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2024
Conference

The 4th International Electronic Conference on Biosensors

20-22 May 2024 | Online

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#IECB2024

The 4th International Electronic Conference on Biosensors

The 4th International Electronic Conference on Biosensors

20–22 May 2024 | Online



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Welcome from the Chairs

Dear *Biosensors* Community,

It is our pleasure to invite you to join the **4th International Electronic Conference on Biosensors (IECB 2024)**, which will be hosted online from **20 to 22 May 2024**.

The aims of this online conference are to gather important experts from around the world who are currently working in biosensors and 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 the discussion 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 others.

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

1. Artificial intelligence in biosensors;
2. Ingestible, implantable and wearable biosensors;
3. Smartphone-based biosensors;
4. The evolution of biological recognition elements in biosensors;
5. Microfabrication and printing techniques in biosensors;
6. Nanomaterials and smart surfaces in biosensors;
7. Technological advancements in biosensor actuators;
8. Paper-based biosensors;
9. Optical and photonic biosensors.

We hope you will join us in presenting your work at IECB 2024 and be part of this stimulating online experience.

Kind regards,

Prof. Giovanna Marrazza and Dr. Sara Tombelli

The chairs of the 4th International Electronic Conference on Biosensors.



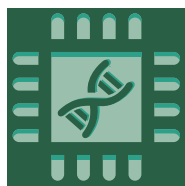
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Program at a Glance

The 4th International Electronic Conference on Biosensors 20–22 May 2024, Online

DAY 1 Morning	DAY 2 Morning	DAY 3 Morning
Session A. Artificial Intelligence in Biosensors Session G. Technological Advancements in Biosensor Actuators	Session C. Smartphone-based Biosensors Session I. Optical and Photonic Biosensors	Session E. Microfabrication and Printing Techniques in Biosensors Session H. Paper-based Biosensors
DAY 1 Afternoon	DAY 2 Afternoon	DAY 3 Afternoon
Session F. Nanomaterials and Smart Surfaces in Biosensors	Session B. Ingestible, Implantable and Wearable Biosensors Session D. The Evolution of Biological Recognition Elements in Biosensors	Poster Session

IECB 2024 Program

20 May 2024 (Monday)

Opening Ceremony

Session A. Artificial Intelligence in Biosensors

Session G. Technological Advancements in Biosensor Actuators

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:40	15:30–15:40	Welcome from the conference chairs—Professor Giovanna Marrazza and Dr. Sara Tombelli	
9:40–9:50	15:40–15:50	Welcome from the session chair—Prof. Dr. Benoît Piro	
9:50–10:10	15:50–16:10	Invited Speaker Dr. Matteo Sensi	Electrolyte-gated transistors based on reduced graphene oxide and organic semiconductors for monitoring health and food
10:10–10:30	16:10–16:30	Invited Speaker Prof. Dr. Piero Cosseddu	Highly conformable electronics, towards a new generation of smart wearable systems
10:30–10:45	16:30–16:45	Selected Speaker Sreerag Kaaliveetil	Machine learning-driven calibration in impedimetric biosensors
10:45–11:00	16:45–17:00	Selected Speaker Rabaï Boudershem	Ethical and regulatory challenges for AI-biosensors in healthcare
11:00–11:15	17:00–17:15	Selected Speaker Cintia Ricale Ferreira da Silva	Integration of multiple biosensors for emotion classification with artificial intelligence
11:15–11:30	17:15–17:30	Selected Speaker Jaume Reverté	Detection of tetrodotoxins and their analogues in pufferfish with a single-cell biosensing device
11:30–11:45	17:30–17:45	Selected Speaker Niranjan Haridas Menon	Development of a fully automated microfluidic electrochemical sensor on the essence platform for rapid detection of single-stranded DNA
11:45–12:00	17:45–18:00	Selected Speaker Inderpreet Singh	AI-driven improvements in electrochemical biosensors for effective pathogen detection at point-of-care

Session F. Nanomaterials and Smart Surfaces in Biosensors

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:10	20:00–20:10	Welcome from the session chair—Prof. Dr. Michael Thompson	
14:10–14:30	20:10–20:30	Session chair Prof. Dr. Michael Thompson	On reduction of the ubiquitous biosensor surface fouling issue
14:30–14:50	20:30–20:50	Invited Speaker Dr. Zewei Luo	The novel-shaped fiber optic-based local surface plasmonic resonance for integration with cytosensing and photothermal treatment
14:50–15:10	20:50–21:10	Invited Speaker Prof. Dr. Eden Morales-Narváez	Paper-based plasmonic network for remote surface enhanced Raman spectroscopy
15:10–15:25	21:10–21:25	Selected Speaker Silvia Maria Cristina Rotondi	Design of a multiplex sensing platform: AFM as a nanolithographic tool
15:25–15:40	21:25–21:40	Selected Speaker Hassan N. Al Hashem	Laser-graphitised diamond electrode for biomedical applications
15:40–15:55	21:40–21:55	Selected Speaker Jing Wei	Ultrasensitive detection of 3-hydroxy-2-butanone biomarker at low temperatures through trace Au Atom enhancement in mesoporous SnO ₂ spheres
15:55–16:10	21:55–22:10	Selected Speaker Stelian Lupu	Electrochemical sensing of neurotransmitters using a metal nanoparticle-based composite platform
16:10–16:25	22:10–22:25	Selected Speaker Peng Qi	In situ real-time monitoring and simulation of metabolic activity in biofilm of sulfate-reducing bacteria
16:25–16:40	22:25–22:40	Selected Speaker Shifa Felemban	Ferromagnetic nanoparticles-modified immunosensor: A novel methodology for polycyclic aromatic hydrocarbons (PAHs)

21 May 2024 (Tuesday)
Session C. Smartphone-based Biosensors
Session I. Optical and photonic Biosensors

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:40	15:30–15:40	Welcome from the session chair—Prof. Dr. Jun Kameoka	
9:40–10:00	15:40–16:00	Invited Speaker Prof. Dr. Mara Mirasoli	Exploiting 3D printing for rapid prototyping of smartphone-based colorimetric and luminescence biosensors
10:00–10:15	16:00–16:15	Selected Speaker Toru Nohgi	Investigation of affordable electrode material combinations in electrochemical biosensors
10:15–10:30	16:15–16:30	Selected Speaker Zhuoya Liao	Wearable uric acid electrochemical sensor with a scratched graphite electrode
10:30–10:35	16:30–16:35	Welcome from the session chair—Prof. Dr. Jun-Jie Zhu	
10:35–10:55	16:35–16:55	Keynote Speaker Dr. Lynn Dennany	Lighting the way towards point of use analysis
10:55–11:15	16:55–17:15	Invited Speaker Prof. Dr. Francesco Dell’Olio	Metasurfaces at THz, visible, and near infrared for next-gen biosensors
11:15–11:30	17:15–17:30	Selected Speaker Yaqi Huang	Ultrasensitive lateral-flow immunoassay based on magnetically modulated fluorescent nanodiamonds and machine learning enhancement
11:30–11:45	17:30–17:45	Selected Speaker Afsaneh Emamiamin	Development of a chemiluminescent immunoassay for the detection of dehydroepiandrosterone in counterfeit cosmetic products
11:45–12:00	17:45–18:00	Selected Speaker Rui C. Martins	Non-invasive hemogram analysis: A step towards an optical bracelet wearable device

Session B. Ingestible, Implantable and Wearable Biosensors
Session D. The Evolution of Biological Recognition Elements in Biosensors

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–14:05	20:00–20:05	Welcome from the session chair—Prof. Dr. Cecilia Cristea	
14:05–14:25	20:05–20:25	Invited Speaker Prof. Dr. Pedro Bertemes-Filho	Biosensor measuring systems based on biospectroscopy
14:25–14:45	20:25–20:45	Invited Speaker Dr. Hatice Ceylan Koydemir	Integrated imaging and sensing devices for point of care diagnostics
14:45–15:00	20:45–21:00	Selected Speaker Beatriz Sequeira-Antunes	Field-effect transistor-based biosensor for pH sensing and IgG detection
15:00–15:05	21:00–21:05	Welcome from the session chair—Dr. Paolo Bollella	
15:05–15:25	21:05–21:25	Keynote Speaker Dr. Wei Gao	Skin-interfaced wearable biosensors
15:25–15:45	21:25–21:45	Invited Speaker Dr. Xiaojun Xian	CMOS imager-based wearable sensors for environmental health monitoring
15:45–16:00	21:45–22:00	Selected Speaker Verdiana Marchianò	An enzyme-based amperometric biosensor for the detection of an emerging drug: Propofol.
16:00–16:15	22:00–22:15	Selected Speaker Aline Roberta Xavier da Silva	Development of an implantable sensor for recording neural activity in the auditory pathway of rats
16:15–16:30	22:15–22:30	Selected Speaker Arman Ahnood	Miniature wireless retinal implant

22 May 2024 (Wednesday)
Session E. Microfabrication and Printing Techniques in Biosensors
Session H. Paper-based Biosensors

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
9:30–9:40	15:30–15:40	Welcome from the session chair—Dr. Iva Chianella	
9:40–10:00	15:40–16:00	Invited Speaker Prof. Dr. Roger Narayan	Recent innovations in materials and devices for transdermal biosensing
10:00–10:20	16:00–16:20	Invited Speaker Dr. Amir Hatamie	Insights into diabetes unveiled: Exploring fusion pore dynamics and Insulin secretion in human pancreatic beta cells through single-cell amperometry
10:20–10:30	16:20–16:30	Welcome from the session chair—Prof. Dr. Guozhen Liu	
10:30–10:50	16:30–16:50	Session Chair Prof. Dr. Guozhen Liu	Microfluidic paper-based analytical devices for intelligent point-of-care diagnosis
10:50–11:10	16:50–17:10	Invited Speaker Prof. Dr. Katrina Campbell	Smart diagnostics: Are paper diagnostics the future?
11:10–11:25	17:10–17:25	Selected Speaker Natalia Maria Christopoulou	Dipstick test for DNA-based identification of olive oil cultivar origin
11:25–11:40	17:25–17:40	Selected Speaker Elisa Lazzarini	A lab-on-paper biosensor for ATP quantification via a chemiluminescent DNA nanoswitch assay
11:40–11:55	17:40–17:55	Selected Speaker Esra Alemdar	Advancing early diagnosis of Alzheimer's disease: An artificial intelligence-driven paper-based aptasensor for detecting A β (1–42) and p-tau181 from plasma using CdTe quantum dot

Poster Session

CEST (Central European Summer Time)	CST Asia (China Standard Time)	Speaker	Title
14:00–15:30	20:00–21:30	Poster Session	The Poster Sessions will take place in Zoom break-out rooms.

Poster List

Poster Session	
Name	Title
Kavya Saravanan	Glucose Detection Using mmWave Biosensor
Dimitra Kourti	Detection of Aflatoxin M1 in Milk with a Mach–Zehnder Interferometric Immunosensor
Pankaj Arora	Ultrasensitive Surface-Plasmon-Resonance-Based Biosensor for Efficient Detection of SARS-CoV-2 Virus in Near-Infrared Region
Raffaella Signorin	Raman and Luminescent Thermometers for Determining Local Temperatures at the Nanoscale
Martina Tozzetti	Development of a Sensor Platform for the Protein FKBP12
Francesco Gagliani	An Innovative and Versatile Reconfigurable Sensor for Biomolecule Detection via Metal-Ion-Mediated Recognition
Ahmed Akouibaa	Numerical Investigation of a D-Shaped Fiber-Optic Biosensor Utilizing Surface Plasmon Resonance for Early Cancer Cell Detection
P. Barciela	Advancing Food Safety Sensing through Artificial Intelligence: Machine Learning-Enhanced Biosensors in Action
María Jesús Ortiz-Aguayo	Electrolyte-Gated Organic Field-Effect Transistors for Point-of-Care Tests
Rosalía González-Brito	Electrochemical Determination of Serotonin Exocytosis in Human Platelets with BDD-on-Quartz Multielectrode Array Biosensors
Mehmet Tosun	Development of a Flexible Piezoelectric Biosensor That Integrates BaTiO ₃ –Poly(dimethylsiloxane) for Posture Correction Applications
Haluk Çelik	The Validation of Smartphone-Based Point-of-Care Urinalysis Vivoo App
Seyedeh Rojin Shariati Pour	Monitoring Salivary Biomarkers in Astronauts during Spaceflight: A Versatile and Reusable Portable Microfluidic Biosensor Based on Functionalized Superparamagnetic Microbeads for Performing Multiplex Chemiluminescent Immunoassays
Gabriela Pereira de Freitas	Pretreatment Methods Enhance Cancer Detection Biosensor Performance via Optimized Deposition of Multilayer Chitosan and Hyaluronic Acid Films
Anastasia Kanioura	Superoxide Dismutase Determination on Silver Nanostructured Substrates through Surface-Enhanced Photoluminescence

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Abstracts

Session A. Artificial Intelligence in Biosensors

sciforum-086067: “CogniFlora”—Intelligent Leaf Disease Recognition and Remediation

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Leaf diseases pose a substantial threat to global agriculture, impacting crop yields and food security. Traditional methods of disease detection often prove time-consuming and labor-intensive, leading to delayed responses and increased losses. In response to this challenge, our research introduces an innovative solution that combines the power of deep learning techniques with targeted treatment recommendations.

Our methodology involves the development of a sophisticated deep learning model trained on a diverse dataset comprising images of leaves affected by various diseases. This model excels in accurate disease classification, enabling it to provide specific and nuanced treatment recommendations based on the identified pathogens. The integration of a user-friendly interface ensures accessibility for farmers with varying technological expertise, fostering seamless interaction with the system.

Extensive field trials conducted across diverse geographical regions and crop varieties validate the adaptability and reliability of our approach. The results affirm the potential of our system as a practical and scalable solution for real-world implementation in various agricultural settings.

Beyond accurate disease identification, our system contributes to sustainable farming practices by offering precision treatment strategies. By understanding the specific pathogens causing the disease, farmers can implement targeted interventions, reducing the reliance on broad-spectrum treatments and minimizing environmental impact.

In conclusion, our research presents a transformative paradigm for leaf disease management, combining the strengths of advanced deep learning technology, realtime processing, and user-friendly interfaces. This holistic approach positions our model as a valuable tool for farmers, empowering them with actionable information for informed decision-making, ultimately contributing to increased agricultural sustainability and food security.



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sciforum-089753: Data Augmentation for Reagent-Less Spectroscopy Point-of-Measurement in Hydroponics

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Nutrient quantification is crucial for hydroponic systems. However, reagent-less spectral quantification of nitrogen (N), phosphate (P), and potassium (K) encounters challenges in identifying information-rich spectral signals and separating interference from each component. We introduce the concept of ‘information specificity’, as opposed to ‘chemical specificity’, which requires physical or chemical reactions to isolate information from a specific nutrient in a complex hydroponic mixture, the optical configuration used transmittance fiber optics with six illumination fibers and a center collection fiber. To study spectral interference and specificity of information of NPK in Hoagland nutrient solutions, a UV–Vis Deuterium/Halogen light source was used, emitting in the 200–550 nm range. ‘Information Specificity’ in spectral quantification is paramount to understand if the constituent is being quantified by its unique information and not by a spurious relationship present in the knowledgebase. This is especially relevant when resilient systems are necessary for application in harsh hydroponic conditions, where contamination that leads to spectral interference occurs. Herein, we show that nutrient Hoagland solutions exhibit spectral information specificity for N, P, and K, and this information is preserved in more complex samples obtained from uncontrolled fertirrigation production sites, allowing maximization of information about NPK, minimizing information about interferents, and allowing better predictions under extrapolation. We also present a method for overcoming extrapolation difficulties by data augmentation of the knowledge base by combining the spectral features of a small group of outlier samples and Hoagland nutrient solutions, greatly increasing the prediction accuracy of unknown samples under blind testing.



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sciforum-087048: Exploring Chili Plant Health: A Comprehensive Study Using IoT Sensors and Machine Learning Classifiers

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Red chili, scientifically known as “*Capsicum annum*”, belongs to the Solanaceae family. It is extensively utilized in various cuisines worldwide to enhance flavor and impart heat to dishes. Moreover, red chili exhibits medicinal properties such as pain relief, anti-inflammatory effects, a metabolism boost, cardiovascular health benefits, and antioxidant properties. The primary objective of this research paper is to identify specific diseases affecting different instances of chili plants. We will analyze this through IoT sensors to determine which soil is optimal for chili cultivation. For this research, we created our dataset by collecting pictures of various specific diseases. The dataset comprises five features: Bacterial Spot, Powdery Mildew, Anthracnose, Phytophthora Root Rot, and Fusarium Wilt. In this study, a machine learning classifier was employed to detect chili plant diseases. Additionally, we identified various types of diseases in chili plants and evaluated their overall health. Experimental observations reveal that a Convolutional Neural Network (CNN) performs well compared to other deep learning classifiers. The training accuracy of CNN is 98.2%, and the testing accuracy is 96.7%. The minimized training and testing errors demonstrate that the model effectively handles new or unseen data. We have compared our proposed model to the state of the art and found that the proposed model performs well.



