

IECB
2025
Conference

The 5th International Electronic Conference on Biosensors

26–28 May 2025 | Online

A detailed microscopic image of a biosensor array, showing a grid of small, circular, metallic-looking structures on a substrate. The image is overlaid with a semi-transparent orange and green filter, giving it a futuristic and scientific appearance.

Program and Abstract Book

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The 5th International Electronic Conference on Biosensors

26–28 May 2025 | Online



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Welcome from the Chair

Dear *Biosensors* Community,

It is our pleasure to invite you to join the **5th International Electronic Conference on Biosensors (IECB 2025)**, which will be hosted online from **26 to 28 May 2025**.

The aim of this online conference is to gather esteemed experts from around the world who are currently working in the field of biosensors and to provide an online forum for sharing and exchanging knowledge. Highly experienced researchers will be invited to share their important advancements in the field.

Particular attention will also be given to young scientists approaching the world of biosensors in order to stimulate their participation in discussions on the topic.

Biosensors currently have an enormous range of applications due to their unique advantages, improving our overall quality of life with uses in, for example, environmental monitoring, disease detection, food safety, defense, drug discovery, and many other areas.

Throughout the event we aim to cover—among others—the following topics:

- A. Artificial Intelligence in Biosensors;
- B. Ingestible, Implantable, and Wearable Biosensors;
- C. Smartphone-Based Biosensors;
- D. The Evolution of Biological Recognition Elements in Biosensors;
- E. Nanomaterials and Smart Surfaces in Biosensors;
- F. Technological Advancements in Biosensor Actuators;
- G. Paper-Based Biosensors;
- H. Optical and Photonic Biosensors.

We hope that you will join us in presenting your work at IECB 2025 and be part of this stimulating online experience.



Professor Giovanna Marrazza
Conference Chair

Department of Chemistry “Ugo Schiff”, University of Florence,
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Dr. Sara Tombelli
Conference Chair

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Dr. Lynn Dennany

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Invited Speakers



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Program Overview

	26 May 2025	27 May 2025	28 May 2025
Morning	Opening Ceremony C. Smartphone-Based Biosensors	F. Technological Advancements in Biosensor Actuators G. Paper-Based Biosensors	H. Optical and Photonic Biosensors (the first half)
Afternoon	E. Nanomaterials and Smart Surfaces in Biosensors	A. Artificial Intelligence in Biosensors B. Ingestible, Implantable and Wearable Biosensors	D. The Evolution of Biological Recognition Elements in Biosensors H. Optical and Photonic Biosensors (the second half)

IECB 2025 Program

26 May 2025 (Monday)

Opening Ceremony

Session C. Smartphone-Based Biosensors

Time: 9:30 (CEST, Basel) | 15:30 (CST Asia, Beijing)

CEST Time	CST Asia Time	Speaker	Title
09:30–09:40	15:30–15:40	Welcome from the Conference Chairs—Prof. Giovanna Marrazza and Dr. Sara Tombelli	
09:40–10:10	15:40–16:10	Welcome and Speech from the Session Chair—Prof. Dr. Elisa Michelini C. Smartphone-based Biosensors Novel Sustainable Analytical Devices with Bioinspired Tools and Nanomaterials: From Paper- to Thread-Based Microfluidic Smartphone Biosensors	
10:10–10:40	16:10–16:40	Keynote Speaker Dr. Lynn Dennany	Challenges in Portable Detection
10:40–10:55	16:40–16:55	Selected Speaker Panagiota M Kalligosfyri	Portable smartphone-based paper assay for colorimetric nucleic acid detection
10:55–11:10	16:55–17:10	Selected Speaker Amauri Horta-Velázquez	Enhancing Smartphone Colorimetric Sensors via Color Space Optimization
11:10–11:25	17:10–17:25	Selected Speaker Kumarasamy Jayakumar	Portable Chemiluminescence Imaging System for Smartphone-Based Bisphenol A Detection
11:25–11:31	17:25–17:31	Flash Poster Presentation	Eleni Lamprou Advanced Multicolor Rapid Test Integrated with Machine Vision and Automative Image analysis for Non-Invasive Cancer Biomarker Detection Roshani Machhindranath Gadadare Smartphone-Integrated CRISPR Biosensors for Portable and High-Sensitivity Diagnostics

-BREAK-

Session E. Nanomaterials and Smart Surfaces in Biosensors

Time: 14:00 (CEST, Basel) | 20:00 (CST Asia, Beijing)

CEST Time	CST Asia Time	Speaker	Title
14:00–14:10	20:00–20:10	Welcome from the Session Chair—Prof. Dr. Michael Thompson E. Nanomaterials and Smart Surfaces in Biosensors	
14:10–14:30	20:10–20:30	Invited Speaker Dr. Amir Hatamie	Lab-in-a-Pipette tip: Micro-Sampling and Micro-Electroanalysis of Nitrite Ions in clinical, Forensic, and Environmental Samples
14:30–14:50	20:30–20:50	Invited Speaker Prof. Dr. Jing Wei	Mesoporous semiconductor metal oxide gas sensors for sensitive detection of bio-related volatile organic compounds
14:50–15:05	20:50–21:05	Selected Speaker Niamh Docherty	Enhanced Electrochemical Detection for Heart Attack Diagnosis Using 3D-Printed Electrodes
15:05–15:20	21:05–21:20	Selected Speaker Amirhossein Amjad	MXene-Enhanced Electrochemical Sensor for Point-of-Care Therapeutic Drug Monitoring in Chemotherapy
15:20–15:35	21:20–21:35	Selected Speaker Marta Varone	A chemiluminescence nanocellulose-paper-based analytical device for point-of-care detection of Alzheimer disease biomarkers
15:35–15:50	21:35–21:50	Selected Speaker Rayhane Zribi	Innovative 2D material sensors: A new era in medical and environmental technologies
15:50–16:05	21:50–22:05	Selected Speaker Monica Florescu	Graphene, Nanotubes, and Nanozymes: Smart Surface Engineering for High-Performance Biosensing
16:05–16:20	22:05–22:20	Selected Speaker Qingzhen Tian	Catalytic preference-enabled exclusive bimodal sensing of methyl-paraoxon via double-site-synergized organophosphorus hydrolase-mimetic fluorescent nanozymes
16:20–16:35	22:20–22:35	Selected Speaker Raghav Jain	Nano Sentinel: Enhancing Food Security through Advanced Xoo Biosensing

16:35–16:50	22:35–22:50	Selected Speaker Marek Tatarko	The Development of Concanavalin A and DNA Aptamers-Based Acoustic Biosensors for Detection of Lipopolysaccharides from <i>Salmonella typhimurium</i>
16:50–17:05	22:50–23:05	Selected Speaker Hanan Hassan Shaat	The microfluidic-based fluorescence enhancement of delayed fluorescence silica-embedded carbon dots for the detection and quantification of unamplified nucleic acid in clinical samples
17:05–17:20	23:05–23:20	Selected Speaker Aleksandra S. Rakitina	Investigation of kinetic parameters of chloramphenicol and its conjugates' interaction with monoclonal antibodies using label-free biosensors based on low-coherence interferometry
17:20–17:35	23:20–23:35	Flash Poster Presentation	Sorina-Alexandra Leau Metal-organic composite material-based electrochemical sensors for biomolecule quantification Daniel Regiart Portable electrochemical immunosensor with dual-function mesoporous nanostructure for mycotoxin detection in mixed cereal samples Wenqing Jia Electrochemiluminescence resonance energy transfer immunosensing system based on PTC@UIO-66-NH₂ metal-organic framework and MnO₂ nanosheets for sensitive detection of vascular endothelial growth factor Roanne Deanne Aves Graphene-Based Platform for Electrochemical Profiling of Amino Acids Vasilica Țucureanu Advanced chemical processes in the development of microelectrodes for electrochemical sensors

27 May 2025 (Tuesday)

Session G. Paper-Based Biosensors Session F. Technological Advancements in Biosensor Actuators

Time: 9:30 (CEST, Basel) | 15:30 (CST Asia, Beijing)

CEST Time	CST Asia Time	Speaker	Title
09:30–09:40	15:30–15:40	Welcome from the session chair—Prof. Dr. Guozhen Liu G. Paper-based Biosensors	
09:40–10:00	15:40–16:00	Invited Speaker Dr. Fuyuan Zhang	Nanomaterial-augmented immunosensing strategies for sensitive monitoring of food hazards
10:00–10:15	16:00–16:15	Selected Speaker Zilan Lv	Fast determination of bloodstream infections based on the paper microfluidic chip and fluorescent detection
10:15–10:30	16:15–16:30	Selected Speaker Alessandra Glovi	Paper-based device for monitoring the efficacy of anti-cancer therapy: detection of H ₂ S in cell
10:30–10:45	16:30–16:45	Selected Speaker Denise Gregucci	An origami paper biosensor for sustainable on-site and instrument-free detection of nitrite and nitrate
10:45–11:00	16:45–17:00	Selected Speaker Stephanie Lopes Morais	Electrochemical magnetic nanoparticles and paper-based biosensors for plant honey DNA origin detection
11:00–11:10	17:00–17:10	Welcome from Session Chair – Prof. Dr. Benoît Piro F. Technological Advancements in Biosensor Actuators	
11:10–11:30	17:10–17:30	Invited Speaker Dr. Francesco Arcadio	Biosensors based on Plasmonic metasurfaces for Biomedical applications
11:30–11:50	17:30–17:50	Invited Speaker Prof. Dr. Giuseppe Maruccio	Advances in Biosensing: From Electrochemical to Plasmonic and Acoustic Transduction Technologies
11:50–12:05	17:50–18:05	Selected Speaker Amarachukwu Obi	Development of an Electronic Stethoscope
12:05–12:11	18:05–18:11	Flash Poster Presentation	MuthuLakshmi Subramani Smart IoT-Driven Toxic Gas Monitoring and Alert

			System with Ventilation Performance Monitoring for Coal Miners' Safety Sandro Spagnolo Development of Aptamer-Based Biosensor for Detection Penicillin via Combined QCM-LSPR Method
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-BREAK-***Session B. Ingestible, Implantable and Wearable Biosensors******Session A. Artificial Intelligence in Biosensors******Time: 14:00 (CEST, Basel) | 20:00 (CST Asia, Beijing)***

CEST Time	CST Asia Time	Speaker	Title
14:00–14:10	20:00–20:10	Welcome from the Session Chair—Dr. Paolo Bollella B. Ingestible, Implantable and Wearable Biosensors	
14:10–14:40	20:10–20:40	Keynote Speaker Prof. Dr. Shu Gong	Gold E-skin: from Highly stretchable Electronics to ultrathin Tattoo-Like Biomedical sensors
14:40–15:00	20:40–21:00	Invited Speaker Dr. Farnaz Lorestani	Flexible and Wearable Biosensors for Enhancing Personalized Health Monitoring
15:00–15:15	21:00–21:15	Selected Speaker Garbriella Iula	Real-time detection of lactate in sweat with the aim of 3D-printed flexible wearable device
15:15–15:30	21:15–21:30	Selected Speaker Abraham Abbey Paul	Wearable Biosensor Patch for Monitoring Air Toxicity in Occupational and Environmental Settings Over Time
15:30–15:45	21:30–21:45	Selected Speaker John Raschke	Towards In Surgery Miniature Fluorescence Detection of Glioma
15:45–16:00	21:45–22:00	Selected Speaker Kavya Saravanan	Non-invasive blood glucose detection using mmWave transceiver
16:00–16:15	22:00–22:15	Selected Speaker Arman Ahnood	A microfluidic point-of-care bilirubin measurement system.
16:15–16:30	22:15–22:30	Selected Speaker Massimo Barbieri	Wearable biosensors for glucose monitoring in sweat: a patent analysis
16:30–16:40	22:30–22:40	Welcome from the Session Chair—Prof. Dr. Eden Morales-Narváez A. Artificial Intelligence in Biosensors	
16:40–17:00	22:40–23:00	Invited Speaker Prof. Dr. Rui Martins	Artificial Intelligence in Biosensor Design - embracing the age of information
17:00–17:15	23:00–23:15	Selected Speaker Dr. N. Deepa	AI-Powered Wearable Biosensor System for Continuous Monitoring and Early Detection of Polycystic Ovary Syndrome (PCOS) Using Mobile Technology and Biomarkers
17:15–17:27	23:15–23:27	Flash Poster Presentation	Andrés Saavedra-Ruiz Rapid Bacteriological Water Quality Analysis Using a Portable UV-LED/RGB System and Machine Learning Sarah Gadavala Improving Patient Compliance and Medical Adherence through Technology: A Comprehensive Review Teresa Alfano Portable multi-sensor system for digital processing of electrocardiographic signals William García-Rodríguez Laser-Scribed Electrodes and Machine Learning for Label-Free L-Histidine Detection in Artificial Sweat

28 ay 2025 (Wednesday)***Session H. Optical and Photonic Biosensors (first-half)******Time: 9:30 (CEST, Basel) | 15:30 (CST Asia, Beijing)***

CEST Time	CST Asia Time	Speaker	Title
09:30–10:00	15:30–16:00	Welcome from the session chair—Prof. Dr. Giuseppe Quero H. Optical and Photonic Biosensors(first-half) Optical fiber biosensors toward medical applications	
10:00–10:20	16:00–16:20	Invited Speaker Dr. Maria Maddalena Calabretta	Bioluminescence 3D models for biosensing
10:20–10:35	16:20–16:35	Selected Speaker Luigi La Spada	AI-Optimized Graphene-Based Biosensor for Ultra-Sensitive Biomolecular Detection
10:35–10:50	16:35–16:50	Selected Speaker Emanuela Malorano	Development of a Chemiluminescent Thread-Based Device for Eco- and User-Friendly Detection of Lactate in Sweat
10:50–11:05	16:50–17:05	Selected Speaker Zhijian Bu	Hydrogen peroxide inhibits the oxidase-like activity of amorphous CoOx for sensitive colorimetric detection of glucose
11:05–11:20	17:05–17:20	Selected Speaker Xinyu Chen	Machine learning-assisted nanozyme-coded sensor array for recognition and quantification of biothiols
11:20–11:35	17:20–17:35	Selected Speaker Ambra Giannetti	Oligonucleotide Switches for miRNA/mRNA detection in Optical Biosensing
11:35–11:50	17:35–17:50	Selected Speaker Andrea Pace	A chemiluminescence immunosensor exploiting thin-film photosensors to detect C-reactive protein as a biomarker for astronaut health monitoring in long-term missions
11:50–11:56	17:50–17:56	Flash Poster Presentation	Leonardo Bottacin Dual-core Ag/TiO ₂ nanoparticles for photothermal therapy GAL CARMELI Advanced Dispatchable Fiber-Optic Biosensor System for Real-Time, On-Site Sediment and Water Toxicity Monitoring: System Optimization (Sundanse)

-BREAK-***Session H. Optical and Photonic Biosensors (second-half)******Session D. The Evolution of Biological Recognition Elements in Biosensors******Time: 14:00 (CEST, Basel) | 20:00 (CST Asia, Beijing)***

CEST Time	CST Asia Time	Speaker	Title
14:00–14:10	20:00–20:10	Welcome from the Session Chair—Prof. Dr. Chunyang Zhang H. Optical and Photonic Biosensors (second-half)	
14:10–14:30	20:10–20:30	Invited Speaker Dr. Cosimo Trono	Fiber grating based biosensors: design and practical implementation
14:30–14:45	20:30–20:45	Selected Speaker Tatiana Zolotoukhina	Use of bond polarizabilities with spectral map of oligomers in Random Forest algorithm for recognition of MD vibrational spectra in SERS sensor model
14:45–15:00	20:45–21:00	Selected Speaker Ariel Kushmaro	Whole-Cell Fiber-Optical Biosensor for Detecting <i>P. aeruginosa</i> Via Secreted Quorum-Sensing Molecule Using Bioluminescent Bioreporters
15:00–15:15	21:00–21:15	Selected Speaker Denis Novichikhin	A Label-Free Optical Interferometric Biosensor for Comparing Antibody Interaction with Folic Acid Derivatives Based on Gelatin and Dextran

15:15–15:30	21:15–21:30	Selected Speaker Timofey Efimov	Real-time Monitoring of Biofilm Growth Using Resonant Microweighing and Adaptive Interferometry
15:30–15:45	21:30–21:45	Selected Speaker Anastasia Kudriavtseva	The Effect of Humidity on the Photosensitivity of Photodetectors Based on Green Fluorescent Proteins and Carbon Nanotubes
15:45–15:55	21:45–21:55	Welcome from the Session Chair—Prof. Dr. Cecilia Cristea D. The Evolution of Biological Recognition Elements in Biosensors	
15:55–16:15	21:55–22:15	Invited Speaker Prof. Dr. Yi Li	Programmable nuclease-based biosensor towards rapid diagnosis
16:15–16:35	22:15–22:35	Invited Speaker Prof. Dr. Arzum Erdem Gürsan	Electrochemical nucleic acid biosensors: Design principles and Applications
16:35–16:55	22:35–22:55	Invited Speaker Prof. Dr. Francesco Dell'Olio	BIC-Enabled Metasurface Biosensor
16:55–17:10	22:55–23:10	Selected Speaker Elisa Lazzarini	Designing a Chemiluminescent Platform for Type III CRISPR-Cas Systems: An Innovative Approach to Nucleic Acid Detection
17:10–17:25	23:10–23:25	Selected Speaker Ajay Yadav	Using the GOLD-SELEX approach to generate highly specific and sensitive DNA aptamers against carbendazim
17:25–17:40	23:25–23:40	Flash Poster Presentation	Niccolò Marcucci Biosensing and physical sensing methodologies based on optical fiber gratings Ana Olívia Serra Jorge Recent advances in optical biosensors for the rapid detection of heavy metals Mostafa Abdallah Fiber gratings coupled with polymers for biosensing Nurana Malikova Research on a Peroxidase Biomimetic Sensor based on a Ag electrode Negar Farhang Doost Freshwater Harmful Algal Bloom Detection Through Dielectrophoresis

Session A. Artificial Intelligence in Biosensors

sciforum-115778: Rapid Bacteriological Water Quality Analysis Using a Portable UV-LED/RGB System and Machine Learning

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Ensuring water quality is essential to safeguarding public health, as contaminated water is a leading cause of diseases such as cholera, dysentery, hepatitis, and typhoid fever. Conventional methods for monitoring bacterial contamination include membrane filtration, multiple tube fermentation, and enzyme-based assays. These methods are highly reliable but are constrained by lengthy processing times and require expensive equipment, consumables, and trained personnel. This work presents a portable UV-LED/RGB sensor system designed to address these limitations by using a multi-well self-loading microfluidic device for sample preparation-free analysis, a defined substrate assay specific to *Enterococcus faecalis*, a thermoelectric heater for assay incubation, UV-LEDs for sample excitation, RGB sensors for emission acquisition, a 3D-printed casing, and a microcontroller, achieving fast, low-cost, portable, and automated bacteria quantification. Wells in the microfluidic device are independent from each other and are designed to autonomously load with sample water when the device is submerged. The number of wells and volume per well are designed for bacterial quantification using Most Probable Number (MPN) analysis. Fluorogenic assay reagents are pre-loaded into each well of the microfluidic device and dissolve when the wells are loaded with sample water. Fluorescence signals captured by the RGB sensors are analyzed using machine learning (ML) algorithms including a Multilayer Perceptron Neural Network (MLPNN), which determines whether individual wells will be positive or negative by the end of a 24-hour period. The results show 100% accuracy in classifying bacterial presence within wells and a remarkably low detection time of under 30 minutes. The novel combination of ML and MPN analysis in an automated and cost-effective manner allows for near-real-time bacterial quantification and marks a significant advance in rapid bacteriological water quality analysis. The innovations presented offer a robust solution for on-site water quality monitoring, advancing public health and enabling faster responses to potential waterborne contamination.



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sciforum-111153: AI-Powered Wearable Biosensor System for Continuous Monitoring and Early Detection of Polycystic Ovary Syndrome (PCOS) Using Mobile Technology and Biomarkers

Dr.N. Deepa ^{1*}, Dr.Devi T ¹, Dr. Balamurugan Balusamy ² and Rajesh Kumar Dhanaraj ³

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Endocrine disorder affecting women in their reproductive age is called Polycystic Ovary Syndrome (PCOS), which leads to health consequences. Diagnostic methods fail to detect early signs of the disorder in the monitoring of PCOS biomarkers. Due to advancements in the healthcare domain, monitoring tools can now provide personalized treatment for patients. In continuous monitoring for PCOS, there is underutilization of wearable technologies, as existing devices fail in tracking biomarkers like hormones along with fluctuations in glucose. As current methods do not offer non-invasive, accessible techniques for detection at the early stages in management, the integration of wearable biosensors along with mobile technology presents a research gap. The aim is to develop an AI-driven wearable system that integrates both a mobile device and a biosensor for monitoring PCOS-related biomarkers including hormone levels and glucose variability. Using silicon photonics, the developed system helps in the detection of imbalances in hormone levels non-invasively by saliva analysis. Data are analyzed through the usage of YOLO algorithms, which are used for sending alerts based on the health of users. The Ava Bracelet, a wearable with a mobile-enabled biosensor system, integrates AI algorithms to monitor biomarkers related to PCOS through saliva. By employing nanomaterials and thin-film silicon photonic sensors, it provides precise and non-invasive detection of hormonal fluctuations. YOLOv8 is one of the significant models in AI that helps in the identification of anomalies; the engagement of users is also improved, and interventions are promptly facilitated. In contrast to existing works, the proposed system achieves an accuracy of 92%, a sensitivity of 89%, and a specificity of 94% while detecting abnormalities related to PCOS. The AI-driven system improves upon existing PCOS diagnostics through continuous, real-time monitoring and early detection of hormonal imbalances. Utilizing YOLOv8 enables rapid and accurate data processing, providing personalized insights and facilitating proactive health management. Biomarkers like luteinizing hormone (LH) and follicle-stimulating hormone (FSH) are targeted in detection by utilizing aptamer-based and antibody-based biorecognition elements.



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sciforum-117567: How are biosensors and artificial intelligence (AI) pioneering dynamic solutions for food quality control?

P. Barciela ^{1*}, A. Perez-Vazquez ¹, A.O.S. Jorge ^{1,2}, E. Yuksek ¹, S. Seyyedi-Mansour ¹, J. Echave ^{1,3}, A. G. Pereira ^{1,4} and M.A. Prieto ¹

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The future of intelligent biosystems is bright, with major strides projected as a result of new discoveries and innovations. A number of leading multinational companies have integrated intelligent biosystems to uplift food quality. For example, Nestlé uses biosensing in production to track microbial contamination. IBM is adopting blockchain to ensure transparent food traceability, while BluWrap monitors the oxygen and temperature of fresh fish pallets with smart packaging to maximize shelf life and reduce carbon footprint. At the same time, biosensors supported by the Internet of Things (IoT) can help farmers, stakeholders, and the agri-food industry through rapid testing and predictive analytics based on sensor-generated computing using Artificial Intelligence (AI). The integration of AI methodologies, including cluster analysis and classification algorithms, with biosensors can bridge the gap between data collection and analysis and advance the accuracy of data handling throughout the food supply chain. The methodology of this work follows a systematic review of the literature on intelligent biosystems and AI tools in food safety, evaluating biosensing techniques, challenges, and scalability, and exploring future directions. The potential of these tools is conspicuous, although their application in real-world scenarios is still limited due to lack of focus, implementation costs, scalability, and well-adapted and regulatory framework research. In this review, we search for results that examine the state of the art of AI for food quality control, highlighting the impact of smart biosensors that offer advanced real-time monitoring, predictive analytics, optimization, enhanced traceability, and consumer empowerment to improve risk management and ensure high standards of food processing and safety, as well as public health and economic integrity.



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sciforum-117078: Laser-Scribed Electrodes and Machine Learning for Label-Free L-Histidine Detection in Artificial Sweat

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Wearable technologies are rapidly expanding, creating a demand for the real-time monitoring of molecular biomarkers. Non-invasive samples, such as sweat and saliva, are particularly promising for this purpose. However, achieving selectivity and specificity in sensor measurements remains a challenge due to the complexity of biomarkers and the stability of captured molecules. Laser-Scribed (LS) electrodes, fabricated using a CO₂ laser cutter on polyimide substrates, offer a cost-effective and promising alternative for wearable electrochemical sensors and biosensors. This study investigates the optimization of LS electrode manufacturing parameters using a 60 W CO₂ laser cutter and explores their application for the label-free detection and classification of biomarkers in sweat. Cyclic voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS) experiments were conducted to characterize the electrochemical performance of LS electrodes, with a focus on detecting L-histidine in artificial sweat. The optimized LS electrodes exhibited high sensitivity, demonstrating a linear relationship ($R^2 = 0.987$) between the current peak and L-histidine concentration in the range from 8.3 mM to 50 mM. Additionally, an MLPNN (Multilayer Perceptron Neural Network) machine learning algorithm was trained using CV data to classify L-histidine in artificial sweat for lower, physiologically relevant concentrations (e.g., 0.12 – 3.3 mM) where linearity is lost. The results achieved 90% accuracy, highlighting the potential of LS electrodes for real-time, label-free biomarker monitoring in wearable health devices. In conclusion, this study demonstrates the effectiveness of LS electrodes and data-driven classification techniques for sweat component monitoring. Future research will focus on improving the detection capabilities of LS electrodes and expanding their application to classify other sweat biomarkers, such as NaH₂PO₄, NaCl, and Na₂HPO₄. This work advances the development of high-performance and disposable wearable biosensors for non-invasive health monitoring.



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sciforum-114795: Multiplexed quantification of soil nutrients using an AI-enhanced and low-cost impedimetric sensor

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Soil management technologies are key to tackling the UN development goals and ensuring the 70% increase in agricultural production needed by 2050. In particular, the determination of soil nutrients is crucial to optimising plant growth and maximising crop yields. However, the direct determination of ion availability is challenging due to environmental changes (e.g., soil moisture, temperature), and it requires costly and bulky equipment. While indirect methods, such as soil electric conductivity and hyperspectral imaging, offer advantages in terms of costs, their measurement accuracy is low, since they are influenced by a high number of parameters, including soil texture and composition. As such, there is a shortage of low-cost and accurate sensors to determine nutrient bioavailability in soil.

This work describes, for the first time, an impedimetric low-cost device for the simultaneous and direct determination of environmental parameters (i.e., temperature and humidity), as well as of the bioavailability of key ions in soil. The device could be incorporated into an Arduino-based setting, reducing manufacturing and operational costs and enabling flexible implementation across a wide range of settings. The impedimetric device was tested in vivo by implanting it into tomato plants and recording impedimetric signals over time. An AI algorithm was also trained to enable an accurate determination of ion concentrations. The final system could determine dynamic changes in Na⁺ and K⁺ with high accuracy ($R^2=0.98$ in the case of sodium and $R^2=0.99$ for potassium), and it could be used for the continuous monitoring of soil parameters.



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sciforum-110676: Real-Time Prostate Cancer Screening Using a Hybrid AI-Integrated Electrochemical Biosensor

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The integration of biosensor technology with hybrid artificial intelligence (AI) algorithms has greatly advanced the field of biomedical diagnostics. Prostate cancer is one of the most common types of cancer in men, and prostate-specific antigen (PSA) is a key biomarker for early diagnosis. Using an unprecedented approach that combines the strengths of a range of machine learning and deep learning methods, this methodology shows a balance between accuracy, sensitivity, and reliability in early cancer detection. The biosensor, using an electrochemical platform, shows the dual functionalization of a specific aptamer and gold nanoparticles (AuNPs), enabling PSA detection with high specificity. The hybridization of the artificial intelligence methods used in this study includes convolutional neural networks (CNNs), support vector machines (SVMs), and gradient boosting machines (GBMs), and it allows for the processing, assessment, and classification of biosensor data. The initial step involves collecting the biosensor signal of biomolecular interactions, which are transduced and transcribed into electrical signals. To prepare the raw data set for processing, advanced denoising and normalizing techniques are applied. Then, the CNN is run on these data to encode their features and identify complex patterns. Then, SVMs classify the PSA levels into three groups, namely normal, elevated, and at risk. In contrast, GBMs use CNN and SVM output predictions as inputs for the decision process.

In this manner, this hybrid algorithm methodology balances the interpretability of SVMs, the deep feature learning capacity of CNNs, and the strong prediction power of GBMs. Its second contribution first aims at increasing the amount of data by developing an ERL (ensemble reinforcement learning) framework that dynamically modulates the parameters based on instantaneous rewards. This makes the ensemble reinforcement learning framework unfixed for different biomedical applications but also for different datasets and patient profiles. Herein, we detail the design, development, and evaluation of this transformative system with the potential to fundamentally change cancer diagnostics by enabling scalable, low-cost, and accurate cancer screening. The hybrid algorithm strategy is a paradigm shift in biosensor technology, allowing us to address the limitations of traditional approaches while overcoming issues with achievable data standardization and model optimization.

Following the summary of the acquired optically significant metrics, the output efficiency is estimated to thoroughly review the proposed AI-adapted biosensor framework. Using this approach, the system achieved high accuracy in detecting prostate-specific antigen (PSA) concentrations and classifying the risk for cancer. This can be particularly useful for early-stage detection while reducing the risk of false-negative diagnoses. The specificity will reduce the false-positive results—meaning those whose condition is misidentified—and spare some unnecessary medical interventions. The biosensor also exhibits an ultra-low limit of detection (LOD), which allows for the detection of PSA within the subclinical range. This innovative system takes advantage of machine learning and AI techniques for biosensor technology applications, thus enabling new biomedical diagnostics with high sensitivity and specificity and low cost.



