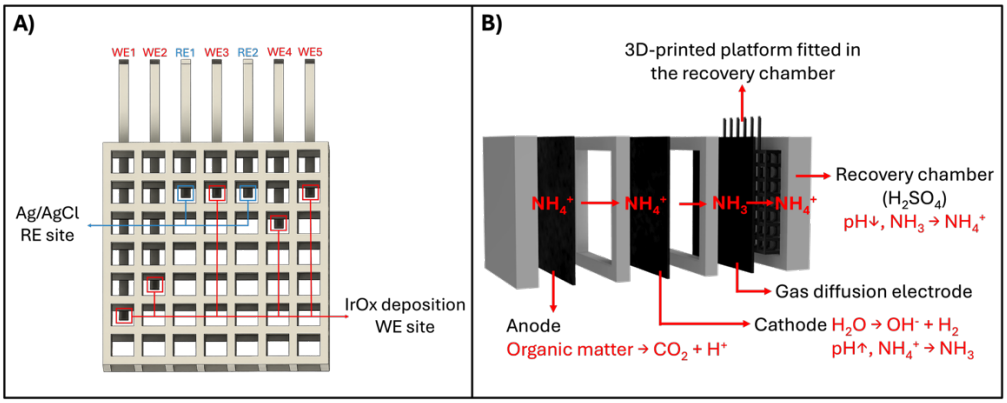

Figure 1. A) Schematic illustration of the 3D-printed sensing platform for pH monitoring. B) Scheme of the ammonia-recovery biochemical reactor with the 3D-printed sensing platform integrated.

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Development of electrochemical sensors from revalorized biomass for emerging pollutant monitoring

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The development of efficient analytical methods for emerging pollutant quality control is essential to ensure drug safety and environmental monitoring. While traditional chromatographic and spectroscopic techniques accurately quantify multi-component formulations, their high cost, operational complexity, and limited portability restrict their application in rapid, on-site screening [1]. To overcome these limitations, we propose a low-cost electrochemical sensing strategy utilizing biochar-modified carbon composite electrodes for the sensitive detection of ibuprofen and paracetamol.

In this study, composite graphite electrodes were rationally functionalized with biochar to synergistically combine the inherent advantages of electrochemical sensors with the sustainable and surface properties of biochar. Using linear sweep voltammetry (LSV) and differential pulse voltammetry (DPV) as the electroanalytical technique, the sensor's (Figure 1) analytical performance was systematically evaluated and compared with conventional screen-printed electrode (SPE) [2]. The modified composite electrodes showed promising analytical responses toward paracetamol, demonstrating the potential of biochar modification to sensing approach by enhancing surface reactivity and interfacial charge-transfer properties. With the advantages of simplicity, sustainability, low cost, and compatibility with portable electrochemical devices, the proposed composite biochar-carbon based sensor offers a promising alternative for rapid on-site emerging pollutant screening.

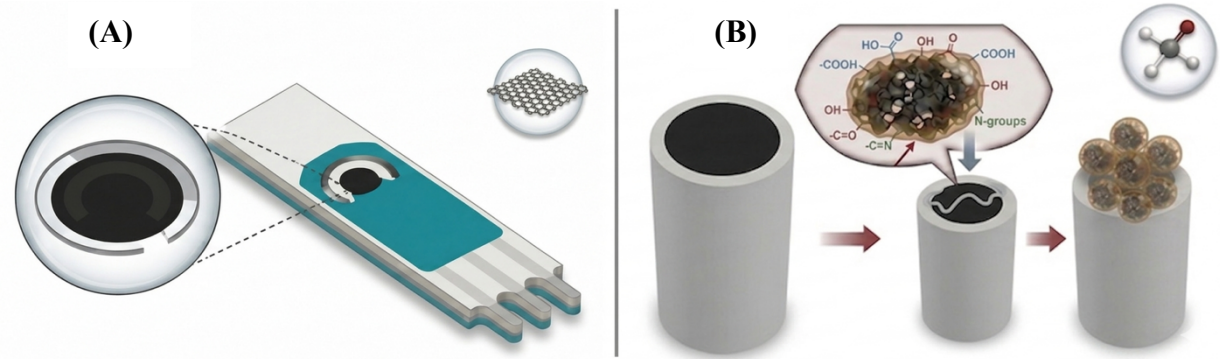

Figure 1: (A) SPE and (B) composite graphite and biochar electrode

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Development and Characterization of Microfluidic Systems for Extracting High-added-value Compounds from Bio-oil