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sciforum-086208: Integrated Sensor System for Real-Time Monitoring and Detection of Fish Quality and Spoilage

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The increasing demand for high-quality and safe seafood necessitates the development of efficient monitoring systems to ensure the freshness and safety of fish products. In this research, we present an innovative approach utilizing a sensor array consisting of MQ137, MQ135, MQ3, MQ9, TGS 2610, TGS 2620, TGS 2600, and TGS 822 sensors. These sensors, sensitive to various gases associated with fish spoilage, are integrated into a comprehensive system for fish quality monitoring and spoilage detection. The developed system includes an array of chemical gas sensors, a data acquisition system, a processing unit for handling data, and a machine learning model for classification. The chemical gas sensor array enables the real-time detection of the volatile compounds released during the spoilage of fish. The data acquisition system collects and processes information from the sensor array, while the data processing system extracts relevant features for subsequent analysis. A pattern recognition system, employing a robust LDA-XGBoost model, was employed to differentiate between fresh and spoiled fish. The experimental results demonstrate the system's high accuracy in classifying fish quality, achieving an impressive classification accuracy of 96.12%. The integration of various sensors ensures sensitivity to a broad spectrum of chemical compounds associated with fish spoilage, enhancing the system's reliability. The proposed sensor-based approach provides a cost-effective, rapid, and accurate solution for fish quality monitoring, offering potential applications in the seafood industry to ensure the delivery of safe and fresh products to consumers.



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sciforum-089365: A Fog Computing Based Cost-Effective Smart Health Monitoring Device for Infectious Disease Applications

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COVID-19 epidemic has raised awareness to exactly how crucial it is to maintain an eye on issues and diagnose respiratory problems early. Although the respiratory system is the primary objective of the disease's acute phase, subsequent complications of SARS-CoV-2 infection might trigger enduring respiratory problems and symptoms, according to new research. These signs and symptoms, which collectively inflict considerable strain on healthcare systems and people's quality of life, comprise but aren't restricted to congestion, shortage of breath, tightness in the chest, and a decrease in lung function. Wearable technology offers a promising remedy to this persistent issue by offering continuous respiratory parameter monitoring, facilitating early control and intervention of post-COVID issues with respiration. In an effort to enhance patient outcomes and reduce expenses related to healthcare, this paper examines the possibility of using wearable technology to provide remote surveillance and early diagnosis of respiratory problems in individuals suffering from COVID-19. In this work, a fog computing based cost-effective smart health monitoring device is proposed for infectious disease applications. Further, the proposed device consists of three different biosensor modules namely MAX90614 infrared temperature sensor, MAX30100 pulse oximeter and a microphone sensor. All these sensor modules are connected to a fog computing device especially Raspberry PI microcontroller. Also, the three different sensor modules are integrated with the Raspberry PI microcontroller and the individuals' physiological parameters such as Oxygen Saturation (SPO2), Heart beat rate and Cough Sounds are recorded inside the computing device. Additionally, the Convolutional Neural Network (CNN) based deep learning algorithm is coded inside the Raspberry PI which is trained with normal and COVID-19 Cough sounds from KAGGLE database. This work appears to be of high clinical significance since the developed fog computing based smart health monitoring device is capable of identifying the presence of infectious disease with individual physiological parameters.



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sciforum-087047: Advancing Food Safety Sensing through Artificial Intelligence: Machine Learning-Enhanced Biosensors in Action

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Current food safety techniques and equipment are struggling to meet the evolving demands of the food industry. Traditional practices rely on reactive measures, leading to delays in monitoring, early warnings, and risk assessments, thereby impeding their effectiveness in risk mitigation. The integration of nanotechnology and biosensors into food sensing offers significant advantages, including enhanced speed, cost-effectiveness, and on-site detection, surpassing the capabilities of larger analytical tools. This integration is pivotal for the early detection of pathogens, the effective control of fresh food, and the prevention of food-borne illnesses by identifying spoilage before it reaches consumers. Nevertheless, biosensors based on antibodies or aptamers face limitations in lifetime and stability that impact their commercial viability. To overcome these challenges, researchers are turning to artificial intelligence as a groundbreaking solution. The application of machine learning, also known as deep learning, has the potential to transform conventional biosensors into intelligent systems capable of automated analyte prediction through a decision-making process. This facilitates the control of harmful substances during food traceability processing. However, this innovative convergence has raised ethical and privacy concerns that demand careful consideration [1–5]. This review evaluates the integration of artificial intelligence into biosensors, aiming to create cost-effective, real-time recognition devices for the identification of contaminants in food matrices.



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sciforum-087013: AI-Driven Improvements in Electrochemical Biosensors for Effective Pathogen Detection at Point-of-Care

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The rapid and accurate detection of pathogens is vital for effective disease management and control. This paper introduces a novel approach to pathogen detection by integrating artificial intelligence (AI) into electrochemical biosensors. Real-world samples can present background interference from other analytes and unwanted noise in the signal, particularly when utilizing portable point-of-care devices. To overcome these challenges, we propose an intelligent electrochemical device optimized for improved performance in detecting viral pathogens. Our approach involves two key AI strategies. First, a denoising autoencoder is employed to effectively remove noise from the electrochemical signals, bringing the performance of portable devices on par with their standalone counterparts. This enhancement is crucial for point-of-care applications where environmental and operational factors often compromise data quality. Second, we utilize an Artificial Neural Network (ANN) to detect the presence of background interference. Smartphones are often used as interface for portable electrochemical devices, our approach leverages the computational capabilities of smartphones to run the AI algorithms for processing the electrochemical signals in real-time. The proposed system has been validated using COVID-19 data, demonstrating its potential as a powerful tool in the rapid and accurate detection of SARS-CoV-2 and other pathogens. The integration of AI into electrochemical biosensing offers a more reliable and accessible option for healthcare professionals and researchers.



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sciforum-089367: Analysis of Textile Electrode Fabrication for Digestive Health Using Explainable Artificial Intelligence

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Recent days, the digestive abnormality is common due to modern life style and food habits followed. For every ten adults in the world, four suffer from functional Gastrointestinal (GI) disorders of varying severity. Further, this is demonstrated by a study of more than 73,000 people across 33 countries. Also, the subjects who have undergone surgery/medication may feel healthy and they cannot feel or realize the internal health disorders resulting in severe consequences. In this regard, Electrogastrograms (EGG) has got more significance since it is non-invasive and easy process for screening digestive abnormalities. EGG are electrical signals which has strong association with digestion. Also, the EGG can be recorded using non-invasive/surface electrodes. In this work, two different conductive textile materials namely stainless-steel fibers and Copper-Nickel plated nylon are utilised to fabricate non-invasive electrodes. Further, the developed electrodes are placed on the abdomen over stomach and the EGG signals are acquired from normal individuals. Also, various time and frequency domain features are extracted from two different EGG signals acquired using developed electrodes with different materials are analysed. Additionally, the XAI namely Shapley Additive exPlanations (SHAP) technique is utilised to analyse and test the efficacy of the developed textile-based electrodes and to select the best electrode for EGG signal acquisition. This work appears to be of highly significant since the developed electrode selected using XAI tool shall be wide scope in wearable applications.



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sciforum-088328: Detection of Alzheimer's and Parkinson's Diseases Using Various Deep Learning-Based Transformer Models

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Alzheimer's disease is a neurodegenerative condition primarily attributed to environmental factors, abnormal protein deposits, immune system dysregulation, and the consequential death of nerve cells in the brain. On the other hand, Parkinson's disease manifests as a neurological disorder featuring primary motor, secondary motor, and non-motor symptoms, accompanied by the rapid demise of cells in the brain's dopamine-producing region. Utilizing brain images for accurate diagnosis and treatment is integral to addressing both conditions. This study harnessed the power of artificial intelligence for classification processes, employing state-of-the-art transformer models such as Swin Transformer, Vision Transformer (ViT), and Bidirectional Encoder representation from Image Transformers (BEiT). The investigation utilized an open-source dataset comprising 450 images, evenly distributed among healthy, Alzheimer's, and Parkinson's classes. The dataset was meticulously divided, with 80% allocated to the training set (390 images) and 20% to the validation set (90 images). Impressively, the classification accuracy surpassed 80%, showcasing the efficacy of transformer-based models in disease detection. Looking ahead, this study recommends delving into hybrid and ensemble models and leveraging the strengths of multiple transformer-based deep learning architectures. Beyond contributing crucial insights at the intersection of artificial intelligence and neurology, this research emphasizes the transformative potential of advanced models for enhancing diagnostic precision and treatment strategies in Alzheimer's and Parkinson's diseases. It signifies a significant step towards integrating cutting-edge technology into mainstream medical practices for improved patient outcomes.



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sciforum-086814: Development of a Fully Integrated Color Detection Biosensor for Agricultural and Biomedical Applications

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Colorimetric strips have a wide range of applications in medical and agricultural fields. There are many test kits available for measuring these analytes. These tests kits typically comprise of several activated test strips with a color-matching legend printed on the label of the bottle. The test process typically involves dipping the test strip in the sample, then comparing the changed color of the test strip against the color samples printed on the label and finding the closest match. While this method is good enough for determining the approximate value of the concentration of the analyte, in addition to being prone to human error, it can never provide precise concentration due to the limited number of color samples that can be printed on the label.

Therefore, there is a need to develop a biosensor that can provide a precise measurement of the concentration of the analyte. In this research, we propose the design of a fully integrated and standalone biosensor that can read out a color strip and provide a value in the actual units such as ppm or percentage. Using this biosensor, the user tests the sample by dipping a colorimetric strip in the sample, and finally puts the strip next to the color sensor. The micro-controller reads out the developed color of the strip, determines the concentration of a particular analyte present in the test sample, and displays the concentration in ppm. Since the aim is to design a universal sensor that can be adapted to various applications, therefore, an AI model is being developed and trained for various known concentrations of several analytes. These samples are pre-tested in the lab to fully calibrate the biosensor. Since this biosensor can be fully calibrated in different lighting conditions, human error can be eliminated from the color-matching part of the process.



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sciforum-086290: Enhancing Ethanol Fermentation Monitoring through Data-Driven Modeling and Synthetic Time Series Generation

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This study presents a novel data-driven modeling approach employing machine learning to develop predictive “soft sensors” for real-time monitoring of ethanol and substrate levels during bioethanol fermentation processes. By utilizing readily measurable parameters such as pH, redox potential, capacitance, and temperature, the model enables continuous prediction of less frequently measured variables including ethanol, substrate, and cell concentrations. Eleven fermentations were conducted, focusing on intensified ethanol production from sugarcane substrate, utilizing cell cycling techniques to augment output. Despite the importance of fermentation data, its acquisition is often constrained by limitations in availability and resources. To address these challenges, this research integrates synthetic time series data generation, thereby enhancing the applicability of machine learning. Through the use of a variational autoencoder (VAE), synthetic time series data was successfully generated, facilitating training and testing of a deep neural network on both original and synthetic datasets. Results demonstrate a significant 30% increase in prediction robustness with the incorporation of generated data, while maintaining comparable accuracy levels. The augmented data effectively enhance the generalization ability of trained models, mitigating overfitting and expanding decision boundaries, thereby overcoming challenges associated with small datasets and inevitable data deviations. This innovative approach offers a promising avenue for enhancing the reliability and scalability of bioethanol fermentation monitoring through AI-based biosensors.



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sciforum-088430: Ensuring Food Security and Biodiversity: A Novel Convolutional Neural Network (CNN) for Early Detection of Plant Disease in Precision Agriculture

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Conventional disease detection methods in agriculture are constrained by the presence of personal opinions and the amount of work required, which hinder broad-scale disease monitoring. This study aims to overcome these difficulties by introducing a biosensor-assisted deep learning system that improves disease identification in precision agriculture. Biosensors, such as hyperspectral or electrochemical sensors, offer an initial means of collecting objective data, which complements subsequent analysis using deep learning techniques. The performance of popular deep learning models (VGG16, MobileNetV2, ResNet50) in classifying diseases across 15 categories is assessed via evaluation on the PlantVillage dataset. In addition, a new Convolutional Neural Network (CNN) structure, which achieves a higher accuracy (99.05%) compared to pre-existing models, is shown. Biosensor data serve as a first screening process, which has the ability to decrease the number of photos that need to undergo deep learning analysis. By utilising this integrated method, the precision and effectiveness of disease identification are enhanced. This framework allows for the early and accurate detection of diseases, which in turn allows for specific therapies and encourages the use of sustainable farming methods. The exceptional precision (99.05%) creates opportunities for practical implementation, perhaps reducing production losses and optimising resource allocation.



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sciforum-080362: Ethical and Regulatory Challenges for AI Biosensors in Healthcare

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AI biosensors are devices that can detect and measure biological or chemical signals of interest, such as glucose, DNA, hormones, toxins, pathogens, etc. They have many applications in various fields, such as healthcare, environmental monitoring, food safety, biodefense, and bioengineering. However, AI biosensors also pose some regulatory and ethical challenges that need to be addressed before they can be widely used and accepted by society. Some of these challenges are safety and reliability, privacy and data protection, social and cultural implications, innovation, and regulation. AI biosensors are constantly evolving and innovating with new technologies, materials, methods, or applications. This may pose challenges for the existing regulatory frameworks and authorities that may not be able to keep up with the pace and scope of innovation. AI biosensors should balance between innovation and regulation, and we should ensure that they are developed and used in a responsible and sustainable manner. Various stakeholders, such as researchers, regulators, policy makers, industry partners, civil society groups, and end-users should engage with AI biosensors to foster dialogue, collaboration, and public trust. Proposed in April 2021 and expected to enter into force in 2025, the European Union Artificial Intelligence Act (EU AI Act) will be the first EU regulatory framework for AI and could serve as a law model for the regulation of AI biosensors. There are some scattered international instruments and frameworks that address some of the ethical, legal, and social issues related to biosensors. States and the World Health Organization (WHO), with its constitutional mandate to deal with global public health, should regulate the use of AI-biosensors and adopt legally binding rules and international standards in this sensitive field.



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sciforum-086991: Integration of Multiple Biosensors for Emotion Classification with Artificial Intelligence

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Introduction

Emotion detection has proven to be valuable in biofeedback for the development of assistive technologies, the enhancement of gaming experiences, and advancements in the treatment of mental health issues, among other applications. The objective of this study was to integrate electroencephalogram (EEG), electrocardiogram (ECG), and galvanic skin response (GSR) sensors using the lazypredict library to return classifier models with the highest accuracy in detecting emotions.

Methods

OpenVibe software; Brain Products' V-Amp amplifier (sample rate 512 Hz); a cap with 16 channels placed in temporal, parietal, frontal, and prefrontal regions for EEG; and a BIP2AUX adapter connected to the AUX ports for acquiring ECG signals with three electrodes on the wrists and leg were utilized. The GSR module adapter, with two electrodes on the index and middle fingers, was used for GSR. Each participant was exposed to 400 emotional stimuli (100 for each emotion—fear, happiness, anger, and sadness) through PsychoPy software. Data were processed using the Python programming language, involving filtering, epoching, epoch selection, feature extraction using discrete wavelet transform (DWT), and normalization. Subsequently, the data were cleaned and classified using the lazypredict library.

Results

The classifier models that exhibited the highest accuracy were the Calibrated Classifier CV, the AdaBoost Classifier, and the Decision Tree Classifier.

Conclusions

Our findings contribute to advancements in the field of emotion detection, emphasizing the crucial role played by artificial intelligence in the process.



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sciforum-087020: Machine Learning-Driven Calibration in Impedimetric Biosensors

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Electrochemical biosensors are leading the way in the development of point-of-care devices. Many of these biosensors predominantly use electrochemical impedance spectroscopy for their detection mechanism. The standard method for creating calibration curves in impedimetric biosensors is to fit the impedance spectrum to an equivalent circuit model (ECM). The calibration curve is then created using the circuit parameter that shows the maximum variance. This standard approach has multiple limitations. First, in a complicated system, the identification of an ECM that correctly describes the system is not a trivial task as it might involve complicated processes. Second, in many cases, multiple ECMs could fit a given impedance spectrum which could introduce errors or biases in the analysis. To overcome these limitations, in this work, we use machine learning (ML) algorithms to develop calibration curves for impedimetric sensors without the use of equivalent circuit models or by manually picking points from the impedance spectrum. For this, raw impedance spectrum corresponding to different impedimetric sensors were obtained from the literature and a labeled dataset was created for training the ML model. Principal component analysis was done to extract the features that show maximum variance. These features were then used to train multiple machine-learning models to create a calibration curve. The errors of the different models are compared to identify the best-performing ML model. Finally, a comparison was made between the calibration curve obtained from the conventional approach and that obtained from the ML model. This comparison shows that errors were lower for predictions made using the calibration curve obtained from the ML model.