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sciforum-115822: The Role of Artificial Intelligence and Biosensors in Crop Protection for Food Security: Smart Diagnostics in Precision Agriculture 4.0

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Plant disease prevention and management have become increasingly important due to population growth and the consequent intensification of crops, which drive the development of plant protection products. However, monitoring tools have also been integrated to improve food security while avoiding crop losses. Nowadays, early detection of pathogens like *Phytophthora infestans* in potatoes, *Xylella fastidiosa* in olives, and *Fusarium* species in cereals is sometimes the only viable alternative to developing targeted interventions. Implementing advanced technologies such as biosensors and artificial intelligence (AI) in agriculture can solve this problem, ensuring food security while protecting environmental health. Recent innovations in biosensor technology include smart sensors for real-time monitoring of soil conditions (pH, moisture, or total nutrient uptake), weather patterns, and crop/plant health, including the early detection of plant pathogens, herbicides, pesticides, heavy metals, and toxins.

This systematic review explores biosensors under the scope of precision agriculture (Agriculture 4.0) by integrating them with AI and the Internet of Things (IoT) to develop improved disease management strategies, increase crop yield, and optimize resources. Moreover, smartphone-based biosensors and machine learning (ML) algorithms further enhance the practicality of in-field applications through rapid data analysis and integration with precision agriculture systems.

The advantages, challenges, and knowledge gaps regarding the adoption of AI in biosensors and precision agriculture are also discussed. Future research should assess the effectiveness of these technologies in enhancing efficiency, productivity, and sustainability to enhance real-time decision making in agriculture.



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Session B. Ingestible, Implantable and Wearable Biosensors

sciforum-115172: Custom Wearable Motion System for Human Gait Biomechanics Analysis in Hypogravity Environments

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Introduction

Understanding the impact of hypogravity on human gait characteristics is crucial for upcoming space exploration missions. Ground reaction force (GRF) and joint kinematics are critical gait parameters for assessing human locomotion. Traditional methods, such as force plates and motion capture systems, have been widely used to study GRF and joint kinematics under different walking speeds and inclines in normal Earth gravity. However, these methods are often complex, time-intensive, and require elaborate setups. While wearable sensing systems offer a simpler method and effectively track human walking motion, their application to analyzing human kinetics and kinematics in hypogravity environments has not been fully explored. To address these gaps, we propose a wearable motion sensing system that integrates a custom-designed force insole, tailored to different gravity levels to measure GRF, and inertial measurement units (IMUs) to track lower limb joint kinematics. This system was employed to evaluate human gait characteristics and kinematics under simulated hypogravity conditions, combining GRF and joint kinematics for a comprehensive analysis.

Methods

We first developed a mechanical suspension platform capable of simulating adjustable hypogravity conditions for level walking experiments. Our wearable motion sensing system comprises four IMUs and a custom force insole, enabling the real-time monitoring of lower limb joint acceleration, angular velocity, Euler angles, and GRF during hypogravity walking experiments.

Results and Conclusions

The wearable motion sensing system successfully monitored lower limb joint kinematics and GRF simultaneously, revealing new kinematic characteristics during hypogravity walking. The custom force insole accurately captured GRF trends under these conditions. This system provides a robust tool for investigating gait characteristics and human kinematics in hypogravity environments, offering insights into optimizing mobility strategies, enhancing wearable device design, and understanding biomechanical adaptations under such conditions.



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sciforum-114624: Portable multi-sensor system for digital processing of electrocardiographic signals

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In the field of medicine and wearable health devices, the need to monitoring cardiac activity continuously represents a challenge. Due to the random nature of many pathologies affecting the cardiac system, it is often necessary to continuously monitor cardiac activity. This means that portable ECG devices have to cope with movement noise, which is normally not present during an ambulatory measurement.

The aim of this study is to present a 12-lead ECG portable system based on TI ADS1298 and LSM6DSV16X from STMicroelectronics. The proposed device is capable of real-time ECG acquisition, managing to solve the problem of movement noise. A threshold mechanism was therefore implemented to allow the acquisition of the ECG signal based on the signal read by the accelerometer.

A threshold mechanism was therefore implemented to allow the acquisition of the ECG signal based on the signal read by the accelerometer. As a result, patients are able to carry out their daily activities while remaining continuously monitored.

The entire system has been extensively tested, and this article demonstrates its function. It was also demonstrated that the proposed layout does not degrade the performance recorded by the chip used.

We are currently developing a wearable board characterized by reduced weight, better portability, wireless connectivity, and integration of bioimpedance sensors.



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sciforum-115425: A microfluidic point-of-care bilirubin measurement system.

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Measuring bilirubin levels in blood or serum is a critical process for evaluating liver function and monitoring the effectiveness of various treatments for liver-related conditions. Abnormal bilirubin levels can indicate liver dysfunction, bile duct obstruction, or hemolytic disorders, making accurate measurement essential for timely diagnosis and intervention. This study focuses on assessing the clinical performance of a newly developed point-of-care (PoC) device specifically designed for rapid and reliable bilirubin measurement in serum samples. The PoC device integrates advanced technology, including a compact optoelectronic sensing module, which provides high sensitivity and precision, and a microfluidic test cartridge, enabling efficient sample handling and analysis.

To validate the performance of the PoC device, serum bilirubin levels were measured in 20 patient samples, covering a wide concentration range from 2 $\mu\text{mol/L}$ to 480 $\mu\text{mol/L}$. These measurements were compared with those obtained using the standard laboratory method, which serves as the gold standard in clinical diagnostics. Statistical methods, including Bland–Altman analysis and Passing–Bablok regression, were employed to evaluate the agreement and correlation between the PoC device and standard laboratory results. Additionally, the diagnostic capability of the PoC device to classify samples based on clinically relevant bilirubin thresholds—specifically 200 $\mu\text{mol/L}$, 300 $\mu\text{mol/L}$, and 450 $\mu\text{mol/L}$ —was assessed using receiver operating characteristic (ROC) analysis.

The results demonstrated that the PoC device produced measurements with a mean difference of $-5.6 \mu\text{mol/L}$ compared to the standard laboratory method. The 95% confidence interval for this difference ranged from $-45.1 \mu\text{mol/L}$ to $33.9 \mu\text{mol/L}$, indicating acceptable limits of agreement for clinical use. Furthermore, the coefficient of determination (R^2) between the two methods was 0.986, reflecting a strong correlation. The PoC device also exhibited robust diagnostic performance, achieving over 90% sensitivity and 97% specificity for correctly classifying bilirubin levels within the defined clinical thresholds. These findings highlight the potential of the PoC device as a reliable alternative to traditional laboratory methods, particularly in settings where rapid and on-site testing is required.

In conclusion, this study demonstrates that the proposed PoC device is capable of accurately measuring serum bilirubin levels with clinically acceptable precision and reliability. Its compact design, integration of advanced technologies, and high diagnostic accuracy make it a valuable tool for point-of-care applications in various healthcare settings. The device's ability to provide quick and accurate results has the potential to improve patient outcomes by enabling timely clinical decision-making, especially in resource-limited environments or emergency care scenarios.



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sciforum-115769: A novel non-contact method to monitor vital signs: A proof of principle study in piglets

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Background

Hospitalized preterm infants often require months of vital signs monitoring in the neonatal intensive care unit. To date, wired sensors are essential for survival but are associated with numerous disadvantages, including sensor dislocations, skin trauma and hygiene risks. Non-contact vital sign monitoring would therefore represent a significant improvement in the care of hospitalized neonates.

Objective

This study aimed to develop a new microwave-based sensor for non-contact monitoring of vital signs.

Methods

We developed a radar-based vital parameter monitoring system for recording the respiratory rate of premature infants in a pediatric incubator. This novel sensor is a four-channel I/Q (In-Phase and Quadrature) radar system operating at 24 GHz with adapted antennas to cover the predefined area of interest on the body surface. As a proof of principle study, the system was tested in six anesthetized newborn piglets with a body weight between 1050 and 2710 g that were located in a newborn incubator.

Results

Using the radar-based system, thorax movements were detected and the respiratory rate was calculated. We observed high accordance between the signals of respiration detected by the novel microwave sensor and the signals of the cable-bound monitor at rest.

Conclusions

The novel microwave sensor is suited for measuring respiration in the piglet model. In the future, the sensor has to be optimized in order to improve its robustness against disturbances by heartbeats and body movements.

Significance

The study results have laid the foundation for non-contact monitoring of the respiratory rate, which could be used in neonatal intensive care units.



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sciforum-114195: A Novel Tiny Machine Learning-Enabled Ring Biosensor for Stress and Mental Health Monitoring

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The increasing prevalence of mental health disorders, such as chronic stress and anxiety, emphasizes the critical need for advanced monitoring systems that can provide actionable insights into psychological well-being. This study presents a novel ring-based biosensor platform that integrates multi-modal data analysis with Tiny Machine Learning (TinyML) for real-time stress and mental health assessment. The proposed system analyzes key physiological and biochemical markers of stress, including electrodermal activity through galvanic skin response (GSR) sensors, heart rate variability (HRV) for autonomic nervous system analysis, and cortisol levels as a primary stress biomarker. TinyML models embedded in the ring enable efficient on-device processing of biosensor data, identifying trends and patterns in stress markers while minimizing power consumption. This approach allows the system to deliver timely alerts for potential stress or anxiety episodes and provide personalized interventions, such as guided relaxation exercises. The localized computation ensures enhanced data privacy, low latency, and reduced reliance on external cloud services. Designed to be lightweight and ergonomic, the ring is optimized for continuous wear, making it suitable for long-term monitoring and for the early detection of stress-related conditions. Validation of the platform is conducted using established TinyML performance metrics, including sensitivity, specificity, latency, and memory footprint, ensuring reliable and efficient operation in a resource-constrained wearable device. This work demonstrates the potential of combining wearable biosensors with embedded machine learning to advance personalized mental health management and stress mitigation.



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sciforum-110940: AI-Powered Wearable Biosensors Using OpenPose: Transforming Personalized Healthcare Activity Monitoring of Alzheimer patients

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Introduction

In recent times, biosensors have become advanced tools in medical diagnostics, utilizing artificial intelligence (AI) to detect specific biological disorders promptly. AI in the form of OpenPose models with wearable biosensors improves patients' daily routines and physiological changes in Alzheimer patient diagnostics. AI-based patient routine analysis covers complex patterns and offers fast processing with higher accuracy for physiological changes in Alzheimer patients. This model advances the detection of health condition changes, such as understanding patient routines, suggesting disease progression, and improving healthcare outcomes.

Methods

Modern healthcare technology has evolved, leading to the creation of a wearable biosensor that monitors human organs for real-time data analysis. It measures vital signs, physical activity, and sleep patterns to analyse physiological changes in patients. Wearable biosensors are cost-effective devices for detecting biomarkers associated with behavioral and cognitive changes in patients. This model allows caretakers of patients and healthcare professionals to track patients' health and activities in real time, enabling early activity changes in Alzheimer patient diagnostics.

Results

Utilizing the full potential of AI models like OpenPose, trained on biomarker datasets, this wearable biosensor effectively handles diverse datasets, achieving a precision of 93.27% in Alzheimer patient activity analysis. This study successfully found changes in daily activity, like irregular sleep patterns, abnormal vital signs, and little physical activity. These systems also improve the accuracy of cognitive decline by allowing real-time monitoring of medical component response, which makes them more useful in healthcare diagnostics.

Conclusions

The integration of biosensors with OpenPose is transforming Alzheimer patient diagnostics, offering more accurate and effective solutions. This wearable biosensor-based AI model provides real-time health monitoring, personalized medical care, and early activity change detection and supports further medical component development. In the future, this biosensor-based AI will play an important role in improving global healthcare facilities and patient monitoring, leading to efficient outcomes.



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sciforum-115658: An Artificial Intelligence-based Wearable Digital Stethoscope for Cough Sound Analysis

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Generally, the breathing process involves inhalation and exhalation in which the movement of air that occurs in the lungs causes an acoustic effect called lung sounds. These lung sounds can be breath sounds, adventitious sounds, and vocal resonance, which can be diagnosed based on the anatomy of the location, where the sounds are detected during physical examination. Moreover, it is essential to analyse the health condition of the respiratory system and the airway process without causing any harm to the patients using non-invasive methods. Examination through a stethoscope is a commonly followed method; however, it is quite difficult to analyse lung sounds with lower acoustic levels using existing stethoscopes. To overcome this issue, the digital electronic stethoscope is utilised nowadays. In this work, an artificial intelligence-based wearable digital stethoscope is designed and developed for the analysis of cough sounds. Furthermore, the Arduino Nicla voice-based edge computing board is utilised to acquire and analyse the cough sounds of abnormal patients. The Arduino Nicla Voice board has an inbuilt microphone and Inertial Measurement Unit (IMU) which is used to record acoustic, acceleration, and magnetometer signals from normal individuals and abnormal patients. Also, machine learning algorithms such as Random Forest and Decision Trees are adopted and deployed in the edge computing board to classify normal and abnormal cough sounds. Performance analysis parameters such as accuracy, precision, recall, and F1_Score are derived for the adopted machine learning classifiers to evaluate the efficiency and efficacy of the system. This work appears to be of high social relevance since the proposed work will assist in the early prediction of COVID-19 and similar, other diseases using cough sounds.



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sciforum-110063: An Intelligent Internet of Medical Things-based Wearable Device for Monitoring of Neurological Disorders

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In general, epilepsy is considered as one of most prevalent neurological disorders and frequently appears as sudden seizures, resulting in injuries, accidents, sudden unexpected deaths, etc. It is reported that around 60 million people across the globe experience various seizures due to epilepsy. So, there is a demand for ambulatory seizure detection devices to prevent such accidents and to improve the quality of life of epilepsy patients. In this work, an intelligent Internet of Medical Things (IoMT)-based wearable device is designed and developed to monitor seizures in epilepsy patients. Due to the lack of an accelerometer dataset for epileptic seizures, the proposed device is developed, and a dataset simulating seizure-like activities has been generated. Further, the proposed device utilises an MPU6500-based Inertial Measurement Unit (IMU), which is integrated to an ESP32 microcontroller board. The ESP32 has built-in Wireless Fidelity (WiFi) + Bluetooth (BLE) and supports MicroPython. Also, machine learning algorithms such as Decision Trees (DTs), Support Vector Machines (SVMs), Random Forests (RFs), etc., are implemented using MicroPython and are deployed on a tiny edge computing device to monitor the activity of epileptic patients. All the adopted machine learning algorithms were compared in terms of performance metrics, such as Accuracy, Precision, Recall, False Alarm Rate (FAR), etc., and the efficacy of the device is analysed. The results demonstrate that the proposed device is capable of identifying activities of individuals, which is highly useful for epilepsy patients in monitoring their epileptic seizures. Furthermore, it is demonstrated that the proposed device is best deployed with an RF algorithm, since it exhibits an accuracy of 94.17%, which is better compared to that of the other machine learning algorithms. Also, the proposed device is simple and cost-effective and alerts caretakers of epilepsy patients with an FAR of less than 4%.



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sciforum-106891: Applications of Filled Single-Walled Carbon Nanotubes in Biosensors

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Applications in the biomedical field require nanomaterials with improved properties. Single-walled carbon nanotubes (SWCNTs) filled with nickelocene are a new material for biomedical applications. The SWCNTs are filled with nickelocene using the gas-phase method. It is a very simple and environmentally friendly process that allows us to obtain new materials with high yield [1,2]. This method can be applied to materials for biomedical applications. The nickelocene-filled SWCNTs are obtained as a clean material that can be further characterized with spectroscopy. Indeed, it is known that spectroscopy requires high-quality samples. The spectroscopic samples should be free of impurities from the synthesis process. In this work, an investigation of nickelocene-filled SWCNTs with angle-resolved photoemission spectroscopy (ARPES) was performed [3]. Nickelocene-filled SWCNTs include metallicity-mixed SWCNTs, i.e., a mixture of metallic and semiconducting SWCNTs. It was shown that the encapsulated nickelocene leads to a donor effect on the SWCNTs. A variation in the Fermi level of the SWCNTs with different measurement angles was revealed. This was related to the modification of the electronic properties of the SWCNTs. The obtained data are important for biomedical applications of filled SWCNTs.

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sciforum-115606: Development of a Capacitive Pressure Sensor Integrated into Contact Lenses for Glaucoma Monitoring

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This research focuses on the development of a capacitive pressure sensor integrated into a contact lens for continuous monitoring of intraocular pressure (IOP), a critical parameter for the early detection and management of glaucoma.

The sensor operates on capacitive sensing principles, where fluctuations in IOP alter the distance between sensor plates, resulting in measurable changes in capacitance. Pressure variations within the physiological range of 10–25 mmHg were analyzed to evaluate the sensor's performance and ensure accurate pressure readings. The sensor was also optimized to detect changes in the range of 2–5 mmHg. COMSOL Multiphysics simulations provided detailed insights into the sensor's durability, sensitivity, and performance by analyzing capacitance variations and electric field intensity. Laboratory experiments simulated IOP changes under realistic conditions to assess the sensor's accuracy and reliability. Unlike traditional methods, often limited to clinical environments, this approach offers a continuous, real-time solution for monitoring IOP.

This system addresses current diagnostic limitations by enabling earlier and more precise interventions in glaucoma care. Integrating the sensor into a contact lens allows for practical and patient-focused solutions, helping reduce the risk of vision loss. This project also contributes to advancements in wearable biomedical technologies and paves the way for broader applications in continuous health monitoring.



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sciforum-117413: Development of Test Kit and Smartphone Analysis for Detecting CN^- Ions: Synthesis of “Naked-eye” Colorimetric and Fluorescent Chemosensor for CN^- based on 1,8-Naphthalimide

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Introduction

It is unanimously known that cyanide (CN^-) is one of the most toxic ions because it can interfere with the body's physiological phenomena, causing endocrine disorders, respiratory failure, hypoxia, vascular necrosis, and even death. Therefore, it is essential to develop cost-effective, sensitive, rapid, and efficient methods for sensing CN^- ions.

Methods

The chemosensor was synthesised via a multi-step reaction, and its photophysical properties were analysed using UV-visible and fluorescence analyses. Binding was confirmed through Job's plot, $^1\text{H-NMR}$, HR-MS, and FT-IR, with TD-DFT validation using Gaussian 09W software.

Results

The chemosensor exhibited high selectivity and specificity for CN^- , with a distinct naked-eye colour change from yellow to blue. Additionally, a “turn-off” fluorescence response was observed, attributed to the inhibition of the Intramolecular Charge Transfer (ICT) process. The fluorescence quenching efficiency for CN^- was 73.21%, with a Stern–Volmer quenching constant of $1.22 \times 10^5 \text{ M}^{-1}$. The detection limit was determined to be $5.47 \mu\text{M}$. Furthermore, FT-IR spectroscopy, $^1\text{H-NMR}$ titration, and HR-MS analysis were conducted to study the plausible binding site. TD-DFT calculations and topological analysis were performed to investigate molecular orbitals and their localisation in the free probe and its CN^- complex.

Conclusions

The optical behaviour of the chemosensor towards CN^- was noted in this study. The “naked-eye” changes led to the development of test kit and smartphone analysis. Moreover, the fluorescent “turn-off” behaviour could be exploited for confocal fluorescence imaging of CN^- in living cells.



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sciforum-113978: Improving Patient Compliance and Medical Adherence through Technology: A Comprehensive Review

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Patient compliance and medical adherence are critical factors in achieving optimal treatment outcomes, reducing healthcare costs, and enhancing patients' quality of life. However, non-compliance and poor adherence remain persistent challenges, often stemming from factors such as complex treatment regimens, lack of patient education, financial barriers, and psychological resistance. These issues can compromise therapeutic efficacy, increase hospitalization rates, and burden healthcare systems. In recent years, technological advancements have paved the way for innovative solutions to address these challenges. Mobile health (mHealth) applications, wearable devices, artificial intelligence (AI)-driven interventions, telemedicine, and blockchain technology have emerged as powerful tools to improve medication adherence and patient engagement. These technologies offer personalized reminders, real-time health monitoring, predictive analytics, and secure data sharing, fostering better communication between patients and healthcare providers. AI algorithms can predict adherence risks, while blockchain ensures data transparency and security. Additionally, gamification strategies and virtual coaching have shown promise in motivating patients to adhere to treatment plans. This review comprehensively explores these cutting-edge technological approaches, analyzing their impact on bridging the adherence gap and revolutionizing patient care. By leveraging these advancements in healthcare system, healthcare systems can create more patient-centric models, ultimately leading to improved health outcomes and sustainable healthcare practices.



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sciforum-115452: Non-invasive blood glucose detection using mmWave transceiver

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The increasing number of diabetic patients worldwide, especially in developed countries, requires an urgent need for better and painless alternatives to monitor blood glucose. The advantages of millimeter-wave sensors in the frequency range of 30-300 GHz in non-invasive monitoring include greater sensitivity to biological tissues and penetration of the skin without invasive procedures. This paper discusses the feasibility of using mmWave sensors for continuous glucose monitoring, based on variations in dielectric properties determined by blood glucose levels. This study focused on a miniaturized transceiver operating at 61 GHz based on FMCW radar; the usage scenario was within the frequency range of 60 to 64 GHz. The system adopts a digital signal processing-based approach to guarantee precise and reliable glucose measurements. The dimensions of the miniaturized transceiver are 76 × 56 × 27.6 mm, with excellent performance in detecting blood glucose levels from 25 mg/dL to 400 mg/dL. The R-squared value is more than 95%, indicating the high accuracy and reliability of the device in tracking glucose trends. This novel, non-invasive glucose monitoring technique holds great promise for real-time and accurate blood glucose detection, which would be more convenient and patient-friendly in diabetes management. Such a development opens a new door to an improved quality of life for diabetic patients and a potential reduction in complications associated with conventional invasive methods of monitoring.



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sciforum-117312: Polymeric ionic liquids as effective components of biosensors

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Introduction

Polymer ionic liquids (PILs) are a new class of ionic liquids that have great potential in various fields of application. PILs play a role in business development, prosperity, and high business activity, as well as in the development of business in general[1,2]. These are polyelectrolytes that contain a polymer base and, at the same time, must have fragments of ionic liquid (IL) in each of the links, which are repeated. These ionic polymers can be fully insulated for a long time.

PILs in medicine. Multidimensional sensor devices based on PILs are extremely promising for the development of high-performance screening in the field of environmentally friendly chemistry and biology, while providing easier identification of a variety of analyzed substances.

PILs as electronic skin. PILs can also be considered an ionic skin. These are self-healing materials that allow partial or even complete self-healing after damage and essentially mimic natural systems. Such sensors are beneficial to monitoring human body movement.

PIL actuators in dielectric elastomers. These substances and materials are necessary for soft robotics and medical purposes and are being actively improved at the moment. Development and progress in this area are directly related to decision making. The latest research is now focused on the synthesis and testing of more advanced actuators fabricated from PIL–dielectric elastomers.

Conclusions

The unique properties present great prospects for PIL research in these areas, where progress and breakthrough technologies can be expected in the coming years. The research was carried out under Russian National Research Project No. AAAAA-A21-122040600057-3.

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sciforum-115512: Real-time detection of lactate in sweat with the aim of 3D-printed flexible wearable device

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The real-time monitoring of sweat lactate provides valuable physiological insights for assessing exercise outcomes and athletic performance. Conventional lactate detection methods often lack sensitivity, portability, and user-friendliness for in-body applications. To address these limitations, electrochemical biosensing has emerged as a leading approach, enabling non-invasive, real-time analysis. Wearable bioelectronic devices integrate lactate-specific enzymes with electrochemical transducers, offering practical solutions for continuous monitoring. In this study, a wearable lactate electrochemical biosensor was developed using custom screen-printed electrodes modified with a bio-hybrid probe comprising Prussian blue, carbon black, and lactate oxidase. After optimizing key parameters, the biosensor demonstrated a detection limit of 0.06 mM and a linear range up to 20 mM. A filter paper strip was incorporated to enhance sweat collection and serve as the sample chamber, achieving 6% repeatability and efficient sweat handling. The system was validated using three sweat samples, showing strong correlation (96–101%) with LC-MS/MS, a standard laboratory method. The biosensor was integrated into a 3D-printed thermoplastic polyurethane (TPU) armband, designed for efficient sweat collection and transport, combining lightweight durability with a customizable, ergonomic design suitable for dynamic activities. This low-cost, wearable system represents a significant step forward in non-invasive, continuous, and personalized health monitoring, providing a practical tool for tracking physiological parameters in real time.



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sciforum-115432: Towards In-Surgery Miniature Fluorescence Detection of Glioma

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Patients diagnosed with glioma have a 5-year survival rate of less than 5% [1]. Due to the difficulty distinguishing between healthy and tumour tissue, recurrence of glioma is likely to occur after surgery [2]. An area of interest in improving tissue distinguishment during surgery is fluorescence-guided surgery. One implementation utilises 5 aminolaevulinic acid (5-ALA) [3], which causes a build-up of Protoporphyrin IX (PpIX) in tumour tissue, caused by different metabolic processes between tumour tissue (glycolysis) and brain tissue (haem) [4]. PpIX fluoresces pink (635 nm peak) under blue light excitation (highest absorption at 405 nm) [5]. This fluorescence is difficult to see with the naked eye in lower concentrations of PpIX (found in edge cases of glioma). There have been many attempts to detect this fluorescence, though most devices are not suitable for miniaturization or for in-surgery use [6] [7]. To tackle this issue, a system for quantitatively measuring these fluorescence spectra has been developed. The system houses a miniature CMOS multispectral sensor alongside micro-LEDs to provide excitation and recording in a small footprint (3 mm x 3mm), which encourages further developments to integrate the system into existing surgical tools. The photosensor was benchmarked using a gelatine model mixed with ink to provide fluorescence close to the desired peaks (515 nm, 625 nm). The system mapped a fluorescence distribution area of 16 mm x 16 mm, with results being compared to a spectrometer's performance. The system achieved a high correlation with the spectrometer ($R^2 > 0.98$), confirming its accuracy and suitability for real-time detection. Integrating this system into existing surgical tools can help in surgical detection of glioma tissue, increasing the glioma tissue removed, reducing the chance of recurrence, and increasing the survival rate of patients.

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sciforum-113913: Wearable Biosensor Patch for Monitoring Air Toxicity in Occupational and Environmental Settings Over Time

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Canaries thrive in the air and fish in water, providing rapid and sensitive readings of their environments. Humans can detect volatile organic compounds and toxic chemicals but cannot accurately estimate exposure levels, especially when using protective gear. In space, bacterial bioreporters can measure cumulative radiation exposure, whereas, on Earth, they can estimate air exposure levels. Bioluminescent biosensors have emerged as promising tools for air toxicity assessment, offering sensitive and low-cost air quality monitoring. Despite working in real time, these bioreporters need nearly an hour to respond, which is negligible for long exposures. Thus, genetically engineered bacteria can be used in wearable sensor systems. We will describe how our whole-cell biosensors can be used to monitor exposure to harmful substances in real time in environmental or occupational air, providing an estimation of toxicity, which no enzymatic sensor can provide, due to not being 'living.' The lux reporter system generates luminescence, which can be converted to an electrical signal if needed. Our wearable design involves an array of five bioreporters immobilized onto alginate hydrogels integrated into clothing. Readings are taken offline to prevent light contamination, and the accumulated data provide insight into exposure and health risks. Industrial workers, urban dwellers in polluted cities, and first responders would benefit from these patches, which only require connection to an offline reading device for immediate results. Bacterial bioreporters are immobilized in calcium alginate pads that maintain humidity and allow gas diffusion. The bacteria respond semi-quantitatively to toxic aerosols, providing a response within one hour of exposure.



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sciforum-114143: Wearable biosensors for glucose monitoring in sweat: a patent analysis

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Metabolic diseases are increasing in relevance both in health and the economy in most countries. In this direction, if gold-standard technologies are to be based on blood analysis, non-invasive glucose monitoring is a relevant and great challenge that has not yet been fully resolved. This paper provides an overview of the patent landscape related to wearable biosensors for the monitoring of glucose levels in sweat.

Sweat represents a more suitable medium for the non-invasive sensing and monitoring of glucose than other bodily fluids, such as saliva, tears, or urine. However, the measurement of glucose levels requires the use of highly precise and sensitive sensors, given the low glucose concentration in sweat.

Patents' data were retrieved from the Espacenet database (www.espacenet.com), provided by the European Patent Office and freely accessible. The search strategy was based on 3 main keywords: "wearable" AND "sweat" AND "glucose". A set of single sub-keywords allowed for further data retrieval and clustering.

A total of 115 records were collected from Espacenet. After excluding some records that were identified as duplicates or related to applications rather than wearable devices, 95 records were included in the review.

China (63) is the country with the highest number of filings, followed by the USA (28) and Europe (21). The first application was filed in 2006; however, it was not until 2014 that an upward trend in filings became evident, with notable peaks in 2017 and 2021.

A total of 41.5% of the applications are currently pending, while only 35.1% have been granted patents.

The majority of claimed electrochemical sensors are enzymatic sensors.

Graphene represents the most prevalent carbon material utilized in the electrode, followed by rGO and carbon nanotubes. The employment of MXenes and MOF is comparatively limited.

The power supply unit may include a solar cell, a fuel cell, or a lithium-ion battery, but a small-sized lithium battery is preferably used.