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One of the current challenges in bio-oil valorisation is the development of efficient, fast, sustainable, and economically viable separation technologies for the recovery of high-addedvalue compounds. Such technologies are crucial for lowering bio-oil processing costs and promoting its industrial-scale implementation.
In this context, microfluidics emerges as a promising alternative to conventional liquid–liquid extraction processes, which typically require significant human intervention.
Therefore, the aim of this study is to explore a potentially more efficient and sustainable alternative to conventional polyphenol extraction methods by employing microfluidic technology instead of traditional liquid–liquid extraction.
To this end, several microfluidic devices with different channel widths were designed and fabricated using Low-Temperature Co-fired Ceramics (LTCC). Additionally, the influence of horizontal and vertical inlet and outlet configurations relative to the extraction channel was investigated. A strong dependence of phase separation on the flow rate was observed, with the best performance achieved at lower flow rates. Furthermore, devices with horizontal inlet and outlet configurations exhibited greater phase-separation stability.
The extraction efficiency was first evaluated using a synthetic sample. The extraction capacity was quantified using the Folin–Ciocalteu method, previously calibrated with gallic acid as the standard. Subsequently, the extraction performance of selected devices was assessed using a real bio-oil sample.
The results demonstrate the feasibility of employing microfluidics for the extraction of polyphenols from bio-oil and highlight the potential of this technology for the development of more efficient, sustainable, and automated extraction processes for industrial applications.

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Characterization of Soils by Sequential Extraction Procedures and Nutrient Probes for a Better Understanding of Nutrient Dynamics in Soils

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This experimental work addresses the temporal and spatial variability of nutrients in the soil, specifically nitrate and potassium, as this is one of the limiting factors for fertilization efficiency in conventional agriculture and one of the triggers for environmental problems such as the contamination of aquifers by nitrates.

In this context, it is hypothesized that the analytical signal of the nutrient probes depends on the electrostatic properties of the solid phase of the soil, which can influence the mobility and availability of ions. The main objective of this work is to characterize a sandy-loam olive grove soil doped with zeolites subjected to different fertilization levels (0%, 50%, and 100%) at different depths and seasons. This is done to subsequently correlate these data with the response of the nutrient's probes (Nutrisens).

The methodology used is based on the physicochemical characterization of the soils through the determination of chemical parameters such as soil pH, Cation Exchange Capacity (CEC), Anionic Exchange Capacity (CIA) or the Point of Zero Salt Effect (PZSE). It also includes sequential extraction procedures to determine nutrient distribution across different soil fractions, as well as continuous monitoring of nitrate and potassium concentrations during the nutrient addition and leaching processes using Nutrisens probes.

The results show a basic pH in all samples, with variations depending on depth and time. Nitrate and potassium exhibit differentiated distributions among soil fractions, influenced by fertilization, depth, and time. The electrochemical parameters (PZSE, CEC, and AEC) also vary according to the experimental conditions. Overall, a general correlation is observed between soil properties and the response of the Nutrisens probes.

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The authors thank the financial support from Spanish Ministry of Science and Innovation through the project PID2024-157904OB-I00 and the Catalonia Government through 2021SGR00124.

Methoxy-Substituted Pentamethine Cyanines as Photosensitizers for Antimicrobial, Antifungal, and Anticancer Photodynamic Therapy

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Photodynamic therapy (PDT) is a light-activated treatment based on the interaction between a photosensitizer (PS), light, and molecular oxygen to generate reactive oxygen species (ROS) capable of inducing microbial or cellular death. In this work, two pentamethine cyanines containing methoxy substituents on the heterocyclic rings, NP11 and SP24, were synthesized, characterized, and evaluated as photosensitizers for antimicrobial, antifungal, and exploratory anticancer PDT applications.

Photophysical characterization confirmed the ability of both compounds to generate singlet oxygen ($^1O_2$), with NP11, bearing a single methoxy group on the heterocycle, exhibiting superior photosensitizing performance compared with SP24 and the reference compound methylene blue (MB). The influence of irradiation mode was also investigated by comparing continuous and intermittent light exposure. No significant advantage was observed for intermittent irradiation, supporting the use of continuous irradiation under the tested conditions. Photostability studies further highlighted the importance of molecular structure in PDT performance, demonstrating that photosensitizer efficacy depends not only on ROS generation but also on factors such as photostability and interactions with biological targets.