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sciforum-086929: Rapid, Portable, and Low-Cost Water Quality Assessment Device Based on Machine Learning

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Water quality has a significant impact on public health. Inadequate water conditions are associated with diseases such as cholera, dysentery (shigella), hepatitis, and typhoid fever. Established techniques like Membrane Filtration (MF), Multiple Tube Fermentation (MTF), and enzyme-based defined substrate technology (DST) assays are used to monitor bacteriological water quality, measuring indicators like *Enterococcus faecalis* (*E. faecalis*), *Escherichia coli* (*E. coli*), and total coliforms. Despite their high sensitivity and specificity, these methods take 24 to 48 h to produce results, as well as requiring access to laboratory facilities, specialized equipment, sample preparation steps, and trained personnel. This study presents a portable and low-cost UV-LED/RGB water quality sensor which includes a microfluidic device, a fluorogenic defined substrate assay for the detection of *E. faecalis*, RGB sensors for fluorescent data acquisition, ultraviolet-light-emitting diode (UV-LED) for sample excitation, a portable incubation system, and embedded systems for data storage and processing. The microfluidic device has a number of independent wells used to carry out Most Probable Number (MPN) analysis for bacteria quantification. The device is pre-loaded with the defined substrate assay and is self-loading when immersed in the target water sample for sample-preparation-free analysis. RGB sensors detect fluorescence from each well to automate the MPN results. Results from fluorescence-versus-time curves are used to generate a comprehensive database. Machine learning (ML) algorithms and real-time RGB data are used to predict whether each individual well will be positive or negative using only the first three hours of fluorescent data. Coupled with MPN, this method significantly reduces the timeframe of bacteria detection and quantification, making it a cost-effective and efficient solution for on-the-go water quality monitoring, addressing critical public health concerns, and underscoring the importance of swift and reliable water quality assessments.



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sciforum-089265: Miniature Wireless Retinal Implant

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A wireless miniature epiretinal stimulator implant is reported. The power and data delivery to the implant is achieved using near-infrared pulses of laser beam operated within the safe illumination intensities. The the implant's 256 electrodes are controlled using an application-specific integrated circuit (ASIC). The ASIC is powered using an advanced photovoltaic (PV) cell and programmed using a single photodiode. High density packaging methods are using to implement the implant circuitry, as well as individual connections between a stimulator chip and 256 electrically conductive nitrogen-doped ultrananocrystalline diamond electrodes with a high charge injection capacity needed for effective simulation of retinal ganglion cells. The device is encapsulated in an optically transparent, mechanically robust and bioinnert diamond capsule. A PV cell with a monochromatic power conversion efficiency of 55% and operated within the safety limits is used to provide 15 mW of power the implant. A photodiode is used to detect the pulse modulate forward data telemetry of stimulation parameters at bandwidth of 3.7 MHz. Laser power delivery enables a high degree of miniaturisation and lower surgical complexity, partially when compared to implants using coils for power and data transfer. This development provides a route to fully wireless miniaturized minimally invasive implants with sophisticated functionalities, in the eye or under the skin.



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sciforum-086342: A Wearable Microfluidic Device for Capture and Quantitative Analysis of Glucose Coupled with Skin Electrodermal Activity

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A multiparametric, non-invasive, and reagentless sensing strategy for diabetic monitoring is proposed based on a bespoke graphite ink “writable” formulation (including biocompatible binders and modifiers) used as a conductive layer for glucose oxidase immobilisation within an epidermal patch. This enables the encapsulation of heterocyclic quinoid species 1,10-phenanthroline-5,6-dione [1] which acts as a proton and electron acceptor for FADH₂ cofactor regeneration. The surface characterisation of the ink layer was achieved via FTIR, thermal analysis (TGA/DSC), and scanning electron microscopy. Voltammetric and pulse techniques establish analytical performance criteria for the mediated device over physiological glucose levels in sweat (10–200 mM) [2] at neutral pH levels. Hygroscopic hydrogels (chitosan/poly vinyl alcohol) and nanofibrous mats form overlaid membranes as sweat collection zones, sandwiched beneath a cotton fabric wicking layer for fingertip perspiration harvesting.

The prototype electronic control system involves a customisable Arduino-based potentiostat [3] with off-the-shelf electronic components capable of performing electrochemical measurements, as well as recording temperature and galvanic skin sensor responses (GSR) [4]. The addition of electrodermal activity via a GSR sensor detection module and a temperature probe makes for a multiparametric system which responds to electrical activity in the skin due to the variation in moisture levels due to sweating. GSR reflects sweat gland activity and changes in the sympathetic nervous system, as well as the activity of the sweat glands in response to sympathetic nervous stimulation [4]. Calibration parameters can thus be adjusted dynamically relative to changes in temperature and other measurement variables. Such a system requires small sample volumes (50 µL), provides rapid time to result 1 min, and is portable and disposable. The integration of allied electronics has the potential to carry out transduction and wireless transmission, enabling smart and remote healthcare.



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sciforum-089705: An Enzyme-Based Amperometric Biosensor for the Detection of an Emerging Drug: Propofol

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Propofol is widely recognized as the preferred intravenous anaesthetic for short-term sedation due to its rapid onset and elimination, gentle recovery from anaesthesia, and minimal side effects [1]. Improper administration, either excessive or insufficient, may result in propofol infusion syndrome (PRIS) or intraoperative awareness, leading to physiological and psychological harm to patients. Notably, there is considerable variability in individual responses to propofol anaesthesia. Additionally, there is a growing global concern about addiction and fatalities associated with propofol abuse in recent years. Therefore, the assessment of plasma propofol levels is crucial in drug metabolism and pharmacokinetics (DMPK) as well as forensic toxicology research [2,3]. In this work, an innovative smartphone-based enzymatic amperometric biosensor was developed by using horseradish peroxidase (HRP) immobilized onto carbon based screen-printed electrodes. In particular, HRP was operated in mediated electron transfer (MET) using [Os(4,4'-dimethyl-2,2'-bipyridine)2(poly-vinylimidazole)10Cl]^{2+/+} as immobilized mediator, monitoring the inhibition of H₂O₂ catalytic activity of HRP induced by propofol [4]. The modified electrodes were characterized by using cyclic voltammetry and amperometry to extract the biosensor analytical figures of merit (e.g., dynamic linear range, limit of detection (LOD), sensitivity and stability). The electrodes were finally tested in blood samples using a smartphone-integrated system in order to develop a blood-prick propofol screening test.

References

1. McKeage, K.; Perry, C.M. Propofol: A review of its use in intensive care sedation of adults. *CNS Drugs* **2003**, *17*, 235–272.
2. George, A.A.; Hargrove, V.M.; Molina, D.K. Postmortem propofol levels: A case of residual detection long after administration. *Am. J. Forensic Med. Pathol.* **2016**, *37*, 4–6.
3. Sahinovic, M.M.; Struys, M.M.; Absalom, A.R. Clinical pharmacokinetics and pharmacodynamics of propofol. *Clin. Pharmacokinet.* **2018**, *57*, 1539–1558.
4. Bollella, P.; Gorton, L. Enzyme based amperometric biosensors. *Curr. Opin. Electrochem.* **2018**, *10*, 157–173.



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sciforum-087025: Design of Internet of Things Enabled Textile Based Biosensors

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During a health crisis or pandemic, people with breathing issues may find it challenging to receive timely medical attention as access to healthcare services are limited. Breathing difficulties can contribute to anxiety, stress, uncertainty and fear associated with a health crisis can further negatively impact mental health. To effectively tackle this situation, it is essential to diagnose them early. Furthermore, the primary symptom of such diseases is difficulty in breathing, accompanied by coughing. To identify these conditions, the various sensor technologies such as Plethysmography Sensors, Pressure Transducers, Acoustic Sensors, Accelerometers, Gyroscopes etc. were used. However, the use of these sensors poses certain challenges such as accuracy, calibration issues, discomfort, influence of body position, noise interference, cost, reliability in dynamic environments and user acceptance. In this work, a textile-based sensor using conductive thread is designed and developed for the measurement of respiration rate. Further, the conductive thread is mend with a woollen material to form a chest band which can be affixed to any person. Also, the developed sensor in the form of chest band is integrated to the Internet of Things (IoT) controller which measures the respiratory rate of the users while performing various activities such as walking, running, practicing exercises, standing still etc. Results demonstrate that the developed sensor can store respiratory rate in the IoT cloud platform. Further, it is observed that the frequency of the acquired signals due to respiration changes for various activities. Additionally, the increase in frequency increases the noise in the acquired signal and it is removed using a filter algorithm. This work appears to be of high clinical significance since the developed sensor diagnoses the breathing disorders in terms of respiration rate.



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sciforum-087037: Developing a Wearable Sensing Platform for Well-Being Monitoring in Individuals with Dopamine-Related Neurological Disorders

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Neurological disorders are heterogeneous diseases that affect the body's autonomic, peripheral and central nervous system. These disorders gradually diminish cognitive and motor abilities, hindering daily activities and resulting in a loss of independence. Detection and continuous monitoring of protein biomarkers involved in these disorders are painful and uncomfortable as they are found in hard-to reach body fluids such as cerebrospinal fluid or blood. However, several biomarkers or metabolites reside in peripheral biofluids such as saliva, urine and sweat, facilitating the development of wearable biosensors for their non-invasive detection.

Electrochemical sensors offer amazing potential for the development of wearable devices because they can be miniaturized and integrated into comfortable wearable devices (bracelets, smartwatches, etc.).

This study introduces a new analytical wearable platform based on screen-printed electrodes for monitoring dopamine in real samples by differential pulse voltammetry. The sensor was created by electrodepositing a biocompatible polymeric conductive layer onto carbon screen-printed electrodes. The polymeric layer was further modified by electrodepositing gold nanoparticles, in order to direct detect electroactive molecules. The modified platforms were characterized using cyclic voltammetry and electrochemical impedance spectroscopy. The experimental conditions for dopamine detection in body fluids were studied and optimized. Linear calibration curve in the range of 0–100 μM with a limit of detection of 0.002 μM for dopamine determination was obtained. The analytical performances of the sensors in terms of reproducibility and selectivity were also evaluated.

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sciforum-087003: Development of a Flexible Piezoelectric Biosensor That Integrates BaTiO₃–Poly(dimethylsiloxane) for Posture Correction Applications

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The global issue of prolonged desk work, which leads to poor posture, has prompted a growing need for effective solutions. This study explores a transformative approach developing and creating a flexible Barium titanate–poly(dimethylsiloxane) (BaTiO₃–PDMS) piezoelectric biosensor tailored to addressing posture challenges [1]. Harnessing the distinctive properties of BaTiO₃, this innovative biosensor has the potential to revolutionize posture correction strategies. First, piezoelectric BaTiO₃ nanoparticles (NPs) were synthesized using a sol-gel method, utilizing barium acetate and titanium tetrabutanol as precursors. The characterization of these NPs was conducted using XRD and TEM. A BaTiO₃–PDMS composite was then formed by combining PDMS polymer and its cross-linking agent in a 10:1 weight ratio, with the addition of 40 g of BaTiO₃ nanoparticles.

The NPs were manually dispersed in the polymer mixture for 5 min. The mixture was cured at 100 °C for 1 h. Evaporation was carried out to achieve a thickness of 2.572 kÅ on both surfaces. Copper was evaporated in order to obtain a conductive material on the surface of the BaTiO₃–PDMS. The outcome was a 0.7 mm wide BaTiO₃–PDMS biosensor, as measured with a digital multimeter. In testing, the BaTiO₃–PDMS sensor generated a 400 mV signal on the oscilloscope, indicating its potential effectiveness for posture correction applications (Figure 1). In conclusion, our exploration of the BaTiO₃–PDMS flexible piezoelectric biosensor for posture correction unveils promising initial results. This research is a vital step toward attaining a thorough grasp of this biosensor's capabilities. Future research and optimization are necessary to unlock the optimum amount of BaTiO₃–PDMS to use in addressing the ongoing challenge of slumped posture.

Reference

1. Jeronimo, K.; Koutsos, V.; Cheung, R.; Mastropaolo, E. PDMS-ZnO Piezoelectric Nanocomposites for Pressure Sensors. *Sensors* **2021**, *21*, 5873. <https://doi.org/10.3390/s21175873>.



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sciforum-087014: Development of an Implantable Sensor for Recording Neural Activity in the Auditory Pathway of Rats

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Introduction

Ensuring the secure and efficient application of invasive microelectrode arrays (MEAs) in chronic experiments is crucial. Therefore, this study aims to develop an implantable multi-channel MEA for simultaneous neural activity recording in the auditory cortex (AuC) and medial geniculate nucleus (MGN) of rats.

Methods

We utilized 32-channel tungsten tetrode arrays, comprising eight tetrodes, each constructed from four twisted microwires with a diameter of 15 μm , coated with 1.5 μm -thick isonel insulation. The tetrode lengths varied based on the region (5.4 or 5.8 mm), maintaining a minimum spacing of 300 μm . The tetrodes were threaded through an acrylic template (5 $\times$ 4 mm) containing stereotaxic coordinates of target regions in the left hemisphere. Subsequently, the wires were secured with composite resin, and a printed circuit board connected to an analog headstage (Plexon) was affixed to the template. Array coordinates were organized based on a rat brain atlas, focusing on auditory regions of interest: primary AuC (Au1, tetrodes 1Au1 and 2Au1), secondary AuC dorsal (AuD) and ventral (AuV), MGN ventral (1 MGV and 2 MGV) and dorsal (1 MGD and 2 MGD).

Results

Following implantation surgery, extracellular recordings and triaxial inertial sensor data were collected from behaving Wistar rats ($n = 5$). Results indicate that tetrodes in Au1 regions (1 Au1: -0.483 ± 0.008 , 2 Au1: -0.618 ± 0.008), AuV (-0.618 ± 0.005), and AuD (-0.472 ± 0.007) exhibited signals with greater amplitudes compared to tetrodes in MGV (1 MGV: -0.228 ± 0.006 , 2 MGV: -0.256 ± 0.004) and MGD (1 MGD: -0.193 ± 0.008 , 2 MGD: -0.162 ± 0.004).

Conclusions

These findings suggest that the developed tetrode array sensor may function as an electrophysiologically stable device for recording neural activity in the AuC and MGN of rats.



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sciforum-087008: Electrochemical Diagnosis of Urinary Tract Infection Using Ring-Based Electrochemical Sensing Platform

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Urinary tract infections (UTIs) are among the most common infections in all age groups. A fast and accurate diagnosis is essential to ensure timely and effective therapy. Alongside reference culture-based methods, several point-of-care tests for early UTI detection have been developed, but they have not been significantly implemented in current clinical practice. Additionally, some UTI diagnoses based on a urine culture for a bacteriuria analysis are time-consuming and often lead to the wastage of hospital resources due to false-positive UTI cases. Therefore, the development of new, accurate, faster, simpler, and more cost-effective diagnostic methods is highly demanded. In this work, a portable and wearable nitrite (NO_2^-) sensor for a fast urine analysis has been developed on a tiny ring. To our knowledge, the presence of an abnormal level of nitrite ions (NO_2^-) in urine samples is recognized as a biomarker for the diagnosis of UTI. The obtained quantitative analysis data show that the fabricated lab-on-ring works as a small, light, portable, miniature lab; this platform, instead of current expensive and complex analytical instruments, can perform a voltammetric electroanalysis in a short time period (a few seconds) and in micromolar (μM) ranges of nitrite ions with high selectivity, and also requires only a microliter (μL) volume of a urine sample for the detection of UTI. In conclusion, besides clinical and nitrite detection, our sensing platform system paves the way for effective field assays of chemical threats in connection with diverse applications in environmental, criminal, industrial, and military areas.