This analysis aims to identify promising technologies and related IP for the non-invasive assessment of glucose in wearable systems: continuous monitoring, reliability, and interaction with infusion pumps are just the start.



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sciforum-115812: Wearable biosensors for non-Communicable disease management: monitoring physiological and pathological responses after nutrient intake

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Today's population faces a major challenge in the prevention and treatment of non-communicable diseases such as cardiovascular diseases, obesity, or type 2 diabetes, which are closely related to unhealthy lifestyle habits, including an inadequate diet and sedentary patterns. Identifying physiological and pathological parameters can help prevent and treat these diseases. In this respect, biosensors have been proposed as useful tools for analytical devices with biological sensing elements capable of detecting both physiological indicators and pathological markers that aid in the diagnosis, treatment, and long-term monitoring of these diseases. These tools also play a key role in the observation and assessment of physiological activities, with wearable biosensors being of particular interest due to their ability to provide continuous, real-time physiological information. Knowing the potential applications of these devices could aid in monitoring the real effect of these products' consumption. Given the rising interest in functional foods to improve public health, wearable biosensors hold the potential to monitor the physiological effects of their consumption. This systematic review aims to analyze the current state of wearable biosensor development, highlighting their applications, benefits, and limitations. Specifically, it focuses on implications for individuals using these devices and the challenges associated with data collection, interpretation, and extrapolation. By addressing these aspects, this review provides insights into the real-world applicability of wearable biosensors for disease prevention and personalized health management focused on nutrient intake.



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Session C. Smartphone-Based Biosensors

sciforum-114400: A frugal microscopic device for cell morphology and counting features on a smartphone

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Smartphone-based portable microscopic systems provide a viable alternative for meeting a variety of imaging and cell counting requirements in healthcare and other monitoring applications. Herein, we propose the design of a frugal microscopic imaging device that operates in bright-field mode using a smartphone for cell morphology and counting applications. Our device utilizes the inbuilt primary camera and the computational power of the phone. With the aid of readily available optical components, the designed platform is transformed into a high-throughput microscopic device. A custom-designed do-it-yourself (DIY) microfluidic chip, combined with a tailored Android app, simplifies the sample loading and automatic counting process. The microscopic device operates at three different optical magnifications and yields a lateral resolution of 1.21 μm over an acceptable field of view (FoV) of diameter $\sim 4530 \mu\text{m}$. The versatility of the system is demonstrated through imaging and counting of blood cells automatically. The results from our smartphone-based microscopic system show good agreement with values obtained from the widely used traditional hemocytometer. The affordability and portability of the proposed system suggest that it can be effectively implemented in resource-scarce areas. Additionally, we envision that the system would be significant for true point-of-care applications, research, and STEM education.



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sciforum-115496: Advanced Multicolor Rapid Test Integrated with Machine Vision and Automative Image analysis for Non-Invasive Cancer Biomarker Detection

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Liquid biopsy has emerged as a transformative approach in modern diagnostics, offering a non-invasive means to detect and monitor cancer biomarkers such as microRNAs, circulating tumor DNA, and exosomes. Its versatility and potential for early detection have positioned it as a key player in advancing personalized medicine and real-time patient monitoring. However, challenges such as low biomarker concentrations and the need for accurate multiplexing persist. Lateral flow assays (LFAs) have evolved as versatile diagnostic tools, widely applied across diverse scientific disciplines. Recent advancements in artificial intelligence (AI) and automated image analysis have significantly enhanced the performance of LFAs, transforming them into user-friendly, point-of-care (POC) diagnostic devices. The integration of machine vision with LFAs represents a significant leap forward, enabling precise and real-time interpretation of results. This study introduces a novel multicolor LFA platform that leverages AI-driven image processing for the simultaneous detection and differentiation of three microRNA biomarkers (miR-21, miR-let-7a, and miR-155) in liquid biopsy applications. By employing distinct polystyrene beads as reporters, each color-coded to a specific microRNA, the system achieved multiplexed detection with limits as low as 1.56 fmol for each target. The innovative platform is paired with a smartphone-based application and a web application, which automate the reading and interpretation of test results, ensuring high accessibility and accuracy. The developed method was rigorously validated using real urine samples, demonstrating exceptional diagnostic performance with 99.3% accuracy, 99.1% sensitivity, and 100% specificity.



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sciforum-115684: Enhancing Smartphone Colorimetric Sensors via Color Space Optimization

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Smartphone-based colorimetric (bio)sensors are a promising alternative for developing affordable, deliverable, and user-friendly analytical tests for healthcare, food safety, and environmental monitoring. However, their effectiveness is limited by sensitivity to lighting conditions, which frequently requires the use of housings with controlled light sources that compromise affordability and simplicity. This study introduces a novel framework for enhancing smartphone-based colorimetric sensing via color space optimization. This approach enables accurate and consistent measurements under varying lighting conditions without additional housing. We evaluated the performance of smartphone-based colorimetric models to quantify monotonal color gradients with spectral compositions covering a wide range of visible spectra. In addition, we benchmarked the smartphone-based colorimetric models against absorbance-based models built using a benchtop UV-Vis spectrophotometer. Our findings indicate that smartphone-based quantification can achieve accuracy, precision, and detection limits comparable to absorbance-based models while offering a broader dynamic range. By assessing the quantification performance across several color spaces—RGB, HSV, and CIELAB—we found that the a^* and b^* chromatic coordinates of CIELAB demonstrate exceptional resilience to changes in illumination. We introduce the concept of Equichromatic Surfaces as an innovative framework for understanding the illumination resilience of CIELAB. This concept serves as a guide for developing reliable, housing-free, illumination-invariant optical (bio)sensors.



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sciforum-112965: Hybrid CNN-LSTM Model for Real-Time Body Odor Detection and Monitoring Using Gas Sensor Arrays

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An array of gas sensors is combined with a mobile device to identify body odor. Metal-oxide semiconductor and nanomaterial-based sensors detect Volatile Organic Compounds (VOCs). VOCs like ammonia, acetic acid, trimethylamine, and hydrogen sulfide are associated with body odor. The array of sensors (MQ-135) captures the odor from the human body, and the system utilizes Artificial Intelligence (AI) algorithms to find the odor by using Convolutional Neural Networks (CNNs) and Long Short-Term Memory (LSTM) networks for complex pattern recognition. The CNN layers identify the pattern across multiple sensors, i.e., spatial features. The spatial feature data become smoothened in the CNN layer and converted into a 1D vector. The LSTM receives this 1D vector as input to the model. The LSTM layers identify the odor intensity and composition over time. The MQ-135 is connected to the mobile device through a USB connection. This connection delivers real-time feedback to the user about the intensity of the odor like low, medium, or high. The user can then connect this device to a mobile device to identify human body odor. This procedure will not reduce the battery power of the mobile device. The proposed system is cost-efficient, portable, and accurate. It is important to focus on personal healthcare, hygiene, and wearable devices. In the future, gas sensors will be added to smart watches, sensor sensitivity will be increased, and better solutions can be provided by using AI models.



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sciforum-111232: Portable Chemiluminescence Imaging System for Smartphone-Based Bisphenol A Detection

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Portable real-time detection of Bisphenol A (BPA) in plastic-bottled water and large-scale milk samples presents significant challenges. Analytical techniques must prioritize specificity and sensitivity for accurate analysis. Affordability and rapid detection are also crucial to ensure practical application. Additionally, sustainability is essential when analyzing plastic-bottled water and large-scale water samples. The imaging sensor for smartphone-based portable CL imaging has significant potential for point-of-care applications. When combined with a smartphone readout device, it enables convenient and efficient environmental sensing, which makes it a promising tool for real-time detection in various environmental contexts. We designed and made the 96-well plate for CL image sensing of BPA by hydrothermally synthesizing a mixed-ligand MOF on the surface, characterized by spectrochemical characterization. With luminol, NaOH, H₂O₂, and BPA, the modified plate demonstrated high selectivity and tolerance for BPA. It exhibited distinct colour changes in the chemiluminescence (CL) image. Additionally, it was compatible with diluted plastic water and milk samples containing varying levels of BPA. Compared to conventional liquid chromatography–mass spectroscopy techniques, the modified plate yielded CL images at 1 pg/mL with recoveries exceeding 90% (n = 3), serving as a demand-driven alternative imaging device that eliminates the need for an additional light source and simplifies the basic operating system design essential for point-of-care biomedical diagnosis.



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sciforum-115621: Portable smartphone-based paper assay for colorimetric nucleic acid detection

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The present work addresses the need for a simple, cost-effective, and portable tool to detect specific nucleic acid sequences. Current nucleic acid detection methods are often complex and expensive, limiting their applicability in decentralized settings. The proposed approach utilizes a colorimetric, paper-based assay employing the sequence-specific cyanine dye DiSC₂(5) without the need for surface modification or sophisticated labelling systems. This portable device integrates a 3D-printed dark chamber with smartphone-based detection, allowing for image capture and analysis with the open-access ImageJ tool. A TATA box sequence, characterized by alternating A/T base pairs, was used as the model target in this study. The target was stored on a paper-based disk and subsequently detected through the blue color produced by the binding of DiSC₂(5). The assay effectively identifies TATA sequences, with the intensity of the blue color being directly correlated to target concentration. Specificity studies confirmed the assay's capability to differentiate between alternating and random A/T-containing sequences, highlighting its reliability. Furthermore, applications to synthetic PCR products demonstrate a limit of detection down to 10 nM. These results suggest that this portable, all-in-one, and low-cost platform could be effectively used for real-world samples, offering a promising alternative to traditional nucleic acid detection methods in point-of-care diagnostics and resource-limited settings.



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sciforum-115753: Smartphone-Based Biosensors: Current Trends, Challenges, and Future Prospects

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Smartphone-based healthcare and diagnostic biosensors are adaptable, cost-effective, and accessible alternatives to traditional medical devices. This study examined smartphone-integrated biosensor advances in illness diagnosis, health monitoring, and personalized medicine. Biosensors on cell phones enable portable, real-time health examinations for a broad population by leveraging mobile technologies. How the electrochemical, optical, and biosensing biosensors detected biomarkers for diabetes, cardiovascular disease, infections, and cancer was also considered. This review focuses on user-friendly smartphone apps and mobile health (mHealth) platforms for data collection, processing, and interpretation. This study observed that even though smartphone-based biosensor technology has advanced, there are unresolved challenges. Addressing biosensor sensitivity and accuracy issues is crucial to reliable diagnostics. The effects of human variability, environmental disturbances, and sensor calibration on performance require improved sensor accuracy. Production costs, scaling problems, and healthcare system interactions slowed adoption in resource-limited regions. This study shows the need for affordable, easy-to-use sensors that can give patients and doctors vital information. Smartphone biosensors will benefit from nanotechnology, AI, and ML. These improvements should be smartphone biosensors' usability, precision, and efficiency, making them more reliable and versatile for consumer and medical use. Smartphone-based biosensors may improve individualized therapy, preventive care, and healthcare delivery, according to studies. This review also presents information on smartphone-based biosensor technology's advances, problems, and future uses.



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sciforum-116758: Smartphone-Integrated CRISPR Biosensors for Portable and High-Sensitivity Diagnostics

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The combination of CRISPR-based biosensors with smartphone technology is changing point-of-care (PoC) diagnosis by offering fast, portable, and highly sensitive diagnosis of the disease. CRISPR/Cas biosensing has recently been further developed with Cas12a, Cas13a, and Cas14 proteins, and new signal transduction strategies, including DNAzymes, binary 3D DNA walkers, and photoelectrochemical sensing have been introduced to boost the sensitivity and specificity of CRISPR diagnostics for real-life use. Moreover, electrochemical and field-effect transistor (FET)-based biosensors, quantum dot-assisted fluorescence, and surface-enhanced Raman scattering (SERS) have also been used to enhance the sensitivity and accuracy of the signal.

Lab-on-a-Chip (LoC) microfluidic platforms have been integrated with diagnostic devices to achieve automated and multiplexed testing for high-throughput and low-cost testing strategies. AI-based smartphone applications now offer real-time data analysis, cloud-based result sharing, and machine learning-based interpretations of results to enhance diagnostic care and decision-making. In addition to nucleic acid detection, CRISPR systems engineered from bacteria and viruses have been deployed to recognize proteins, metabolites, and small molecules for their use in infectious disease surveillance, cancer screening, antimicrobial resistance detection, and environmental monitoring. However, there are several problems, including reagent stability, large scale clinical validation, and efficient signal amplification. A major concern with respect to CRISPR reagents is their robustness in different environmental conditions, and this remains an issue that requires urgent solutions.

The main challenges include developing isothermal amplification methods and obtaining regulatory signatures. In the future, research should be aimed at the application of graphene-based nanomaterials for the increase in the signal transfer rate, the optimization of the CRISPR reagents to have a long shelf life, and the creation of wearable biosensors for healthcare purposes. The combination of CRISPR technology, nanomaterials, artificial intelligence, and digital health solutions is likely to redefine decentralized diagnostics and extend globally to affordable and scalable healthcare solutions.



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Session D. The Evolution of Biological Recognition Elements in Biosensors

sciforum-116399: Designing a Chemiluminescent Platform for Type III CRISPR-Cas Systems: An Innovative Approach to Nucleic Acid Detection

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CRISPR-Cas systems serve as an adaptive immune mechanism in prokaryotes, targeting and neutralizing mobile genetic elements. These systems are categorized into two main classes and various subtypes, with Type III systems being particularly distinctive for their RNA-targeting capabilities. Using a multi-subunit effector complex guided by CRISPR RNA (crRNA), these systems recognize and degrade foreign RNA molecules. This process also activates the Cas10 subunit, initiating the production of cyclic oligoadenylate (cOA) signaling molecules. These cOA molecules then activate effector proteins equipped with sensory domains, which drive further biochemical reactions.

Type III CRISPR-Cas systems have been repurposed for innovative nucleic acid detection due to their ability to amplify signals. One established approach uses Csx1, an RNase activated by cOA, in conjunction with an RNA-targeting complex, to produce a detectable fluorescent signal. However, fluorescence-based methods rely on external light sources, complicating their use in portable diagnostic devices.

To address this limitation, a chemiluminescent (CL) detection strategy was developed. This technique employs a G-quadruplex (G4) RNA probe, which catalyzes a chemiluminescent reaction between luminol and hydrogen peroxide in the presence of hemin. When the target RNA is present, Csx1 is activated by the CRISPR-Cas complex, leading to the degradation of the G4 probe and resulting in the loss of the chemiluminescent signal. This method offers a simple, highly sensitive detection system without the need for external light sources. The chemiluminescent readout provides a practical solution for creating portable and efficient diagnostic tools, making it an ideal choice for on-site nucleic acid testing.

This work was supported by the Nano-ImmunoEra project that has received funding from the European Union's MSCA Staff exchange Horizon Europe programme, Grant Agreement Number 101086341.



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sciforum-115790: Advanced Micro-Electrochemical Biosensor for Acetylcholine Neurotransmitter Detection

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Introduction

Acetylcholine (AChE) is an essential enzyme in neurotransmission, and its inhibition serves as a diagnostic marker for diseases like Alzheimer's and poisoning by organophosphates. We investigate an AChE-based electrochemical biosensor with an integrated microfluidic platform for the sensitive and rapid detection of AChE inhibitors. The biosensor utilizes a working electrode designed using MEMS (Micro-Electro-Mechanical Systems) technology, incorporating a Glassy Carbon Electrode (GCE), Gold Nanoparticles (AuNPs), PEDOT:PSS, and Carbon Nanotubes (CNTs), intended to detect pico-molar concentrations.

Methods

The AChE enzyme was immobilized onto the electrode surface of a microfluidic chip, facilitating precise control of the sample, and the reagent flow was studied in an FEM-based numerical platform. The MEMS-based working electrode was designed, and subsequently, an optimized structure was fabricated. The said electrode featuring a GCE modified with AuNPs, PEDOT:PSS, and CNTs was designed to maximize the electron transfer and enhance the conductivity. This design enabled the sensor to detect AChE inhibitors with high sensitivity. Amperometric and cyclic voltametric techniques were employed to evaluate the sensor's performance, including its detection limit, response time, and selectivity for common AChE inhibitors such as organophosphates. The mathematical modeling of the sensor included a mass transport equation for the electrode and the active molecules in the DLME, the electron transfer reaction on the working electrode, and the charge transfer kinetics. The model was validated and rigorously investigated through the depletion of concentrations of PBS and blood, where the applied potential affected the current through the electrolytes. The CV of the sensor was plotted for peak potential (0.4 v) and peak current (8 pA to 100 nA) measurements with respect to the concentration. Further, an EIS study was carried out, and the CV response was studied using different scan rates and redox couple concentrations. The observed peaks indicated the detection of biomolecules even at pico-molar concentrations.

Results

The presented MEMS-based microfluidic integrated electrochemical biosensor demonstrated excellent pico-molar sensitivity, with detection limits as low as the 10 picomolar level for acetylcholine and its inhibitors. The inclusion of AuNPs and CNTs significantly enhanced the electrochemical response, while PEDOT:PSS improved the electrode's stability and conductivity. The microfluidic platform ensured rapid (10 seconds) and selective detection, with the sensor maintaining high sensitivity over several weeks of use.

Conclusions

The presented AChE biosensor, designed using MEMS technology and an advanced electrode with multilayered materials, offers a highly sensitive, rapid, and cost-effective approach to detecting AChE inhibitors, even at pico-molar concentrations, in a robust device configuration. The integration of microfluidic control and MEMS technology enhances the system's potential for applications in environmental monitoring, clinical diagnostics, and toxicological testing. Future improvements could focus on further optimizing the sensor for portability and enhancing its selectivity in complex biological matrices.



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sciforum-116579: Dielectric Properties of Cells Under Simulated Microgravity Conditions

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Introduction

Human activities beyond Earth have steadily increased. During spaceflight, NASA observed that the lack of Earth's gravity causes a 1-1.5% monthly loss in the mineral density of weight-bearing bones. Even after returning, rehabilitation may be ineffective. The effects extend to muscles, the neuro-vestibular system, heart, eyes, and more. Understanding microgravity's effects on the human body is critical; however, sending samples to space is costly and time-consuming. Thus, technologies like the clinostat can simulate microgravity on Earth.

Methods

RBCs from cancer patients are used to investigate the impacts of microgravity. The link between microgravity-induced metabolic changes in their morphology and cytoplasm properties is poorly understood. To explore these changes, we will expose the RBCs to microgravity using a 3D clinostat, and using dielectrophoresis, an electrokinetic technique, we will analyze the dielectric profile related to morphological and cytoplasmic changes. The cells are suspended in media (8.6wt% sucrose + 0.3wt% dextrose in 100ml DI water), transferred into 1.5-ml centrifuge tubes, and exposed to microgravity for 1-24 hours at a specific conductivity (0.01 S/m), adjusted with 1xPBS.

Results

Cell behavior is quantified using the DEP crossover technique (when no DEP force occurs), where cells neither migrate toward nor away from the high electric field region at a specific AC frequency and peak-to-peak voltage. The results show statistically significant variations in membrane permittivity and conductivity between Earth and microgravity conditions. The folding factor of microgravity-induced cells decreased drastically. A decrease in the folding factor suggests altered cell structure and function, potentially affecting protein folding, morphology, and cellular processes.

Conclusions

These results help understand the effect of microgravity on changes in the morphology and cytoplasm of RBCs. The goal of this research is to enhance the understanding of the impacts of microgravity on the human body and advance space health studies.



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sciforum-114905: Advancements in Mechanical Biosensors for the Detection and Measurement of Biological Molecules: A review

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Mechanical biosensors represent a cutting-edge analytical technology for detecting and measuring biological molecules with unparalleled precision and sensitivity. These innovative devices rely on the integration of biological recognition elements and mechanical transducers to convert molecular interactions into quantifiable signals. Their utility spans a range of applications, including healthcare, environmental monitoring, and food safety, making them indispensable in modern analytical sciences. At the heart of mechanical biosensors are bio-receptors, biological components such as enzymes, antibodies, or nucleic acids, which bind selectively to target molecules. These bioreceptors are immobilized on transducer surfaces using techniques like physical adsorption, covalent bonding, or entrapment, ensuring stable and specific interactions even in complex biological matrices. Advancements in sensor design and material sciences have significantly enhanced the performance of mechanical biosensors. Embedding magnetic elements such as Fe₃O₄ nanoparticles amplifies detection sensitivity. Mechanical biosensors detect target molecules through surface stress measurement, mass detection, and force sensing. These capabilities make them highly versatile, with applications in medical diagnostics for detecting disease biomarkers, environmental monitoring for identifying pollutants, and food safety for detecting contaminants such as pathogens and chemical residues. Despite their advancements, challenges remain, including minimizing non-specific interactions and improving sensor reproducibility. Future innovations are expected to integrate nanotechnology, multi-analyte detection capabilities, and compact designs for wearable and portable applications.



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sciforum-117592: Electrophysiological profiling of peripheral blood mononuclear cells (PBMCs) for early pancreatic ductal adenocarcinoma (PDAC) detection using dielectrophoresis

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Pancreatic ductal adenocarcinoma (PDAC) is the most common form of pancreatic cancer, and is known to have an extremely low survival rate. The lack of early diagnostic techniques and tools, combined with non-specific symptoms, makes PDAC undetectable until it reaches advanced stages. PDAC is known to have resistance to treatment, largely due to the tumor's ability to suppress natural killer cells. Given the high mortality rate associated with this aggressive PDAC, there is an urgent need for innovative diagnostics to enable early detection, followed by an adequate and effective treatment procedure.

In this study, we used dielectrophoresis (DEP) to obtain dielectric profiles of peripheral blood mononuclear cells (PBMCs) isolated from PDAC patients under a non-uniform electric field gradient. Our hypothesis is based on cellular changes caused by PDAC interacting with the immune system, subsequently affecting the extracellular matrix (ECM) of the plasma membrane and the cell interior of PBMCs. These changes, resulting from the aggressive growth of dense fibrotic stroma, influence the cells' size, shape, permittivity, conductivity, and other dielectric properties, potentially serving as reliable biomarkers for early PDAC detection.

Using a single-shell model in 3DEP, we quantified the electrophysiological properties to discriminate PDAC PBMCs from non-cancerous pancreatic PBMCs in benign or pre-cancerous states by comparing their electrical biomarkers. Our preliminary results show significant differences in cytoplasm conductivity, membrane permittivity, conductance, and capacitance parameters of the PBMCs. These findings highlight the potential of dielectrophoresis as a technique for developing a diagnostic device for PDAC, providing relevant insight into cellular changes associated with the disease while enhancing our clinical understanding of its pathophysiology. This study has great potential for the development of accessible point-of-care devices for early PDAC diagnosis.



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sciforum-117572: Freshwater Harmful Algal Bloom Detection Through Dielectrophoresis

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Introduction

Harmful algal blooms (HABs) happen when colonies of algae grow out of control and exert toxic or harmful effects on people and marine life. Human diseases caused by HABs can be severe and, in some cases, fatal. *Chlorella vulgaris* is a type of green microalgae that can be found in freshwater. *Chlorella* is a dominant species in HABs. Various methods are available for detecting HABs, including light microscopy, flow imaging microscopy, immunoassays, and liquid chromatography. However, these techniques have several limitations, such as high costs, lengthy analysis times, the need for specialized training, and the inability to perform on-site detection. To address these challenges, we propose a novel detection approach utilizing the dielectrophoresis (DEP) technique. A critical step in developing this detection tool is characterizing the dielectric profile of *Chlorella vulgaris*.

Methods

Chlorella vulgaris was cultivated in Proteose medium under a **16:8-hour light cycle**, positioned **18 inches from the light source**. After cultivation, the cells were resuspended in a buffer solution containing **8.5 g of sucrose and 0.3 g of glucose**, with conductivities adjusted to **100, 200, 300, 400, and 500 $\mu\text{S}/\text{cm}$** . Using **3DEP equipment**, we characterized the dielectric properties of *Chlorella vulgaris*, including **cytoplasm conductivity, cytoplasm permittivity, specific membrane conductance, and specific membrane capacitance**.

Result

Data collection and analysis are ongoing, and the complete results will be presented at the conference.

Conclusions

Data collection and analysis are ongoing, and complete conclusions will be presented at the conference.



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sciforum-115456: Molecularly Imprinted Polymers: Novel Affinity-Based Detection for Sensor Development of Fulvic Acid

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Fulvic acid (FA) is a water-soluble molecule belonging to the group of organic compounds called humic substances, which are derived from the decomposition of organic matter. Known for its significance in soil fertility and nutrient availability, it is considered a water pollutant due to its ability to become precursor for the formation of toxic halogenated disinfection by-products and complexes with heavy metals in soil. Several methods have been developed to remove this in water, such as coagulation and adsorption methods, but the efficiency is significantly affected by different factors such as the solubility, size, and concentration of the molecule.

Molecularly imprinted polymers (MIPs) are synthetic polymers that show promising properties to become an adsorbent for the removal of FA in water. MIPs exhibit robustness even in high pH and high temperature conditions and high selectivity for the target even in the presence of matrix interferers; they are also reusable, and their synthesis is simple and straightforward. This study explored the formulation of MIPs specific for FA using methacrylic acid, methacrylamide, and acrylamide as functional monomers.

Prior to MIP synthesis, this study employed the functionalization of silica gel with chitosan, followed by the immobilization of FA as the target and humic acid (HA) as the control molecule on the functionalized silica gel. Verification was performed through a series of FT-IR analyses conducted to ensure accuracy and consistency in the processes. The MIP's selectivity was tested using HA, the control molecule. After the three-hour contact time with triplicate samples of FA and HA separately, the initial and final concentrations of MIP were analyzed using UV-Vis spectroscopy at a 190–400 nm range.

The 30 ppm MIP solution exhibited 65% FA recovery versus 1.69% HA recovery, proving the selectivity of the synthesized MIP towards the target. This paper could lay the groundwork for future researchers aiming to advance the development of a similar sensor or other innovations.



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sciforum-107896: Research on a Peroxidase Biomimetic Sensor based on a Ag electrode

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Introduction

Rapid and accurate determination of trace amounts of C₂H₅OH in aqueous media of various origins is very important. The desire to improve the sensitivity and selectivity, as well as the durability of biosensors, has generated a huge amount of research. In our work, a peroxidase-type biomimetic sensor using Ag as a transducer was studied through potentiometric research.

Methods

The experiments were carried out in an electrochemical cell. The experimental setup for these studies included an electrode part, a cell, and a B7-21A universal voltmeter. The electrode part of the installation consisted of a reference electrode (Ag/AgCl/Cl⁻) and a biomimetic sensor (TPhPFe³⁺/Al₂O₃/electrode) manufactured by us. The electrochemical installation was equipped with a magnetic stirrer to create an equilibrium solution. The background solution was double-distilled water.

Results

As a result of the research work, we found that the biomimetic sensor developed by TPhPFe³⁺/Al₂O₃/Ag allowed one to determine a given concentration in a few seconds. The sensitivity threshold was 10⁻⁶ mass%.

Conclusions

The developed peroxidase-type biomimetic sensor based on smart material detected a low concentration of ethyl alcohol. The developed and synthesized peroxidase-type biomimetic sensor based on TPhPFe³⁺/Al₂O₃/Ag was highly sensitive, stable, and remained inactive for a long time. The sensitivity threshold for C₂H₅OH was 10⁻⁶ wt.%.



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sciforum-115367: Using the GOLD-SELEX approach to generate highly specific and sensitive DNA aptamers against carbendazim

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Carbendazim (CBZ) is a fungicide that is widely used in agriculture for controlling fungal diseases. However, its excessive presence in food, feed, agricultural soils, and water bodies poses severe environmental, human, and animal health risks due to its toxicity. Among the various available detection techniques, aptamers have gained prominence as highly sensitive, cost-effective, and reliable tools for on-site detection. This study employed gold nanoparticles (GNPs) combined with the Systematic Evolution of Ligands by Exponential Enrichment (SELEX) method, specifically using the GOLD-SELEX approach, to identify a highly specific and sensitive aptamer for CBZ detection in food and feed products. The process involved ten rounds of SELEX, incorporating counter-SELEX against commonly used and structurally related pesticides, such as Mancozeb, Chlorpyrifos, Glyphosate, Monocrotophos, Atrazine, Thiamethoxam, and Methyl Parathion, to enhance specificity. A graphene oxide (GO)-based fluorescence assay was utilized to monitor aptamer enrichment throughout the SELEX process. In the final SELEX round, PCR amplification was performed using unmodified primers, and the amplified sequences were cloned using a blunt-end cloning kit from Takara. High-throughput sequencing (HT-SELEX) was then conducted to analyze the abundance and motifs of the enriched aptamers. The identified aptamer sequences will undergo further characterization to determine their dissociation constant (K_D) and assess their sensitivity and specificity toward CBZ. Ultimately, the most effective aptamer will be utilized to develop a rapid, cost-effective, and user-friendly diagnostic kit for detecting carbendazim in food and environmental samples.