The antibacterial activity of NP11 and SP24 was evaluated against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Micrococcus luteus*. Both cyanines exhibited PDT-mediated bactericidal activity, with Gram-positive bacteria being more susceptible than Gram-negative species. While *P. aeruginosa* showed partial resistance, particularly to SP24, near-complete eradication was achieved for *S. aureus* and *M. luteus* after irradiation. Notably, SP24, which contains additional methoxy substitution on the heterocyclic system, displayed negligible dark toxicity and complete elimination of *S. aureus* after 15 min of irradiation, representing a particularly favorable PDT profile.

Both dyes also demonstrated potent antifungal activity against *Candida albicans*, achieving complete eradication after 15–30 min of irradiation while exhibiting negligible toxicity in the absence of light. These findings highlight their potential as effective light-activated antifungal agents.Their therapeutic potential was further explored in human fibroblasts (HFF-1), keratinocytes (HaCaT), and B16-F10 melanoma cells. NP11 displayed the most favorable biological profile, combining low dark cytotoxicity with strong concentration-dependent phototoxicity in all tested cell types. In contrast, SP24 exhibited higher dark toxicity and a more variable cellular response. The adaptation and validation of PDT protocols for both microbial and mammalian cell models also constituted an important methodological outcome of this work.

Overall, the results identify these methoxy-substituted pentamethine cyanines as promising photosensitizers for PDT applications. SP24 demonstrated excellent antimicrobial efficacy, particularly against S. aureus, whereas NP11 combined effective antimicrobial and antifungal activity with superior biocompatibility and anticancer phototoxicity. These findings highlight the importance of both photochemical properties and structural features in determining PDT performance and support the further development of NP11 and SP24 for antimicrobial and therapeutic applications.

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Automated Detection of Fumonisin B_1 Using Magnetic Microfluidics

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Fumonisin B_1 (FB_1) is one of the most prevalent and toxic mycotoxins produced by *Fusarium* species, frequently contaminating cereals such as maize, wheat, and rice. Due to its association with serious health effects, including esophageal cancer and liver and kidney damage, reliable monitoring of FB_1 in food products is essential.
In this study, an automated microfluidic platform was developed and optimized for the sensitive determination of FB_1 using a magnetic-particle-based immunoassay. The system integrates incubation, washing, and detection steps within a single device while enabling controlled manipulation of magnetic particles through an external magnetic platform. Detection is based on a competitive assay in which FB_1 and a NanoLuc-luciferase conjugate compete for binding sites on anti-FB_1 antibodies immobilized on protein A/G-modified magnetic particles. The resulting luminescent signal, generated through the NanoGlow substrate reaction, is inversely proportional to the toxin concentration.
Key hydrodynamic and kinetic parameters were optimized to improve assay reproducibility and analytical performance. Calibration with FB_1 standards produced a characteristic sigmoidal response, yielding an IC_{50} value of 14.4 ng/mL. This result is comparable to that obtained under conventional batch conditions (IC_{50} = 16 ng/mL), demonstrating that the automated microfluidic approach maintains analytical sensitivity while offering enhanced integration and automation. These findings highlight the potential of the proposed platform as a rapid and efficient tool for FB_1 monitoring in food safety applications.

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Multiplexed Immunosensor for Co-Occurring Marine Neurotoxins: Paralytic Shellfish Toxins and Tetrodotoxins

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Tetrodotoxin (TTX) and saxitoxin (STX) are potent marine neurotoxins that may accumulate in seafood, representing a significant concern for both food safety and public health. Although these toxins have traditionally been considered separately, increasing evidence of their co-occurrence in pufferfish and shellfish has highlighted the need for analytical approaches capable of detecting both simultaneously. In this work, we developed a multiplexed electrochemical immunosensor for the concurrent determination of TTX and STX [1]. The platform integrates two magnetic bead-based immunoassays within an electrode array and incorporates thresholds corresponding to current regulatory or recommended maximum concentrations for each toxin group. Following optimisation of the immunoassays, harmonisation of the analytical conditions, assessment of matrix effects, and validation of assay performance, the system was applied to the analysis of 40 seafood samples. The results were subsequently compared with those obtained using established reference analytical methods. The immunosensor successfully detected TTX and STX individually or in combination and correctly classified samples according to whether toxin concentrations were above or below the relevant safety thresholds. These findings demonstrate the potential of this multiplexed platform as an integrated tool for the simultaneous monitoring of multiple marine neurotoxins within a single analytical run.

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Combining Biosensing and Mass Spectrometry to Safeguard Freshwater Continental Aquaculture from Cyanotoxins

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The increasing occurrence of harmful cyanobacterial blooms in freshwater systems represents a growing challenge for continental aquaculture. Cyanobacteria produce toxic secondary metabolites, such as microcystins (MCs) and nodularin (NOD), which can be transferred through aquatic food webs and accumulate in farmed fish, posing risks to animal health, aquaculture production, and food safety. Consequently, there is a pressing need for effective monitoring strategies capable of providing early warning of toxin occurrence in aquaculture facilities.