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sciforum-089113: Glucose Detection Using mmWave Biosensor

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The global surge in diabetes prevalence necessitates continuous advancements in glucose detection technologies. Traditional methods like blood glucose monitoring, which is effective, pose inconveniences and invasiveness for patients, driving the exploration of innovative biosensors. The challenging nature of glucose detection in complex biological environments emphasizes the importance of developing a reliable and accurate detection system. This work aimed to revolutionize glucose detection by leveraging millimeter-wave (mmWave) biosensors, capitalizing on their unique advantages for improved accuracy and non-invasiveness to enable real-time and continuous glucose monitoring, offering a more convenient and accessible solution for individuals managing diabetes. The primary goal was to fill the existing gap in glucose monitoring methods by introducing a technology capable of overcoming the limitations of traditional approaches where the sensor operates near the target tissues, ensuring precise measurements without invasive procedures or susceptibility to environmental interference. The approach involved integrating mmWave technology into biosensor applications, utilizing experimental methods and theoretical models. The mmWave captured minute changes in dielectric properties associated with varying glucose concentrations. The main results revealed the efficacy of the mmWave biosensor in accurately detecting variations in glucose levels and demonstrated enhanced sensitivity, showcasing its potential for the development of a portable and wearable biosensor system in real-world applications, thus addressing the need for continuous glucose monitoring in daily life. The results emphasize the potential of this technology to revolutionize diabetes management by providing timely and precise glucose measurements in near-field conditions, demonstrating promising levels of accuracy and sensitivity. The near-field operation of the mmWave biosensor presents distinct advantages, including reduced susceptibility to environmental interference, enhanced spatial resolution, and the potential for integration into wearable devices. This work envisions a future where mmWave biosensors transform glucose monitoring, improving life for individuals managing diabetes with accessibility.



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sciforum-089703: Molecularly Imprinted Polymer Modified Microneedle Array for Smart Active Triggered Drug Release

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The skin, the largest organ in the human body, provides several benefits for drug delivery. These advantages stem from its expansive surface area and the avoidance of the first-pass metabolism in the gastrointestinal tract. This, in turn, enhances drug bioavailability and minimizes potential side effects [1]. Currently, transdermal drug delivery (TDD) relies on topical products or transdermal patches. However, these methods face limitations due to the physio-chemical properties that impede their permeation through the lipophilic stratum corneum (SC) and their slow diffusion rate through the skin. To overcome these challenges, microneedles (MNs) have been developed. These microneedles penetrate the SC in a minimally invasive manner, creating “micro-conduits” that facilitate the transport of drugs into the skin tissue from the skin surface [2].

Herein, we have developed a microneedle array modified with molecularly imprinted polymers (MIPs) able to entrap bovine serum albumin (BSA) and insulin labeled with fluorescein isothiocyanate (FITC). Several MIPs based on the co-polymerization of *o*-phenyldiamine and gallic acid (1:1, 1:3 and 1:10) were tested in order to ensure the formation of hydrogen bonds between the polymer and the target. The target release was triggered by electrochemical and bioelectrochemical oxygen reduction reaction (ORR) occurring at the electrode surface [3].

References

1. Fakhraei Lahiji, S.; Kim, Y.; Kang, G.; Kim, S.; Lee, S.; Jung, H. Tissue interlocking dissolving microneedles for accurate and efficient transdermal delivery of biomolecules. *Sci. Rep.* **2019**, *9*, 7886.
2. Oliveira, D.; Correia, B.P.; Sharma, S.; Moreira, F.T.C. Molecular imprinted polymers on microneedle arrays for Point of Care transdermal sampling and sensing of inflammatory biomarkers. *ACS Omega* **2022**, *7*, 39039–39044.
3. Bollella, P.; Sharma, S.; Cass, A.E.G.; Antiochia, R. Minimally-invasive microneedle-based biosensor array for simultaneous lactate and glucose monitoring in artificial interstitial fluid. *Electroanalysis* **2019**, *31*, 374–382.



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sciforum-085907: Plant-Wearable Sensors Made on Eco-Friendly Mats for On-Site and Fast Pesticide Detection

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Sustainable materials for designing eco-friendly wearable sensors are needed to reach the increasing demand for new technologies for agriculture 5.0. Herein, we present the use of biocompatible mats made of poly(lactic acid) (PLA) fibers obtained using the solution-blow spinning technique as a substrate for screen-printed carbon electrode (SPCE) fabrication. The low-cost plant-wearable sensor (US\$ 0.08 per unit) was used to detect carbendazim and diquat pesticides in food and crop samples using differential pulse voltammetry (DPV). The current signals increased linearly from 0.2 to 1.4 μM for carbendazim and diquat. The linear regression of $I\text{ (A)} = 3.42 \times 10^{-8} + 2.85 C_{\text{Carbendazim}}\text{ (M)}$ and $I\text{ (A)} = -2.95 \times 10^{-8} + 16.55 C_{\text{Diquat}}\text{ (M)}$ yielded the detection limits of 43 and 57 nM for carbendazim and diquat, respectively. We also compared the analytical performance of a plant-wearable sensor made on a PLA substrate with a petroleum-derived polyethylene terephthalate (PET) substrate reaching a 5-fold and 4-fold increase in the sensitivity of carbendazim and diquat detection. The plant-wearable sensor was used to detect agrochemicals residues in apple and cabbage samples, providing good recovery values between 90 and 110%. Thus, the plant-wearable sensor could be helpful in offering real-time alerts on pesticide residues in fruit and vegetable samples. The eco-friendly sensor was successfully used on the skin of apples and cabbage surfaces for discriminating carbendazim and diquat. All those outcomes show the potential of the eco-friendly mats made of poly(lactic acid) fibers as a substrate for the development of screen-printed electrodes, providing a sustainable technology for non-enzymatic pesticide detection.



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sciforum-089159: Upgraded Motion Sensor with Novel Nanocomposite with Improved Mechanical Stability and Conductivity

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Conductive hydrogels possess promising potential as sensor materials due to their biocompatibility and mechanical flexibility, mimicking the properties of human skin. However, limitations such as lack of stretchability, hardness, and fatigue resistance hinder their sensing capabilities and durability. This study addresses these challenges by developing an extremely flexible, robust, and anti-fatigue conductive nanocomposite hydrogel.

The synthesized nanocomposite hydrogel, denoted as NIPAm_lap_GNP, was obtained through a two-step process involving free-radical polymerization. Initially, Laponite was dispersed in a solution containing gold nanoparticles (GNP) via sonication. Subsequently, NIPA monomer was added, followed by the initiation of polymerization with ammonium persulfate (APS) and N,N,N',N'-tetramethylethylenediamine (TEMED) at room temperature, yielding a homogeneous solution.

Characterization of the resulting hydrogel composite included assessments of stretchability, toughness, and fatigue resistance using mechanical testing equipment such as a tensile meter, compression meter, and rheometer. Results revealed impressive mechanical properties, with tensile stress ranging from 50 to 60 kPa, a tensile elongation of 1300–1400%, a compressive stress of approximately 25–30 kPa, and a toughness of 27.76 MJ·m⁻³. Furthermore, the hydrogel demonstrated remarkable motion sensitivity through electrochemical measurements, exhibiting a linear response to tensile strain (up to 250%) and bending finger angles (15–120°).

In conclusion, the NIPAm_lap_GNP hydrogel exhibited exceptional mechanical properties, including high stretchability and toughness, making it suitable for wearable sensor applications. The incorporation of gold nanoparticles (GNP) significantly enhanced electrical conductivity, while Laponite (Lap) increased crosslinking points and mechanical stability. This innovative nanocomposite hydrogel holds promise for various applications in flexible and conductive wearable sensors. Future research directions may explore its potential in other biomedical or electronic devices.



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Abstracts

Session C. Smartphone-Based Biosensors

sciforum-080612: The Validation of Smartphone-Based Point-of-Care Urinalysis Vivoo App

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Point-of-care (POC) analysis has become a crucial method for delivering fast and convenient medical diagnostics. The use of smartphone-based solutions further enhances the accessibility and convenience of POC, facilitating efficient analysis on the go. Integrating smartphone technology with POC has led to innovative applications like the Vivoo app, which enables users to conveniently monitor various health parameters. The Vivoo app can detect bilirubin, ketone, leukocyte, pH, specific gravity, protein, magnesium, sodium, calcium, creatinine, vitamin C, and MDA parameters in the same way as existing biosensors. In our test, we performed the detections with the Smartphone-Based Point-of-Care Urinalysis Vivoo app and compared the results to existing biosensors. Our research aimed to confirm the accuracy and dependability of the Vivoo mobile application for urinalysis, using a comparative approach. We compared artificial urine samples analyzed through both the Vivoo app and traditional laboratory methods, assessing a wide range of health parameters. Throughout the study, we evaluated a total of 2618 strips using Vivoo. The results showed that these strips consistently matched the expected measurement results. Moreover, when we applied a ± 1 color block acceptance criterion, 2608 out of 2618 measurements from the tested strips aligned perfectly with the expected results. Based on these findings, the 95% confidence interval for the exact match agreement proportion of Vivoo falls within $87.55\% \pm 1.27\%$ and $99.62\% \pm 0.24\%$. Consequently, our study concludes that Vivoo is a reliable and high-performing device for wellness purposes. Its ability to provide precise and timely health insights holds great promise for improving individual health management, particularly in the context of smartphones' growing role in modern healthcare.



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sciforum-088981: Investigation of Affordable Electrode Material Combinations in Electrochemical Biosensors

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This study investigated carbon-based electrode materials for the application of wearable biosensors measuring uric acid concentration. This investigation focused on assessing various combinations of carbon-based electrodes, such as CVD-graphite, graphene ink, and carbon nanotubes, aiming to enhance sensor performance. These carbon materials were deposited on stainless steel (SUS304 SS) plates (2 mm × 10 mm), and their sensitivity for detecting uric acid was evaluated by utilizing cyclic voltammetry (CV) and employing differential pulse voltammetry (DPV). Among the nine electrode combinations tested with potassium ferricyanide, two were identified that generated reversible CV waveforms, indicating their potential for uric acid detection. The effective combinations consisted of one set with CVD graphite for both the working and counter electrodes (WE and CE) and another set combining CVD graphite for the WE with carbon nanotube ink for the CE. The assessments demonstrated that these electrodes could efficiently detect the electron current from the redox reaction of ferricyanide, indicating their potential capability to measure uric acid concentrations effectively. Subsequent analysis using uric acid concentrations ranging from 100 μM to 400 μM showed that CVD-graphite electrodes provided distinct, quantifiable responses in both CV and DPV tests. Notably, the DPV profile for CVD-graphite displayed a significantly high peak current, facilitating the creation of a reliable calibration curve for uric acid concentration detection. The findings concluded that CVD-graphite stands out as the optimal material for both the WE and the CE in uric acid detection within sweat, with a practical detection limit (LOD) of 5.25 μM . This LOD is notably significant, aligning well with the average uric acid concentration in normal sweat, approximately 60 μM , thereby affirming the viability of these carbon-based electrodes for effective disease diagnosis and monitoring through wearable biosensors.



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sciforum-087050: Smartphone-Assisted Biosensors: A Systematic Review Exploring the Application and Future Direction of Sensors

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Miniature diagnostic devices combined with powerful smartphone processors have revolutionized health-care diagnostics by bringing it to our homes, where it was previously confined to laboratories. Smartphone-assisted glucose monitoring systems like iBGStar and iHealth exemplify this by incorporating glucometers in smartphones for data display, analysis and tracking of glucose levels. Inbuilt sensors in smartphones like cameras are being utilized as analytical tools in microfluidic and colourimetric assays for disease diagnosis, where the RGB (red, green blue) intensities can be quantified to determine the severity of the disease. During the COVID-19 pandemic, research in this field rapidly accelerated, as observed by the rapid development and commercial availability of many smartphone-based sensors like the iHealth and Ellume COVID-19 antigen detection kits and application software like the Arogya Setu app for contact tracing using Bluetooth assistance within small distances. AI-assisted Chabot and telehealth platforms further helped patients to remotely access doctors in limited resource settings, while the wearable sensors in smartwatches helped in personalized monitoring of physiological parameters. This promoted isolation of patients, which was a mandate for containment of the disease, indicating their significance in decentralised health management. Wearable sensors offer futuristic development using implantable biosensors, wherein tiny biosensor chips are placed under the skin or in the body to monitor various biological and physicochemical parameters, ranging from diabetes, cardiac movements, and brain activity to cancer biomarkers, in patients for precision and personalized healthcare. The review analyzes the sensing technologies employed in smartphone biosensors, further addressing the strengths and limitations of their integration within point-of-care devices. It concludes by focusing on the future direction of research and development and the potential of smartphone biosensors for personalized and decentralized health management.



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sciforum-089062: Wearable Uric Acid Electrochemical Sensor with a Scratched Graphite Electrode

Zhuoya Liao, Jixin Shang and Jun Kameoka

Waseda University

Uric acid levels in sweat are indicative of various health conditions, including gout and cardiovascular diseases. A significant challenge in monitoring uric acid in sweat remains due to the low concentration of uric acid, which necessitates a substantial enhancement in the sensitivity of sensors in an economical manner. Thus, we have developed a new and low-cost method to improve the sensitivity of sensors with a non-smooth graphite surface using a scratched electrode.

Utilizing xurography, we constructed a compact, three-layered graphite sensor suitable for wearable applications, featuring a working electrode, counter electrode, and a reference electrode with a silver/silver chloride coating, all 1 mm wide.

To integrate this development with smartphone-based biosensors, the enhanced graphite sensor's electrical signals are transmitted to a smartphone application, enabling the real-time monitoring and data analysis of uric acid levels in sweat. This connectivity not only augments the portability and convenience of health monitoring but also leverages the widespread availability of smartphones to facilitate accessible health management.

In testing, we prepared uric acid solutions in phosphate-buffered saline and measured them using Differential Pulse Voltammetry (DPV) with a PalmSens4 device. Sensors with different surface roughness were tested against uric acid solutions to evaluate their effect on sensitivity.

The results demonstrated that sensors with rougher surfaces detected uric acid at lower limits. Specifically, the limit of detection (LOD) with unscratched working electrodes was 100 μM , while with scratched surfaces, the LOD improved to 25 μM . The DPV profiles showed peak currents of 5.954 μA for smooth-surface sensors and 90.478 μA for roughened-surface ones, when detecting the high-concentration (1000 μM) uric acid solution.

In conclusion, increasing the surface roughness of graphite electrodes significantly improves the sensitivity of uric acid detection in sweat. This study presents a low-cost yet effective method to increase the surface roughness, providing a reference for the more efficient fabrication of wearable uric acid sensors.



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Abstracts

Session D. The Evolution of Biological Recognition Elements in Biosensors

sciforum-086977: Electrochemical Determination of Serotonin Exocytosis in Human Platelets with BDD-on-Quartz Multielectrode Array Biosensors

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Introduction

About 90% of blood serotonin is stored in secretory granules of platelets and is released by exocytosis. Serotonin is a biogenic amine and the mechanisms for its accumulation in secretory granules and exocytosis are similar to some neurotransmitters. As it is an electroactive molecule, its release can be detected via amperometry. Thus, platelets are an easily accessible human cell model to study exocytosis.

Methods

We have optimized boron-doped diamond (BDD) on multielectrode array (MEA) systems that allow the detection of amperometric recordings from the quantum release of serotonin from human platelets. Exocytotic events are detected as transient oxidation currents. Our initial experiments were carried out with microelectrode devices on silicone matrices (BDD-on-silicon MEAs) [1]. We introduce here a new transparent material which allows microscopy observations: a BDD-on-quartz MEA.

Results

BDD-on-quartz MEA devices exhibit excellent electrochemical properties similar to BDD-on-silicon MEAs [1]. We present the amperometric data obtained from unloaded platelets and after loading the platelets with 10 μ M serotonin for 2 h, as well as a comparative study of the quantum and kinetic characteristics of amperometrical spikes obtained with both MEA chips.

Conclusions

We demonstrate the effectiveness of BDD-on-quartz MEAs as biosensors for the amperometrical measurement of serotonin exocytosis from human platelets.

Reference

1. González Brito, R.; Montenegro, P.; Méndez, A.; Carabelli, V.; Tomagra, G.; Shabgahi, R.E.; Pasquarelli, A.; Borges, R. Multielectrode Arrays as a Means to Study Exocytosis in Human Platelets. *Biosensors* **2023**, *13*, 86. <https://doi.org/10.3390/bios13010086>.



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sciforum-089147: SPR Studies of the Impact of Mercury(II) on DNA Duplex Formation: Towards Novel Applications in Nanoparticle-Based Hg²⁺ Biosensing

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Biosensors employing DNA oligonucleotide probes and electrochemical readout have become valuable tools of growing importance in environmental analysis. DNA-based electrochemical aptasensors owe their broad applicability to the unique sensing properties of single-stranded oligonucleotides. Their appropriate design can result in DNA probes capable of achieving selective interactions with different analytes, such as heavy metal ions. Among these, the determination of Hg²⁺ in drinking water is still a pressing challenge due to the fact that high mercury concentrations are very harmful for human health, often leading to death.