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Session E. Nanomaterials and Smart Surfaces in Biosensors

sciforum-113171: In vitro Selection of ss DNA Aptamers and Their Role in the Fabrication of a Biosensing Platform for Gastric Cancer Diagnostics

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Research has revealed that over 90% of duodenal ulcers and approximately 80% of gastric ulcers are linked to *Helicobacter. pylori* infections. Beyond ulcers, it can cause mild chronic gastric inflammation and may even lead to gastric cancer. Several diagnostic techniques have been developed to detect *H. pylori*, spanning bacteriological, genomic, isotope tracing, pathological, serological, and molecular methods. Despite their effectiveness, most of these methods necessitate specialized equipment and skilled personnel, limiting their application in early detection and prevention, which can have serious health and economic implications. Hence, there is an urgent need for a simple, rapid, highly specific, and cost-effective approach for detecting *H. pylori*. This study presents the first selection, identification, and biosensing application of the *H. pylori* surface protein Cag A and the development of a novel label-free electrochemical aptasensor used for signal enhancement to achieve the facile, rapid, and direct detection of the Cag A antigen using a conductive SA hydrogel as an efficient solid support on the ITO surface. The fabricated aptaprobe has a satisfactory selective recognition function toward the Cag A antigen via the DPV technique, even in the presence of a high concentration of co-existing elements. The aptasensor demonstrated an acceptable wide linear range ($0.1\text{--}80\text{ ng mL}^{-1}$), high sensitivity [$22.64\text{ mA log}_{10}(\text{mL ng}^{-1})\text{ cm}^{-2}$], a low sensing limit (0.17 ng mL^{-1}) and limit of quantification (0.54 ng mL^{-1}), and a rapid response time ($\sim 14\text{ min}$). Although clinical validation is needed to establish its clinical utility, the findings of our study are promising and encouraging.



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sciforum-114527: Advanced chemical processes in the development of microelectrodes for electrochemical sensors

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Stable electrodes are crucial for the creation of high-performance electrochemical microsensors, as they guarantee reliable long-term operation and enhanced sensitivity. Silver electrodes coated with a thin film of silver chloride (AgCl/Ag) form the basis of analytical electrodes due to the excellent charge transfer characteristics and non-polarization of the AgCl material. Also, there is great interest in the integration of nanoparticles with carbon materials due to their unique properties, though challenges related to their hydrophobicity remain. In this study, we modified the silver substrate to create nanostructured reference electrodes and prepared the carbon substrate for the working electrode to improve its compatibility with nanoparticles. The chemical modification process, performed by means of the chlorination of the metal microelectrodes on silicon wafer, included the following steps: degreasing and chemical roughening of the Ag film; washing, drying, and chlorination of the Ag film at room temperature; washing and chemical and thermal stabilization of the nanostructured AgCl film. The enhancement of the hydrophilic properties of nanocrystalline graphite films was achieved by using an acid treatment on the film. The electrodes were structurally characterized, highlighting the formation of the silver chloride film, the degree of purity, and the structural integrity of the carbon material. Microscopic studies allowed us to observe the morphology and roughness of both the modified carbon material and the film, consisting of spherical particles AgCl/Ag with a thickness of about 300 nm. Contact angle analysis was used to investigate the film-wetting properties of the two types of electrodes.

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sciforum-114707: Design of amino-functionalized MIP silica particles for biosensor development with selective recognition of lipopolysaccharides

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The global spread of pathogenic bacteria is an ongoing issue, where detecting bacterial endotoxins, known as lipopolysaccharides (LPSs), is vital for addressing environmental and healthcare challenges. LPS is responsible for various infections and has recently been implicated in the development of Parkinson's disease. Traditional methods for detecting LPS in research and clinical settings, such as ELISA and LAL assay, have significant drawbacks. These techniques often exhibit low sensitivity and involve complicated, time-consuming processes. Consequently, there is an increasing demand for the development of innovative and cost-effective methods, e.g., electrochemical detection, especially in the fields of environmental science and medicine. This work describes the design of amino-functionalized MIP silica particles for the selective recognition of a specific targeted type of LPS (i.e., LPS from *Pseudomonas aeruginosa*) from different bacterial strains. The obtained MIP particles were incorporated in a lab-made carbon paste formulation and drop-casted on the working electrode surface of a screen-printed electrode (SPCE). MIP silica particles were synthesized using the Stöber method in the presence of the target molecule LPS via the polycondensation of the functional monomer 3-Aminopropyltriethoxysilane and the structural monomer, tetraethyl orthosilicate, in the basic medium. Herein, two types of cationic surfactants (cetyltrimethylammonium bromide and benzyl trimethyl ammonium chloride) were utilized to stimulate and control the formation of silica particles at a nano level. To ensure the capacity of the MIP particles of recognizing LPS, computational docking was assessed to predict the binding affinity of 3-Aminopropyltriethoxysilane towards LPS. The ¹H-NMR results sustained the docking predictions. Other modern techniques, including structural and morphological analyses, were employed to characterize the obtained MIP particles in the raw phase and after their embedment and deposition on the final biosensors. Cyclic voltammetry and differential pulse voltammetry, along with the static and selective adsorption analysis, were submitted to determine the imprinting factor, sensitivity, and selectivity for the targeted LPS. As a result, the obtained amino-functionalized MIP silica particles proved to be an effective and low-cost alternative for biosensor development for the detection of lipopolysaccharide from *Pseudomonas aeruginosa*.



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sciforum-114728: Metal–organic composite material-based electrochemical sensors for biomolecule quantification

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A novel electrochemical sensor offering superior analytical performance criteria has been developed to quantify various biomolecules involved in life-threatening ailments [1,2]. The composite material comprises a layer of poly(3,4-ethylenedioxythiophene) conducting polymer (PEDOT) and platinum nanoparticles (PtNPs) electrodeposited on a glassy carbon electrode (GCE) surface through the application of a sinusoidal voltage (SV) procedure with tailored electrochemical parameters. The sinusoidal voltage method relies on the application of a sinusoidal voltage on a constant voltage for a precisely monitored timeframe. The antifouling capability of the polymeric matrix, combined with the enhanced sensitivity and the remarkable catalytic properties offered by the metallic nanoparticles, ensures the accurate and reliable detection of biologically important molecules. Moreover, the newly synthesized analytical device displays a trend of cost-effective production associated with the potential for additional functionalization using renewable or sustainable material sources for environmental protection. The GCE-PEDOT/PtNP electrochemical sensor was successfully implemented for serotonin determination in a synthetic buffer solution. The sensor responded selectively to serotonin, with a linear response range of 1–80 μM . The sensor's optimum analytical capacity was validated, achieving a detection limit of 1.8 μM for the target analyte. Moreover, the analytical performance of the devised sensing platform proved to be in agreement with the data available in the literature. The results point to the effectiveness of the SV procedure for the selective determination of target analytes in a complex medium featuring various interfering molecules.

Acknowledgments: This work was performed within the research theme “Development of Electrochemical Sensors for Biologically Active Compounds Determination” of the Erasmus+ Traineeship Program between POLITEHNICA University of Bucharest and the University of Modena and Reggio Emilia.

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sciforum-115404: Modified Laser-Induced Graphene Electrodes for Dual-Mode Capacitive Sensing: From Nitrite Detection to Kanamycin Monitoring

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Introduction

The improper use of nitrite ions and the widespread presence of antibiotics like kanamycin in food products pose significant risks to human health. To address these challenges, we developed two advanced electrochemical sensing platforms using laser-induced graphene (LIG) electrodes for sensitive and selective detection of these contaminants.

Methods

For nitrite detection, LIG electrodes were modified with an electrochemically deposited melanin-like film (MeLF), leveraging its redox-active catechol and o-quinone moieties. Redox capacitance spectroscopy was employed as a probe-free detection method. For kanamycin detection, LIG electrodes were functionalized with gold nanoparticles and a kanamycin-specific aptamer. Non-faradaic capacitance measurements were utilized to detect interactions between aptamer and kanamycin. Both sensors were characterized electrochemically and validated in real sample matrices.

Results

The MeLF-modified LIG sensor exhibited enhanced electron transfer kinetics, an increased electroactive surface area, and improved charge capacitance. It detected nitrite ions with a limit of detection of 2.45 μM and a dynamic range of 10 μM to 10 mM, achieving high recovery rates in water and processed meat samples. The aptamer-functionalized LIG sensor demonstrated a proportional increase in non-faradaic capacitance with kanamycin concentration, achieving a linear range from 100 fg/mL to 10 $\mu\text{g/mL}$, with successful real-time application in milk samples.

Conclusions

These novel sensing platforms demonstrate the versatility of modified LIG electrodes in electrochemical sensing. The combination of redox-active films and aptamer-based recognition elements with capacitive detection offers promising solutions for food safety monitoring and environmental analysis, providing sensitive, reliable, and practical analytical tools for real-world applications.



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sciforum-114727: Polydopamine-PEDOT-based composite material for electrochemical sensing applications

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A novel sensing material has been synthesized for the design of an electrochemical sensor for epinephrine detection. The sensing material is composed of poly(3,4-ethylenedioxythiophene) polymer (PEDOT), polydopamine (PDA), and gold nanoparticles (AuNPs). The use of low-cost chemicals and the development of water-based preparation methods without the need for organic solvents were intended to comply with a sustainable development goal in the sensor's preparation. The biocompatibility and adhesion properties of PDA were explored in the sensor's design. The inclusion of AuNPs featuring pronounced electrocatalytic properties was aimed at improving the analytical sensitivity. The sensing material has been synthesized onto glassy carbon electrodes by using cyclic voltammetry and sinusoidal tension and current methods. The morphological analysis of the sensing material was carried out by scanning electron microscopy. The sinusoidal currents method [1] achieved the best analytical performance of the PEDOT-PDA-AuNP sensor toward epinephrine determination. A linear response in the range of 0.4 - 100 μM and a detection limit value of 0.11 μM epinephrine were obtained. The sensing material shows improved antifouling properties and stability in the detection of epinephrine in synthetic samples. The detection of epinephrine in spiked synthetic and urine samples was achieved with good accuracy and minor interferences from uric acid. The sensor is designed for reuse of the electrodic substrate, while the modifier can be eliminated by local procedures. The analytical performance of the sensor is comparable with that of other sensors prepared with conventional methods.

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sciforum-115761: The Development of Concanavalin A and DNA Aptamers-Based Acoustic Biosensors for the Detection of Lipopolysaccharides in *Salmonella typhimurium*

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Bacterial lipopolysaccharides (LPSs) are important indicators of bacterial infection in organisms or food contamination. They can be therefore used for medical diagnostics as well as for the detection of microbiological contamination in food and dairy products. We performed a comparative analysis of different techniques to isolate LPSs from *Salmonella enterica serotype typhimurium* (*S. typhi*). Different stages of the isolation method were applied to receive LPSs and the lipid component responsible for LPS toxicity called Lipid A was separated. As receptors for LPS detection, we used the lectin concanavalin A (ConA) or DNA aptamers immobilized at the gold layers of the quartz crystal modified by 11-mercaptopundecanoic acid. Using carbodiimide chemistry, the covalent immobilization of ConA or amino-modified DNA aptamers was possible. The interaction of LPSs with the sensing surface was studied by quartz crystal microbalance with dissipation monitoring (QCM-D). We have shown that DNA aptamers that specifically bind to lipid A in LPSs from *S. typhi* more strongly decrease the resonant frequency and increase the dissipation in comparison with ConA layers. Significant changes in the resonant frequency were observed already at 0.3 ng/mL of LPSs. The specificity of the interaction was confirmed by using LPSs isolated from other bacteria such as *E. coli*. We also used an extract of the bacterial membranes from Gram-positive bacteria *Listeria monocytogenes* that do not contain LPSs. In this case, no significant changes in frequency and dissipation were observed. Thus, the QCM-D is a sensitive tool for the detection of LPSs using DNA aptamers with high sensitivity and selectivity.

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sciforum-115600: A chemiluminescence nanocellulose-paper-based analytical device for point-of-care detection of Alzheimer disease biomarkers

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Cellulose is one of the most abundant biopolymers, and its many properties make it suitable for application in numerous fields, such as sensor and biosensor fabrication. It is indeed biodegradable and renewable, nontoxic, biocompatible, and widely available at low cost (<https://doi.org/10.3390/chemosensors10090352>). In addition, cellulose boasts different structural arrangements such as Cellulose Nanocrystals (CNCs), which are among the most promising cellulose-derived nanomaterials for applications in biosensors. In fact, CNCs can be formulated into thin films to be used as support material for the immobilization of proteins (enzymes, antibodies, etc.) (<https://doi.org/10.3390/chemosensors10090352>, <https://doi.org/10.1016/j.sbsr.2020.100368>). In this work, we exploited antibody-functionalized CNCs to develop a microfluidic paper-based analytical device (μ PAD) for the detection of myeloperoxidase blood levels, which have been shown to be altered in patients with Alzheimer's disease (AD) (<https://doi.org/10.5539/gjhs.v6n5p87>, <https://doi.org/10.1111/j.1471-4159.2004.02527.x>, <https://doi.org/10.1016/j.arr.2020.101130>). In particular, upon their covalent functionalization with anti-myeloperoxidase antibody, CNCs were deposited onto filter paper, thus providing a uniform and stable functionalized layer. Subsequently, employing the origami format, myeloperoxidase contained in the sample was captured by the immobilized antibody and then detected, exploiting its ability to catalyse the luminol/hydrogen peroxide chemiluminescence reaction. Emitted photons were detected by employing a portable highly sensitive charge-coupled device (CCD) camera and analyzed to obtain quantitative information. A limit of detection of 5.8 ng/mL was obtained, which enables clear distinction between healthy and AD patients' myeloperoxidase blood levels (<https://doi.org/10.3233/jad-131469>). In addition, the selectivity of the system was evaluated by testing the possible interference of haemoglobin, which is also able to catalyse the chemiluminescence reaction. In the future, the same approach will be used for developing origami μ PADs for detecting other AD biomarkers exploiting chemiluminescence sandwich immunoassays.

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sciforum-115282: A High-Sensitivity Electrochemical Sensor Utilizing Polyaniline/Sodium Alginate Composite for Lead and Cadmium Detection

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Water pollution remains one of the most pressing global environmental challenges, posing significant threats to ecosystems, human health, and biodiversity. Among the various pollutants, heavy metal contamination is particularly concerning, even at trace concentrations, due to its bioaccumulative and toxic effects. The efficient detection of heavy metals is essential for effective environmental monitoring and public health protection. Electrochemical sensors have emerged as promising tools for heavy metal detection, offering high sensitivity, selectivity, and accuracy alongside operational flexibility.

This study presents the development of an advanced electrochemical sensor based on polyaniline (PANI) incorporated into a sodium alginate (SA) matrix. Sodium alginate, a natural polymer, is notable for its excellent ion exchange properties and acid stability, making it an ideal candidate for composite materials. Blending alginate fibers with conducting polymers like PANI creates materials with enhanced functional properties suitable for advanced applications.

The PANI/SA composite was synthesized via in situ polymerization, improving the material's electrical conductivity and mechanical stability. The composite was then employed to modify a glassy carbon electrode, creating a robust electrochemical sensor for the sensitive detection of heavy metals such as lead (Pb) and cadmium (Cd). This sensor combines the high electrical conductivity of PANI with the biocompatibility and gel-like properties of SA, resulting in a highly efficient detection platform. The PANI/SA sensor demonstrated exceptional sensitivity, stability, and rapid response times, with low detection limits for Pb and Cd, showcasing its potential for real-world environmental applications.



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sciforum-114940: Advances in Enzyme-Based Biosensors: Emerging Trends and Applications

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Enzyme-based biosensors have emerged as a transformative technology, leveraging the specificity and catalytic efficiency of enzymes across various domains, including medical diagnostics, environmental monitoring, food safety, and industrial processes. These biosensors integrate biological recognition elements with advanced transduction mechanisms to provide highly sensitive, selective, and portable solutions for real-time analysis. This review explores the key components, detection mechanisms, and applications of and future trends in enzyme-based biosensors. Artificial enzymes, such as nanozymes, play a crucial role in enhancing enzyme-based biosensors by mimicking natural enzyme activity while offering improved stability, cost-effectiveness, and scalability. Their integration can significantly boost sensors' performance by increasing their catalytic efficiency and durability. The functionality of enzyme-based biosensors is built on three essential components: enzymes as biocatalysts, transducers, and immobilization techniques. Enzymes serve as the biological recognition elements, catalyzing specific reactions with target molecules to produce detectable signals. Transducers, including electrochemical, optical, thermal, and mass-sensitive types, convert these biochemical reactions into measurable outputs. Effective immobilization strategies, such as physical adsorption, covalent bonding, and entrapment, enhance the enzymes' stability and reusability, enabling their consistent performance. In medical diagnostics, they are widely used for glucose monitoring, cholesterol detection, and biomarker identification. Environmental monitoring benefits from these biosensors in detecting pollutants like pesticides, heavy metals, and nerve agents. The food industry employs them for quality control and contamination monitoring. Their advantages include high sensitivity, rapid response times, cost-effectiveness, and adaptability to field applications. Enzyme-based biosensors face challenges such as enzyme instability, interference from biological matrices, and limited operational lifespans. Addressing these issues involves innovations like the use of synthetic enzymes, advanced immobilization techniques, and the integration of nanomaterials such as graphene and carbon nanotubes. These advancements enhance enzymes' stability, improve their sensitivity, and reduce the detection limits, making this technology more robust and scalable.



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sciforum-113587: An analysis and comparison of microelectromagnetic vibration energy harvesters.

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Based on microelectromechanical (MEMS) technology, this paper presents two electromagnetic vibration energy harvesters. We designed and fabricated two models with different vibration structures. As part of the energy harvester, a permanent magnet is attached to a vibration structure (resonator) made from silicon and a very small wire-wound coil. The total volume of the coil is about 0.9 cm³. Tests and comparisons are performed on two energy harvesters with different resonators.

The maximum load voltage of Model A is 143 mV, and, for Model B, it is 196 mV. Model A generated a maximum load power of 51.52 μ W across a 405 Ω load at 347 Hz. Model B generated a maximum load power of 135.35 μ W at 311.4 Hz with an acceleration of 0.5 g. Compared to Model A, Model B has a higher output voltage and greater working bandwidth. Under similar experimental conditions, Model B's performance is better than Model A's. Using simple analysis, the results indicated that electromagnetic energy harvesting with Model B provided better results. Furthermore, it shows that a non-linear spring might be able to extend the frequency bandwidth and increase the output voltage.



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sciforum-117563: An emerging high-throughput biosensing platform for membrane interaction studies

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This presentation highlights the use of an emerging electrochemical biomembrane sensor for the (bio)membrane activity assessment of nanomaterials/advanced materials. It utilizes a self-assembled dioleoyl phosphatidylcholine (DOPC) monolayer on a fabricated microHg-on-Pt chip electrode to generate characteristic rapid cyclic voltammograms (RCV) at 40 Vs⁻¹. These RCVs contain current peaks due to underlying phase transitions in response to the applied electric field. Changes in the RCV scan and associated capacitance peaks in the presence of (bio)membrane active substances are related to membrane disruption, detailing the nature and extent of the interactions. These interactions will be related to the MIE (molecular initiating event) of each species, providing insight into the mechanism of their interaction with the biomembrane-like sensor layer. Extracting membrane affinity parameters from the data enables the estimation of the structure–activity relationships (SARs) of the materials with the sensing layer. The biomembrane sensor has successfully been intercalibrated with in vitro analysis through MTT assays using colchicine, methyl methane sulfonate and chlorpromazine and exhibited more than ten times higher sensitivity. This unique advanced material screening technology, the results and their analysis will be presented at this conference.

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sciforum-115098: Antibody-embedded functionalized magnetic nanoparticles for the immunodetection of venom proteins: a preliminary study

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Snakebite envenoming is predominantly a life-threatening occupational disease caused by venom proteins in the bite of a venomous snake. The development of reliable rapid diagnostics is the need of the hour for timely snakebite diagnosis and the early administration of antivenom for treatment. Magnetic nanoparticles (MNPs) conjugated with antibodies have been extensively explored for the selective detection of biomarkers for diagnostic purposes. The purpose of the current study is to develop antivenom antibody-immobilized MNPs for the efficient immunodetection of snake venom proteins. Iron oxide magnetic nanoparticles were synthesized by the co-precipitation of Fe^{2+} and Fe^{3+} in sodium hydroxide (NaOH) solution. These MNPs were functionalized by sodium citrate solution. The synthesized citrate-capped MNPs with at least one carboxylic acid group on the surface were used for the immobilization of $\text{F(ab}\phi)_2$ antibodies present in commercially available polyvalent antivenom. For the site-directed immobilization of antibodies, EDC-NHS ((1-ethyl-3-(3-dimethylaminopropyl) carbodiimide hydrochloride/N hydroxysuccinimide)) was used as linker. The antibody-immobilized and non-immobilized MNPs were characterized by X-ray diffraction and Fourier-transform infrared spectrometry analysis, and their size was estimated with the help of zeta potential. To validate the performance of antibody-conjugated MNPs in detecting snake venom proteins, a dot blot assay was performed using Russell's viper venom protein antigens. The presence of snake venom-specific phospholipase A_2 (PLA_2) in human serum is an early indicator of snake bite envenomation and serves as a potential biomarker for the detection of free-flowing venom protein. Thus, antibody-immobilized MNPs were used as an immunoaffinity-based platform to capture a purified viper venom PLA_2 . The present study demonstrated the successful conjugation of antibodies to the surface of magnetic nanoparticles and their ability to recognize viper venom proteins. Further, antibody-coated MNPs displayed the capability to effectively immunocapture a venom PLA_2 protein. Such antibody-coated nanoparticle-based immunodetection platforms will provide efficient enrichment and selective separation of snake venom-specific venom proteins from human serum. Additionally, immunoaffinity platforms based on nanoparticles for snake venom proteins with high sensitivity and high purity, and quick characterization will facilitate the early diagnosis of snakebite envenomation.



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sciforum-116086: Application of a Reduced Graphene Oxide-Multiwalled Carbon Nanotube Composite for the Development of a Electrochemical Aptasensor for Oxytetracycline Detection

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Antibiotics are extensively used in veterinary medicine for the treatment of bacterial infections. However, their uncontrolled use can cause infiltration into milk and meat, which can cause antimicrobial resistance. Therefore, the development of sensitive and selective methods for the detection of antibiotics is an urgent need. Conventional methods such as HPLC or ELISA can detect antibiotics with high sensitivity; however, they require experienced personnel, expensive antibodies, and expensive instruments. Biosensor technology is an alternative to conventional analytical methods. A biosensor is composed of sensing layers with immobilized receptors and a transducer that convert chemical signals into measured electrical, optical, or acoustic values. DNA aptamers are relatively novel receptors that are also known as chemical antibodies. In contrast with antibodies, they are more stable and can be immobilized on various surfaces. We developed an electrochemical aptasensor based on a nanocomposite of reduced graphene oxide (rGO) and multiwalled carbon nanotubes (MWCNTs) enriched with carboxylic groups for sensitive detection of oxytetracycline (OTC). The amino-modified DNA aptamers were covalently immobilized on rGO-MWCNTs layers drop-casted on a glassy carbon electrode (GCE). Differential pulse voltammetry (DPV) in the presence of 5 mM $[\text{Fe}(\text{CN})_6]^{3-/4-}$ was used for OTC detection. The limit of detection (LOD = 0.46 ng/mL) was much lower than the maximum residue limit (MRL) established for OTC by the EU (100 ng/mL). The selectivity of the sensor was demonstrated by using kanamycin, penicillin, chloramphenicol, and tetracycline antibiotics. The aptasensor was validated in 3.5 % fat milk with successful recovery.



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sciforum-115735: Au nanoparticle-modified carbon aptasensor for the ultrasensitive detection of tetracycline

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Carbon electrode materials have the unique advantages of being low-cost, being easily manufactured, and exhibiting good electronic conductivity and high thermal and chemical stability [1]. Carbon exhibits a good choice for solid screen-printed electrodes that can be readily utilized in electrochemical biosensing. In particular, within this work, the surface of carbon screen-printed electrodes with a diameter of 2mm was modified with Au nanoparticles via electrodeposition for the immobilization of aptamers [2,3]. For this purpose, Au-thiolated aptamers were selected, and the route of chemisorption was followed, to allow the formation of a covalent bond with the Au nanoparticles. After the aptamer was immobilized, the system was used for the detection of tetracycline (TET). In particular, a concentration of 1 μ M aptamer was incubated on the Au-sensitized carbon working electrode (WE), followed by 0.1mM of Mercaptohexanol (MCH), and these were left overnight. Following that, different concentrations (5nM to 1000nM) of TET were used. Differential pulse voltammetry was performed using a Ag/AgCl reference and a Pt wire as a counter. The results yielded a limit of detection of the order of 10⁻⁹nM. It can be noted that the aptasensor developed in this study can potentially be used for the detection of tetracycline in pharmaceutical preparations, drinking water, and contaminated food samples such as milk.



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sciforum-114406: Binary transition metal oxide nanostructures and their potential biosensor applications

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Binary metal oxide nanostructures have received much attention as potential materials in biosensor development, due to their chemical and structural stability, good conductivity, catalytic activity, and high reversible capacity. By combining metal oxides (e.g., TiO_2 , In_2O_3 , ZnO , and CuO), various versatile materials are obtained, capable of creating sensitive and selective platforms for detecting certain biological or chemical analytes. Among them, $\text{In}_2\text{O}_3\text{-TiO}_2$ is considered a promising structure for speeding up electron transfer, preventing the recombination of electron-hole pairs, and has superior photocatalytic activity and remarkable photonic activity under visible light illumination.

In this study, the $\text{In}_2\text{O}_3\text{-TiO}_2$ nanostructures were synthesized by the cation precipitation method, varying the conditions of the synthesis process and thermal treatment at the optimum temperature of 550°C . Different analytical methods were used to evaluate the characteristics regarding the identification of functional groups, determination of the shape and size of the samples, and the purity and crystallinity of the samples. Structural characterization was conducted using FTIR spectroscopy, highlighting bands assigned to In-O and Ti-O bonds; XRD was conducted to find structures of high crystallinity and purity; and EDX provided information at the atomic level. SEM microscopy allowed morphological characterization, finding agglomerated formations of almost-spherical particles of small size. The applicability of the $\text{In}_2\text{O}_3\text{-TiO}_2$ nanostructures is supported by their hydrophilic behavior and the possibility of percolation, properties determined by contact angle measurements.

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sciforum-115111: Catalytic preference-enabled exclusive bimodal sensing of methyl-paraoxon via double-site-synergized organophosphorus hydrolase-mimetic fluorescent nanozymes

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Given their hazardous effects on the environment and human health, the monitoring of pesticide residues is recognized as the most effective means to guard food and public safety. Oxidoreductase-type nanozymes (peroxidase and oxidase) have been widely employed to develop optical methods for pesticide detection, but these methods are susceptible to matrix redox interference and lack detection specificity for intended targets. To overcome the above deficiencies, here we designed a novel organophosphorus hydrolase-mimicking nanozyme, namely, nanosized ceria capped by Ca^{2+} -chelated 2-aminoterephthalic acid (Ca-ATPA@CeO_2) featuring stable fluorescence and dual-site-empowered high catalytic activity, to enable the exclusive dual-mode detection of hypertoxic methyl-paraoxon (MP). The synergy of hard Lewis acid Ca^{2+} and nanoceria creates dual active sites that jointly promote the binding and hydrolysis of MP to yellow *p*-nitrophenol (pNP) specifically. Meanwhile, the generated pNP quenches the intrinsic fluorescence of Ca-ATPA@CeO_2 via the inner filter effect. As a result, dual-mode colorimetric and fluorescence determination of MP was achieved using the designed versatile nanozyme. The alliance of excellent target catalytic specificity and bimodal cross-check characteristic enables accurate quantification of the individual pesticide in complex matrices. Our work introduces a new reliable strategy for MP selective detection that can avoid potential interference from redox substances.



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sciforum-115634: Controllable Development of Dual-Modified Protein Molecules for Bio-Computational Tasks

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Introduction

The development of biomolecular systems for computational tasks is a promising area in bioengineering and biosensor techniques. Using modified protein molecules as functional components of such systems enables the creation of next-generation devices based on the principles of biocomputing. In this study, we explored approaches to synthesizing dual-modified proteins with controlled surface characteristics and their potential application in implementing logical operations.

Materials and Methods

Dual-modified proteins were synthesized through the controlled sequential conjugation of test proteins, bovine serum albumin, and gelatin with low-molecular-weight compounds such as chloramphenicol and biotin, using carbodiimide chemistry. Low-molecular-weight substances were dissolved in a mixed buffer system with dimethyl sulfoxide, and their carboxyl groups were activated by a carbodiimide reagent. The activated compounds were then added to a protein solution in borate buffer, maintaining a precise molar ratio of 1:37:12 to ensure proper structural organization. This step allowed for an equilibrium distribution of surface charges, optimizing molecular interactions. The entire process was meticulously monitored using a label-free optical biosensor system based on spectral-phase interferometry (SPI). The final conjugates were diluted in a phosphate buffer and stored at 4 °C.

Results and Discussion

This study investigated the potential of using the obtained modified protein molecules to perform computational tasks, exemplified by the logical operations “YES” and “NOT.” By adding low-molecular-weight substances to the protein solution in a specific sequence during conjugation, the surface characteristics of the resulting product could be tailored. The steric properties of the surface determine the interaction pattern of the conjugate with other molecules in the solution, enabling it to reproduce specific reactions in a defined environment. These reactions, representing the output signals of a logical operator (logical “0” or “1”), were recorded using the SPI method and digitized.

Conclusions

This study demonstrates the potential of dual-modified proteins for use in biocomputing systems. Future work will focus on expanding the range of logical operations and optimizing the synthesis of dual-modified proteins to enhance their reproducibility and performance in biocomputing systems.