Here, we present a dual analytical approach that combines biosensing technologies with mass spectrometry methods for the comprehensive monitoring of freshwater aquaculture ecosystems. This strategy enables rapid screening of toxin contamination in water as an early warning tool, while providing unequivocal confirmation and detailed toxin profiling in both environmental and fish samples to support food safety assessments. An electrochemical immunosensor based on a competitive magnetic bead immunoassay performed on electrode arrays has been developed. The system is capable of detecting the major MC congeners (MC-LR, MC-RR, MC-YR, and MC-WR) as well as NOD with the sensitivity required for environmental monitoring. In parallel, a liquid chromatography–tandem mass spectrometry (LC-MS/MS) method has been established, allowing the identification and quantification of an even broader range of MC congeners and NOD.

Both approaches will be applied to the analysis of water and *Cyprinus carpio* samples. Water samples will be screened for the presence of cyanotoxins to provide early warning of contamination events, whereas different fish tissues (liver, brain, muscle, intestine, kidney, and skin) will be analysed to investigate toxin distribution, tissue-specific accumulation, and transfer within the organism.

By integrating rapid biosensing with accurate and comprehensive multi-toxin profiling, this dual approach aims to strengthen early warning systems, improve our understanding of cyanotoxin transfer from water to fish and across tissues, and ultimately contribute to safer and more sustainable freshwater aquaculture production.

Electrochemical aptamer-based biosensor for detection of NIE protein from *Strongyloides stercolaris*

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Strongyloidiasis is a neglected parasitic infection caused by the nematode *Strongyloides stercoralis*. It can develop into a chronic and potentially life-threatening infection, especially among immunocompromised individuals in tropical and subtropical regions where sanitation conditions are inadequate. Common clinical symptoms of strongyloidiasis include diarrhea, constipation, abdominal pain, and anorexia. However, early and accurate diagnosis remains challenging due to the limitations associated with currently available conventional diagnostic methods, particularly microscopy and serological assays. Microscopy-based methods generally have low sensitivity due to the intermittent and low larvae output, often requiring repeated sample collection and the involvement of experts in this erea. Similarly, serological assays can exhibit cross-reactivity with other helminth infections and cannot reliably differentiate between active and previous infections. The NIE protein, a recombinant antigen derived from *S. stercoralis*, has therefore emerged as a promising biomarker for enhancing diagnostic applications. At the same time, aptamers, which are short single-stranded nucleic acids capable of recognizing and binding target molecules with high affinity and specificity, have attracted considerable interest as potential alternatives to antibodies in biosensing applications. Their advantages include low-cost and animal-free production, high chemical stability, ease of modification, and reproducible synthesis. In this study, we aim to develop a high-affinity aptamer targeting the NIE protein using SELEX (Systematic Evolution of Ligands by Exponential Enrichment) and subsequently integrate the selected aptamer into an electrochemical aptamer-based (EAB) biosensor. This strategy combines the high selectivity of aptamers with the sensitivity and rapid response of electrochemical detection, with the ultimate goal of developing a robust, cost-effective, and point-of-care diagnostic tool for strongyloidiasis.

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Development of an Electrochemical Single Nucleotide Polymorphism (SNP) Detection Platform for Cardiovascular Point-of-Care Diagnostics

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Cardiovascular disease (CVD) remains the leading cause of death worldwide, accounting for approximately 20 million deaths annually and nearly one-third of all global deaths. Among these, ischemic heart disease (IHD) is the single largest contributor to cardiovascular mortality and is expected to remain the leading cause of death due to ageing populations and the increasing prevalence of cardiometabolic risk factors. Current cardiovascular risk assessment is limited by inadequate early prediction of recurrent events, reliance on conventional clinical risk scores that do not fully capture individual genetic variability, dependence on costly and time-consuming laboratory testing, limited point-of-care diagnostic tools, and unequal access to advanced diagnostic infrastructure.