The most common Hg²⁺-sensing mechanism utilizes mercury(II)'s affinity to thymine nucleobases. Various mechanisms of measurable signal generation triggered by ion–aptamer binding are known. The most common ones include the following: (i) Hg²⁺ binding by aptamers composed of thymines, where thymine bridges (T-Hg²⁺-T) are formed between two neighbouring DNA strands, (ii) a cooperative mechanism in which, apart from thymines, other nucleotides also support the adoption of a specific secondary DNA form (usually a 'hairpin' or 'sandwich' conformation), (iii) a competitive mechanism in which DNA with an initial 'hairpin' structure undergoes a conformational change under the influence of mercury(II) ion through its dissociation or by Hg²⁺-dependent hampering of DNA–DNA duplex formation. The selection of the signal generation mechanism is crucial for the design of aptasensors and their working parameters.

The research presented here describes comparative studies on different DNA aptamer sequences for Hg²⁺ detection according to different mechanisms. They include the formation of intra- and intermolecular T-Hg²⁺-T bridges. The thermodynamic stability of such probe–analyte complexes is compared to classical dsDNA duplexes. For this purpose, we use label-free methods, i.e., SPR or QCM, to measure the kinetics of ion–aptamer interactions. The final step is the application of the selected DNA-based receptor for the biofunctionalization of magneto-catalytic nanoparticles. Their use should further improve the performance of DNA biosensors.



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sciforum-086901: Electrochemical Biosensor Based on Graphene–Folic Acid Nanobiocomposite for Detecting Overexpressed Folate Receptor in Breast Cancer Cells

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Enhancing the analytical performance of biosensors is a key factor in fabricating well-organized sensing platforms with high sensitivity. The main challenge in developing selective and sensitive biosensors is the lack of a sensing architecture that allows the detection of small biomolecules at low concentrations in crowded biological media. The functionality and stability of biosensors improve when the surface patterns are in a well-organized arrangement, and when biomaterials are present at a good density. It is common to use antibodies or aptamers as capture molecules for the target analyte, but they have limitations in terms of density and orientation when immobilized on sensor surfaces. Alternatively, simple non-toxic molecules such as folic acid (FA) can be used as recognition elements. They have the ability to construct nanostructures and produce sensing devices with good selectivity and sensitivity. In this study, the conjugation of FA to reduced graphene oxide (rGO) was prepared and then used to functionalize a glassy carbon electrochemical (GCE) electrode for the detection of breast cancer cells (MCF-7). The cyclic voltammetry (CV) technique was employed to characterize the electrochemical proficiency of the developed electrode for detecting MCF-7 cells. The rGO-FA nanobiocomposite demonstrated itself as a promising substrate, offering good electrochemical signals after capturing cancer cells in the range between 1×10^3 and 1×10^5 cells/mL. The CV results indicated the successful binding of the folate receptor overexpressed on the surface of the cell membrane in the MCF-7 cells to the rGO-FA-modified sensor. The simple design of rGO-FA/GCE showed good, reliable, and satisfactory performance, which may significantly contribute to the development of low-cost biosensors for future cancer diagnosis.



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sciforum-086945: Field-Effect Transistor-Based Biosensor for pH Sensing and IgG Detection

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Introduction

Maintaining the balance of urine pH and urine metabolite concentrations is vital for a good health, with abnormal levels indicating various conditions such as infection, kidney disease, or metabolic disorders. Hence, this work aims to create a biosensor using field-effect transistors (Bio-FET) to measure urine pH and detect multiple metabolites, starting with Immunoglobulin G (IgG).

Methods

Our Bio-FET system comprises a microfabricated gold electrode, working as an Extended Gate (EG) and a readout circuit for signal detection and amplification. pH tests were conducted with six distinct solutions (10.34, 8.60, 7.40, 7.00, 4.00, and 2.91) applied onto the EG surface, resulting in I_{ds} - V_{ref} transfer curves performed within the linear region of a MOSFET, allowing us to create a calibration curve (I_{ds} -pH). For the IgG detection, an Anti-IgG was covalently bound to a mixed 11-Mercaptoundecanoic acid (MUA) and 11-Mercapto-1-undecanol (MUD) (ratio 1:2) Self-Assembled Monolayer (SAM) on the gold electrodes. Each step of the surface functionalization was characterized using ellipsometry. Preliminary tests were conducted to the Bio-FET response when exposed to two distinct solutions: (1) phosphate-buffered saline (PBS) solution at pH 7.40; and (2) PBS solution spiked with IgG (0.01 mg/mL).

Results

Regarding pH tests, the results showed a linear relationship, wherein elevated pH values were associated with increased current values, with a corresponding sensitivity of 2.20 $\mu A/pH$. The binding of target IgG with the specific antibodies immobilized on the EG surface triggered a positive vertical shift of the PBS-IgG solution transfer curve when compared to the one obtained when the PBS solution alone was used.

Conclusions

The Bio-FET system shows a good response both for pH measurement and IgG detection. However, regarding IgG detection, further tests using different PBS-IgG solutions are required to evaluate the limit-of-detection and linear range of the Bio-FET system as an IgG sensor.



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sciforum-089146: Screen-Printed Organic Electrochemical Transistor: A Protein Immobilization Approach to Detect Aromatic Water Pollutants

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In response to the environmental threat posed by xenobiotic aromatic pollutants in water, we have developed a compact device that integrates biosensor scaffolds with organic electronics. This innovative approach addresses the challenge of detecting these pollutants, which often lack easily detectable functional groups. Our sensor module is specifically designed for the rapid, economical, reliable, and ultra-sensitive detection of phenol, a common water pollutant. The key to our sensor's functionality is the biosensing protein MopR, which we have coupled with an organic electrochemical transistor (OECT). To ensure the effective integration of the MopR sensing scaffold, we have optimized graphene oxide (GO) nanosheets to serve as a host immobilization matrix. This MopR-GO immobilized sensor module is then used as the gate electrode in the OECT, with PEDOT:PSS serving as the organic semiconductor material. The resulting OECT sensor offers a conducive microenvironment for protein activity, thereby maintaining high specificity in pollutant detection. It has demonstrated the ability to exclusively detect phenol with minimal sensitivity loss (less than 5% error), even in complex pollutant mixtures and real environmental samples. This fabrication strategy, which effectively combines biological biosensors with organic electronics, holds significant potential for the detection of a wide range of emerging pollutants. It represents a promising step towards more effective environmental monitoring and sustainability.



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sciforum-086813: Development of A Laser Induced Graphene-based Sensor for Onsite Measurement of Soil Nitrogen

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Laser-induced graphene (LIG) sensors are becoming popular in various agricultural applications due to their ease of fabrication and superior characteristics. These LIG sensors can be used for real-time nutrient monitoring. By using a one-step laser engraving process, it is possible to create flexible graphene electronics on polyimide substrates. A CO₂ laser was used for engraving purpose as it changes sp³-hybridized carbon which is present in substrates like polyimide into sp²-hybridized carbon. Selective patterns of polyimide film (Kapton tape) can be converted into sp²-hybridized carbon using laser beam. A 30 W CO₂ laser was used to engrave the LIG sensor on polyamide sheet with optimized settings i.e., 11% power and 1.2% speed. Distinct ionophores specific to NH₄⁺ (nonactin) or NO₃[−] (tridodecylmethylammonium nitrate) were functionalized within poly (vinyl chloride)-based membranes to create distinct solid contact ion-selective electrodes (SC-ISEs) for NH₄⁺ and NO₃[−] ion sensing cocktails by drop casting on working electrode, respectively. An Ag/AgCl electrode printed with Ag/AgCl ink operated as the reference electrode, while the LIG electrode worked as the working and counter electrode. The electrochemical ion-selective detection of plant accessible nitrogen (i.e., including ammonium and nitrate ions: NH₄⁺ and NO₃[−]) in soil samples was conducted using these LIG sensors. Using a three-electrode setup, Cyclic Voltammetry (CV) scans were performed to determine the various concentrations of ammonium and nitrate in soil samples.



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sciforum-089260: Development of the Microfluidic Lab-on-a-Foil Platform for Pre-Analytical Separation of Human IgG

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Serological diagnostics, crucial for disease detection and monitoring, rely on qualitative antibody tests for viral infections (e.g., COVID-19, HIV), bacterial infections, and autoimmune diseases. Immunoenzymatic assays from whole blood often encounter errors due to sample complexity. While pre-separation protocols mitigate these issues, they are costly and time-consuming. Small-scale IgG purification currently involves complex manual processes using microplates coated with bacterial protein, extending analytical time. To address this, cost-effective microfluidic devices using simple technology and materials are being developed, enabling the miniaturization of advanced analytical systems compatible with optical and electrochemical detection. This innovation holds promise for enhancing serological diagnostics by streamlining IgG separation and contributing to the construction of more efficient health monitoring systems.

The presented study investigates the construction of low-cost, flexible and disposable platforms for rapid separation of whole serum antibodies by their reversible capture using protein A/G immobilized on polyester foil substrates. A simple microsystem is fabricated by laser cutting and bonding biomedical films, while the flow is generated by an external pump. The process of capturing and eluting antibodies from the sample is based on a pH-controlled sequence of injections carried out entirely in a single-channel microfluidic system. In addition, a microfluidic mixer module is developed to allow neutralization of the pH of the eluate.

The developed system allows pre-treatment of small-scale samples prior to their further use in bioanalytical assays (e.g., ELISA, lateral flow or homophasic agglutination tests). The developed, simple and versatile IgG separation module can also find application in more advanced, integrated μ TAS systems for the analysis of serological profiles or capture of antibody-antigen complexes.



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sciforum-086986: Integration of Robotic and Printed Nanosensor for Electroanalysis in Surface and Underwater Environments

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Smart and remote monitoring has been studied and developed extensively in recent years, expanding rapidly in environmental, health, military, and medical areas. The present study describes an innovative strategy that integrates electrochemical sensors with a remotely controllable submarine robot to perform on-site sensitive monitoring of toxic pollutants (such as toxic phenolic compounds) and heavy metals (such as Hg^{2+}) in surface waters, such as rivers, and underwater environments, such as sea waters. To achieve this, we synthesized a conductive nanoink formulation and used it to draw an electroanalytical three-electrode system on the body of a controllable submarine robot. The equipped submarine, with an electrochemical sensor, can stay or dive into water like seawater and perform on-site electroanalysis of its environment.

In this work, initially, nanoconductive ink consisting of graphite, silver nanostructures, acetone, and nail polish as an adhesive component was fabricated and used to draw three-electrode systems on the body of the submarine. The electrochemical properties of the designed sensors were studied, and synthesized Ag nanostructures and printed electrodes were imaged using TEM and SEM microscopes, respectively. Then, the robot sensor was tested for the detection and determination of trace levels of Hg^{2+} in deep water using the stripping voltammetry technique at the ppb level and of toxic phenolic compounds with the cyclic voltammetry technique on the water surface at the ppm level.

Finally, the performance of the developed robot sensor was acceptable, and we believe that the robot sensor offers a direct and reliable assessment of contaminated sites in irregular places or inaccessible locations, such as in-depth water. This significantly reduces the time and cost of sampling and analysis steps while providing remote sensing capabilities. Furthermore, this strategy can expand the horizons of electrochemical technology into new areas and mediums that have not been explored before.



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Abstracts

Session F. Nanomaterials and Smart Surfaces in Biosensors

sciforum-089235: Comparative Analysis of Bacterial Lipopolysaccharides Detection at the Surfaces of Concanavalin A Using DNA Aptamers and QCM-D Method

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Bacterial lipopolysaccharides (LPS) are important indicators of bacteria presence in any samples. They can be therefore used for detection of microbiological contamination in food and dairy products. We performed comparative analysis of different bacterial models by application of liposomes containing LPS from *Salmonella enterica* serotype typhimurium at the surface of 11-mercaptopundecanoic acid (MUA) monolayer chemisorbed at the gold surface of quartz crystal. Using quartz crystal microbalance with dissipation monitoring (QCM-D) we were able to monitor formation of the lectin, concanavalin A (ConA), layer on the MUA surface. We determined optimal concentration of the ConA for the layer formation. ConA of 0.3 mg/mL was selected as the most suitable adsorption of liposomes containing LPS. Using Sauerbrey equation, we calculated that approximately 1.13×10^{12} ConA molecules per cm^2 were adsorbed at MUA surface, which closely corresponds to the 1.19×10^{12} molecules per cm^2 by theoretical models. Later mixed LPS liposomes containing dipalmitoyl phosphatidyl choline (DPPC), dipalmitoyl phosphatidyl ethanolamine (DPPE) and cholesterol successfully interacted with the ConA layer, which resulted in decrease of the resonant frequency and increase of dissipation. We compared adsorption of liposomes with different fraction of LPS and containing LPS from different bacteria. Lack of any LPS in liposomes caused weaker adsorption on ConA layer. Liposomes containing 50% LPS caused the most prominent adsorption and were suitable for interaction with DNA aptamers specific to certain LPS. Addition of the aptamers to the surface of ConA covered by LPS-containing liposomes resulted in decrease of resonant frequency and increase of the dissipation. Using Kelvin-Voigt viscoelastic model and multiharmonic response of acoustic sensors we also determined changes of viscoelastic values of the molecular films during interaction with liposomes and ConA layer.



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sciforum-086920: Electrochemical Sensing of Neurotransmitters Using a Metal Nanoparticle-Based Composite Platform

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Neurotransmitters play important roles in the normal functioning of the central nervous system. The accurate and sensitive quantification of neurotransmitters using chromatographic and optical analytical methods is of key interest in the management of related neurodegenerative maladies. In this study, electrochemical sensors based on electrodes modified with composite nanomaterials were investigated as reliable, fast and low-cost analytical devices for direct neurotransmitter quantification. A sensing platform was developed by means of an innovative preparation method using alternating currents (ACs). Low-cost sensing materials based on gold nanoparticles (AuNPs) and poly(3,4-ethylenedioxythiophene) were synthesized in situ onto glassy carbon electrodes by means of AC. A polymeric matrix was prepared by applying an AC at a frequency of 100 mHz for 300 s, resulting in an increase in roughness. AuNPs were synthesized by applying an AC at a frequency of 50 mHz for 100 s. The use of AC enabled the preparation of AuNPs embedded in the polymeric matrix characterized by increased electroactive surface area. The sensing platform was tested and successfully validated in the detection of epinephrine, with good analytical performance, achieving a low detection limit of 1.8 μM and a wide linear response range of 2 to 100 μM epinephrine. The practical applicability of the electrochemical sensing platform was demonstrated in the detection of epinephrine in human serum samples with good accuracy and recovery. AC frequency modulated the electrodeposition process, resulting in enhanced roughness. Consequently, the novel AC-based method ensured an improved sensitivity of the sensing platform compared to other electrochemical epinephrine sensors produced by classical methods, like potentiostatic and galvanostatic ones.

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sciforum-086926: Novel Platforms for Electrochemical Sensing of Antioxidant Compounds

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Quercetin (QR-3,3',4',5,7-pentahydroxyflavone) is very well known as a strong antioxidant with anti-inflammatory, antiviral, antineoplastic, antithrombotic properties that can acts as free radical scavenger to human beings. It can be found in vegetables such as caper, lovage, broccoli, lettuce, spinach, onions, tea, seeds, fruits skin. QR is recognized as the most important nutrients in a human daily diet. Lipoic acid (LA) known as 1,2-dithiolane-3-pentanoic acid is synthesized by animal, plants and human cells from fatty acids and cysteine. LA is often used in the treatment of oxidative stress, diabetes, cardiovascular and hepatitis diseases and heavy metal poisoning. In the literature there are several chromatographic and optical methods developed in order to determine the lipoic acid and quercetin with low detection limit, but these methods have drawbacks such as sample pretreatment, use of hazardous and expansive chemicals, sophisticated extraction procedures. In view of this, an alternate electrochemical method for sensitive determination of LA and QR is required. In the present work we have developed novel electrochemical platforms for LA and QR sensing based on PEDOT-PB (Prussian Blue) and PEDOT-AgNPs. Both nanocomposite materials were synthesized using sinusoidal currents method (SC). The amplitude and the frequency of the SC method have been optimized. The developed electrochemical sensing platforms using PEDOT-PB and PEDOT-AgNPs were assessed and validated for LA and QR determination in synthetic and real samples in terms of limit of detection, limit of quantification, and linear response range. The proposed sensing platforms ensured comparable, fast, simple, and reliable detection of the target analytes QR and LA without sample pretreatment as it is required usually by other analytical methodologies like chromatographic and optical methods.