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sciforum-115463: Design of Pentagon-Shaped THz Photonic Crystal Fiber Biosensor for Early Detection of Crop Pathogens Using Rotation-Dilated Invariant Convolutional Cascaded Secretary-Bird Visual Attention Networks

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Crop pathogens pose a significant threat to global agricultural production, resulting in substantial yield and economic losses. Conventional detection methods often exhibit limitations in accuracy, speed, and timely intervention. To address these challenges, this study presents a Pentagon-Shaped Terahertz (THz) Photonic Crystal Fiber (PCF) Biosensor integrated with a Decision-Cascaded 3D-Return-Dilated Secretary-Bird-Aligned Convolutional Transformer Network (DC3D-SBA-CTN). The proposed model employs a multi-stage feature extraction approach using Cascaded 3D-Dilated Convolutional Networks (CD-Net) and a Return-Aligned Decision Transformer (RADT) for accurate pathogen classification. Parameter optimization uses the Secretary-Bird Optimization Algorithm (SBOA), enhancing robustness and reducing false positives.

The biosensor's innovative pentagon-shaped design optimizes light-matter interactions, achieving heightened sensitivity and minimal signal loss. Simulation and experimental evaluations validate the biosensor's exceptional performance, with a detection accuracy of 99.9%, demonstrating resilience against morphological and environmental variations. Additionally, the system's adaptability ensures its applicability across diverse agricultural settings, providing a reliable solution for real-time pathogen detection. The proposed solution enhances early intervention capabilities, contributing to reduced crop loss and increased agricultural productivity.

These findings establish the Pentagon-Shaped THz PCF Biosensor with DC3D-SBA-CTN as a transformative advancement in smart agricultural technology. The proposed approach contributes to precision farming and supports sustainable agricultural practices by enabling early detection and intervention.



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sciforum-115325: Development of a Flexible Biosensor based on Green-Synthesized Hematite–Graphene Oxide Nanocomposites for Electrochemical Detection of Bisphenol A

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Bisphenol A (BPA), a hazardous endocrine disruptor with strong estrogen-like effects, has raised environmental and health concerns. Therefore, it is crucial to develop an approach that is greener, simpler, cost-effective, flexible, environmentally friendly and efficient for detecting BPA. This work introduces a user-friendly electrochemical sensing platform to detect BPA, utilizing hematite nanoparticles (α -Fe₂O₃NPs) combined with reduced graphene oxide (rGO) on a carbon cloth substrate. Green synthesis, facilitated by *Cinnamomum tamala* leaf extract, produced α -Fe₂O₃NPs, which were subsequently integrated with graphene oxide to form reduced graphene oxide (rGO), which served as a stabilizing as well as a reducing agent for α -Fe₂O₃NPs. The sensing surface was prepared using electrophoretic deposition, resulting in a nanostructure with superior conductivity and a high surface area, enhancing its electrochemical response on carbon cloth (CC) (i.e., α -Fe₂O₃NPs@rGO/CC) owing to the synergistic effect. The α -Fe₂O₃NPs@rGO/CC sensor exhibited remarkable performance, including a wide detection range (from 1.9×10^{-10} to $1.00 \mu\text{M}$), high sensitivity ($33.04 \mu\text{A} (\log \mu\text{M})^{-1} \text{cm}^{-2}$), and the lowest detection limit ($0.23 \mu\text{M}$), alongside excellent reproducibility, stability, as well as selectivity, ultimately providing satisfying outcomes. Moreover, the sensor was validated using real-world samples, i.e., food and environmental samples confirmed its applicability, paving the way for detecting other similar environmental contaminants.



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sciforum-115691: Electrochemical aptasensing utilizing titania-based surfaces for tetracycline detection

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Electrochemical aptasensors have been successfully applied in a number of fields, including food safety, environmental monitoring and the health sector, providing a robust approach to the detection of a number of analytes. In particular, aptasensors have the advantage of flexible design, low immunogenicity and relative chemical/thermal stability. Moreover, aptamers, i.e. in-vitro synthesized oligonucleotides, can offer a valid alternative to antibodies. In this work, we focus on electrochemical aptasensors based on semiconducting materials utilizing a mesoporous Mn:TiO₂ working electrode (WE) for the detection of tetracycline (TET). For this purpose, Mn:TiO₂ electrodes were prepared via the screen printing route, providing a low-cost approach. In particular, 5 µM of the DNA aptamer with the following sequence: 5'-CCC CCG GCA GGC CAC GGC TTG GGTGG TCC CAC TGC GCG-3' [1,2] was used for the detection of different amounts of TET ranging from concentrations of 0.3 to 25.0 ng/ml in spiked aqueous samples. Detection was performed via differential pulse voltammetry (DPV) using a Pt wire cathode. In particular the buffer used in the experiment was Tris-HCl (20 mM, pH 7.6), 100 mM NaCl, MgCl₂ (2 mM), KCl (5 mM) and CaCl₂ (1 mM). The limit of detection was lower than the maximum residue limit required by the European Commission for 100 ng of tetracycline/mg, showing a low-cost alternative for TET detection.



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sciforum-113044: Electrochemical Biosensor Fabrication for Lysozyme Enzyme Detection in Food Products

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Introduction

The emergence of new technologies in the food industry has led to the production of a variety of nutritious foods containing allergenic proteins. Therefore, the accurate identification and measurement of allergens and the implementation of appropriate labeling rules on the product have become greatly important. Lysozyme is used in the beverage industry as a stabilizer and fermentation inhibitor instead of sulfites. It is also used in the production of cheese or beer as an inhibitor of butyric acid-producing bacteria. We also use lysozyme to prevent the loss of the beverage's desired color and to reduce the flora of lactic acid-producing bacteria in the product after malolactic fermentation is complete. Lysozyme may cause allergic reactions in sensitive individuals, even in small amounts.

Methods

This study presents the development of an electrochemical biosensor for detecting lysozyme in food samples. The biosensor utilizes a nanocomposite consisting of polyaniline nanowires, multi-walled carbon nanotubes, and gold nanoparticles (PANI NWs/MWCNTs-Au), combined with aptamer strands. To achieve this, Au nanoparticles were first synthesized by reducing gold (III) chloride salt with trisodium citrate dihydrate. The synthesized nanoparticles were then characterized using a UV-Vis spectrophotometer, FESEM, DLS, and FT-IR graphs. After that, a nanocomposite of multi-walled carbon nanotubes and gold nanoparticles (MWCNTs-Au) was synthesized and dropped onto the surface of a platinum (Pt) electrode. Then, polyaniline nanowires (PANI NWs) were synthesized on the MWCNTs-Au/Pt surface by the electrochemical method and chronoamperometry.

Results

The three-component PANI NWs/MWCNTs-Au nanocomposite enables easier and more stable immobilization of aptamer strands, thereby improving the biosensor's electrochemical signal. The electrochemical DPV technique was used to examine the output signals received from the biosensor after its incubation with lysozyme solution and the specific binding of aptamer sequences and lysozyme enzyme. The results showed that the developed electrochemical biosensor can measure lysozyme enzymes in a linear concentration range of 0.1 picomolar to 100 nanomolar, with a low limit of detection (LoD) of 3.5 femtomolar. The biosensor also provided acceptable results under selectivity, stability, and practical application tests in diluted egg white samples.

Conclusions

Under optimized experimental conditions, the developed PANI NWs/MWCNTs-Au/Pt-based biosensor can be used for quantitative determination based on the linear relationship between ΔI_p and the logarithm of lysozyme concentration in the range of 0.1 picomolar to 100 nanomolar with a detection limit of 3.5 femtomolar. The obtained PANI NWs/MWCNTs-Au nanocomposite can be a potential compound in biosensing applications for the detection of allergenic agents.



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sciforum-115428: Electrochemical immunoplatfom for the quantification of epithelial extracellular vesicles applied to prostate cancer diagnosis

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Introduction

Prostate cancer (PCa) represents the second most commonly diagnosed cancer in men worldwide. This cancer is the most frequently diagnosed and the third cause of cancer-related deaths [1-3]. It is of vital importance to diagnose this cancer early to implement an effective treatment [4-5]. The present work reports an electrochemical immunoplatfom based on magnetic microbeads (MBs) to determine epithelial extracellular vesicles (EpEVs) applied to PCa diagnosis.

Methods

Our method employs magnetic microparticles (MBs) as an immobilization platform. In an immune-electrochemical system, MBs enhance sensitivity through efficient capturing, analyte concentration, and easy washing in the presence of an external magnetic field. So far, no reported proposed sensor has been developed to detect EpCAM + extracellular vesicles (EVs) in diagnosing PCa. Hence, we report an electrochemical sandwich-type bioassay for assessing EpCAM + EVs in the early stages of PCa. Through the immobilization of the capture antibody (monoclonal anti-EpCAM) on HOOC-MBs, its incubation with EVs and a specific biotinylated detector antibody (anti-CD81) labeled with a streptavidin horseradish peroxidase (strep-HRP) polymer are observed. The amperometric detection of the affinity reaction was performed using disposable screen-printed carbon electrodes (SPCEs) and the hydroquinone (HQ)/H₂O₂ system.

Results

The detection limits for the proposed method and the ELISA test were 0.4 ng μL^{-1} and 5 ng μL^{-1} , and the intra- and inter-assay coefficients of variation were below 3.81% and 6.54%, respectively.

Conclusions

Our electrochemical immunoplatfom offers an interesting analytical tool for PCa diagnosis and prognostics.

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sciforum-109926: Electrochemical/Optical detection of alpha synuclein biomarkers in clinical samples

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Alpha-synuclein (α -synuclein) is a key biomarker for neurodegenerative diseases, including Parkinson's disease (PD) and dementia with Lewy bodies (DLB). Its early and accurate detection in biological samples is crucial for timely diagnosis and disease management. This study presents a dual-platform biosensor that integrates electrochemical impedance spectroscopy (EIS) and surface plasmon resonance (SPR) for highly sensitive and specific α -synuclein quantification.

The electrochemical biosensor is based on nanostructured gold electrodes functionalized with monoclonal antibodies that selectively capture α -synuclein, inducing measurable impedance changes upon binding. SPR-based optical detection provides a label-free, real-time analysis of the same interaction, allowing for the cross-validation of results. The sensor was tested using spiked and clinical samples, demonstrating a detection limit of 12.5 pM (EIS) and 8.3 pM (SPR), with a linear range of 10 pM–100 nM. Both techniques exhibited high specificity, effectively distinguishing α -synuclein from common biofluid interferents.

This dual-detection strategy enhances the reliability, reproducibility, and accuracy of α -synuclein quantification, providing complementary insights into biomarker interactions. Furthermore, the biosensor's design enables potential miniaturization for portable point-of-care (POC) diagnostics, facilitating early intervention and improved disease monitoring. By integrating advanced biosensing technologies, this study addresses key challenges in biomarker detection, paving the way for more accessible and effective clinical diagnostics for neurodegenerative diseases.



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sciforum-114807: Electrochemiluminescence resonance energy transfer immunosensing system based on PTC@UIO-66-NH₂ metal-organic framework and MnO₂ nanosheets for sensitive detection of vascular endothelial growth factor

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Introduction

Vascular endothelial growth factor (VEGF) is acknowledged as a crucial biomarker for tumor angiogenesis, playing a significant role in the progression, development, and metastasis of tumors. Therefore, developing an ultra-sensitive detection method for VEGF is vital for early cancer prevention and surveillance of disease status.

Methods

In this research, we constructed a sandwich-style quenching electrochemiluminescence (ECL) immunosensor by employing the mechanism of electrochemiluminescence resonance energy transfer (ECL-RET), aiming for highly sensitive identification of VEGF₁₆₅.

Results

The PTC@UIO-66-NH₂ complex was prepared by integrating the organic luminescent probe, derived from the ammonolysis of Perylene-3,4,9,10-tetracarboxylic dianhydride (PTC), into the UIO-66-NH₂ metal-organic framework. This complex was subsequently modified on the surface of a polished carbon electrode to serve as an ECL substrate. The VEGF antibody was then conjugated to this substrate via an amide reaction. Meanwhile, bovine serum albumin-functionalized MnO₂ nanosheets (BSA-MnO₂), which were linked to VEGF₁₆₅ aptamers, functioned as the ECL acceptor. Upon selective recognition and binding to VEGF₁₆₅, ECL-RET occurred between the PTC@UIO-66-NH₂ (ECL donor) and BSA-MnO₂ (ECL acceptor), leading to a significant reduction in the ECL signal, which could be readily captured by the instrument. Additionally, the intensity of the ECL response diminished as the concentration of VEGF₁₆₅ increased. Under optimal experimental conditions, the ECL immunosensor exhibited a linear detection range spanning from 5 pg/mL to 50 ng/mL, with a minimum detectable limit of 3.5 pg/mL, which underscores its exceptional sensitivity. Furthermore, the ECL-RET immunoassay was subjected to rigorous validation procedures to confirm its specificity and stability.

Conclusions

In a nutshell, our ECL immunosensor presents a novel method for the early identification of VEGF in human serum, offering a fresh approach for timely detection. Furthermore, this technology depicts its potential to function as a flexible and promising platform, capable of detecting other circulating tumor biomarkers.



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sciforum-116048: Enhanced Electrochemical Detection for Heart Attack Diagnosis Using 3D-Printed Electrodes

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Electrochemical biosensing has been extensively explored as a solution to cardiac troponin I (cTnI) detection. Biosensing has evolved to include signal amplification strategies such as nanoparticle-functionalised electrodes and using conductive coatings to enhance detection limits. However, these methods often introduce challenges, including signal noise, increased complexity requiring bulky equipment, intricate fabrication processes, and reduced assay reproducibility, limiting their clinical applicability. Three-dimensional printing allows for rapid and customisable electrode production, making it an ideal candidate for innovative electrode design which meets specific user needs and minimises variability in carbon electrode manufacturing. This study details various small electrodes fabricated using fused filament fabrication 3D printing [1], integrating multiwall carbon nanotubes and polylactic acid (MWCNT/PLA) as a simpler, more robust alternative. The 3D-printed electrodes were tailored for the electrochemical detection of oxidised tetramethylbenzidine (TMB_{ox}) using an electrochemical enzyme-linked immunosorbent assay (ELISA) for cTnI detection as formulated by previous work [2]. Electrodes of varying sizes and composite materials were fabricated and evaluated to optimise performance for TMB_{ox} detection. A sandwich ELISA format was used to capture and label cTnI, allowing for the indirect quantification of cTnI via chronoamperometric measurements, with absorbance-based ELISA as a comparator. This presentation will discuss how the miniaturisation and material optimisation of 3D-printed electrodes improve electrochemical ELISA sensitivity and reliability, and the prospects of integrating these technologies into a portable electrochemical ELISA format.

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sciforum-114721: Functionalized S-layer protein surface to target folate receptors in cancer cells

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Biological nanomaterials that exhibit repetitive functionalities with high spatial precision, density, and orientation are of great interest for the development and production of biosensors. In particular, biomaterials which can self-assemble on technologically relevant surfaces are of paramount importance. In this context, bacterial surface layer proteins (SLPs) are highly interesting nanomaterials as they fulfil all these requirements. Additionally, the proteinaceous lattice has water-filled pores and shows a thickness of only few nanometres. These features make self-assembled SPLs ideal as an intermediate surface for biosensors utilizing surface-sensitive techniques as read-out system. Moreover, the SLP lattice provides a surface where molecules can be bound in precise spatial distribution and orientation whereby almost no unspecific binding occurs.

To demonstrate the suitability of SLP lattices as smart surfaces, folate was chemically bound to the SLP from *Lysinibacillus sphaericus* CCM 2177 (SbpA). This construct was subsequently self-assembled on a gold-coated quartz disc. The specific recognition of folate receptors by the SbpA-immobilized folate was investigated by quartz crystal microbalance with dissipation monitoring (QCM-D). Folate receptors are highly expressed on the cell membrane of some cancer cells, such as the human breast adenocarcinoma cell line MCF-7. The developed sensor shows specific binding of MCF-7 cells whereas human liver cancer cells lacking folate receptors on their cell membrane give no shift in the QCM-D signal. This biosensor offers the ability to recognize cells in situ and in real time, and it is even possible to discriminate between different MCF-7 cell viability levels.

The proposed smart surface has several advantages like the nanometer thickness and low unspecific binding properties of the SLP lattice. These features increase the sensitivity and cell capturing efficiency. Hence, this biosensor comprising SbpA-folate biorecognition elements provides a promising strategy for designing smart sensing platforms to diagnose early-stage cancers.



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sciforum-117474: Graphene-Based Platform for Electrochemical Profiling of Amino Acids

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Introduction

Traditional protein sequencing methods, such as mass spectrometry, struggle with novel protein variants, isoforms, and the precise locations of post-translational modifications (PTMs). We propose a graphene-based sensing platform for single-point amino acid and PTM analysis, utilizing graphene field-effect transistors (GFETs) to capture the distinct electrochemical fingerprints of amino acids and their modifications.

Methods

We modeled the electrochemical dynamics of amino acids during pH titration [1], leveraging their amphoteric nature to generate unique charge and capacitance profiles measured using GFETs. To validate our model, we started with optimizing a functionalization protocol for directional amino acid attachment to graphene, monitored via surface plasmon resonance (SPR). We developed three platforms to enable the process in GFETs: one for sensor preconditioning, another for functionalization with amino acids and peptides, and a third for pH titration-based amino acid fingerprint analysis using GFETs.

Results

The coupling reactions with the graphene linker and directional amino acid attachment were monitored with single-layer precision. SPR results showed the regulation of the number of molecules, ensuring reproducible surface density control critical for the analysis of surface potential measurements. The functionalization chemistry also enables in situ peptide synthesis on graphene. Additionally, our platforms function effectively in both aqueous and organic solvents, and the Dirac point of graphene has been tracked in different conditions.

Conclusions

This work presents a promising graphene-based framework for single-point protein sequencing, enabling detailed amino acid characterization. By optimizing protocols and developing platforms for consistent GFET measurements, we controlled molecular coverage for electrochemical profiling. The building blocks for this technology have been optimized for our platforms and can offer an alternative to traditional methods, with applications in proteomics, biomarker discovery, and diagnostics. Furthermore, our platforms and chemistry offer versatility to probe chemical affinity to peptides.



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sciforum-117519: Graphene, Nanotubes, and Nanozymes: Smart Surface Engineering for High-Performance Biosensing

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The integration of nanotechnology in biosensor development has unlocked new possibilities for highly sensitive and selective molecular detection. Nanomaterials exhibit exceptional electrical, catalytic, and structural properties that can be tailored to optimize biosensor performance. This presentation examines how engineered nanostructures and smart surface modifications enhance biosensor performance. Traditional enzyme-based biosensors were compared with integrated nanomaterial designs, optimizing enzyme immobilization and detection method parameters for the best stability and selectivity. For nanomaterial-based sensors, functionalization with graphene (G), carbon nanotubes (CNs), and NiCo₂O₄ improved charge transfer and catalysis, while chemically and biologically synthesized gold nanoparticles (AuNPs) were evaluated for enzyme-mimetic (nanozyme) and antioxidant properties.

Nanomaterial-functionalized biosensors demonstrated significant improvements in sensitivity and detection limits. A glucose oxidase-based biosensor utilizing a layer-by-layer self-assembly approach with G-CN composites achieved a low operational potential of -0.2 V vs. Ag/AgCl and a detection limit of 41 μ M. Thyroxine detection was enhanced by incorporating NiCo₂O₄ on graphene oxide platforms, reducing the detection limit from 23 nM to 6.1 pM. Furthermore, biosensors leveraging the peroxidase-like activity of AuNPs enabled efficient oxidative stress detection via H₂O₂ quenching. Notably, biologically synthesized gold nanoparticles (Bio-AuNPs) preserved the intrinsic antioxidant properties of plant extracts, offering a sustainable and biocompatible alternative for biosensing applications.

The integration of nanostructured materials and smart surface engineering has significantly advanced biosensor technology, demonstrating superior analytical performance and real-sample applicability. These findings highlight the potential of nanomaterial-based biosensors for next-generation point-of-care diagnostics, paving the way for highly efficient, biocompatible, and sustainable sensing platforms.

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sciforum-116927: Innovative 2D material sensors: a new era in medical and environmental technologies

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Recently, the rise of 2D materials has revolutionized sensor technology, offering cutting-edge solutions for both medical and environmental applications. These ultra-thin, highly sensitive sensors are transforming the way we monitor health and the environment, enabling real-time, precise measurements with minimal energy consumption. In the medical field, 2D-material-based sensors provide breakthroughs in non-invasive diagnostics, wearable health monitoring, and personalized treatment, significantly enhancing patient outcomes. They enable early disease detection; in some cases, continuous monitoring; and even real-time tracking of biomarkers in bodily fluids, reducing the need for invasive procedures. In environmental and food safety technologies, 2D-material-based sensors offer unparalleled detection capabilities for pollutants, water quality, and air monitoring, contributing to more effective environmental protection and sustainability efforts. Their high surface-area-to-volume ratio and exceptional electronic properties make them highly effective for detecting pesticide traces in food, toxic gases, heavy metals, and other contaminants in different concentration ranges. These sensors can play a crucial role in combating climate change, ensuring a safe water supply, and improving air quality. This presentation will examine the innovations behind 2D material sensors and explore how changing the size and thickness of these materials affects their sensitivity. Understanding these relationships is essential for optimizing sensors' performance and unlocking new applications across various scientific and industrial domains.



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sciforum-115639: Investigation of kinetic parameters of chloramphenicol and its conjugates' interaction with monoclonal antibodies using label-free biosensors based on low-coherence interferometry

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Introduction

Chloramphenicol (CAP) is a widely used antibiotic in veterinary medicine, posing a risk of contamination in animal-derived food products. Detecting CAP is crucial due to its potential health hazards, such as allergic reactions and antibiotic resistance. Immunoanalytical test systems based on monoclonal antibodies (mAbs) are commonly used to detect CAP. However, most studies focus on mAb interactions with CAP-conjugates, while the kinetics of interactions with free CAP remain poorly understood. Our study addresses this gap, for the first time evaluating the kinetic parameters of mAbs binding to both CAP-conjugates and free CAP. This dual characterization is essential for designing more effective detection systems.

Materials and Methods

To achieve this, we used a label-free biosensor system based on low-coherence interferometry. Carboxylated glass chips immobilized with bovine serum albumine (BSA-CAP) conjugates served as the sensor surface. The interactions of the sensor with monoclonal antibodies and mixtures of antibodies with free CAP were analyzed. A tailored kinetic model was applied to calculate dissociation constants and evaluate the binding dynamics.

Results and Discussion

Our results reveal the kinetic parameters for mAb interactions with both BSA-CAP conjugates and free CAP. The dissociation constants and binding dynamics provide critical insights into the affinity and specificity of mAbs under different conditions. This approach demonstrates the system's capacity to differentiate interactions with conjugated and free CAP, showcasing its applicability in developing precise and reliable CAP detection methods.

Conclusions

This study establishes a novel methodology for characterizing mAb interactions with free CAP alongside conjugated forms. By leveraging a low-coherence interferometry-based biosensor, the findings contribute to the creation of advanced, high-sensitivity detection systems for CAP, ultimately enhancing food safety monitoring.-----



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sciforum-115396: Laser-induced graphene electrodes scribed onto a composite membrane for dopamine sensing

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An innovative approach was employed to develop composite membranes conducive to the production of advanced electrodes for electrochemical applications based on laser-induced graphene. This technique is based on the laser synthesis of graphene-based nanomaterials, specifically laser-induced graphene and reduced graphene oxide. The synthesis of these materials was performed using CO₂ laser (10 mm). Direct laser writing of graphene is commonly used on solid surfaces based on polyimide, polyether sulfone and polyether ether ketone, which are widely used in many applications, including electrochemical processing, water desalination and fuel cells.

Herein, LIG was successfully synthesized on composite membranes composed of amino-functionalized polyether sulfone and carbon black. Comprehensive characterization of the prepared composite membranes and electrodes was carried out, employing various techniques such as Fourier transform infrared spectroscopy, scanning electron microscopy and thermogravimetric analysis, as well as cyclic voltammetry and Nyquist diagrams, to evaluate their surface morphology and thermal stability. The electrochemical performance of laser-induced graphene electrodes (LIGEs) demonstrated substantial enhancements in comparison to the pristine NH₂-PES membrane. After optimizing the laser writing parameters for these novel composite membranes, their performance as electrodes was evaluated. Specifically, gold nanoparticle-modified LIG electrodes (AuNPs/LIG) were successfully employed for the electrochemical detection of dopamine (DA), demonstrating the potential of these materials in sensor applications.



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sciforum-115780: Metallic nanozymes of different compositions for sensitive lateral flow immunoassays for antibiotics in meat products

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Lateral flow immunoassays (LFIA) are a promising means of food quality control due to their rapidity and ease of implementation. Commonly, LFIA results are recorded based on the coloration of certain zones of test strips, in which immune complexes labeled with colored nanoparticles are formed. However, many nanoparticles have catalytic activity (are nanozymes) and can transform chromogenic substrates, enhancing coloration. Unfortunately, the choice of nanozyme size, shape modification technique, and degree of covering by immunoreagents for efficient LFIA remain empirical.

The given work presents an application of different nanozymes for sensitive LFIA for antibiotics in meat products. This is in high demand due to the numerous negative consequences of antibiotics entering the human body with food and the expansion of the list of antibiotics requiring extensive monitoring to protect consumer health.

A comparison was made for mono-, bi-, and tri-component nanoparticles of noble metals (gold, silver, and platinum) of different sizes and shapes as peroxidase-like nanozymes. The advantages of nanoparticles with a branched surface obtained by two-stage synthesis, namely, the formation of spherical gold nanoparticle cores and their partial surface modification with platinum, as catalysts were shown. Changes in the catalytic and antigen-binding activity of nanozyme-antibody complexes with varying surface densities of immobilized antibodies were considered. The limits of detection (LODs) for nanozyme-based LFIA were reduced by tens of times compared to traditional LFIA using spherical gold nanoparticles (AuNPs). For example, in the case of tetracycline, a 7.6-fold reduction was demonstrated using AuNPs as nanozymes instead of their direct photometry. Working with Au@Pt core-shell nanozymes led to a 20-30-fold reduction in LODs for chloramphenicol, tylosin, and tetracycline. The LFIA were conducted by following the developed accelerated (15-20 min) protocols of sample preparation for raw and finished meat products.

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sciforum-115208: MXene-Enhanced Electrochemical Sensor for Point-of-Care Therapeutic Drug Monitoring in Chemotherapy

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Effective therapeutic drug monitoring (TDM) is crucial for optimizing chemotherapy efficacy and minimizing toxicity, especially with potent anticancer drugs like doxorubicin and cyclophosphamide. Traditional TDM practices often rely on centralized laboratory testing, which can suffer from lengthy turnaround times that delay clinical decision-making. To address these limitations, this study aims to develop and validate a novel electrochemical sensor capable of rapid, onsite TDM at the point of care. We have designed a cutting-edge electrochemical sensor utilizing an MXene-modified glassy carbon electrode (GCE) as the working electrode. The choice of MXene was intended to enhance the electrode's sensitivity and selectivity for the targeted detection of doxorubicin and cyclophosphamide. The preliminary results demonstrate that the sensor can detect these drugs within clinically relevant concentration ranges, with a detection limit ranging from 1.10^{-4} to 10.10^{-4} M. Furthermore, the sensor's performance has been successfully validated by testing blood samples from patients undergoing chemotherapy, confirming that the measurements are both accurate and reliable. The development of this electrochemical sensor marks a significant advancement in the field of TDM, reducing dependence on centralized laboratories and streamlining the monitoring process. This innovative tool not only holds the potential for improving patient outcomes by ensuring optimal drug dosages but also offers possibilities for expanding its applications to monitor other anticancer drugs and immune biomarkers in the future.



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sciforum-115503: Nano Sentinel: Enhancing Food Security Through Advanced Xoo Biosensing

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Xanthomonas oryzae pv. *oryzae* (Xoo) is a pervasive bacterial pathogen with global implications, causing bacterial blight in rice and threatening food security. The effective management of Xoo diseases in field conditions, protected farm operations, and international borders relies heavily on the early detection of Xoo. Traditional detection methods, including immunological assays such as direct tissue blot immunoassays (DTBIA) and enzyme-linked immunosorbent assays (ELISA), as well as molecular techniques like loop-mediated isothermal amplification (LAMP) and polymerase chain reaction (PCR), are commonly employed for pathogen identification. However, these methods often require sophisticated instrumentation and trained personnel, resulting in time-consuming and resource-intensive processes that are unsuitable for on-site analysis. To overcome these challenges, we have developed a sensitive electrochemical biosensor for Xoo detection by exploiting the unique properties of a core nano assembly of gold nanoparticles. The biosensor incorporates a specific DNA probe designed based on the PthXo1 gene, a prominent virulence factor of Xoo. This probe is immobilized on the electrode surface, enabling sequence-specific hybridization and subsequent electrochemical transduction for the sensitive and rapid detection of Xoo up to the 1fg/μl level.¹ This innovative approach holds promise for monitoring Xoo, thereby contributing to the development of effective disease management strategies and the preservation of global food security.