To address these challenges, next-generation personalized medicine approaches are emerging that integrate portable point-of-care technologies, multiplex biomarker detection, advanced data analysis, rapid turnaround times, and decentralized diagnostics. In this work, we are developing an electrochemical platform for the multiplexed detection of single nucleotide polymorphisms (SNPs) for cardiovascular disease risk assessment and pharmacogenomic profiling using fingerprick blood samples. The platform is based on the isothermal solid-phase bridge recombinase polymerase amplification (RPA) of target sequences on gold electrodes. Ferrocene-labelled dNTPs (Fc-dNTPs) were included in the amplification mixtures for signal transduction once incorporated into the amplification products. Clinically relevant SNPs associated with cardiovascular disease susceptibility and drug response were first identified. Allele-specific reverse primers were then designed with their 3'-terminal bases being complementary to the SNP sites of each target. To enhance discrimination between wild-type and variant alleles, reverse primers were modified using the Amplification Refractory Mutation System (ARMS) and validated with real-time qPCR and microplate-based solid-phase RPA primer elongation with colorimetric detection. Using the human house-keeping β-globin gene as a model target, experimental conditions including the Fc-dNTP/native dNTP molar ratio and post-RPA washing/denaturation were optimized to allow electrochemical detection while maintaining amplification efficiency. Preliminary results on the effective detection of CVD-related SNP targets are demonstrated, while further work is focused on establishing multiplex detection of additional SNP targets using both synthetic DNA and genotyped clinical samples.

Overall, this work lays the foundation for a rapid, sensitive, and multiplex genetic testing platform that supports personalized cardiovascular risk stratification and precision therapeutic decision-making in decentralized healthcare settings.

Development of a Fully 3D-Printed Electrochemical Electrode Platform for Biosensing Applications

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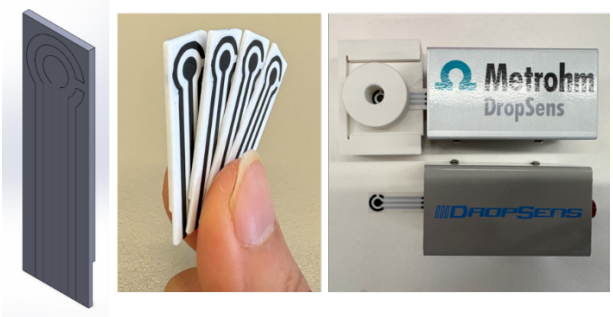
Additive manufacturing has emerged as a powerful tool for the rapid prototyping of electrochemical devices, offering advantages in cost, customization, and scalability. However, achieving reliable electrochemical performance and robust device integration remains challenging for fully 3D-printed platforms. In this work, a fully 3D-printed electrochemical platform was fabricated by fused deposition modeling (FDM) using conductive carbon black/polylactic acid (CB/PLA) and insulating PLA filaments. The influence of electrode design, fabrication parameters, and activation procedures on electrochemical performance was investigated. Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were employed for electrode characterization. Hydrogen peroxide was used as a model analyte to evaluate the analytical performance of the platform. The fabricated electrodes exhibited stable electrochemical responses after activation treatment. The effect of printing parameters and electrode architecture on electron-transfer behavior was assessed. Preliminary experiments demonstrated the feasibility of the platform for electrochemical sensing and highlighted key factors affecting device performance. The proposed approach provides a simple and low-cost strategy for the fabrication of electrochemical platforms and establishes a basis for the future integration of magnetic particle/HRP-based assays and biomarker detection applications.



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Rapid and accessible molecular detection of group B *Streptococcus* for Maternal–neonatal health

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Streptococcus agalactiae or group B Streptococcus (GBS) is a gram-positive coccus that commonly colonizes the lower gastrointestinal and genital tract of healthy adults. Maternal GBS colonization is a major risk factor for early-onset neonatal disease being the leading cause of neonatal sepsis, meningitis, and mortality worldwide. The burden is particularly high in the global south, where routine screening is often constrained by limited laboratory infrastructure. [1,2] Current gold standard strategy is primarily based on microbiological culture performed at 36-37 weeks of gestation. However, the turnaround time and laboratory requirements of culture-based methods may limit their usefulness for intrapartum decision-making, particularly when maternal GBS status is unknown at delivery or in decentralized healthcare settings. Consequently, many neonatal infections are detected too late leading to preventable deaths, inappropriate antibiotic use, and increased antimicrobial resistance. Therefore, affordable, rapid, and user-friendly molecular diagnostic tools capable of operating outside conventional laboratory settings are needed. This work evaluates a diagnostic strategy combining PCR amplification in a battery-operated thermocycler with a lateral-flow readout (Figure 1), with the aim of simplifying molecular GBS detection.

The feasibility was preliminarily assessed using previously classified samples by the current gold standard. All positive samples generated visible test and control lines, whereas all negative samples produced only the control line. These preliminary findings support the technical feasibility of combining portable PCR amplification with an instrument-free post-amplification visual readout. This strategy may facilitate decentralized maternal GBS screening.