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sciforum-087045: A Novel Integration of Acoustic and Optical Methods for the Simultaneous Detection of Penicillin

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The issue of controlling antibiotic residues poses a severe threat that the society urgently needs to address. An effective way to enhance antibiotic control would be implementing a rapid, sensitive, and cost-effective detection method [1]. In this work, we report the development of a novel system based on integrating localized surface plasmon resonance (LSPR) and quartz crystal microbalance (QCM) methods in a fluidic chamber. We performed penicillin (PEN) detection utilizing DNA thiolated aptamers as receptors chemisorbed on gold nanoparticles (AuNPs, diameter 80 nm) immobilized on quartz crystal (Figure 1A). The sensing area was incubated with PEN in a 1–100 μM concentration range. This resulted in a decrease in the resonant frequency of QCM, as well as changes in the LSPR signal observed as a shift of the extension peak (Figure 1B). Subsequently, the sensor specificity was determined using oxytetracycline, kanamycin, and ampicillin. The results demonstrate that the sensor specifically binds PEN. Although we have not reached high detection limits in the nM range, this work shows the preliminary results of a correlative, and real-time detection system for biosensing. Furthermore, the advantage of a simultaneous measurement is that when a detection is made, it can be confirmed by double measurement. The sensitivity of the two techniques can also be compared. With LSPR, the wavelength shift was proportional to the penicillin concentration in the range 0.01–0.03 nm, with a noise of 0.01 nm, while with QCM, the resonance shift was 6–21 Hz, considering a noise of 1–2 Hz.

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Reference

1. Laich, F.; Fierro, F.; Martín, J.F. Production of Penicillin by Fungi Growing on Food Products: Identification of a Complete Penicillin Gene Cluster in *Penicillium griseofulvum* and a Truncated Cluster in *Penicillium verrucosum*. *Appl. Environ. Microbiol.* **2002**, *68*, 1211–1219. <https://doi.org/10.1128/AEM.68.3.1211-1219.2002>.



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sciforum-086922: A Self-Assembled Hydrogel Based on Guanosine with Peroxidase-like Activity as a Novel Material for H₂O₂ Detection

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Chemiluminescence (CL) is a widely used detection technique in biosensing due to its high sensitivity, simplicity of analysis and low cost. These characteristics make it commonly used to quantify hydrogen peroxide (H₂O₂) by carrying out its reaction with luminol in the presence of the horseradish peroxidase enzyme (HRP). Hydrogen peroxide is a clinically relevant biomarker since it appears to be involved in numerous pathologies including diabetes, cancer, Parkinson's disease, Alzheimer's disease and cardiovascular and neurodegenerative disorders. In addition, H₂O₂ is a reaction product of various oxidases such as glucose oxidase [1] and, therefore, can be used to indirectly quantify the substrates of these enzymes. Hydrogels are hydrophilic, highly water-swelling polymer networks that have become of great interest in the development of biosensors, owing to their high biocompatibility and ability to incorporate foreign substances while preserving a benign environment for biosensing. Due to the 3D porous structure of hydrogels, which increases the surface area of these materials, it is possible to load large amounts of recognition bioelements while maintaining the native structure of the biomolecules [2]. A CL guanosine-derived hydrogel was prepared via the simultaneous incorporation of luminol and hemin. The self-assembled hydrogel consisted of K⁺-stabilized hemin/G-quadruplex structures, showing significant peroxidase-like activity to the H₂O₂-mediated oxidation of luminol [3]. After adding H₂O₂, the generated CL signal lasts for several minutes and is intense enough to be captured via smartphone's CMOS camera. As a proof of principle, this biomaterial was also used for the indirect detection of glucose in artificial serum samples after the incorporation of glucose oxidase into the hydrogel. The sensor showed a linear response with an estimated limit of detection of 50 µmol L⁻¹ (equivalent to 5 nmol of glucose) [4].

References

1. Calabria, D.; Guardigli, M.; Mirasoli, M.; Punzo, A.; Porru, E.; Zangheri, M.; Simoni, P.; Pagnotta, E.; Ugolini, L.; Lazzeri, L.; et al. Selective chemiluminescent TURN-ON quantitative bioassay and imaging of intracellular hydrogen peroxide in human living cells. *Anal. Biochem.* **2020**, *600*, 113760.
2. Buenger, D.; Topuz, F.; Groll, J. Hydrogels in sensing applications. *Prog. Polym. Sci.* **2012**, *37*, 1678–1719.
3. Ye, J.; Zhu, L.; Yan, M.; Xiao, T.; Fan, L.; Xue, Y.; Huang, J.; Yang, X. An intensive and glow-type chemiluminescence of luminol-embedded, guanosine-derived hydrogel. *Talanta* **2021**, *230*, 122351.
4. Calabria, D.; Pace, A.; Lazzarini, E.; Trozzi, I.; Zangheri, M.; Guardigli, M.; Pieraccini, S.; Masiero, S.; Mirasoli, M. Smartphone-Based Chemiluminescence Glucose Biosensor Employing a Peroxidase-Mimicking, Guanosine-Based Self-Assembled Hydrogel. *Biosensors* **2023**, *13*, 650. <https://doi.org/10.3390/bios13060650>.



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sciforum-090574: An Electrochemical Sensing Platform Based on a Carbon-Paste Electrode Modified with Graphene Oxide/TiO₂ Nanocomposite for Atenolol Determination

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Atenolol is a medication belonging to the class of drugs known as beta blockers, used to treat high blood pressure (hypertension) and irregular heartbeats (arrhythmia). Its presence in the environment has serious impact for human, animals and water ecosystem. In this context, the aim of this study was to develop a simple voltammetric method for the determination of atenolol (ATN) using a carbon-paste electrode modified with nanomaterials TiO₂ and GO/TiO₂. The analytical performance of the modified sensor was evaluated using square wave voltammetry and cyclic voltammetry in 0.1 mol L⁻¹ acid sulfuric solution (H₂SO₄), pH 2. The nanocomposite electrode CPE/GO/TiO₂ exhibits excellent electrocatalytic activity towards ATN oxidations at 0.1 mol L⁻¹ H₂SO₄ compared with unmodified carbon-paste electrodes CPE and electrodes modified with titanium oxide CPE/TiO₂. Different experimental and conditional parameters were optimized such as supporting electrolyte, pH, amplitude, frequency, etc. Under optimal conditions, linear calibration curves were obtained ranging from 1.7 to 23.2 μmol L⁻¹ for ATN with detection limits of 0.05 μmol L⁻¹, respectively. The modified nanocomposite CPE/GO/TiO₂ sensor showed good sensitivity and good repeatability (RSD ≤ 0.61%) for ATN determination. The proposed sensor is mechanically robust and presented reproducible results and a long-term useful life. In order to verify the usefulness of the developed method, the nanocomposite sensor CPE/GO/TiO₂ was applied to the detection of atenolol in a real sample (pharmaceutical tablets without any pre-treatment). Excipients present in the tablets did not interfere with the assay. Recoveries ranging from 97.7% to 106% were obtained. The results proved that the CPE/GO/TiO₂ voltammetric sensor might be successfully applied in the routine quality control of ATN in complex matrices.



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sciforum-089100: Anisotropic Ag Nanostructures for Determination of FKBP12

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The aim of this work is the realization of a nanostructured platform for the rapid and selective determination of the FKBP12 protein in biological fluids, i.e., CSF and blood. FKBP12 is a peptidyl-prolyl cis-trans isomerase with a clear role both in neurodegenerative processes and in the anti-rejection response after surgical transplantation. The sensor platform is built on a QCM support on which plasmonic silver nanoparticles (AgNPs) are assembled. Self-assembled monolayers (SAM) containing the GPS-SH1 receptor, specifically designed and synthesized to bind FKBP12 were prepared on the nanostructures using different anti-fouling molecular spacers.

The plasmonic nanostructures were obtained by electrodeposition and have manifold functions: of increasing the sensitivity of QCM measurements as well as of creating a plasmonic coating for SERS and SPR applications. Exploring different experimental conditions for the electrodeposition, we prepared two different types of AgNPs: flower-like nanostructures and dendritic nanostructures. The AgNPs were characterized by means of UV-Vis and reflection spectroscopy, SEM, QCM and contact angle. The body of the results showed that the preparation of the nanostructures was reproducible and provided homogeneous coating of the surface with the AgNP.

The SERS performance of the plasmonic nanoarchitectures was studied using Rhodamine 6G as analyte, the measurements revealed low detection limits for both nanostructures indicating the Ag dendrites as the most promising platform for SERS-based nanosensor. QCM measurements have shown that the dendritic nanostructures functionalized with SAM of containing GPS-SH1 allowed the detection of the FKBP12 protein at picomolar concentrations. Furthermore, it has been demonstrated that two proteins, i.e., BSA and IgG, present in the biological fluids of interest, do not interfere with the determination of FKBP12 when used at their physiological concentrations. Finally, it was found that the addition of ethanol, following the absorption of FKBP12 and/or interferents, allows the sensor to be fully regenerated.



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sciforum-089090: Biofunctionalization of CTAC-Stabilized Gold Petal-like Gap-Enhanced Raman Tags with Monoclonal Antibodies via a Polydopamine Coating for the Detection of the SARS-CoV-2 Spike Protein

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Introduction

Incorporating SERS tags into clinical diagnostics holds the potential to increase the sensitivity of diagnostic techniques. Gold petal-like gap-enhanced Raman tags (pGERTs) exhibit an exceptionally high Raman signal. However, the complexity of pGERT functionalization with recognition molecules limits their application in immunoassays. In this study, we have developed a novel method for biofunctionalization of pGERTs with monoclonal antibodies specific to the SARS-CoV-2 spike protein, employing controlled assembly of polydopamine (PDA) on the nanoparticle surface.

Methods

CTAC-coated pGERTs, containing 4-nitrobenzenethiol (4-NBT), were synthesized and characterized. Prior to PDA layer deposition, pGERTs were pre-functionalized with various polymers. Conjugation of PDA-coated pGERTs with monoclonal antibodies specific for S-protein was conducted, and the success of conjugation was confirmed via a dot-immunoassay.

Results

It was demonstrated that replacing CTAC with polystyrene sulfonate on the surface of 60 nm pGERTs allows for controlled PDA growth, resulting in a 3–4 nm-thick PDA layer. Spectrophotometry revealed a broadening of the absorption spectrum and a 4 nm red-shift in the absorption peak of PDA-coated pGERTs. The SERS spectrum of these particles exhibited all characteristic bands of 4-NBT. A dot-immunoassay confirmed the selective staining of the S-protein at varying concentrations (1, 10, 50 µg/mL) by the resulting conjugates.

Conclusions

We have developed a method for the biofunctionalization of pGERTs with monoclonal antibodies specific to the S-protein. The obtained results offer potential applications in the development of SERS-based immunoassay systems.

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sciforum-085641: Catalase Biomimetic Sensor Based on Metals

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Introduction

In recent years, there has been development in the creation of biomimetic sensors, in which bioselectors are replaced by enzyme analogues that combine high sensitivity and stability. The requirements of a modern analysis are sensitivity, selectivity, low cost, simplicity and expressness. Biomimetic sensors perfectly meet these requirements. This work is devoted to the study of a catalase biomimetic sensor using a smart material, where metals such as Pb, Ag and Al were used as transducers.

Methods

Experimental studies of the electrode potential of the catalase reaction as a function of time were carried out using the potentiometric method. The experiments were carried out in an electrochemical cell consisting of a reference electrode ($\text{Ag}/\text{AgCl}/\text{AgCl}^-$) and biomimetic sensors. Double-distilled water served as a background solution.

Results

The experiments were carried out at various concentrations of H_2O_2 . The presence of hydrogen peroxide in the system leads to a change in the value of ΔE , and an increase in the H_2O_2 concentration increases the jump in the electrochemical potential. The results showed that biomimetic sensors based on metals (Pb, Ag, Al), using smart material ($\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3$), exhibit high sensitivity and detect the lowest trace concentrations of hydrogen peroxide in an aqueous solution.

Conclusions

The developed biosensors $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Pb}$, $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Al}$ and $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Ag}$ of the catalase type are active and make it possible to determine trace concentrations of H_2O_2 in an aqueous solution.

Synthesized catalase biosensors are characterized by long-term stability, high sensitivity and reproducibility. The maximum sensitivity to the concentration of H_2O_2 in an aqueous solution for $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Pb}$ was 10^{-8} wt.%; for $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Al}$, it was -10^{-6} wt.%; and for $\text{TPhPFe}^{3+}/\text{Al}_2\text{O}_3/\text{Ag}$, it was -10^{-8} wt.%.



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sciforum-084266: Conductive Mesh Electrodes for Electrochemical Biosensors

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Introduction

The rate of recruiting a target analyte on a receptor-functionalized electrode is a limiting step in most electrochemical biosensors, and is predominantly diffusion-controlled. Enhancing the interaction dynamics between the target analyte and the electrode-immobilized receptors offer great potential for improving electrochemical assay parameters in terms of assay time and sensitivity. Nanostructured electrodes, such as those modified with nanoparticles, can enhance the functional surface area; however, they have a limited ratio of sample volume to electrode surface area.

Methods

We propose the use of highly conductive mesh electrodes as a solid support for the immobilization of receptors (using antibodies as a model) and apply this in an electrochemical sensor that can be used for the detection of a range of target species. This approach involves coating commercially available mesh supports with low-fouling conductive polymers, which can be further modified with bio-receptors such as antibodies, proteins, or aptamers.

Results and Conclusions

These functionalized mesh electrodes are employed for the isolation and detection of target biomarkers. The system is integrated within a 3D-printed microfluidic chip to allow real-time isolation and detection of the analytes under continuous flow using impedimetric, voltammetric, or amperometric assays. This integrated system allows for high target recovery within the mesh-like structures, overcoming the mass transport limitations associated with conventional disc or screen-printed electrode-based electrochemical assays. Additionally, this system is applied for dual-mode target isolation, where the mesh electrode enables size-based exclusion of the target analyte, thereby improving assay specificity. This method significantly boosts the ratio of sample volume to surface area (approximately a tenfold increase compared to disc electrodes), facilitating a more effective interaction between target analytes and receptors immobilized on the electrode. This augmentation is bolstered by the flow-through format of the system, as opposed to the traditional sample incubation method used with disc electrodes.



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sciforum-089193: Design of a Multiplex Sensing Platform: AFM as a Nanolithographic Tool

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Coupling spectroscopic ellipsometry (SE), quartz crystal microbalance with dissipation (QCM-D), X-ray photoemission spectroscopy (XPS), and atomic force microscopy (AFM), we developed a multi-technique approach to characterize the surface immobilization of probe DNA strands, as a tool for the design of a DNA-based biosensor for the detection of disease-related oligonucleotide strands [1–3]. The hybridization of complementary target sequences is monitored through in situ, non-destructive, and real-time analysis.

The multiplexing detection of different oligonucleotide sequences is of great interest for differential diagnosis. To this end, we exploit AFM in a nanolithography mode to obtain micrometric platforms of thiolated DNA. Grafting is performed by removing previously chemisorbed inert alkanethiol SAMs and replacing them with short thiolated DNA molecules. Changing grafting parameters, DNA patches with different molecular densities were obtained. The analysis of images acquired in low-perturbative quantitative imaging (QI) mode highlighted the coexistence of molecular domains of different heights and thus different densities, which were not formerly observed using contact AFM imaging. By exposing the DNA platforms to target DNA (down to the nM level), all patches increased in height, indicating a successful hybridization. Comparing the height of the patches before and after hybridization showed a higher relative height increase in the less dense patches, indicating them as most suitable for targeting oligonucleotide sequences [4]. This method allows the grafting of different thiolated DNA strands onto the same substrate. Different sequences, characterized by 10 mismatches, were employed. Upon exposing the platform to different targets, a selective hybridization of specific probe DNA patches was observed, demonstrating efficient multiplexing targeting.

References

1. Pinto, G.; Parisse, P.; Solano, I.; Canepa, P.; Canepa, M.; Casalis, L.; Cavalleri, O. Functionalizing gold with single strand DNA: Novel insight into optical properties via combined spectroscopic ellipsometry and nanolithography measurements. *Soft Matter* **2019**, *15*, 2463–2468.
2. Pinto, G.; Canepa, P.; Canale, C.; Canepa, M.; Cavalleri, O. Morphological and Mechanical Characterization of DNA SAMs Combining Nanolithography with AFM and Optical Methods. *Materials* **2020**, *13*, 2888. <https://doi.org/10.3390/ma13132888>.
3. Pinto, G.; Dante, S.; Rotondi, S.M.C.; Canepa, P.; Cavalleri, O.; Canepa, M. Spectroscopic Ellipsometry Investigation of a Sensing Functional Interface: DNA SAMs Hybridization. *Adv. Mater. Interfaces* **2022**, *9*, 2200364. <https://doi.org/10.1002/admi.202200364>.
4. Rotondi, S.M.C.; Canepa, P.; Angeli, E.; Canepa, M.; Cavalleri, O. DNA Sensing Platforms: Novel Insights into Molecular Grafting Using Low Perturbative AFM Imaging. *Sensors* **2023**, *23*, 4557. <https://doi.org/10.3390/s23094557>.