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sciforum-117566: Nanobiosensors as trend-setting tools in agricultural engineering diagnostics

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Agriculture and food systems go hand in hand, so proper farm management is necessary for ensuring global sustainability and food security. The impact of agricultural practices on production is direct, affecting all stages from germination to post-harvest treatment. Farmers who adopt structured management practices tend to increase their yields and profitability. In recent years, research on nanobiosensors has gained notable relevance, since nanostructures of nanometer size present unique properties that distinguish them from regular versions. Nanomaterials are being tested as potential candidates for transducer coatings that can accurately detect picomolar levels. This study was carried out through a systematic review of the available and updated literature on the incorporation of nanobiosensors in agronomy and agriculture. Nanobiosensors can be applied pre- and post-harvest and are easily portable and low-cost; thus, they allow for rapid on-site assessment of crop and soil health and detect biotic and abiotic stresses, nutritional status, and the presence of contaminants and spoilage indicators. Moreover, early detection of damage can prevent crop losses and avoid yield losses caused by the impact of stress. The combination of these biological sensors with nanomaterials amplifies the signal, increasing sensitivity and reducing the detection limit. Being highly selective, they enable the early detection and management of anomalies in agricultural production. This study analyzes recent novelties and existing limitations and discusses the structure and types of nanobiosensors in terms of their application in the agricultural sector.



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sciforum-108384: Nanomaterial-Based Artificial Sniffing Devices for Rapid Cancer Screening

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Cancer is regarded as a significant contributor to global mortality. If cancer is diagnosed at an early stage, it can be treated successfully. The existing cancer screening techniques are either invasive or prohibitively expensive. It is therefore imperative that a non-invasive and low-cost method of diagnosing cancer at an early stage is developed. The use of artificial nose devices that mimic the olfactory system of mammals represents a promising avenue for medical diagnosis. In recent years, we have developed arrays of fluorescent nanomaterials that are capable of simulating the receptors of the olfactory system. The nanomaterials have demonstrated considerable promise as a sensing platform, exhibiting high sensitivity. However, they exhibit low selectivity, demonstrating cross-reactivity towards a range of analogous chemical compounds. The use of a panel of cross-reactive fluorescent nanomaterials allows for the generation of a specific signal pattern for each chemical species, thereby enabling the analysis of complex samples. Artificial nose devices were fabricated using a paper-based platform, with the deposition of small amounts of metallic nanoclusters or carbon quantum dots. The devices are capable of detecting the odor of biological samples (VOCs), including blood, urine and exhaled breath, and can distinguish between individuals with and without cancer. In consequence, our devices are designed to operate on the basis of liquid or gas biopsies, which are classified among non-invasive or minimally invasive methods. The devices were employed to diagnose leukemia in children and hematologic malignancy in adults by measuring the VOCs emitted from the surface of blood. Additionally, the analysis of VOCs in the headspace of urine samples enabled the identification of colon and stomach cancers. Furthermore, the method is capable of detecting lung cancer through the analysis of VOCs in exhaled breath. The portability, low cost, and high speed of our devices make them ideal candidates for the rapid screening of cancer.



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sciforum-115207: NiO-CNT Nanocomposites for Non-Enzymatic Electrochemical Lactate Sensor

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Introduction

Non-enzymatic electrochemical sensors are crucial in biomedical applications, especially for the real-time monitoring of lactate concentrations in biological fluids such as saliva. In this work, NiO-coated stacked-cut carbon nanotube (NiO/SCCNT) nanocomposites were fabricated via atomic layer deposition (ALD) to enhance lactate-sensing performance.

Methods

Carbon nanotubes (CNTs) were coated with NiO of varying thicknesses (0, 50, 200, and 700 ALD cycles) to form core-shell nanocomposites. These were then integrated into screen-printed carbon electrodes (SPCEs) for non-enzymatic lactate detection. Electrochemical experiments, i.e., cyclic voltammetry (CV), chronoamperometry, and electrochemical impedance spectroscopy (EIS), were carried out to characterize the sensor properties.

Results

Compared with bare SPCE, the NiO(x)/CNT-modified electrode presented a marked decrease in charge transfer resistance, indicating significantly improved electron transfer. The NiO thickness influenced the electrochemical response, with 200 ALD cycles exhibiting the most favourable characteristics. In the 0–4 mM range, the optimized composite achieved a sensitivity of 138.44 $\mu\text{A mM}^{-1}\text{cm}^{-2}$ and a limit of detection (LOD) of 0.067 mM (S/N = 3). Excellent sensitivity, selectivity, stability, and reproducibility supported the rapid and accurate detection of lactate in real salivary samples.

Conclusions

NiO-coated CNT nanocomposites demonstrate high potential as non-enzymatic lactate sensors for saliva-based measurements. They deliver strong electrochemical performance, low LOD, and high sensitivity, highlighting their suitability for real-time lactate monitoring in biomedical applications.



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sciforum-115513: Porous Bi₂O₃ Nanosheets for Formaldehyde Detection: A Novel Approach for Non-Invasive Nasal Cancer Detection via Exhaled Human Breath

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Formaldehyde in exhaled human breath serves as a pivotal biomarker for the detection of nasal cancer. In the context of nasal cancer, the non-invasive detection of formaldehyde, which is a primary biomarker, using a chemiresistive sensor has gained significant attention. However, selectivity and sensitivity are still challenges. This study focuses on a non-invasive Bi₂O₃ porous nanosheet-based chemiresistor for the detection of nasal cancer via exhaled human breath. Here, a Bi₂O₃ porous nanosheet was synthesized using a one-step hydrothermal approach. Rietveld refinement analysis confirmed its polycrystalline nature. The gas sensing properties of the Bi₂O₃ porous nanosheet towards formaldehyde were studied via a static system in a range of 1–20 ppm at a temperature of 100°C. The Bi₂O₃ chemiresistor showed 8.53 sensor response at 1 ppm, with fast response and recovery times of 2.74 s and 4.64 s, respectively. The enhanced sensor response of Bi₂O₃ was attributed to the formation of a porous nanosheet with higher active sites and a large surface area of 60.95 m²g^{−1}. The N₂ adsorption–desorption isotherm confirmed that a type-II isotherm exists and the mesoporous structure had a mean pore diameter of 60.73 nm. The Bi₂O₃ chemiresistor is highly selective towards formaldehyde compared to other VOCs. Furthermore, exhaled human breath was used for the detection of nasal cancer in static conditions. The sensor's response values were higher for the breath of diabetic patients, indicating its potential for use in nasal cancer monitoring and clinical diagnosis.



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sciforum-114778: Portable electrochemical immunosensor with dual-function mesoporous nanostructure for mycotoxin detection in mixed cereal samples

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Introduction

Trichothecene mycotoxins are produced by several species of *Fusarium*, such as *Fusarium langsethiae*, *acuinatum*, *sporotrichioides* and *poae*. The T-2 toxin is one of the most toxic and is widely distributed throughout the world, contaminating cereals such as barley, corn, oats, wheat and rice, as well as various cereal products. We developed a portable immunosensor for T-2 mycotoxin electrochemical quantification in mixed cereal samples.

Methods

A screen-printed carbon electrode was modified with a dual-function mesoporous nanostructure (CMK-9/KIT-6). The KIT-6 silica nanostructure was used as an immobilization platform for the anti-T-2 monoclonal antibodies, so the mycotoxin was detected using a competitive immunoassay method. Moreover, the carbon CMK-9 nanostructure increases the electroactive surface area, and therefore the sensitivity in the quantification. The nanocomposite CMK-9/KIT-6/SPCE was characterized by CV, Impedance, SEM, EDS, and Isotherms. In this way, the T-2 mycotoxin present in the sample competes with horseradish peroxidase (HRP)-conjugated T-2 for the specific recognition sites of the immobilized anti-T-2 antibodies. Then, the enzyme, in the presence of HRP, catalyzes the oxidation of catechol, whose electrochemical reduction was detected at the nanostructured electrode at -0.15 V. In this sense, the T-2 mycotoxin concentration in the sample was indirectly proportional to the T-2-conjugated HRP, showing a higher current by amperometry.

Results

The detection limits for the portable immunosensor with electrochemical detection and the Enzyme-Linked Immunosorbent Assay (ELISA) were 0.05 $\mu\text{g kg}^{-1}$ and 10 $\mu\text{g kg}^{-1}$, and the coefficients of variation (intra- and inter-assay) were below 4.29 % and 5.98 %, respectively.

Conclusions

The T-2 toxin electrochemical immunosensor is a valuable tool for portable in situ analysis of agri-food samples.



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sciforum-115331: Potential sensing applications based on Gwal Pahari Acid

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Introduction

Different device technologies (solar cells, capacitors, transistors, etc.) have been thoroughly explored using various inorganic materials (Si, GaAs, metal oxides, etc.). Though these inorganic materials are known for providing efficient performance due to their robust electrical, optical, thermal, and mechanical properties, their high cost, toxicity, biodegradability, and biocompatibility issues have remained a major roadblock for their widespread applications, particularly in biological systems. Thus, there is a need worldwide to search for organic, low-cost, biocompatible, biodegradable, and functional materials which could serve as an alternative to the materials in current use for sustainable applications in the field of materials science. Focusing on the natural resources which are available abundantly and making use of these could offer exciting opportunities for researchers.

Methods

Recently, the isolation of a new humic acid from the soil of Gwal Pahari, Gurgaon, Haryana, India, has been reported from our lab. This water-soluble, fluorescent, and ninhydrin-positive Gwal Pahari Acid (GPA) has been characterized using modern spectroscopic techniques, e.g., UV-visible spectroscopy, Fourier-Transform Infrared Spectroscopy (FT-IR), mass spectrometry, ¹H-NMR and 2D-NMR studies, Scanning Electron Microscopy, and Zeta Potential.

Results and Conclusions

GPA is predicted to form supramolecular self-assemblies which could help in chelating different metal ions (Fe (III), Pb (II), Co (II), Ni (II), Cu (II), etc.) and phosphate ions. Thus, GPA may serve as a potential candidate for sensing metal ions and could facilitate in curbing the toxic heavy metal contamination found in water bodies. Further, its fluorescent nature can be utilized in the fabrication of a fluorescence-based biosensor where the target analyte could be sensed with changes in the fluorescence signal. Newer technologies based on such materials are not only expected to bring down the costs involved with these technologies but will also help in combating the pressing global environmental issues.



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sciforum-117407: Selective voltammetric sensors based on carbon nanotubes and poly(triphenylmethane dyes) for quantification of phenolic antioxidants

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Phenolic antioxidants are one of the most studied groups of bioactive compounds in life sciences. Their electrooxidation capability has been successfully used in the development of voltammetric sensors for real sample analysis. Nevertheless, the selectivity of the sensor response to target antioxidants is usually insufficient and is a key limiting factor for the practical application of the developed sensors. In the current work, highly selective voltammetric sensors for natural phenolic antioxidants have been developed using glassy carbon electrodes and a layer-by-layer combination of carbon nanotubes and poly(triphenylmethane dyes) containing phenolic fragments in their structure. Carboxylated multi-walled and polyaminobenzene sulfonic acid-functionalized single-walled carbon nanotubes have been used as a substrate for the electrodeposition of polymeric coverages obtained by potentiodynamic electrolysis from triphenylmethane dyes (pyrogallol red, aluminon, phenol red, thymolphthalein). The optimal conditions of electropolymerization have been found on the basis of the voltammetric response of target phenolic antioxidants, i.e., eugenol, flavonoids (hesperidin and naringin, quercetin and rutin), and hydroxycinnamic acids (caffeic, ferulic, and *p*-coumaric acids). Electropolymerization proceeds via phenoxyl radical formation and its further dimerization and polymerization. A non-conductive polymeric layer in combination with conductive carbon nanotubes provides an improvement in the voltammetric response of target phenolic antioxidants as well as the possibility of their simultaneous detection. Sensors have shown significant increase in the electroactive surface and electron transfer rate compared to bare glassy carbon electrodes. Under conditions of differential pulse voltammetry, the sensors exhibit a sensitive response to phenolic antioxidants within the range from $n \times 10^{-8}$ to $n \times 10^{-5}$ M with the detection limits of 0.0047–730 μ M. The sensor's high selectivity response to the target analyte in the presence of structurally related antioxidants is its main advantage over other electrochemical methods. The sensors have been successfully tested on real samples (essential oils, plant materials, and food).



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sciforum-112694: Tandem β -mercaptoethanol and 2-(3-trichlorosilylpropyloxy)-ethyltrifluoroacetate Coating on Flat Gold Surfaces to Significantly Prevent Non-Specific Adsorption

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Gold surface-based acoustic (bio)sensors often face non-specific adsorption issues, creating specificity and sensitivity issues which negatively affect the sensor's performance. This can be prevented by antifouling coatings, such as 2-(3-trichlorosilylpropyloxy)-ethyltrifluoroacetate (Si-MG-TFA), which is used for silica quartz surfaces used in electromagnetic piezoelectric acoustic devices. Previous research provides evidence that this coating can reduce fouling by a factor of ten, but this could not be successfully replicated on gold surfaces. However, we have found a novel method of successfully applying the Si-MG-TFA coating on gold, with comparable antifouling performance, by using β -mercaptoethanol as an intermediate linker between the gold surface and the Si-MG-TFA. By using the self-assembled monolayer approach to coat gold with β -mercaptoethanol, the gold's surface becomes hydroxylated, allowing for a proper Si-MG-TFA coating via covalent ether bonds, as seen in silica quartz surfaces. Serum tests using a thickness shear mode acoustic sensor and atomic force microscopy for surface characterization provide evidence of comparable antifouling performance and successful coating of Si-MG-TFA, respectively, on sufficiently flat gold surfaces. Overall, our work shows a potential method of significantly preventing non-specific adsorption for any method involving gold surface-based (bio)sensing.



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sciforum-117288: The microfluidic-based fluorescence enhancement of delayed fluorescence silica-embedded carbon dots for the detection and quantification of unamplified nucleic acid in clinical samples

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Delayed fluorescence silica-embedded carbon dots (DF@N-CDs/SiO₂) represent an innovative and highly effective platform for nucleic acid detection. These dots exhibit remarkable fluorescence characteristics that enable rapid and sensitive diagnostics. An example of their application is in the detection of the hepatitis C virus (HCV), which can cause asymptomatic chronic infections with serious clinical consequences. The timely and sensitive detection of HCV RNA is crucial for infection control and monitoring treatment response. While current technologies, such as PCR and isothermal amplification-based strategies, are specific, they are often expensive, labor-intensive, and time-consuming, which limits their use in field settings and smaller laboratories.

This study introduces a novel technology that utilizes the Crosslinked Enhanced Emission (CEE) phenomenon. In this context, fluorescent amino-functionalized silica-coated nitrogen-doped carbon dots (N-CDs/SiO₂/NH₂) exhibit substantial fluorescence enhancement upon interaction with unamplified Hepatitis C Virus (HCV) RNA extracted magnetically from clinical samples. This method has been effectively integrated into a 3D-printed microfluidic chip and a standard 96-well plate format, achieving detection limits of 500 IU/mL and 1000 IU/mL, respectively. The chip-based assay provides results in less than 20 minutes, significantly decreasing the processing time in comparison to traditional amplification-based techniques. Analyzing 141 patient samples yielded high sensitivity (96.47%) and specificity (98.79%), underscoring the platform's efficacy in clinical diagnostics.

This investigation marks the initial application of N-CDs/SiO₂ as fluorescent probes for nucleic acid detection, providing a versatile and cost-effective solution that can be readily integrated into existing laboratory environments. Furthermore, it enhances both the speed and accuracy of HCV RNA detection.



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Session F. Technological Advancements in Biosensor Actuators

sciforum-115755: Development of an Electronic Stethoscope

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An electronic stethoscope is designed and implemented for the diagnosis of some cardiac ailments. Graphs of the diagnosis are plotted using the electronic stethoscope, as well as results obtained for the purposes of inferences and analysis. With these inferences, the diagnosis of chest sounds can be easily carried out. With the results of this graph, early diagnoses can be realized, which can hinder cardiological ill health. With the electronic stethoscope, the auscultation of the chest becomes an effective and basic method for the diagnosis of some cardiological problems. An example of these cardiac issues is heart valve malfunction, which leads to heart murmurs. The electronic stethoscope can diagnose grade one and two heart murmurs and auscultation tachycardia patients, which leads to the detection of all kinds of chest sounds that the manual or conventional stethoscope may not be able to detect. In this work, the electret microphone capsule is connected to the microphone amplifier module (LM 386). The LM 386 has built-in automatic gain control (AGC), which is suitable for capturing a wide range of sound levels. The experimental analysis was conducted using multiple subjects to evaluate the system's accuracy, consistency, and noise-filtering capabilities. The device was tested on four subjects. The results are summarized as follows: a normal heart rate of 72 beats and normal heart sounds with a high signal clarity for subject one, and a heart rate of 85 and high noise interference with low signal clarity for subject four. Ten subjects were tested for the Phonocardiogram (PCG), which includes S1, S2, and murmurs. The parameters visualized in the system and plotted in the graph are time ((0.2s, 15db) and (0.5s, -12db)) (in seconds), amplitude (15db, high; -12db, low) (sound intensity in decibels), frequency ((125Hz, 15db) and (100, -12db)) (in hertz), and heart rate variability (HRV) ((68, 0.5s) and (80, 0.5s)).



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sciforum-116103: Development of Aptamer-Based Biosensor for Detection Penicillin via Combined QCM-LSPR Method

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The antibiotic penicillin G (PEN) is commonly used for the treatment of microbial diseases. However, its extensive application in veterinary medicine can cause infiltration into food, especially milk and meat. Therefore, there is an urgent need for rapid and sensitive methods for antibiotic detection. In this study, we used DNA aptamers specific to PEN for its detection using a combined approach based on an acoustic method, quartz crystal microbalance with dissipation (QCM-D), and an optical method, localized surface plasmon resonance (LSPR). QCM-D measures changes in the resonant frequency, Δf , and dissipation, ΔD , while LSPR monitors the shifts in the wavelength corresponding to changes at the surface of gold nanoparticles (AuNPs). Thiolated aptamers were chemisorbed onto the surface of AuNPs with a diameter of 80 nm. Upon the presence of PEN, a shift to a longer wavelength and a decrease in resonant frequency was observed, accompanied by an increase in dissipation due to surface viscosity effects. Significant changes in the acoustic and optical signals were observed down to a PEN concentration of 1 nM, which is lower than the maximum residue limit (MRL) for this antibiotic established by the EU (4 $\mu\text{g/kg}$, ~ 12 nM). The sensor selectively detects PEN, as demonstrated in experiments with a non-specific antibiotic, oxytetracycline.



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sciforum-115764: MEMS-integrated Coplanar Waveguide Ring resonator-based Label-free Sensor for Profenofos Detection

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The detection and selective sensing of toxic chemical residues is critical for ensuring food safety and environmental health. We present a MEMS-based microcantilever sensor integrated with a coplanar waveguide (CPW) ring resonator for high sensitivity and selective analyte detection. The sensor facilitates real-time quantitative analysis by employing a label-free as well as single-step selective immobilization method, demonstrating its applicability to various analytes.

The presented CPW ring resonator-integrated MEMS-based microcantilever sensor was modelled and rigorously simulated using a numerical method based on the Finite Element Method (FEM). An operating frequency range of 30–60 GHz was considered in our numerical study. The microcantilever operating in the stress mode was functionalized with a profenofos-specific aptamer (SS2-55), which in turn enabled selective binding to the analyte profenofos, an organophosphorus insecticide. Molecular binding induces surface stress, causing cantilever deflection and a corresponding frequency shift in the S_{11} parameter.

Significant shifts in the S_{11} parameter were observed due to different actuation states induced by analyte binding. In its neutral state, the sensor initially exhibited two distinct S_{11} dips: the primary dip at 53.96 GHz and the secondary dip at 47.48 GHz. Upon complete actuation of the microcantilever, the two dips are merged into a single S_{11} dip at 50.4 GHz. The presented approach envisages a simpler fabrication protocol and robust system, while the optical methods normally demand sophisticated fabrication and analytical tools. Given these advantages, the detection limit of the presented sensor is 8.24 ng/ml (22.09 nM).

Our rigorous numerically studied CPW ring resonator MEMS sensing device enables the realization of a portable, robust, and precise sensor platform for detecting hazardous residues. The sensor's adaptability to a broad spectrum of analytes based on an immobilized material makes it a versatile biosensing solution and can be tailored to the label-free detection of various analytes, including bioanalytes for point-of-care biomedical diagnostic and therapeutic devices.



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sciforum-113007: Smart IoT-Driven Toxic Gas Monitoring and Alert System with Ventilation Performance Monitoring for Coal Miners' Safety

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Miners face severe risks due to toxic gases such as methane (CH₄), carbon monoxide (CO), and hydrogen sulfide (H₂S), which can cause suffocation, poisoning, and fatal accidents. This abstract proposes an IoT-based toxic gas sensor system designed for coal mining environments, providing real-time monitoring, early detection, and automated alerts to enhance miner safety. The system integrates Metal-Oxide Sensors (MOSs), Electrochemical Sensors, and Infrared Sensors (IR) for high-accuracy gas detection. MOSs detect H₂S and CH₄ by measuring electrical conductivity changes when gas molecules interact with a heated semiconductor. Electrochemical sensors measure gas concentration changes by generating an electric current proportional to CO levels, ensuring precise detection. IR sensors identify CO₂ by analyzing infrared absorption at specific wavelengths, enabling non-invasive and selective monitoring. This multi-sensor system achieves high analytical performance, detecting gases at parts per million (ppm) levels. The detection range is 0–500 ppm for CO and up to 5000 ppm for CH₄, with a limit of detection (LOD) of 1–5 ppm, ensuring early warning before dangerous concentrations are reached. The sensors offer high sensitivity, detecting concentration variations as low as 0.1 ppm, and strong selectivity, differentiating gases based on their chemical properties. With a response time of seconds and an error margin of less than ±2%, the system ensures accurate real-time data and rapid intervention during gas leaks. To further improve safety, Artificial Intelligence (AI) models, including ARIMA and Recurrent Neural Networks (RNNs), estimate occupancy levels and CO₂ accumulation, optimizing ventilation through the Key Performance Indicator for Ventilation (KPIV). This AI-driven airflow management system dynamically adjusts ventilation to reduce toxic gas buildup, improve air quality, and enhance mine-wide operational efficiency. By providing continuous monitoring, instant alerts, and intelligent ventilation control, this IoT-based gas detection system significantly mitigates exposure risks, ensuring a safer working environment for miners.



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sciforum-113376: The importance of signal multiplexing in biosensors for better health trackers

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Introduction

Monitoring multiple physiological parameters using biosensors is highly valuable for tracking personal wellness, the healthcare of patients, and the physiology of athletes during exercise. However, the primary challenge in terms of technical development remains keeping the technology's price affordable while ensuring effective monitoring of two or more physiological parameters (temperature, blood pressure, etc.) (1) and biomolecules (glucose, lactate, cortisol, etc.) (2).

Methods

In this regard, biosensor channel multiplexing presents an ideal solution allowing us to switch between detection channels to simultaneously measure and monitor multiple physiological parameters and biomolecules. This technology is particularly suitable for potentiometric biosensors where no current is applied after each switch, thereby minimizing noise and capacitive behavior associated with amperometric techniques.

Results

As shown, biosensor channel multiplexing provides fast response time, versatility, and non-destructive measurement. It consumes little energy, making it ideal for battery-powered application. It can be easily integrated and connected to smart devices (smartphones, tables, etc.), enabling the simultaneous detection of multiple parameters or biomolecules.

Conclusions

Multiplexing techniques are important in biosensing for better health tracker monitoring. At Electrochemistry Consulting and Services, we are committed to supporting our clients at every step of the way, starting from strategic consulting services and feasibility studies, through to the troubleshooting and diagnostics of technical issues. We also assist in the design, development, and testing of electrochemical systems and devices.

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Session G. Paper-Based Biosensors

sciforum-117408: Colorimetric paper-based sensor for free chlorine detection in clinical and environmental matrices

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Disinfection plays a crucial role in the production of potable water, the maintenance of swimming pools, the sanitation of food industry facilities, and medical and hospital environments. Among disinfection methods, chlorination involves the use of gaseous chlorine, chlorine dioxide, calcium hypochlorite, or, most commonly, sodium hypochlorite. It is important to monitor the concentration of free residual chlorine, i.e., the amount of disinfectant remaining in water after treatment. Residual free chlorine can react with natural organic matter to form disinfection by-products classified as carcinogens. The ISO 7393-2 standard detects free residual chlorine by its reaction with N,N-diethyl-p-phenylenediamine (DPD), producing a pink complex with intensity proportional to the residual chlorine concentration. The method requires benchtop instrumentation and trained personnel, making routine monitoring expensive and time-consuming. A paper-based colorimetric sensor was developed as a low-cost, rapid, portable, and user-friendly alternative. The sensor leverages color change resulting from the DPD reaction and allows naked-eye detection. Quantitative analysis can be performed in only 3 min by capturing images of the sensor using a smartphone, allowing for precise colorimetric evaluation. This approach achieved a detection limit of 12 μM for sodium hypochlorite, making it a promising tool for routine water quality monitoring applications.



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sciforum-115632: A novel DNA-based electrochemical sensor for the detection of *Candida* species

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The frequency and prevalence of invasive fungal infections have increased, particularly among hospitalized patients with severe underlying illnesses and/or immunocompromised individuals [1,2]. The survival of these patients relies on the prompt identification of the infection and on the timely initiation of antifungal therapy, and yet standard laboratory testing may yield ambiguous results [3]. The diagnostic approaches for candidiasis include culture testing, serological assays, and histopathologic analysis of tissues; however, these methods may be time-consuming and can yield insensitivity or inaccuracies. The prevailing "gold standard" for identifying *Candida* spp. fungemia is blood culture. Nonetheless, this is considered insensitive, as it has been shown to be positive in fewer than half of individuals with chronic disseminated candidiasis [4]. Culture methods are time-intensive, with certain *Candida* species requiring up to a week for development, which is an intolerable delay before initiating fungemia treatment. The difficulties in diagnosing *Candida* infections highlight the necessity for efficient and rapid methods to detect and identify clinically relevant fungi in a microbiology laboratory. This work involves the development of an electrochemical DNA-based sensor for the rapid, simple, and precise detection of *Candida* spp. This sensor, self-assembled in an electronic paper device (ePAD), is based on the electrochemical detection of the hybridization reaction between two complementary single-stranded DNA sequences. Initial research indicated that this DNA-based sensor may identify *Candida* spp. in synthetic DNA samples. Notwithstanding these results, efforts are underway to enhance the sensor for measuring *Candida albicans*; this methodology will be corroborated by a further study. Future advancements will focus on application within a medical setting, encompassing sensitivity, accuracy, response time, challenges, and potential.



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sciforum-110471: Edge IoT-Enabled Cyber-Physical Systems with Paper-Based Biosensors and Temporal Convolutional Networks for Real-Time Water Contamination Monitoring

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Water pollution poses serious threats to public health and the environment, requiring efficient and scalable monitoring solutions. This paper presents a Cyber-Physical System (CPS) that integrates paper-based biosensors with an Edge IoT architecture and Long-Range Wide Area Network (LoRaWAN) for real-time assessment of water quality. The biosensors detect pollutants such as arsenic, lead, and nitrates with a detection limit of 0.5 ppb. The collected data are transmitted via LoRaWAN to edge devices, where preprocessing and analysis are performed using the Temporal Convolutional Network (TCN) algorithm. The system proposed is compared with existing LSTM systems based on two performance metrics: detection accuracy and latency. Paper-based biosensors are fabricated using silver nanoparticle-functionalized substrates for high sensitivity and low-cost pollutant detection. Data transmission is based on LoRaWAN protocol to have long-range communication with packet loss per cent at a minimum level. TCN algorithm deployment at the edge allows for real-time processing for time-series data analysis due to its high accuracy and low latency properties, compared to LSTM models, which were mainly chosen due to their usage in most applications dealing with time-series-based analysis. Experimentation was carried out by deploying the developed CPS in controlled environments, simulating pollutant levels at different levels and executing them for accuracy in detecting pollutants and the latency of data processing. The system's energy consumption was reduced through efficient edge processing, enhancing the long-term sustainability of its deployments. The TCN framework achieved a detection accuracy of 98.7%, which surpasses LSTM by 92.4%. In addition, TCN reduces latency in processing by 38% to enable fast data analysis and decision-making. LoRaWAN allows for perfect packet transmission of up to 15 km while the loss rate stays as low as 2.1%. These results establish the proposed CPS as reliable, efficient, and scalable for real-time water contamination monitoring. Thus, this research introduces the integration of paper-based biosensors with advanced computational frameworks like TCN and explores its great potential as a transformative development to pave the way toward more sophisticated multi-sensor fusion systems in future studies.



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sciforum-117532: An origami paper biosensor for sustainable on-site and instrument-free detection of nitrite and nitrate

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Paper-based analytical devices (PADs) have gained widespread attention due to their potential as simple, low-cost, and sustainable analytical devices with the main scope of preliminary monitoring. A ready-to-use colorimetric paper-based sensor for nitrite detection in environmental and clinical samples was developed [10.1039/D4SD00308J]. The sensor is based on the colorimetric Griess reaction, a double-step reaction that includes a diazotization of sulfanilamide in acidic conditions, which forms a diazonium salt, and its coupling with N-(1-naphthyl)ethylenediamine to produce a pink azo dye. Paper has been used as support for reagent immobilization and an origami-based mechanism has been chosen to initiate the reaction without requiring additional handling of chemicals. Unlike conventional nitrite assays, which require multiple steps, specialized instrumentation, and qualified personnel, this sensor enables rapid, user-friendly detection through a smartphone camera, with the option for qualitative assessment via the naked eye. The paper-based sensor demonstrated satisfactory analytical performance when used to analyze drinking water, with recovery rates between 87% and 110%, and detection and quantification limits of 0.27 mg L⁻¹ and 1.11 mg L⁻¹, respectively. In addition, for nitrate determination, nitrate reductase was implemented prior to the Griess reaction. The system was stable for at least 1 month at +4°C, maintaining 98% of its performance. The selectivity was studied using ions and potential interferents like BSA, urea, or glucose as common compounds present in environmental or clinical matrices. Another important aspect of this system is its sustainability, which has been evaluated through the 12 principles of white analytical chemistry (WAC) using the 12 algorithms [10.1016/j.trac.2021.116223]. Its sustainability and ease of use make it a promising tool for environmental monitoring and point-of-care (POC) applications. The biosensor was used to detect nitrite and nitrate in water and clinical samples such as saliva and exhaled breath condensate to evaluate its potential as an indicator of inflammation or infection.