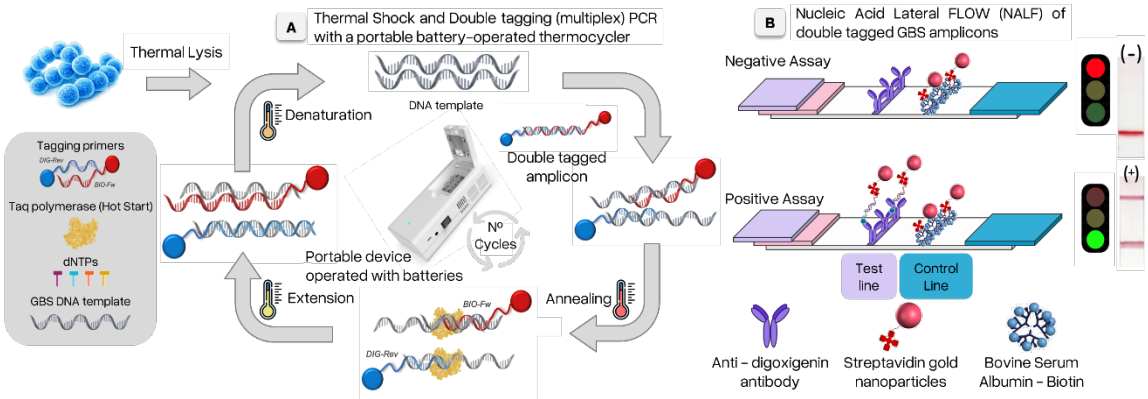

Figure 1. Schematic representation of the integrated workflow for molecular GBS detection. (A). Double tagged PCR amplification is performed in a portable, battery-operated thermocycler using GBS-specific tagging primers. (B). The resulting tagged amplicons are detected through a nucleic acid lateral flow assay (NALF), providing a simple visual readout.

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Biotin-Specific Molecularly Imprinted Polymers as a Biomimetic Test Line in Lateral Flow Assays

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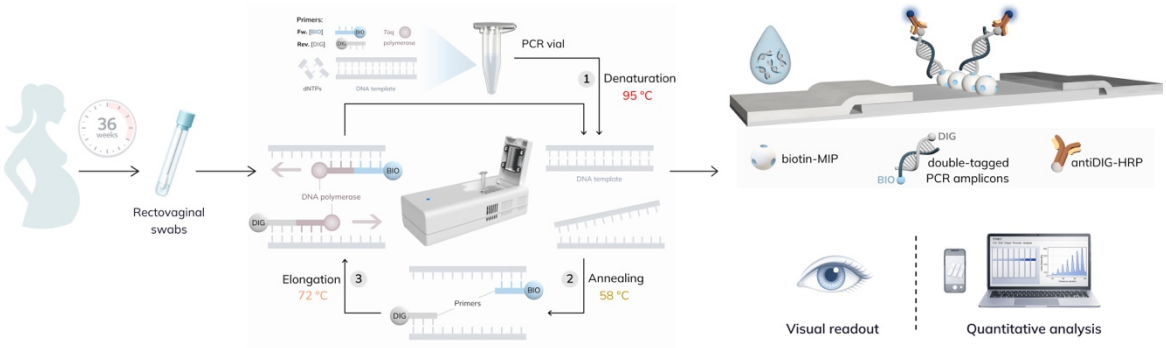
Lateral flow assays (LFAs) are essential tools for rapid and reliable point-of-care diagnostics. However, they still rely mainly on biological recognition elements, particularly antibodies, and therefore suffer from limited stability, batch-to-batch variability, and costly production processes that raise ethical concerns associated with the use of animals. Molecularly imprinted polymers (MIPs) have emerged as promising synthetic receptors that contain tailor-made binding sites and offer high chemical and thermal stability, scalable animal-free production, and reduced manufacturing costs. This work reports the synthesis and characterization of biotin-specific MIPs (biotin-MIPs) and, for the first time, their integration as a test line in nucleic acid lateral flow (NALF) assays[1]. The MIPbased NALF platform was evaluated using double-tagged PCR amplicons from *Escherichia coli* as a model biotinylated target. The assay allowed direct visual interpretation and quantification through analysis of smartphone-acquired images, achieving visual and instrumental detection limits of 2.0 ng mL^{-1} and 1.8 ng mL^{-1}, respectively, comparable to those of conventional immunoassays. The clinical feasibility was further demonstrated in a proof-of-concept study using retrospective rectovaginal swab specimens collected during routine third-trimester screening for Group B *Streptococcus* (GBS), a major cause of neonatal sepsis. After amplification using a battery-operated portable thermocycler, the MIP-based NALF assay showed complete qualitative agreement with the qPCR and microbiological culture reference methods. By combining the stability of MIPs with the simplicity of paper-based tests, this approach addresses the key limitations of antibody-based assays and represents a promising and cost-effective strategy for next-generation decentralized molecular diagnostics.