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sciforum-089283: Detecting Insect Herbivore Attacks Using Metal–Organic Framework (MOF)-Based Colorimetric–Piezoelectric Sensor

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Insects cause substantial damage to crops, with the FAO estimating up to 40 percent of global crop losses, totaling around USD 220 billion annually. This underscores the critical need for innovative insect detection methods. Green leaf volatiles (GLVs) are organic compounds emitted by plants in response to insect attacks, offering potential for early detection. Current detection methods like gas chromatography–mass spectroscopy (GC-MS) are costly and complex, limiting real-time monitoring. There is a pressing need for affordable, portable sensors with high sensitivity to monitor GLVs in real time to address this critical agricultural challenge.

Chemical analyte binding to sensing materials can lead to optical, mechanical, thermal, electrical, and mass changes. By utilizing a transducer capable of detecting these multidimensional changes, sensor performance, including sensitivity and selectivity, can be enhanced. In this study, we developed a novel sensor capable of capturing both piezoelectric and colorimetric signals for the sensitive and selective detection of hexanol, a well-known green leaf volatile. We used a piezoelectric micro quartz tuning fork (MQTF) as the transducer. The MQTF's two prongs were coated with a metal–organic framework (MOF)–thymol blue hybrid sensing material, enabling detection through both color change and resonating frequency shifts upon hexanol binding. MOFs offer a high surface area and tunable pore size, enhancing sensor sensitivity and selectivity. The sensor's frequency shift indicates mass change due to hexanol binding to MOFs, while colorimetric sensing relies on thymol blue's reaction with hexanol. Tests demonstrate the sensor's ability to detect hexanol from 60 ppb to 250 ppm with high sensitivity and selectivity. Its compact size, cost-effectiveness, simple fabrication, wide detection range, and accuracy make the MOF-based colorimetric–piezoelectric sensor an ideal choice for early insect herbivore attack detection in agriculture.



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sciforum-088294: Detection of the Lipopolysaccharide Endotoxin Using Fluorescent Gold Nanoclusters

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Introduction

Accurately detecting bacterial endotoxin levels is essential for effective pharmaceutical quality control. Endotoxins refers to lipopolysaccharides that are present in the outer membrane of Gram-negative bacteria. They elicit a robust inflammatory response upon exposure. Gold nanoclusters (AuNCs) show potential as fluorescent nanotags due to their ease of synthesis, wide Stokes shift, and exceptional photostability. This study introduces fluorescent AuNCs for endotoxin detection for the first time.

Methods

Glutathione-stabilized gold nanoclusters (GSH-AuNCs) were synthesized and characterized. Lipopolysaccharide extraction from *Pseudomonas putida* bacterial biofilms was carried out. The relationship between the change in fluorescence intensity of GSH-AuNCs and the concentration of *P. putida* endotoxin was established. The micelle characterization of the endotoxin was conducted using dynamic light scattering (DLS).

Results

Orange-emitting 1.5 nm GSH-AuNCs were produced. Upon interacting with endotoxin micelles, the fluorescence signal increased and the emission peak shifted by 7–10 nm towards the blue end of the spectrum. This was attributed to the phenomenon of aggregation-induced emission (AIE). The detection limit for the endotoxin in aqueous solutions was determined to be 400 ng/mL. The size of the endotoxin micelles was measured to be 62 ± 15 nm.

Conclusions

We have developed a nanosensor based on fluorescent AuNCs for endotoxin detection without requiring extra recognition molecules. The detection principle relies on the modulation of the fluorescence properties of GSH-AuNCs in the presence of endotoxin micelles. This nanosensor holds potential for endotoxin detection in pharmaceutical preparations and buffer solutions.

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sciforum-089091: Development of a Sensor Platform for the Protein FKBP12

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The aim of this research activity is the design, assembly and development of a device for the rapid and efficient detection of the FKBP12 protein in biological fluids, i.e., CSF and blood. FKBP12 is a peptidyl-prolyl cis-trans isomerase with a well-established role in neurodegenerative processes and the post-surgical anti-rejection response. The proposed nanoplatform consists of a gold- or silver-coated support for a Quartz Crystal Microbalance (QCM) functionalized with a synthetic receptor, GPS-SH1, designed and synthesized specifically to bind FKBP12. The nanostructures containing the receptor were obtained via chemical adsorption of the thiolate GPS-SH1, both alone and mixed with anti-fouling spacers, to form a Self-Assembled Monolayer (SAM). In particular, we examined linear chain alkylthiols, e.g., 1-Dodecanethiol (C₁₂-SH), and a thiol-polyethylene glycol (PEG-SH), a polymer with known anti-fouling properties. The kinetics and thermodynamics of SAM formation, as well as the nanolayer structure, were obtained by means of QCM-d measurements for all harmonic frequencies. The same technique was used to monitor the adsorption of the protein on the nanosensor as a function of the FKBP12 concentration. In all cases, we observed immobilization of the protein on the SAM, but the best results in terms of the LOD and linearity range were obtained for SAMs of the GPS-SH1/C₁₂-SH 1:6 mixture. We also tested BSA and IgG, commonly present in biological fluids of interest, to demonstrate the receptor selectivity for the protein. In collaboration with clinical laboratories, the proposed platform has been tested with blood samples from real patients. The addition of ethanol after the absorption of the proteins allows the sensor to be reconditioned for further analysis. Furthermore, frequency values measured on sensors with newly prepared SAMs or on sensors aged up to six months remained unchanged, indicating a long shelf-life.



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sciforum-089306: Development of an Electrochemical Aptasensor Based on Carbon Nanocomposites for the Sensitive Detection of Oxytetracycline

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Massive use of antibiotics in veterinary medicine has led to their accumulation in meat and dairy products. Consumption of antibiotic-contaminated food can trigger the development of antibiotic-resistant bacteria, endangering human lives. Among antibiotics, the oxytetracycline (OTC) family of antibiotics is most widely used in veterinary medicine. Strict control of the antibiotics in food necessitates the development of fast and effective methods for OTC detection, for instance, in milk. One of the most promising approaches to OTC detection is based on the use of specially designed DNA aptamers. These DNA aptamers are relatively short, 15–60 bases, nucleotides folded in the solution in a 3D structure, forming a binding site for the target antibiotic. Aptamers can be chemically modified for attachment to sensor electrodes. In this work, we investigated the electrochemical detection of OTC using DNA aptamers specific to OTC that have been covalently immobilized onto the nanocomposite surface of a glassy carbon electrode with electrodeposited reduced graphene oxide and multiwalled carbon nanotubes. Differential pulse voltammetry, DPV, in the presence of a ferri/ferrocyanide redox couple was used as an internal standard and to monitor the redox current. In the presence of OTC, the amplitude of DPV decreased, evidencing the blocking of charge transfer. After system optimization, we reached the limit of detection of 0.45 ng OTC /mL, which is 200 times lower than the maximum residue limit established by the European Commission of 100 ng OTC /mg.

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sciforum-086937: Different Systems of Hybrid Particles with Immobilized Enzymes: Balance between Particle Conductivity and Enzyme Activity

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University of Bayreuth

Enzymes have great application prospects in environmental monitoring and catalysis because they are highly specific and sensitive. However, maintaining the activity and stability of free enzymes for a long time is a huge problem. One method to overcome these problems is the immobilization of enzymes onto carriers. Our previous work proposed immobilizing enzymes onto core-shell nanoparticles, which have suitable polymer brushes and can obtain high immobilization yields while maintaining enzyme activity. However, non-conductive polymers and nanoparticle carriers limit the possibility of further applications of enzymes, such as sensors or wearable electronic devices. In this contribution, we aim to construct conductive hybrid particle systems by introducing conductive nanoparticles while loading enzymes and studying the activity of the enzyme at this condition.

We designed two strategies: 1. Fixed metal nanoparticles on the surface of silica particles combined with grafted polymers to immobilize enzymes. 2. Fixed metal particles on the grafted polymer brushes for enzyme immobilization. We also control the thickness of the polymer brushes to find the most suitable system for carrying enzymes by adjusting the polymerization time. Our study provides a better understanding of the positioning of conductive components in hybrid particles and opens the door to novel particle-based inks for the printing of enzymatic biosensors.



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sciforum-089019: Electrolyte-Gated Organic Field-Effect Transistors for Point-of-Care Tests

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Over the last few years, flexible electronics have been resonating in a wide variety of novel (bio)applications. As a key component, electrolyte-gated organic field-effect transistors (EGOFETs) are attracting considerable interest for their inherent advantages in miniaturization, low cost fabrication using solution processing methods, low power consumption, and label-free transduction, among others. Bearing this in mind, the idea in this study is to manufacture a novel EGOFET replacing the liquid electrolyte, which acts as dielectric, for new electrolyte platforms (i.e., hydrogels). This could overcome the limitations that aqueous media present. This material employed as an electrolyte provides OFETs with good mechanical properties and excellent biocompatibility, offering a suitable environment for the immobilization of biomolecules. The experimental approach involves the fabrication and characterization of an EGOFET using an organic semiconductor (OSC) as the active material and different dielectric media. For this reason, our proposal is to fabricate EGOFETs using a processing technique compatible with roll-to-roll processing (i.e., bar-assisted meniscus shearing (BAMS)), which allows the deposition of a layer of OSC blended with polystyrene (PS). Subsequently, the devices were characterized electrically by means of Transfer and Output Characteristics in order to demonstrate that the electrical parameters between both devices are comparable in terms of sensitivity. This work demonstrates that these devices based on hydrogels exhibit comparable electrical performance and long-term stability to those employing liquid electrolytes, and therefore they could be employed in several applications such as sensors of (bio)analytes of interest and point-of-care (POC) devices. In conclusion, this research underscores the promising prospects of EGOFETs in transforming point-of-care testing. The integration of organic semiconductors and electrolyte gating not only enhances device sensitivity but also offers cost-effective and portable solutions for diagnostic applications. Future research may further refine and expand the applications of EGOFETs, paving the way for widespread adoption in routine diagnostic practices.



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sciforum-086021: Ferromagnetic Nanoparticles-Modified Immunosensor: A Novel Methodology for Polycyclic Aromatic Hydrocarbons (PAHs) Detection

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Polycyclic aromatic hydrocarbons (PAHs) encompass an extensive group of organic compounds comprised solely of carbon and hydrogen elements. These substances exert a significant influence as contaminants in the environment, bearing notable implications. Given their link to heightened cancer risks in humans, PAHs raise significant human health apprehensions. Consequently, establishing a means to identify these compounds in various substances that humans come into contact with, such as water, soil, and food, is paramount. The European Drinking Water Directive (98/83/EC) prescribes a stringent threshold of 0.01 ng/mL for Benzo[a]pyrene (BaP) levels in potable water. Traditional practices for PAH detection in the environment have relied on costly instruments like High-Performance Liquid Chromatography with fluorescence detection (HPLC-fluorescence) and Gas Chromatography-Mass Spectrometry (GC-MS). These methodologies entail substantial expenses, employ significant quantities of hazardous solvents, demand substantial time investments, and lack portability. In this research, an alternative electrochemical approach was introduced, offering distinct advantages over established PAH detection techniques. The method achieved a Limit of Detection (LOD) at 0.01 ng/mL and a linear range spanning from 13.7 to 123 ng/mL. This innovative technique also facilitates the automation of steps inherent to immunoassay procedures. Consequently, integration into a portable lab-on-a-chip solution holds promise as a prospective avenue for monitoring water quality. This approach circumvents the need for resource-intensive and inefficient water sample analyses conducted within dedicated laboratories, thus mitigating costs and enhancing efficiency.



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sciforum-089392: Formation of Chiral Plasmonic Silver Nanocrescents Using Colloidal Lithography and Ion-Plasma Sputtering

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Nanomaterials based on plasmonic metal nanoparticles have great potential for medicine, pharmaceuticals and sensors. Their unique optical properties are due to the enhancement of local near fields under the influence of external electromagnetic waves upon the excitation of plasmon resonance. The optical properties of such nanomaterials depend on the characteristics of the nanoparticles: shape, size, material. Therefore, the development of methods for the formation of new nanoparticles with a given shape is an urgent task. The plasmon resonance effect can be especially useful for studying the optical properties of chiral molecules, since they give very weak chiroptical signals due to the difference between molecular sizes and the wavelength of incident light. One of the main methods for studying chiral molecules is circular dichroism spectroscopy (CD). It can be expected that in the field of chiral plasmonic nanoparticles, the CD signal of chiral molecules will also be enhanced.

The authors achieved the formation of chiral plasmonic silver nanocrescents using a combination of colloidal lithography and ion-plasma sputtering methods. The new technique makes it possible to obtain chiral nanocrescents of various orientations and widths by controlling the angles of deposition and sputtering. It was shown that the resulting nanoparticles are characterized by enhanced absorption at wavelengths of 470 nm, 655 nm, 1050 nm, and 1400 nm.

To sum up, a new formation method provides a rapid and inexpensive way of forming chiral nanocrescents. Along with the techniques commonly used to measure the optical properties of metal nanoparticles (extinction and fluorescence spectroscopy), we anticipate that CD will play an important role due to the number of effective ways it can be used to detect interactions between biomolecules and chiral plasmonic systems. Broader research is also needed to determine the relationship of crescent asymmetry with the CD signal and how to integrate such surfaces into functional commercial devices.



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sciforum-086165: In Situ Real-Time Monitoring and Simulation of Metabolic Activity in Biofilm of Sulfate-Reducing Bacteria

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Sulfate-reducing bacteria (SRB) are a typical, well-studied, and highly corrosive microorganism that is closely associated with the formation of biofilms on metal surfaces. Traditional methods for measuring SRB activity in biofilms are unable to distinguish between the metabolic activity of sessile SRB in the biofilm and planktonic SRB in bulk solution, making it difficult to apply in the field. To address these issues, this thesis presents two types of all-solid ion-selective electrochemical microprobes that were used to construct metabolic activity detection platforms for the continuous, in situ detection of SRB metabolic activity in biofilms by selectively recognizing characteristic metabolic substances. Additionally, the feasibility of the SRB metabolic activity detection performances was verified by two organic fluorescent probes. The metabolic activity of sessile SRB in the biofilm on the surface of an inert material and planktonic SRB in bulk solution were continuously measured, and the test results preliminarily revealed the changes and differences in metabolic activity between SRB cells in the biofilm and free SRB cells. Subsequently, the metabolic activity of sessile SRB in biofilm on the surface of metal material and planktonic SRB in bulk solution were continuously measured, and the results were discussed in this thesis. This study was of great significance for revealing the variation regulation and different characteristics of SRB metabolic activity inside and outside the biofilm, and held significant meaning for the research of SRB biofilms' corrosive mechanisms.



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sciforum-089302: Influence of Gold Coating on Dense Electrodes in Multilayer Coatings of Chitosan and Hyaluronic Acid for Tumor Cell Detection

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Introduction

Multilayered films comprising chitosan (CHI) and hyaluronic acid (HA) have prominence in biotechnological applications due to their biocompatibility and capacity to enhance cell adhesion, particularly relevant in cancer research where the interaction between HA and CD44 aids in capturing circulating tumor cells (CTCs). The utilization of these films in biosensing platforms shows significant potential for early detection and monitoring of cancer. This study focuses on the functionalization of titanium electrodes with gold nanoparticles and nanostructured film (CHI-HA) to explore their potential in CTC detection.

Methodology

Ti6Al4V electrodes, were functionalized with gold nanoparticles through cyclic voltammetry, and depositing CHI/HA films using *Layer-by-Layer* technique. Surface morphology was analyzed with atomic force microscopy. PC3 cell adhesion studies were conducted to evaluate the effectiveness of the modified electrodes in promoting tumor cell attachment.

Results

Electrochemical characterization supported the efficacy of cyclic voltammetry-deposited gold nanoparticles, confirming enhanced conductivity of the electrodes, crucial for biosensing applications. Roughness analysis indicated the gold coating's contribution to surface leveling, potentially optimizing interaction with biological molecules. CHI/HA film deposition introduced polymer islands, enhancing surface roughness and promoting cell adhesion. Adhesion studies showed a significant increase in tumor cell attachment on multilayer film-coated electrodes compared to uncoated ones, suggesting their potential for tumor cell detection and CTC capture. Overall, the combination of gold nanoparticle functionalization and CHI/HA film deposition improved conductivity, surface roughness, and tumor cell adhesion properties, promising for cancer diagnostics. Further optimization and validation studies are necessary to fully exploit these electrodes' capabilities in clinical settings.

Conclusions

The study presents the effectiveness of gold nanoparticle functionalization and CHI/HA film deposition in enhancing tumor cell adhesion on electrode surfaces. Providing solid basis for further research in refining fabrication processes and exploring additional functionalities to augment their performance in clinical cancer detection applications.