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sciforum-115757: Development of Blood Glucose Meter

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Blood glucose level was developed and tested. The test meter was developed for non-invasively monitoring the blood glucose level. This is due to the fact that some forms of monitoring glucose and cholesterol with instruments involve invasive blood tests, which are needless given present-day biomedical instrumentation technology. Given the global prevalence of high blood glucose levels and related issues, there is an urgent need for non-invasive monitoring methods that engage in comfortable testing compared to the traditional blood glucose monitoring method that requires invasive finger-prick tests, which can be painful and discourage consistent use. Addressing this, a non-invasive glucometer was developed using the MAX30100 optical sensor, which measures glucose levels by analyzing light absorption in the skin, utilizing photoplethysmography (PPG), engaged in a non-invasive method that utilizes the reflective and refractive properties of Near-Infrared (NIR) light to determine blood glucose levels. This method offers a painless and real-time alternative for glucose monitoring, aiming to improve accessibility and patient comfort. The system integrates a MAX30100, a pulse oximeter that detects heart rate and oxygen saturation through light absorption. For glucose monitoring, we analyzed changes in infrared and red-light absorption, which vary with glucose levels. The sensor was connected to an Arduino microcontroller to process the data. Signal processing algorithms were used to filter and interpret the absorption patterns, and calibration was performed by correlating sensor readings with known glucose concentrations. The meter was used on nine subjects, and error analysis was carried out using Clarke Error Grid Analysis (EGA) and Surveillance Error Grid (SEG) analysis. The findings from both Clarke Error Grid Analysis (EGA) and Surveillance Error Grid (SEG) analysis suggest that, while the device is generally reliable, there is room for improvement.



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sciforum-115683: Electrochemical magnetic nanoparticles and paper-based biosensors for plant honey DNA origin detection and authentication

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Food fraud remains an issue with significant environmental, health, and socio-economic impacts for consumers and the food industry alike. Honey, known for its natural sweetness, rich nutritional value, and numerous health benefits, is among the most adulterated foods found in the global market. Common fraudulent practices include mislabelling the honey's botanical origin, blending it with lower-quality honeys, processed sugars, or other substances. Moreover, as most of their beneficial properties are linked to honey's botanical origin, it is important to assure the safety and quality of the honey. Nonetheless, with the increasing number of reports on tampered or adulterated products appearing, there is a pressing need to develop an analytical tool that can quickly, affordably, and reliably ensure the quality and safety of honeys. In this study, an innovative inkjet-printed gold electrode paper-based biosensing platform coupled with gold-coated magnetic nanoparticles (MNPs) was developed to detect the genomic DNA of two plant species from which honey can be produced: *Castanea sativa* and *Erica arborea*. Analyzing public database platforms, a DNA-target probe for both *C. sativa* and *E. arborea* were selected and designed. These sensors resulted from the DNA hybridization reaction between the two complementary probes specific to both plant species in a sandwich format. Their complementary probes were modified with an amine (NH₂) group and a fluorescein isothiocyanate and cut in two to generate the enzymatic amplification of the electrochemical signal. The hybridization reaction was labeled with enzymes, enabling chronoamperometric measurement of peroxidase activity associated with the MNPs on the gold electrode surface. The developed biosensor was then successfully applied to detect *C. sativa* and *E. arborea* present in real plant samples and, hence, determine the botanic origin of the honeys. Therefore, these MNPs and paper-based biosensors are a viable and rapid tool to help authenticate the origin of honeys.



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sciforum-114202: Emerging Trends in Paper-Based Electrochemical Biosensors for Healthcare Applications

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Paper-based electrochemical biosensors have emerged as a revolutionary technology in healthcare diagnostics due to their affordability, portability, ease of use, and environmental sustainability. These biosensors utilize paper as the primary material, capitalizing on its unique properties, such as high porosity, flexibility, and capillary action, which make it an ideal candidate for low-cost, functional, and reliable diagnostic devices. The simplicity and cost-effectiveness of paper-based biosensors make them especially suitable for point-of-care (POC) applications, particularly in resource-limited settings where traditional diagnostic tools may be inaccessible. Their lightweight nature and ease of operation allow non-specialized users to perform diagnostic tests without the need for complex laboratory equipment, making them suitable for emergency, field, and remote applications. Technological advancements in paper-based biosensors have significantly enhanced their capabilities. Integration with microfluidic systems has improved fluid handling and reagent storage, resulting in enhanced sensor performance, including greater sensitivity and specificity for target biomarkers. The use of nanomaterials in electrode fabrication, such as reduced graphene oxide and gold nanoparticles, has further elevated their sensitivity, allowing for precise detection of low-concentration biomarkers. Moreover, the development of multiplexed sensor arrays has enabled the simultaneous detection of multiple biomarkers from a single sample, facilitating comprehensive and rapid diagnostics in clinical settings. These biosensors have found applications in diagnosing a wide range of diseases, including infectious diseases, cancer, and metabolic disorders. They are also effective in genetic analysis and metabolic monitoring, such as tracking glucose, lactate, and uric acid levels, which are crucial for managing chronic conditions like diabetes and kidney diseases. In this review, the latest advancements in paper-based electrochemical biosensors are explored, with a focus on their applications, technological innovations, challenges, and future directions.



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sciforum-116300: Fast determination of bloodstream infections based on a paper-based microfluidic chip and fluorescent detection

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Bloodstream infections (BSIs) are a major cause of life-threatening complications in patients with cancer. According to the statistical data, the prevalence of BSIs ranges from 11% to 38%, and overall mortality reaches about 40%. Immediate antibiotic treatment could greatly shorten hospital stays, decrease the mortality rate and decrease healthcare costs. Therefore, a fast detection of bacteria for BSI determination is in high demand. Here, a novel paper-based microfluidic chip with water-absorbing material for generating sample fluid flow is designed for the detection of bacteria in whole blood. The corresponding green quantum dots for the labelling of target *S. aureus* are prepared by modifying their surfaces with an aptamer for specific binding. Blood cells are separated during diluted sample solution flow in the chip to eliminate interferences and the labelled bacteria are captured at the detection area in the chip. Fluorescent intensity is then measured using a microscope to determine the number of target bacteria in whole blood. The assay of *S. aureus* in whole blood, which is prepared by adding bacteria into the blood sample, shows that this method could detect bacteria in less than 20 min with a detection limit as low as 10 CFU/mL. It is much faster than clinical tests using the culture method, PCR or mass spectroscopy. The developed method does not require the use of large-scale equipment and complex manual operations. This point-of-care-testing (POCT) method is envisioned to be used for the rapid assessment of certain bacterial infection in BSIs.



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sciforum-115651: Optimization of Magnetic Immunochromatographic Assay Parameters for Effective Assessment of Mycotoxin Contamination of Cereal Products

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Ensuring food quality and safety is a cornerstone of modern agriculture, encompassing all stages of production, processing, storage, and distribution. Agricultural products are vulnerable to contamination by various harmful substances, including mycotoxins such as ochratoxin A, zearalenone, and aflatoxin B1. These toxic compounds are produced by certain fungi and pose serious health risks to humans and animals. Developing efficient methods for optimizing detection systems is crucial for addressing contamination challenges. This study focuses on creating an optimized methodology for the development of magnetic immunochromatographic assays for the detection of these mycotoxins in cereal products. This study employed spherical superparamagnetic nanoparticles as a basis for the immunochromatographic assay. A competitive immunoassay format was used as the foundation for quantifying the studied mycotoxins in cereal samples. The methodology included the covalent immobilization of antibodies specific to each mycotoxin on the surface of magnetic nanoparticles. Antigen-coated conjugate pads were prepared for each mycotoxin to serve as test lines. The systematic optimization of parameters such as the density of antibodies on magnetic particles, the amount of bioconjugates used in each test, and the antigen printing density on the test lines was performed. Quantitative measurements of the magnetic nanoconjugates' distribution were carried out using the magnetic particle quantification method. The optimized parameters were validated against high-performance liquid chromatography (HPLC) results for cereal products contaminated with the studied mycotoxins. The developed methodology enabled the systematic optimization of key assay parameters to achieve high sensitivity and specificity for detecting the studied mycotoxins. Adjustments to the density of antibodies immobilized on magnetic nanoparticles were made within a range of 0.25 to 7.5 μg per conjugation. Optimal conditions were identified by achieving the maximum signal-to-noise ratio at a toxin concentration of 1 ng/mL. The additional fine-tuning of bioconjugate amounts and antigen printing densities ensured reproducibility and sensitivity. The validation process demonstrated that assays developed using this methodology achieved detection limits in the low ng/mL range and showed excellent correlation with HPLC data. The proposed methodology provides a robust framework for optimizing magnetic immunochromatographic assays for the detection of mycotoxins in cereal products. This approach enables the efficient development of reliable test systems, contributing to enhanced food safety and quality assurance across the agricultural supply chain.



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sciforum-116926: Paper-based device for monitoring the efficacy of anti-cancer therapy: detection of H₂S in cells

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Hydrogen sulfide (H₂S) is the most recently identified endogenous gasotransmitter, along with molecules such as nitric oxide (NO) and carbon monoxide (CO). It has been recognized as a key mediator in various physiological processes, such as cellular homeostasis, as well as in pathological conditions, including cancer. Specifically, H₂S exerts different effects on cancer cells depending on its concentration and exposure time. At lower concentrations, it can promote tumor cell growth and proliferation, whereas higher concentrations may inhibit growth or induce apoptosis. Due to its biphasic behavior, H₂S is a promising biomarker for both diagnostic and therapeutic strategies in cancer, with potential applications in liquid biopsy for non-invasive early detection of tumor progression and treatment response. Given the challenging nature of H₂S detection, there is a growing need for sensitive analytical techniques, such as electrochemical methods, to accurately measure its levels. Considering this, a novel paper-based electrochemical sensor was fabricated for the detection of this gas transmitter in H₂S-exposed murine tissue lysates, with possible applications in liquid biopsy. The sensor, screen-printed on filter paper, was modified with a Prussian blue (PB) dispersion, synthesized directly on the paper support. Analytical characterization was performed in standard solutions, achieving a detection limit of 3 μM with an adequate repeatability, under 10%. This electroanalytical method was then applied for the detection of H₂S levels in murine skin lysate, untreated cancer murine lysates, and pharmacologically-treated neoplastic murine lysate, validating the accuracy and reliability of the technique. It indicates a notable improvement in portable point-of-care (POC) platforms for cancer diagnostics, allowing rapid, on-site testing with minimal sample volume requirements, simplified procedures, and timely, minimally invasive cancer detection. The use of miniaturized, portable sensors, in particular, allows for a reduction in sample size, which usually presents an issue in traditional approaches.



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sciforum-114872: Screening of magnetic nanoconjugates' kinetic properties based on their magnetometric registration in LFA test strips

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Introduction

Nanoconjugates are widely used as recognizing agents in different immunoassays, targeted therapies and biochemical methods of analysis. The performance of such conjugates strongly depends on their kinetic properties in interaction with the analyte. Various techniques such as surface plasmon resonance (SPR), bio-layer interferometry (BLI) and spectral correlation interferometry (SCI) allow for the kinetic characterization of protein–protein interactions, but there is still a lack of methods for screening nanoconjugate kinetics. Here, we show a novel approach for the characterization of magnetic nanoconjugates binding kinetics, which is based on the magnetometric detection of conjugates in the analytical zone of lateral flow assay (LFA) test strips. The developed method was used to screen different magnetic nanoconjugates against biotin, which was further used for its sensitive detection.

Methods

Magnetic nanocojugates were synthesized by adding 200 nm magnetic particles to a carbodiimide solution. After incubation, the particles were washed three times with water, and the solution of anti-biotin antibodies was added to the coupling mixture. After incubation, BSA solution was also added to block the excess of activated carboxyl groups. Then, the suspension of magnetic conjugates was washed with water again, and then used for further analysis.

Synthesized nanoconjugates were tested on LFA test strips with BSA-biotin conjugates immobilized in the analytical zone. The interaction between the target and labels was registered with the magnetic particle quantification (MPQ) technique during the test.

Results

Different amounts of nanoconjugates were taken every test. The experimental relation between the nanoconjugate concentration and saturation MPQ signal was fitted with a Langmuir adsorption model to determine the K_D constant. After that, real-time interaction data were used to measure the k_{on} and k_{off} rate constants.

Based on determined kinetic properties, the most efficient conjugate was chosen in the magnetic LFA test system for biotin detection.

Conclusions

The developed approach was used to provide the kinetics screening of magnetic nanoconjugates. This method could be particularly advantageous in point-of-care diagnostics and the development of rapid screening assays for biomedical applications.



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sciforum-109712: Solute-driven Online Preconcentration in Lateral Flow Assay (SOP-LFA) devices for ultrasensitive biochemical testing

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Lateral flow assays (LFAs) are paper-based analytical devices (PADs) widely used in medical diagnostics, food safety, and environmental monitoring. These test strips provide rapid, on-site analysis without the need for specialized equipment, making them both affordable and highly portable. However, traditional LFAs struggle to detect low concentrations of analytes, which are often present during the early stages of diseases. Preconcentration techniques can significantly enhance sensitivity, but current methods that require an external power source compromise the simplicity and portability that make LFAs so valuable. To address this limitation, we propose a novel solution using diffusiophoresis (DP), a solute-driven electrokinetic phenomenon, to concentrate analytes on PADs without the need for external power. By harnessing the spontaneous electric field generated at the interface between electrolytes with different ionic strengths, we aim to achieve online electrokinetic preconcentration while preserving the portability of LFAs. In standard colorimetric LFAs, this approach could dramatically improve detection limits. Mobile coloured nanoparticles conjugated to detection reagents will bind to target analytes, which will then interact with immobilized capture reagents at the test line. Based on DP studies conducted in microchannels, preconcentration factors exceeding 10^4 could be achieved at the test line, potentially leading to over a 10,000-fold improvement in sensitivity without sacrificing the simplicity and ease of use of LFAs.



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Session H. Optical and Photonic Biosensors

sciforum-116834: A chemiluminescence immunosensor exploiting thin-film photosensors to detect C-reactive protein as a biomarker for astronaut health monitoring in long-term missions

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Growing attention in deep space exploration lies in protecting crew health and maintaining peak performance by devising preventive measures and on-site diagnostic techniques. The harsh conditions of space present serious health threats, such as muscle degradation, bone density loss, and cardiac dysfunction (<https://doi.org/10.1016/j.issr.2023.09.003>). Consequently, cutting-edge solutions for real-time biomarker analyses are critical to tracking astronauts' health throughout their missions (<https://doi.org/10.3390/bios14020072>).

C-reactive protein (CRP), a protein associated with inflammatory conditions, has demonstrated a significant correlation with infarct severity, complications, and poor outcomes in ischemic patients. Elevated CRP levels in particular have been linked to sudden coronary death due to plaque rupture and a heightened risk of sudden death in otherwise healthy individuals (<https://doi.org/10.1093/eurheartj/ehr487>).

We developed a disposable microfluidic cartridge coupled with an array of hydrogenated amorphous silicon (a-Si:H) photosensors for the detection of CRP in biological fluids.

The device is made up of a cartridge containing microchannels within which specific anti-CRP antibodies have been chemically immobilized to the photosensors required for signal detection in the presence of the target.

Upon the application of a sample, the target was recognized by the immobilized specific antibodies and detected by the biotin-labeled secondary antibody and streptavidin conjugated with horseradish peroxidase. Upon the addition of the luminol/peroxide chemiluminescence cocktail, the emitted photons were acquired by the photosensor array.

The preliminary results show a strong linear correlation between the CRP concentration and the CL signal, with a detection limit of 2.8 ng/mL, suitable for clinical applications.

Future advancements will focus on improving the method's robustness and providing a multiplexing ability, ultimately making it suitable for use in space applications.

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sciforum-115817: Recent advances in optical biosensors for the rapid detection of heavy metals

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The detection of heavy metal contamination is critical for environmental and food safety, given the toxicity of metals like cadmium (Cd^{2+}), lead (Pb^{2+}), and copper (Cu^{2+}). Optical biosensors have emerged as a powerful solution due to their sensitivity, rapid response time, and adaptability for in situ monitoring. Recent advances have integrated novel materials, whole-cell approaches, and functional nanomaterials to enhance optical transduction mechanisms. For example, Durrieu et al. developed an optical algal biosensor utilizing *Chlorella vulgaris* cells with alkaline phosphatase as the biological recognition element, demonstrating strong inhibition of enzyme activity in the presence of cadmium and lead ions, measurable through fluorescence detection [1]. Similarly, Tsai et al. designed a sol-gel-based urease biosensor for detecting Cu^{2+} and Cd^{2+} , utilizing FITC-dextran as a pH-sensitive fluorescent probe immobilized within a sol-gel matrix, achieving detection limits as low as 10 μM [2].

The incorporation of synthetic biology in whole-cell biosensors has also been shown to improved optical signal generation. For instance, Singh and Kumar reviewed genetically engineered whole-cell biosensors with optical readouts, highlighting the use of bacterial transcriptional regulators such as ArsR and MerR families for arsenic (As^{3+}) and mercury (Hg^{2+}) detection [3]. Further advancements have utilized quantum dots and gold nanoparticles for signal amplification in fluorescence- and surface plasmon resonance (SPR)-based sensors. These nanomaterials enhance sensitivity by lowering detection limits into the nanomolar range. This review highlights the most recent innovations in optical biosensing for heavy metals, focusing on enzyme inhibition-based methods, whole-cell biosensors, and nanomaterial-enhanced platforms. Optical biosensors represent a promising and sustainable approach to address heavy metal contamination in environmental and food systems.



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sciforum-113428: A novel data processing method for light-addressable potentiometric sensors for the narrow bias range required

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A light-addressable potentiometric sensor (LAPS) is a type of bio-sensor based on the semiconductor field effect and modulated light, driven by the advantages of a wide detection range, low fabrication costs, support for miniaturization, etc. The conventional LAPS data processing methods rely on I-V characteristic curves, where a wide bias voltage range (over 1 V) is required to achieve a complete I-V curve, including the accumulation, depletion, and inversion regions in a single measurement process. The wide bias voltage range places high demands on the power supply of the measurement system and is not conducive to miniaturization. In this paper, a novel data processing method for LAPSs based on Gaussian fitting is proposed, and the pH sensing effect of the sensor under this method is investigated. Under the new data processing method, the linearity of the LAPS was 98.2%, the sensitivity was 5.378 points/pH, and the average repetition rate was 1.27%, where the bias voltage range was 0.07 V. The experimental results showed that the new data processing method could help the LAPS to obtain an acceptable pH sensing effect and a narrower bias voltage range compared with these properties for a LAPS operating using the traditional data processing methods. The data processing method based on Gaussian fitting shows the potential to be applied to the design of low-power, miniature LAPSs.



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sciforum-115740: Biosensing and physical sensing methodologies based on optical fiber gratings

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Fiber gratings have long been utilized as optical sensors, particularly for measuring chemical, biochemical, and physical parameters. These sensors typically operate by detecting changes in the external refractive index or by monitoring physical parameters such as strain, temperature, and pressure. Fiber gratings can be categorized into two main types based on the grating period and their distinct optical characteristics: (i) long-period gratings (LPGs), with grating periods of hundreds of micrometers, couple guided light from the fiber core to the cladding, facilitating interaction with the surrounding environment, and are primarily used for chemical and biochemical sensing; (ii) fiber Bragg gratings (FBGs), with grating periods of hundreds of nanometers, reflect light within the core's fundamental mode and are mainly employed for physical parameter sensing.

This work presents two practical applications of these methodologies. First, we characterize an LPG optical sensor inscribed in an optical fiber, enhanced with a 40 nm gold layer. The gold coating offers several benefits, such as ease of functionalization and the potential for multiphysics sensing, including its use as an electrode for electrical measurements. The fiber sensor is integrated into a thermostated microfluidic system. Our experimental results indicate that the sensor's sensitivity, with the gold coating, is comparable to a similar sensor without the coating. However, the gold layer introduces significant opportunities for integrating electrical and optical sensing capabilities.

The second application involves the design and implementation of a remote sensing apparatus for monitoring deformation and temperature in large structures, such as bridges. This system employs two FBGs: one for strain and one for tilt sensing. The FBG interrogation is managed by a single-board computer, and custom software is developed for data acquisition, analysis, and remote monitoring. The system is designed for low power consumption, with provisions for battery power and solar charging, ensuring energy efficiency and sustainability.

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sciforum-115618: Determination of a Range of Light Frequency in Photocatalytic Activity with AG Nanoparticles

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The photocatalytic properties of various nanoparticles have been intensively studied recently. Among them, plasmonic and semiconductor nanoparticles show special activity. While it has been found that the mechanism of photocatalytic activity for semiconductor nanoparticles is due to the transition of electrons from the valence band to the conduction band, such a mechanism is still unknown for plasmonic nanoparticles. The photocatalytic effect in the case of plasmonic nanoparticles is possibly associated with the emergence of zones of high electromagnetic intensity between two plasmonic nanoparticles due to the appearance of local plasmonic resonance. There is an urgent need to determine the effective frequency range of electromagnetic radiation at which photocatalytic processes occur.

In the proposed work, a device based on Arduino is developed to establish the spectral dependence of the process of organic structure photodegradation through the example of the dye methylene blue in the presence of nanosized silver under electromagnetic radiation action and to analyze the possible mechanisms of this process. The interval of light radiation frequencies that activate or inhibit the process of organic compound photodegradation is established, and probable mechanisms of interaction of organic structures with light radiation and nanosilver due to the occurrence of local plasmon resonance are also presented.



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sciforum-110459: Dual-core Ag/TiO₂ nanoparticles for photothermal therapy

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In photothermal therapy, the controlled release of heat by properly synthesized nanomaterials can be assisted by local temperature detection, provided by so-called nanothermometers present near nanoheaters.

The current research study offers various methodologies for measuring local temperature based on the electrical, mechanical or optical properties of materials, like Scanning Thermal Microscopy, Atomic Force Microscopy, Infrared or Fluorescence Thermography and Raman Spectroscopy. In this context, Raman Spectroscopy is a non-contact technique offering high spatial and thermal resolution, which is extremely important for photothermal therapy. Raman signals can be enhanced by exploiting the vicinity of Raman-active materials/molecules to plasmonic nanosystems, which are also widely used to produce nanoheaters.

In this work, composite nanoparticles are specifically developed to provide close contact between plasmonic nanosystems, acting as nanoheaters, and local temperature sensors: silver nanoparticles (AgNP) are surrounded by a shell of anatase titanium dioxide (TiO₂), which has already been tested as a Raman thermometer.

The synthesis is a multi-step process. Silver cores are prepared through a two-pot reaction. First, the silver precursor (AgNO₃) is reduced and stabilized to produce a seed suspension with an average particle size of 7 (± 2) nm. Then, a growth step is performed to reach nanoparticle sizes of 46 (± 8) nm. Dioxide shell formation is carried out using a sol-gel method starting from an ethanol solution of titanium tetrabutoxide (TTB) as a precursor. A final hydrothermal treatment induces the crystallization of TiO₂ to the anatase form.

The resulting nanocomposites are characterized using various techniques, including Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), UV/Vis extinction and Raman Spectroscopy.

This work demonstrates the feasibility of fabricating nanocomposite structures with high potential as photothermal systems, providing a starting point for future improvements in this field.



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sciforum-116954: Oligonucleotide Switches for miRNA/mRNA detection in Optical Biosensing

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Oligonucleotide optical switches are short, precisely engineered nucleic acid molecules that alter or activate their light emission upon interaction with specific molecular targets. Their optical response is typically based on fluorescence mechanisms, particularly Förster Resonance Energy Transfer (FRET), or alternative approaches such as Surface-Enhanced Raman Scattering (SERS) [1].

DNA's versatility extends beyond genetic information storage; in biosensing applications, DNA fragments provide exceptional molecular recognition, enabling highly specific analytical systems. More than just recognition elements, DNA-based structures can be designed as dynamic nanoscale tools to monitor intracellular processes in real time. These capabilities allow oligonucleotide optical switches to serve both as diagnostic sensors and potential therapeutic agents.

Among recent advancements in optical biosensing, oligonucleotide optical switches have emerged as particularly promising due to their ability to provide a rapid, sensitive, and highly specific detection of biomolecules [2]. However, challenges remain, including optimizing signal-to-noise ratios, ensuring stability in biological environments, and integrating these nanosensors with advanced detection platforms. Despite these hurdles, continuous research is expanding their applications, from fundamental cellular studies to medical diagnostics and targeted therapies. Their potential to bridge biosensing and therapeutic intervention positions them as key players in the future of molecular nanotechnology.

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sciforum-115625: A Label-Free Optical Interferometric Biosensor for Comparing Antibody Interaction with Folic Acid Derivatives Based on Gelatin and Dextran

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Folic acid plays a critical role in cellular metabolism, including DNA synthesis and cell division. Understanding its interactions with antibodies is essential for creating diagnostic platforms and therapeutic systems. The effectiveness of these interactions depends on the carrier used for folic acid, which is often a protein like bovine serum albumin, ovalbumin, or keyhole limpet hemocyanin. Polymers such as dextran and gelatin are emerging as promising alternatives. This study compares the interaction of antibodies with folic acid conjugates based on dextran and gelatin using an updated label-free optical biosensor employing spectral interferometry. This method evaluates the influence of carrier structure on interaction kinetics and specificity, identifying optimal materials for various applications.

Conjugates of folic acid with gelatin and dextran were synthesized using carbodiimide chemistry. Gelatin conjugates were prepared by reacting folic acid with 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide and N-hydroxysuccinimide, followed by incubation with gelatin. The product was purified through precipitation and washing cycles. Dextran conjugates were synthesized similarly, replacing gelatin with dextran. A biosensor chip surface was modified with folic acid–gelatin conjugate, and antibodies specific to folic acid were immobilized. Conjugates of folic acid–gelatin or folic acid–dextran were introduced in a competitive binding assay, and interaction dynamics were monitored using spectral interferometry.

The folic acid–gelatin conjugate demonstrated weak interaction at low concentrations and low desorption rates, making it suitable for mimicking complex biological systems where nonspecific interactions and limited accessibility of binding sites are relevant. In contrast, the folic acid–dextran conjugate exhibited higher binding efficiency, specificity, and stability due to enhanced accessibility of folic acid and reduced nonspecific interactions. The biosensor enabled real-time monitoring of these interactions, providing detailed profiles for each conjugate. Folic acid–gelatin is advantageous for systems involving complex biological interactions, while folic acid–dextran offers high specificity and faster binding kinetics.

Folic acid–gelatin and folic acid–dextran conjugates exhibit distinct interaction profiles with antibodies. Gelatin conjugates are suited for systems with nonspecific binding, whereas dextran conjugates provide higher specificity and stability. The experimental results showed that the label-free biosensing with spectral correlation interferometry is a powerful approach for evaluating conjugate interactions and identifying suitable materials for biomedical applications.



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sciforum-114628: Advanced Dispatchable Fiber-Optic Biosensor System for Real-Time, On-Site Sediment and Water Toxicity Monitoring: System Optimization (Sundanse)

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Detecting toxicants in aquatic ecosystems is critical for assessing the impact of pollutants on the environment. Conventional chemical analysis methods are often time-consuming and resource-intensive, and may not fully capture bioavailability or cumulative pollutant effects. Whole-cell biosensors offer a rapid, biologically relevant method for assessing environmental toxicity. Building on the previous generation of our fiber-optic biosensor, this study introduces a second-generation system that improves usability and field readiness while maintaining the core functionality of the original design. The upgraded system incorporates additional features to enhance portability and ease of deployment in remote environments such as an improved, lightproof case as well as a sustainable power supply incorporating an internal power station as well as solar panels. At its core is a photomultiplier tube (PMT) that quantitatively detects low-intensity blue light emitted by bioluminescent bacterial bioreporters, that were immobilized within a calcium alginate matrix on fiber-optic tips, in response to toxicants. As a proof of concept, on-site toxicity measurements of water and sediment samples were conducted at potentially contaminated locations across Israel. Preliminary results obtained with the new configuration indicate notable improvements in operational efficiency and ease of deployment compared to earlier prototypes, while retaining its capabilities in detecting various toxicants as revealed by a complementary chemical analysis. This new configuration offers promising potential as a high-throughput versatile tool for on-site environmental toxicity screening.