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Rapid and portable molecular test for Mycobacterium detection based on double-tagged amplification and electrochemical readout

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Tuberculosis (TB) remains one of the leading infectious causes of death worldwide, emphasizing the need for rapid, sensitive and affordable molecular diagnostics suitable for decentralized testing. Here, we present a portable molecular assay for Mycobacterium detection that combines double-tagged polymerase chain reaction (PCR) with electrochemical magneto-genosensing using a battery-operated handheld reader.

The assay targets the *IS6110* and *gyrB* genes using biotin- and digoxigenin-labelled primers. Following PCR amplification, the double-tagged amplicons are simultaneously recognized by streptavidin magnetic particles and horseradish peroxidase-labelled anti-digoxigenin antibodies in only 15 min. The resulting complexes are transferred into a disposable cartridge enabling magnetic actuation, washing and amperometric detection on a portable electrochemical device. The proposed platform[1] demonstrated sensitive and robust detection over a wide concentration range using *Mycobacterium bovis* BCG-Pasteur as a model organism. Among the evaluated targets, *gyrB* provided the best performance, achieving a limit of detection as low as of 117 CFU mL^{-1}. Comparable electrochemical responses were obtained using either the handheld reader or a commercial laboratory potentiostat. Likewise, PCR amplification performed with a batteryoperated miniPCR® generated amplification products and electrochemical signals equivalent to those obtained using a conventional benchtop thermocycler, supporting the feasibility of a fully portable molecular workflow.

The complete analytical procedure, including DNA amplification and electrochemical detection, can be completed in approximately 1.5 h while requiring minimal instrumentation and user intervention. Overall, this work demonstrates the feasibility of integrating portable nucleic acid amplification with electrochemical biosensing into a decentralized molecular diagnostic platform, providing analytical performance comparable to laboratory-based methods while substantially reducing instrumentation requirements. The proposed strategy represents a promising solution for point-of-care TB diagnosis and can be readily adapted to other infectious diseases by simply modifying the primer sequences.

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Rapid and Portable Diagnostic Test for the Early Detection of Viral Outbreaks in Poultry Farms

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Early and reliable detection of viral infections is essential for the rapid implementation of disease control measures and the control of disease outbreaks in poultry farms.[1] Current diagnostic approaches, such as PCR-based methods, generally require centralized laboratory facilities, specialized equipment, and sample transportation, limiting their applicability for on-farm screening.

Here, we present AviaSens, a rapid diagnostic test (RDT) platform designed for the onsite detection of viral RNA in complex poultry specimens. The platform integrates tailored DNA/RNA probes, magnetic actuation, and electrochemical genosensing into a portable, battery-operated device comprising two components: a disposable cartridge containing magnetic particles functionalized with nucleic acid probes for specific viral RNA capture, and a digital reader integrating the magnetic actuation system and electronics for quantitative electrochemical readout.

The platform was evaluated for the detection of Avian Influenza Virus (AIV), Newcastle Disease Virus (NDV), and Infectious Bronchitis Virus (IBV), three relevant viral infections affecting poultry production.[2-5] Calibration curves were obtained using increasing concentrations of viral RNA following a two-step protocol consisting of hybridization at 50 °C for 30 min and incubation at room temperature for 30 min, followed by electrochemical readout using the portable device. The results demonstrate the feasibility of detecting viral RNA from the three target viruses using the developed platform. AviaSens provides a basis for the development of a rapid, portable, and adaptable diagnostic platform for on-farm viral screening, with the long-term aim of reducing turnaround times and facilitating the detection of emerging viral infections.