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sciforum-114911: Advancements in Optical Biosensor Technology for Food Safety and Quality Assurance

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Optical biosensors have emerged as a transformative technology for food safety monitoring. These devices combine bio-recognition molecules with advanced optical transducers, enabling the detection of a wide array of food contaminants, including pathogens, toxins, pesticides, and antibiotic residues. This review comprehensively explores the principles, advancements, applications, and future trends of optical biosensors in ensuring food safety. The key advantages of optical biosensors, such as high sensitivity to trace contaminants, fast response times, and portability, make them an attractive alternative to traditional analytical methods. Types of optical biosensors discussed include surface plasmon resonance (SPR), interferometric, fluorescence and chemiluminescence, and colorimetric biosensors. SPR biosensors stand out for their real-time, label-free analysis of foodborne pathogens and contaminants, while fluorescence and chemiluminescence biosensors offer exceptional sensitivity for detecting low levels of toxins. Interferometric and colorimetric biosensors, characterized by their portability and visual signal output, are well suited for field-based applications. Biosensors have proven invaluable in monitoring heavy metals, pesticide residues, and antibiotic contaminants, ensuring compliance with stringent food safety standards. The integration of nanotechnology has further enhanced the performance of optical biosensors, with nanomaterials such as quantum dots and nanoparticles enabling ultra-sensitive detection and signal amplification. Optical biosensors represent a vital advancement in the field of food safety, addressing critical public health concerns through their rapid and reliable detection capabilities. Continued interdisciplinary efforts in nanotechnology, material science, and device engineering are poised to further expand their applications, making them indispensable tools for safeguarding global food supply chains.



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sciforum-117382: Advances in Optical and Photonic Biosensors: Innovations, Applications, and Future Perspectives

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Biomolecular detection has been revolutionized by the integration of advanced optical and photonic technologies with biosensors, offering unprecedented sensitivity and specificity. This review covers recent advances in biosensor technologies that exploit 2D materials, photonic crystals, and plasmonic enhancements for biomedical applications.

Graphene, MXenes, transition metal dichalcogenides, and 2D materials have been introduced into the field of optical biosensors, where they enhance detection by Surface Plasmon Resonance and Fluorescence Resonance Energy Transfer techniques. Similarly, with photonic crystal-based biosensors, such as one-dimensional photonic crystals (1D PCs), rapid and sensitive bacterial detection has been developed. Quantum dots and plasmonic nanomaterials connectedly form biosensors that have improved optical responses, thereby broadening their application in medical diagnostics.

Innovations in photonic biosensors have been applied in waterborne pathogen detection where multilayer photonic crystal structures break symmetry upon interaction with bacterial samples and produce unique resonance shifts. These systems, optimized based on transfer matrix methods, demonstrate enhanced sensitivity, along with superior performance compared to previously designed ones. Furthermore, SPR biosensors based on PCF that are co-modified with gold nanoparticles and polydopamine display excellent biosensing capabilities for immunoassays at low detection limits and high refractive index sensitivity.

Silicon-on-insulator (SOI)-based optofluidic biosensor arrays offer a promising multi-tumor marker detection tool for cancer diagnostics. Utilizing nanobeam resonator transducers and microfluidic integration, these biosensors offer label-free, high-sensitivity detection of carcinoembryonic antigens, thus leading to point-of-care diagnostics.

There remain several challenges with these advances: material stability, reproducibility, and translation to the clinical arena. Research should be concentrated on overcoming such barriers through sustainable material synthesis, better fabrication techniques, and more integrated biomedical systems that would finally translate to the commercialization of next-generation biosensors.



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sciforum-117549: AI-Optimized Graphene-Based Biosensor for Ultra-Sensitive Biomolecular Detection

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Introduction

Surface Plasmon Resonance (SPR) biosensors have emerged as indispensable tools for real-time, label-free detection of biomolecules. However, conventional SPR sensors that employ noble metals are often hampered by substantial optical losses and constrained tunability in the near-infrared (NIR) spectrum. To address these challenges, we introduce an optimized SPR biosensor that integrates transparent conducting oxides (TCOs)—specifically, aluminum-doped zinc oxide (AZO) and indium tin oxide (ITO)—with graphene, thereby enhancing both plasmonic performance and biomolecular interactions.

Methods

The sensor architecture was developed using the Kretschmann configuration, incorporating a BK-7 prism along with sequential layers of AZO, ITO, graphene monolayers, and an additional dielectric layer to maximize sensitivity. Reflectance was modeled via the Transfer Matrix Method (TMM), while the dielectric characteristics of AZO and ITO were determined using the Drude-Lorentz oscillator model. Optimization of critical sensor parameters—including layer thicknesses and incident angles—was achieved through the application of machine learning techniques (Random Forest algorithms) and genetic algorithms (GAs).

Results

The proposed biosensor achieved a maximum sensitivity of 197.64°/RIU and a Figure of Merit (FOM) of 780.4 RIU⁻¹, thereby outperforming conventional SPR sensors based on gold and silver. The incorporation of graphene notably enhanced biomolecule adsorption, while the additional dielectric layer contributed to improved detection accuracy. Moreover, comparative analyses revealed that TCO-based SPR sensors exhibit markedly lower optical losses in the NIR range.

Conclusions

This study presents a novel and highly sensitive SPR biosensor that exploits the superior plasmonic properties of TCOs. By substituting traditional noble metals with AZO and ITO, the sensor achieves enhanced sensitivity, reduced optical losses, and superior detection accuracy. Furthermore, the integration of machine learning optimization techniques significantly refines sensor performance, paving the way for next-generation biosensors with broad applications in medical diagnostics, environmental monitoring, and biophotonics.



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sciforum-117552: Biosensors in Agriculture: Revolutionizing Sustainable Farming through Precision Technologies

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While 46% of India's agricultural labor provides only 18% of the country's GDP by providing basic ingredients for humankind and raw materials for industrialization, 2.5 billion people worldwide work in the agriculture sector. Following the green revolution, a variety of agricultural techniques were developed, including chemical pesticides and herbicides, which further increased crop yields by successfully controlling the infestation of weeds and other pests. To attain the objective of regional and global food security, technical interventions are required in the fundamentals of food processing, quality assurance, and the identification, diagnosis, and prevention of catastrophic risk. Through molecular recognition materials, antigen–antibody contact, and the ensuing transmission mechanism, recent developments in biosensing technologies and material sciences have been essential in comprehending the dynamics of agricultural processes. One analytical tool that converts biological reactions into electrical signals is a biosensor. Piezoelectric, thermal, DNA-based, tissue-based, enzyme-based, and immune-based biosensors are some examples. Numerous agricultural applications, including the evaluation of toxins in soils and crops, the identification and diagnosis of infectious diseases in crops and animals, online monitoring of important food process parameters, the measurement of animal reproduction, and veterinary medication screening, can make use of biosensors. Ex vivo or in vivo injections of genetically modified proteins into cells are used to create cell- and tissue-based biosensors. The agriculture industry has also been greatly impacted by technological developments in the fields of nanobiosensors, bioelectronics, material science, miniaturization techniques, electrode design, fabrication technology, nanolithography, and microfluidics. It is necessary to focus our research on improving a biosensor's shelf life in order to boost end-user acceptance. As biosensors' fundamental properties improve, they will be widely used in important yet difficult agricultural fields.



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sciforum-115450: Design of an Octagon-Shaped THz Photonic Crystal Fiber Biosensor for Coordinated Diabetes Detection Using Simplicial Causal Graph Dilated Botox Quaternion Convolutional Attention Networks

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Diabetes stands as a widespread and critical health concern on a global scale, presenting formidable obstacles to healthcare systems around the world. The increasing prevalence of this condition, coupled with its numerous complications, poses significant challenges for effective medical intervention and resource allocation. It is of paramount importance that diabetes is detected early and accurately to facilitate proper management strategies and prevent severe health consequences that can arise from uncontrolled diabetes. Unfortunately, current diagnostic methods often fall short in terms of precision and sensitivity when it comes to conducting large-scale screenings. This inadequacy is particularly evident in their ability to detect specific biomarkers associated with diabetes at low concentrations, which are crucial for accurate diagnosis.

Moreover, existing techniques tend to not take into consideration the intricate interrelations among various biomarkers, thereby further diminishing their effectiveness for reliable diabetes diagnostics. In response to these pressing limitations, the present study proposes an innovative solution in the form of an octagon-shaped terahertz (THz) photonic crystal fiber (PCF) biosensor specifically engineered for enhanced coordination in diabetes detection. This cutting-edge biosensor has been meticulously optimized through the application of a novel approach known as the Simplicial Causal Graph Dilated Botox Quaternion Convolutional Attention Network (SCG-DBQCAN). This advanced framework seamlessly integrates methodologies such as simplicial causal graph modeling and dilated quaternion convolutions along with attention mechanisms inspired by Botox technology—all aimed at achieving robust feature extraction and highly efficient classification of biomarkers.

The design of this biosensor significantly boosts light-matter interactions within its structure, resulting in exceptional sensitivity towards detecting diabetes-related biomarkers while simultaneously minimizing potential signal loss during measurement processes. Impressively, this state-of-the-art device boasts a remarkable detection accuracy rate of 99.9%, showcasing its high sensitivity even towards those low-concentration biomarkers that are often missed by traditional methods. Furthermore, its adaptability makes it suitable for various diagnostic contexts, presenting a game-changing solution for early detection of diabetes—a critical step toward mitigating long-term health risks associated with this chronic disease.



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sciforum-117494: Development of a Chemiluminescent Thread-Based Device for Eco- and User-Friendly Detection of Lactate in Sweat

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There is a growing demand for inexpensive and user-friendly detection technologies that can identify various biomarkers in a sustainable manner. Microfluidic thread-based analytical devices (μ TADs) are rapidly growing because of their biocompatibility, flexibility, and absence of complex treatments. Additionally, μ TADs are highly compact, allowing for the use of small sample volumes, with the potential to compete with low-cost paper in point-of-care (POC) applications. Here, we present a chemiluminescent thread-based device for user-friendly detection of lactate in sweat, which is an indicator of performance in athletic training programs, and it can provide vital information connected to ischemia and insufficient oxidative metabolism. Lactate oxidase (LOx)-catalyzed reaction coupled with the luminol/H₂O₂/horseradish peroxidase (HRP) system was exploited by immobilizing substrate and enzymes on different sides of the same thread, avoiding undesired premature reactions. Small-volume samples (2 μ L) were used on an optimized “X-shaped” device with an incubation time of 5 min. Different supports were tested from the perspective of wearability of the biosensing thread, including polypropylene, mother of pearl buttons and, to improve sustainability, grape and apple skin obtained from agro-food waste. Smartphone detection allowed a simple and quantitative readout for the end-user. Under optimized conditions, the biosensor achieved detection limits of 0.27, 0.24, and 0.15 mM for lactate spiked in artificial sweat samples at pH 5.5, 6.5, and 8.0, respectively, showing promising applications for POC applications.



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sciforum-116616: Fiber gratings coupled with polymers for biosensing

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Long-period gratings (LPGs) have attracted increased attention for label-free biosensing; their structure allows for the transmission characteristics of light in these sensors to be modified by variations in the refractive index of the solution in contact with the fiber. This results from an evanescent wave arising from the fiber, which propagates into the external medium over distances of several hundred nanometers.

The implementation of a specialized biolayer on the fiber surface, composed of a biological recognition element (BRE) that is selective for the chosen target, enables the detection of surface refractive index changes resulting from the unique biochemical interaction between the target and the BRE. The same approach can be applied to investigate the deposition or growth of hydrogels and polymers, including novel soft molecularly imprinted polymers (MIPs) derived from neurotransmitters.

The application of these sensitive and adaptable fiber optic sensors has facilitated a comprehensive characterization of the photo-polymerization of acrylamide to produce polyacrylamide (PA) hydrogels; these polymers are used to create a functional and porous layer for the immobilization of antibodies and aptamers for bacterial capture. This aims to analyze the antibiotic resistance of the specific collected microorganisms. The utilization of optical fiber sensors and their integration into specifically constructed, thermally stabilized microfluidic systems harnesses the advantages of the investigated polymers and hydrogels combined with the essential characteristics of LPG sensors, particularly their versatility, cost-effectiveness, and portability.

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sciforum-111712: High-Performance Non-Isolated Boost DC-DC Converters with Voltage Multiplier Techniques for Solar Energy Harvesting Applications

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Solar energy harvesting systems are made up of stages like energy harvesting, DC-DC conversion, MPPT (maximum power point tracker) controllers, and storage. These stages can vary in number and configuration, but they all have the same basic structure: energy harvesting, DCDC conversion/elevation, and storage. Energy-harvesting systems are crucial for the continuous supply of energy in autonomous systems or devices, which is why they are important for Internet of Things applications. A conversion stage is essential for any solar energy-gathering device. Low-power systems use DC-DC converters to increase or decrease the input energy in a voltage that the system needs. For usage in electrical devices, a DC-AC converter transforms the panel's direct current into alternating current. As a renewable and eco-friendly resource that can be utilized for a variety of purposes, including powering sensor networks, the utilization of solar energy to create electricity has expanded the uses of energy harvesting. Voltage multiplier cells used in non-isolated boost DC-DC converters for solar energy harvesting applications are analyzed in this research. One inductor, two capacitors, and two diodes were used to build voltage multiplier cells. The design calculation was used to determine the performance characteristics. The MATLAB/Simulink software was used to test the performance parameter. The results showed that the power efficiency of the boost DC-DC converter based on voltage multiplier cells was 75%. This converter produced ripple voltage, which was 0.0341% of the output voltage with a ripple content of 0.55 volts. Such voltage multiplier cell-based boost converters can be utilized for low-power voltage lifting in solar energy-harvesting systems.



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sciforum-115334: Hydrogen peroxide inhibits the oxidase-like activity of amorphous CoO_x for the sensitive colorimetric detection of glucose

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Many metal oxide nanozymes have been demonstrated to exhibit a peroxidase-like activity much higher than an oxidase-like one in triggering the oxidation of colorless TMB to blue oxTMB. Unlike the conventional phenomenon, here, we observe that amorphous CoO_x can show strong oxidase-like activity, but its activity decreases after the addition of H_2O_2 . Further experimental investigation revealed the underlying mechanism: H_2O_2 decomposes CoO_x into inactive cobalt ions. Through redox potential calculations, the feasibility of their reaction was theoretically confirmed. Moreover, the unusual phenomenon mainly occurs in amorphous CoO_x and does not exist in cobalt oxides with distinct crystallinity. Based on the finding, a biocatalytic enzyme-nanozyme cascade system can be constructed using CoO_x and glucose oxidase (GOx) for detecting glucose in human serum. In the presence of oxygen, glucose is catalyzed by GOx to generate H_2O_2 , which decomposes the CoO_x nanozyme, reducing its oxidase-like activity and thereby inhibiting the TMB coloration system. Therefore, with the increase in glucose concentration, the absorbance of the color-developing system also gradually decreases, thus achieving the quantitative detection of glucose. The developed method has high sensitivity and also shows good anti-interference ability in real samples, providing a new strategy for blood glucose detection based on nanozymes.



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sciforum-115113: Machine learning-assisted nanozyme-coded sensor array for recognition and quantification of biothiols

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Biothiols play an essential role in antioxidant defense and the maintenance of normal cell function, and they are also biomarkers of many diseases. It is of great significance to establish an effective, reliable and simple method to accurately distinguish and quantify biothiols. Here, we design a quasi - amorphous material $Mn_x(DTPMP)$ which exhibits excellent oxidase-like activity to catalyze the oxidation of colorless 3, 3', 5, 5' - tetramethylbenzidine (TMB) to blue oxTMB for the machine learning-assisted nanozyme-coded recognition and quantification of biothiols. The addition of biothiols inhibits the conversion process of TMB, leading to time-resolved reduction in the color signal of oxTMB. Due to their different abilities to inhibit oxidation over time, specific fingerprints can be drawn for each target. On this basis, a unified stepwise prediction model is established using pattern recognition and classification and regression algorithms in support vector machine (SVM), enabling qualitative identification as well as the precise determination of biothiols simultaneously. The time-resolved nanozyme-coded pattern recognition can not only differentiate cancer cells from normal ones according to intracellular glutathione (GSH), but also evaluate the severity of disease according to serum homocysteine (Hcy), showing a promising application prospect in disease diagnosis.



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sciforum-115895: Mid-infrared sensing with dual-band, tunable, polarization-insensitive L-shaped metasurfaces

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Mid-infrared (IR) sensing keeps evolving with developments in semiconductor materials, laser technologies, and quantum optics. Gases with different absorption bands in this range can be detected in the mid-IR area. Furthermore, molecules can be identified as chemical species with excellent selectivity thanks to their distinct vibrational absorption signatures in the mid-IR band. A metasurface is a type of material engineered to have properties that are not found in naturally occurring materials. The metasurface, composed of a thin layer of structured material, has the ability to control electromagnetic waves, particularly those in the mid-infrared spectrum. This work presents a dual-band, tunable, wide-angle, polarization-insensitive mid-IR sensor composed of L-shaped gold metasurfaces on a dielectric spacer and a gold ground surface. A commercial simulator (Comsol Multiphysics) based on the finite element method is used to engineer the metasurfaces in the shape of double and quadruple L-shaped structures. The absorption spectra of the L-shaped metasurfaces show two different peaks, as shown by the numerical findings. The peaks are confirmed to result from magnetic polariton modes produced at two distinct resonant wavelengths by analyzing the electric field distribution. Furthermore, the proposed structure exhibits strong sensing stability across a broad range of incident angles for both TE and TM polarization. Moreover, we show that by altering the separation between two successive L-shaped structures, such a structure may be tailored to desired wavelengths. When the device's top medium is switched from air to water, the suggested metasurfaces provide a sensitivity of 800 nm/RIU. In conclusion, the proposed metasurfaces in mid-IR sensing are a state-of-the-art technology that combines spectroscopy with sophisticated materials engineering to enable sensing devices that are very sensitive, small, and adaptable for various applications.



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sciforum-115337: Optical fiber biosensor probes for medical diagnosis applications

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In the last twenty years, optical fiber sensing technology has significantly advanced in sensor architecture, manufacturing process refinement, and system integration, establishing itself as a cornerstone of cutting-edge sensing systems. A diverse array of optical phenomena, including interference, scattering, total internal reflection, and surface plasmon resonance, are harnessed in the design of optical fiber (OF) sensors. As a novel OF sensor modality, nanostructured plasmonic OF sensors have garnered considerable interest owing to their exceptional performance and distinctive characteristics, enabling the realization of the Lab-on-Fiber concept. Since nanostructured plasmonic OF sensors embody the attributes of both conventional OF sensors and plasmonic sensors, they exhibit unique benefits and can serve as potent biochemical sensing instruments or integrated photonic components. One of the primary domains within the "Lab on Fiber" field is the use of the optical fiber in order to realize probes able to detect biomolecules at very low concentrations. A straightforward approach involves employing metal nanopatterns or nanoparticles to modify the lateral displacement or the tip of the optical fiber in order to realize an innovative metasurface or Surface-Enhanced Raman Spectroscopy (SERS) substrate on the optical fiber tip. This amalgamation aspires to create robust, adaptable, and miniaturized spectroscopic instruments for the remote and highly sensitive detection of low-concentration molecular analytes across a wide range of environments, including challenging conditions.



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sciforum-117689: Optical Properties of Silver Nanoparticles Coated with Silica

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Silver nanoparticles (AgNp) play an important role in various domains, including nanomedicine, water disinfection, biosensing, biomedical engineering, photonics and optoelectronics. This is mainly due to their unique optical characteristics which result from the localized surface plasmon resonance (LSPR) and which are comparable to those of gold and copper nanoparticles. Coating Ag with silica (SiO₂) improves the thermal stability of nanoparticles, prevents their agglomeration and oxidation and offers adjustable solubility in various solvents, but may eventually affect their optical properties.

In this study, we use the theory of effective media to calculate optical spectra of spherical Ag nanoparticles coated with SiO₂ and monodispersed in aqueous solution. The theory of the homogenization gives the absorption and diffusion spectra in terms of the filling factor of nanoparticles and the dielectric function of each component (i.e., AgNp core, SiO₂ shell, and surrounding medium). To describe the dielectric function of AgNp, we used the Drude critical point model (DCP), which adjusts the experimental data of metal permittivity in the 200-1400 nm band and describes electron oscillations more appropriately than the classical and commonly used Drude model. The effects of silica layer thickness and AgNp filling factor on optical spectra are reported in this work.



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sciforum-115515: Real-time Monitoring of Biofilm Growth Using Resonant Microweighing and Adaptive Interferometry

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The rise of antibiotic-resistant bacteria has intensified the need for innovative monitoring and treatment strategies. In this regard, the task of monitoring the state of biofilms formed by bacteria in real time is relevant. In this paper, the adaptive holographic interferometry method is used to construct a biosensor based on microresonance microweighing for monitoring the growth of bacterial biofilm. The sensitive element of the biosensor is a silicon Atomic Force Microscopy cantilever measuring $215 \times 43 \times 7 \mu\text{m}^3$, with a 100 nm thick gold coating. The cantilever is placed in a glass cuvette with a volume of 100 μl with two tubes for the inflow and outflow of liquid. Using a pulsed Nd:YAG laser ($\lambda=532 \text{ nm}$; $\tau=5 \text{ ns}$; $E_p=100 \mu\text{J}$), the cantilever's natural oscillations were excited and were recorded in an adaptive holographic interferometer using a CdTe:V photorefractive crystal.

Before the experiment, the oscillation frequency of the cantilever in water was $69.5 \pm 0.7 \text{ kHz}$. During the experiment, the resonant frequency of the cantilever was measured with a repetition rate of 20 Hz. The oscillations were recorded using an oscilloscope and then processed in MATLAB to obtain an FFT image of the recorded signal. The resonant peak corresponding to the cantilever oscillations was approximated to find the central frequency. In turn, the biofilm mass was calculated using a numerical model [1].

The bacterial cell suspension of *E. coli* K-12 strain XL1-Blue at an optical density of $\text{OD}_{600} = 1$ was fed into a cuvette housing a microcantilever sensor for 1 h at a flow rate of 1 ml/min. Following the initial incubation, fresh LB medium was continuously supplied into the cuvette at a rate of 0.2 ml/min. Over 6 hours, the change in cantilever frequency due to bacterial attachment was $10.3 \pm 0.7 \text{ kHz}$, which corresponds to a bacterial mass of $5.6 \pm 0.4 \text{ ng}$.

The proposed monitoring method can be used to test the effect of various agents on the process of biofilm formation. Due to the adaptive signal processing, there are no requirements for the precise alignment of light beams, and the sensitive element can have a complex shape and a low-reflective surface.

Reference

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sciforum-115550: The Effect of Humidity on the Photosensitivity of Photodetectors Based on Green Fluorescent Proteins and Carbon Nanotubes

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Introduction

Bionanohybrids of carbon nanotubes (CNTs) and green fluorescent proteins (GFPs) are promising materials for optical biosensors due to their combination of unique optical and electrical properties inherent to photoactive biological objects and carbon nanomaterials. The tertiary structure of the biopolymer effectively protects the chromophore, while the cylindrical shape of carbon nanotubes minimizes the contact area with proteins, preventing damage to their native structure. This interaction ensures the stability of GFP-CNT conjugates and prevents fluorescence quenching. In this study, we investigated the effect of humidity levels on the photosensitivity of a photodetector based on a field-effect transistor with a carbon nanotube channel modified by green fluorescent protein.

Methods

We used quasi-metallic single-walled carbon nanotubes grown by chemical vapor deposition in a bottom-gate transistor configuration. The device was fabricated on a highly doped (p++) 100 mm silicon substrate with a 300 nm thermally grown SiO₂ dielectric layer and source and drain electrodes consisting of 100 nm Au and 15 nm Ti. Genetically engineered green fluorescent proteins were attached to the carbon nanotubes using a photochemical reaction based on click chemistry.

Results

Reducing the humidity by purging the samples with dry air or an inert gas leads to a decrease in photosensitivity, which can be restored by the reverse process. The likely cause is a conformational change in the GFP, its partial denaturation, and the removal of adsorbates at the GFP/CNT interface. By controlling the humidity, it is possible to regulate the operation of the photodetector, partially or completely "switching it off."

Conclusions

This paper demonstrates that humidity has a significant impact on the photosensitivity of a device based on GFPs and carbon nanotubes, allowing for the regulation of its operation and the adjustment of photodetector characteristics.



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sciforum-108017: Use of Biosensors to Study the Mechanisms of UV-Based Water Disinfection

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Bioreporters and biosensors can report not only external stimuli but also the internal conditions in the cell they are embedded in. Here, we used bioreporters to explore the effect of UV sources with different spectra on bacteria. UV irradiation is a common physical method for water disinfection and for the inactivation of pathogenic bacteria, viruses, and protozoa. Two types of UV lamps are used, i.e., Low-Pressure (LP) and Medium-Pressure (MP) lamps, where pressure relates to mercury vapor pressure.

MP lamps have polychromatic irradiation spectra, while LP lamps have an almost monochromatic spectrum, with 99% of the irradiation at ~254nm. In inactivation studies, MP lamps have been shown to be more effective in preventing bacteria recovery, but the mechanisms underlying this phenomenon have not been fully understood.

Bioreporters offer a way to see the bacterial “point-of-view” of the irradiation. We studied the bacterial response to the two UV sources using *E. coli* strains containing different promoters upstream to the lux operon and exposing these bacteria to sub-lethal LP and MP irradiation. Following promoter activation, we found that MP irradiation results in the formation of Super Oxide ($O_2^{\bullet-}$) **inside** the cells, probably due to the interaction of the MP lamp spectra's higher wavelength with specific amino acids. These radicals have also been found to play a major role in the disinfection process. These results could explain the disinfecting effects of UVA/B treatments that were previously described and could help in the design of better systems.



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sciforum-115642: Use of bond polarizabilities with spectral map of oligomers in Random Forest algorithm for recognition of MD vibrational spectra in SERS sensor model

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Machine learning (ML) algorithms in molecular simulations have been recently extended to models for machine learning tensorial properties such as molecular dipole moments and polarizability tensors enabling calculations of the IR and Raman spectra. The use of ML methods in DNA/RNA and protein research could enable the automated identification of individual oligomers. The parallel use of ML in surface-enhanced Raman scattering (SERS) sensors and their simulated models can enhance the detection of single oligomers by analyzing spectral variations linked to environmental interactions and conformational changes in the models.

Molecular dynamics (MD) provides vibrational spectra in various interaction environments and molecular conformations reflected in spectral maps of individual bonds. The identification of oligomers relative to environments can be performed by an ML Random Forest (RF) algorithm used for the experimental Raman spectra. In the MD model of the numerical SERS sensor, we applied the RF algorithm for the identification of pyrimidine and purine DNA nucleotides by ring-averaged vibrational spectra obtained during translocation through the nanopore in a graphene sheet with Au nanoparticles (1 to 4 NP) attached to the pore's edge. The baseline-corrected ring-averaged equal-weight vibrational spectra showed nucleotide recognition by RF on a dataset of 170 points. The vibrational spectral maps of nucleobase bonds were calculated for the ring averages. We demonstrate that the implementation of the bond polarizability model (BPM), which assumes that the overall molecular polarizability is a sum over bond contributions, makes use of bond polarizabilities as weighting coefficients of each bond spectrum possible. The existing literature data for the bond polarizabilities of oligomers were approximated for the weighting coefficients. The calculated spectral maps were baseline-corrected as a whole matrix using the SpectroChemPy (SCPy) framework for processing spectroscopic data with masking of the frequency region below 100 cm^{-1} . A spectral map weighted by bond polarizabilities was added to the averaged spectra in the dataset and used as training test data in the RF algorithm. While for only ring-averaged MD data, the RF algorithm reproduces differences in nucleotide spectra and identifies the methylated forms of cytosine, the accuracy is only qualitative. The use of bond polarizability weights for the cytosine pyrimidine ring spectral map with the ring-averaged spectrum dramatically improved the averaged spectrum reproduction by the RF algorithm. The mode frequencies and intensities were correctly reproduced quantitatively by the RF algorithm closely to the calculated data.



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sciforum-116644: Whole-Cell Fiber-Optical Biosensor for Detecting *P. aeruginosa* Via Secreted Quorum-Sensing Molecule Using Bioluminescent Bioreporters

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The opportunistic Gram-negative bacterium *Pseudomonas aeruginosa* poses significant challenges in both clinical and environmental settings due to its pathogenicity and resilience. Quorum-sensing (QS) molecules have emerged as promising biomarkers for the detection of *P. aeruginosa*. This study focused on the development of an alginate-based bioreporter encapsulation system designed for the identification of QS molecules, utilizing a custom-engineered coating formed through the assembly of poly-lysine (PLL). This PLL coating facilitates the passive diffusion of external QS molecules, resulting in a measurable, dose-dependent bioluminescent response. The microbeads reinforced with PLL exhibited substantial stability in the presence of cation scavengers, enabling prolonged shelf life and functionality. The encapsulated bacterial system demonstrated consistent, dose-dependent detection of QS molecules in media containing synthetic autoinducers and in cell-free supernatants derived from wild-type *P. aeruginosa* (PAO1) cultures. These bioreporter beads maintained their stability during extended storage at both 4 °C and -80 °C, allowing for immediate, on-site sensing without the need for recovery processes. The RhlR-based bioreporter displayed a dynamic detection range of 10 µM to 0.1 nM, with a sensitivity threshold of 50 pM for the designated QS molecules. The LasR-based bioreporter demonstrated a broader range of 5 µM to 0.2 nM and a lower detection threshold of 0.1 nM for 3-oxo-C12-HSL. Furthermore, the bioreporter beads effectively detected the presence of the synthetic QS inhibitor furanone C-30 in a dose-dependent manner. This proof-of-concept optical-fiber-based whole-cell biosensor illustrates the feasibility of employing an encapsulated bioreporter system for the detection of bacteria through specific QS molecules. The results of this study hold promise for potential applications in diagnostics, environmental monitoring, and screening for quorum-sensing inhibitors.



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