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Portable biosensing device for detecting coliforms in drinking water

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Monitoring drinking water quality is essential for public health. Coliform bacteria, including *Escherichia coli*, serve as key indicators of contamination; their presence signals potential fecal pollution and associated health risks, as certain strains can cause severe illness. Regulatory standards require that drinking water be free from detectable coliforms, making rapid and reliable detection crucial to ensure water safety. Quantitative PCR (qPCR) and microbiological culture methods are considered gold standards for detecting coliforms and *E. coli* in drinking water. However, both approaches require high processing times and specialized personnel, limiting their utility for rapid or on-site testing. To address this issue, the proposed coliform detection test offers a rapid, cost-effective solution with minimal sample handling for industrial water quality monitoring and can also be adapted to detect other water- and foodborne pathogens. This method combines filtration and direct immunomagnetic separation for electrochemical magneto-immunosensing in a handheld device (Figure 1). Optimization studies showed that preliminary sample incubation with the modified magnetic particles at 37 °C enhanced the resulting electrochemical signals. Evaluation of antibody dilution and sample volume demonstrated that lower antibody dilutions yielded stronger electrochemical signals; notably, all tested conditions provided sufficient signal intensity to clearly differentiate between the presence and absence of *E. coli*. Furthermore, specificity testing against potential interfering bacteria confirmed reliable discrimination at regulatory thresholds within a single day. Overall, this method presents a promising, user-friendly alternative to traditional diagnostic techniques.

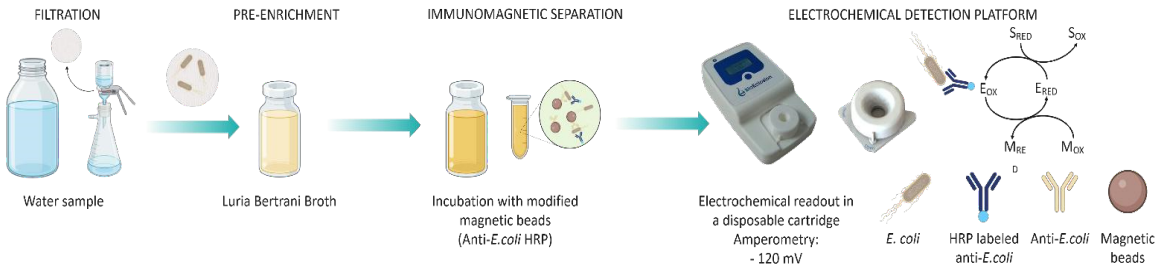

Figure 1. Test for coliform detection including the ISO membrane filtration standard (ISO 9308-1:2024) with a preenrichment step, immunomagnetic separation of E. coli, and electrochemical detection using a new detection platform.

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Smartphone-based optical readout for portable quantification of sTREM-1 by ELISA

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Recent advances in the diagnosis and clinical management of severe infections have highlighted the potential of sTREM-1 as a biomarker of disease severity and mortality risk, enabling the establishment of clinically relevant cutoff values for patient risk stratification.[1]

Although point-of-care (POC) testing strategies for sTREM-1 detection are currently under development, there remains a need to further improve these methods, particularly by reducing reliance on conventional benchtop instruments such as spectrophotometers, while enhancing portability, minimizing maintenance requirements, and reducing costs. Previous studies have demonstrated the potential of mobile phones as portable alternatives to conventional spectrophotometers for the optical readout and quantification of different colorimetric assays, including protein and bacterial quantification.[2]

This study aims to evaluate the feasibility of using a smartphone-based readout as an alternative to the spectrophotometric analysis for the quantification of sTREM-1 in clinical samples. Samples obtained from ICU patients will be analyzed using the commercially available Quantikine Human TREM-1 ELISA Kit.[3] The assay results will be processed using a mobile phone through the app Spotxel® Reader and subsequently compared with the measurements obtained using a spectrophotometer as the reference method.
The proposed approach could represent a low-cost, easy-to-use and portable alternative to conventional spectrophotometric analysis for sTREM-1 quantification, potentially improving access to reliable diagnostic tools, particularly in low-resource settings.

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Integrating nanomaterials to enhance ELISA

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This work explores the integration of nanomaterials into enzyme-linked immunosorbent assays (ELISAs) to improve the sensitivity, adaptability, and accessibility of modern molecular diagnostics. Nanomaterials such as nanoparticles, quantum dots, nanozymes, and plasmonic systems provide enhanced optical, electronic, and catalytic properties that can improve biomarker detection and assay performance. Their incorporation into ELISA, technique that remain the gold standard for biomarker detection, enables highly sensitive, quantitative, and multiplexed analysis, supporting the transition toward precision medicine. In addition, these technologies facilitate the adaptation of ELISA systems to different diagnostic environments, ranging from highly equipped laboratories to low-resource and portable field laboratories. This flexibility contributes to the decentralization of diagnostics and increases the accessibility of advanced clinical testing in resource-limited settings. Overall, nanomaterial-enhanced ELISAs represent a promising strategy for the development of innovative, high-performance diagnostic platforms.