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sciforum-089121: Laser-Graphitised Diamond Electrode for Biomedical Applications

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There is a growing interest in utilising diamond-related electrodes for biomedical applications, like cellular stimulation and tissue engineering, due to their exceptional biostability and long-term durability when implanted into living tissue. Here, we investigate the electrochemical performance and stability of laser-graphitised polycrystalline diamond (PCD) as an electrode and evaluate its biocompatibility with human mesenchymal stem cells (hMSCs). The PCD surface was graphitised using an ultraviolet (UV) nanosecond-pulsed laser under ambient atmosphere and temperature conditions. Microstructural changes were analysed before and after laser writing using scanning electron microscopy (SEM), Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS). The electrochemical performance and stability were evaluated through Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), and multi-potential and multi-current steps over an extended period of time. To study the electrode's biocompatibility, bone marrow hMSCs were cultured on the surface of the electrode and tissue culture plastic (TCP) as controls, followed by a resazurin assay at 24, 48, and 72 h. The laser-graphitised electrode exhibited a high specific double-layer capacitance of $195 \mu\text{F}/\text{cm}^2$ and a specific electrochemical impedance of $129 \Omega \cdot \text{cm}^2$ at 1 kHz. The hMSCs cultured on the electrode showed over 80% viability relative to TCP, indicating the non-cytotoxicity and growth-promoting effect of hMSCs. Notably, the hMSCs cultured on the electrode were elongated after 3 days, aligning with the topography of the laser-graphitised PCD surface. The graphitisation of PCD through nanosecond laser writing presents promising electrochemical properties, indicating its suitability as both a recording electrode for biosensing and a stimulating electrode for cellular modulation. Furthermore, the laser-graphitised PCD demonstrated notable biocompatibility with hMSCs. These findings suggest its potential for various biomedical applications, including biosensing and stem cell therapeutics, through promoting the proliferation and guiding the differentiation of stem cells into specialised cell types.



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sciforum-089158: Laser-Reduced Graphene Oxide-Based Piezoresistive Sensor for Electronic Skin Applications

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Flexible strain sensors have attracted a lot of interest lately, especially in the field of wearable sensors, electronic skin and soft robotics. They are conformable, making them easy to use, and cause minimum discomfort. There is thus a huge demand for highly sensitive, fast-responding, flexible piezoresistive materials that can be used in wearable sensors and point-of-care diagnostic instruments. The most common approach toward developing such materials is adding conductive fillers to elastomeric polymers, the sensitivity of which depends on the filler concentration and homogeneity of the composite, resulting in variations in properties and making them complex to fabricate. Here, we present the fabrication and application of a flexible, conformable, thin piezoresistive sensor design that can be used for pressure sensing in electronic skin application.

Highly exfoliated graphene oxide (GO) solution in de-ionized water was initially synthesized using the modified Hummers method. Lint-free tissue paper (Kimberly Clark make) was soaked in the GO solution and dried several times to obtain a good network of GO in the paper. This was then attached to a partially cured PDMS layer for mechanical stability. The GO was further reduced to rGO using a 450 nm laser by optimizing the intensity. This laser-reduced rGO was placed on interdigitated electrodes to make the sensor.

A 40% change in sensitivity was observed for a 60 kPa pressure when tested using a Keysight source meter. The thickness of the sensor was found to be less than 700 micron, hence making it possible to use for electronic skin applications.



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sciforum-086941: Nanometric Film Functionalization for Surface Modification

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New techniques have been developed for functionalizing surfaces with nanometer-thick organic films, useful for attaching bio-molecules in sensors and biosensors. This method involves a novel surface functionalization technique that anchors alkyl chains at low potentials. It utilizes a process where aryl radicals from dazonium salts, which typically react with surfaces, are instead redirected to create reactive aliphatic radicals.

This is achieved using the 2,6-dimethylphenyl radical, which does not bind to surfaces like other aryl radicals but instead helps in generating alkyl radicals that attach to glassy carbon surfaces, forming stable nanometer-thick alkyl films. This process is more energy-efficient than direct reduction, with a 2 eV advantage.

The method also allows for creating complex, mixed bifunctional nanometer films by reacting an aromatic radical with RI or RBr on the surface. These films can trap other molecules, contributing to the field of nanomedicine, especially in targeted drug delivery using polymeric nanoparticles.

Key findings include the following:

- Transfer of iodine atoms from alkyl iodides to sterically hindered aryl radicals, bypassing surface competition;
- Durability of grafted alkyl chains, resisting harsh conditions like ultrasonication, boiling solvents, and extreme voltage changes;
- Capability to form mono- or multilayer films ranging from 1 to 5 nm;
- Comprehensive characterization using techniques like IR, XPS, electrochemistry, ellipsometry, and water contact angle measurements.

Additionally, this method can be adapted to graft nanomaterials onto non-conductive surfaces using a reducing agent in solution instead of an electrode.



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sciforum-086805: Patent Analysis of Innovative Hyaluronic-Acid-based Hydrogel Biosensors

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Introduction

Hydrogel-based biosensors show promising potential for various applications, including biomedical applications, disease diagnoses, and detecting and quantifying pharmaceuticals. These biosensors employ different detection principles. Hyaluronic-acid-based hydrogels with specific functional groups have been used as cost-effective, miniature biosensors for chemical and biological detection, with sensitivity dependent on factors such as the temperature, pH, and concentration of analytes. In this analysis based on patents, the advances in the development of hyaluronic-acid-based hydrogel biosensors were addressed.

Resources and Methods

Different patent databases have been used according to different keywords related to the topic “hyaluronic-acid-based hydrogel biosensors”. Patent documents were filtered to include only patent applications and granted patents.

Results

From 2003 to 2023, 50 patent documents were published, including 41 patent applications and 9 granted patents. Many patent documents stem from universities and collaborations between academia and industry, as well as foundations. Furthermore, about 54% of all patent documents come from the United States. Cooperative patent classification showed that the majority of patent documents are indeed involving biosensors for measuring characteristics of blood in vivo (e.g., gas concentration, pH value, etc.). More specifically, that concerns measuring glucose by tissue impedance measurement using enzyme electrodes with immobilized oxidase. Based on relevant patents, to create a biosensor, the process involves providing a solid material with an electrode, placing a hydrogel drop on the electrode, subjecting the material to a partial vacuum, spinning it, and finally heating it.

Conclusions and Outlook

In summary, hyaluronic-acid-based hydrogels have enhanced mechanical properties and can be modified to have electrical conductivity, making them suitable for biosensors. These biosensors offer a new perspective for fabricating efficient biosensing systems with applications in various fields. Despite the potential of HA-based hydrogels for biosensors, there are still challenges to be addressed, including regulatory and commercialization hurdles.



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sciforum-087018: Portable and Reliable Metallic-Nanoparticle-Based Surface-Enhanced Raman Scattering (SERS) Substrate for Sensing Applications

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The rapid detection and identification of harmful bacteria for food quality control, environmental pollution, medical diagnostics, and chemical and biological crises constitutes a crucial issue. Here, we demonstrate a strategy for sensing bacteria based on the surface-enhanced Raman scattering method. The procedure involves the synthesis of gold nanoparticles (AuNPs) via a simple chemical reduction method and subsequent studies on bacteria. The concentrated AuNPs, coupled with aluminum foil, form a SERS-active substrate and then the bacterial sample is placed on this substrate to identify the strain of bacteria present. After an interaction time of approx. 5 min, the substrate is put on the sample stage of a Raman spectroscope and a laser source of 785 nm is incident on it. The cell walls and intracellular components of the bacteria have consistent and distinctive characteristic bands which aid in the identification of the bacterial strains present in the sample. This substrate offers advantages such as a rapid acquisition time at an extremely low power, great sensitivity, and a simple operating technique that does not require any complex procedures or protocols to collect bacteria. The substrate shows an enhancement factor to the order of 10^7 and a limit of detection of 10^{-7} M for Rhodamine 6G. The developed SERS-active substrate, with its low cost, reproducibility, and outstanding detection capability, has a wide range of applications, including food safety and tracking the environment.



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sciforum-089319: Pretreatment Methods Enhance Cancer Detection Biosensor Performance via Optimized Deposition of Multilayer Chitosan and Hyaluronic Acid Films

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Introduction

Multilayer films incorporating chitosan (CHI) and hyaluronic acid (HA) offer significant potential for diverse biotechnological applications, particularly in early cancer detection, owing to the interaction between HA and the CD44 receptor, commonly overexpressed on circulating tumor cells (CTCs). This study pioneers the utilization of such films to enhance CTC adhesion on Ti6Al4V alloy electrodes, manufactured through additive manufacturing for the development of biosensors. Therefore, establishing an effective deposition methodology for these films on electrodes is essential to optimize biosensor performance. The investigation of plasma pretreatment and a polyethyleneimine (PEI) film precursor layer on electrodes aims to improve the adhesion of multilayer coatings and surface properties, and consequently increase the selectivity and sensitivity of the biosensor for the detection of oncological diseases.

Methods

Ti6Al4V samples were mechanically sanded and cleaned, with certain electrodes undergoing additional plasma treatment and deposition of a PEI pre-layer. Multilayer films were deposited using the layer-by-layer technique. Surface characteristics of the Ti6Al4V electrodes before and after coating were evaluated, focusing on water affinity and topography relevant to cellular interaction. PC3 cells were cultured for adhesion studies on the electrodes.

Results

The application of the coating increased hydrophilicity, attributed to the well-known properties of HA. AFM analysis revealed a reduction in surface roughness after coating, possibly due to the filling of grooves by HA and CHI. Electrodes subjected to plasma pretreatment and PEI pre-layer deposition showed an intermediate roughness value, suggesting improved adhesion properties. The coated electrodes exhibited superior adhesion of PC3 prostate cancer cells, particularly those with pretreatments, consistent with the interaction of HA with CD44 receptors.

Conclusions

Plasma pretreatment and PEI pre-layer deposition further enhanced cell adhesion by facilitating effective polyelectrolyte deposition, resulting in increased roughness and potentially benefiting PC3 cell adhesion given their contact cell nature.



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sciforum-088922: Raman and Luminescent Thermometers for Determining Local Temperatures at the Nanoscale

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The ability to control and understand the temperature at the nanoscale is fundamental for manipulating physical, chemical, and biological processes.

Nanothermometry is a crucial aspect of scientific and technological applications ranging from electronics to biological systems. The development of well-defined protocols for precise temperature determination is essential for advancing research and applications in nanotechnology. Accurate nanoscale temperature measurements involve the integration of various strategies, including the design and fabrication of new materials, the implementation of detection techniques, and the testing of prototypes for real-world applications.

The utilization of optical techniques, such as fluorescence and Raman spectroscopy, enables the efficient characterization of different materials. The ability to synthesize and test materials using these techniques allows researchers to identify the most suitable and sensitive nanothermometry materials. This is particularly important when prototype devices are developed for biomedical applications, where biocompatibility and non-invasiveness are essential.

This presentation will focus on Raman and luminescent nanostructures. The Raman active material is TiO₂, anatase, while lanthanides, such as Yb³⁺ and Er³⁺, are used as luminescent materials; they are both characterized by a signal strongly dependent on the local temperature.

Anatase nanoparticles are synthesized by MW-assisted (MW) and solvothermal procedures, while core@shell nanoparticles are realized by MW-assisted co-precipitation of CaCl₂, YbCl₃, and ErCl₃ and sol-gel methods. Fluorescence and Raman measurements were conducted on sample powders in the visible and n-IR ranges. The sample, maintained at a defined temperature via a temperature controller, underwent laser beam focalization through a microscope. The signals were then collected through a triple monochromator and a liquid nitrogen-cooled CCD camera. Preliminary findings indicate the feasibility of obtaining reliable temperatures for characterizing the local temperature using fluorescence and Raman techniques.

The preliminary results indicate a reliable and accurate temperature characterization, paving the way for further advances in nanothermometry and its applications in diverse fields, including biomedicine.



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sciforum-088686: Sniffing Out Glutaraldehyde Disinfectants with Mesoporous Lanthanum-Doped Tin Dioxide Spheres

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The electronic nose, an innovative system designed to emulate the olfactory capabilities of biological organisms, shows promising utility across various sectors, including environmental monitoring, disease diagnosis, public safety, and food engineering. The effectiveness of electronic noses largely depends on the sensitivity and selectivity of their gas sensors, which currently face challenges in these areas.

To address these limitations, a chemiresistive gas sensor was fabricated with a gas-sensitive material comprising mesoporous lanthanum-doped tin dioxide spheres, utilizing a self-templating approach coupled with direct thermal decomposition. The spheres had a uniform size (~77 nm in diameter), large pore size (~5.7 nm), and high specific surface area (52–59 m²/g). Based on these characteristics, the chemiresistive gas sensor exhibited exceptional performance in the detection of glutaraldehyde, with a high response value (13.5@10 ppm), rapid response time (28 s), remarkable stability, and a low detection limit (0.16 ppm). The observed sensitivity was threefold higher than that of sensors made from undoped mesoporous tin dioxide spheres. This enhancement could be attributed to lanthanum's ability to improve oxygen diffusion, adsorption, and ionization on the material's surface, thereby increasing the electron depletion layer's thickness and detection sensitivity. Density Functional Theory (DFT) calculations further confirmed that lanthanum doping enhanced the adsorption energy towards glutaraldehyde molecules, facilitating electron transfer and improving sensor performance.

By doping gas-sensitive materials with rare earth elements, it is possible to modulate the interaction between gas molecules and the material's surface interface, significantly improving gas sensing performance. This study not only advances the development of high-performance sensors for glutaraldehyde disinfectants but also lays the groundwork for designing advanced gas sensors and enhancing the capabilities of electronic noses.

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sciforum-086967: Superoxide Dismutase Determination on Silver Nanostructured Substrates through Surface-Enhanced Photoluminescence

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Oxidative stress is defined by an imbalance between the generation of reactive oxygen species and the biological system's ability to neutralize them. This condition is commonly linked to various pathological conditions [1]. Superoxide dismutase (SOD) is a widely used enzyme to assess oxidative stress, and various techniques have been developed for its detection in biological samples such as blood, urine, and saliva [2]. Surface-enhanced photoluminescence (PL) is a particularly sensitive method, offering minimal interference from the sample matrix [3]. In this work, silver nanostructured surfaces were implemented as substrates for the immunochemical determination of SOD in synthetic saliva through PL. The substrates were prepared using a single-step metal-assisted chemical etching method (MACE), resulting in the formation of silicon nanowires decorated with silver dendrites of approximately 1.5 μm in height [4]. For SOD detection, a three-step competitive immunoassay configuration was followed. Briefly, SOD was immobilized onto the substrates and then the functionalized substrates were incubated with mixtures of SOD with anti-SOD primary antibody, prepared either in assay buffer or synthetic saliva. Then, a solution of biotinylated anti-species specific antibody was added, followed by a reaction with streptavidin labelled with the fluorescent dye Rhodamine Red-X, and the signal was determined through an in-house developed optical set-up. The developed method presents similar or slightly lower sensitivity (detection limit 0.05 $\mu\text{g/mL}$) compared to the literature; however, it does not require labor-intensive sample pretreatment steps [5,6]. The aforementioned findings demonstrate the capability of the developed method to detect superoxide dismutase in natural saliva, in order to evaluate the oxidative stress status of an organism.

References

1. Pizzino, G.; Irrera, N.; Cucinotta, M.; Pallio, G.; Mannino, F.; Arcoraci, V.; Squadrito, F.; Altavilla, D.; Bitto, A. Oxidative stress: Harms and benefits for human health. *Oxidative Med. Cell. Longev.* **2017**, 2017, 8416763. <https://doi.org/10.1155/2017/8416763>.
2. Macmillan-Crow, L.A.; Cruthirds, D.L. Manganese superoxide dismutase in disease. *Free. Radic. Res.* **2001**, 34, 325–336.
3. Jeong, Y.; Kook, Y.M.; Lee, K.; Koh, W.G. Metal enhanced fluorescence (MEF) for biosensors: General approaches and a review of recent developments. *Biosens. Bioelectron.* **2018**, 111, 102–116.
4. Kochylas, I.; Gardelis, S.; Likodimos, V.; Giannakopoulos, K.P.; Falaras, P.; Nassiopoulou, A.G. Improved Surface-Enhanced-Raman Scattering Sensitivity Using Si Nanowires/Silver Nanostructures by a Single Step Metal-Assisted Chemical Etching. *Nanomaterials* **2021**, 11, 1760. <https://doi.org/10.3390/nano11071760>.
5. Cottat, M.; D'andrea, C.; Yasukuni, R.; Malashikhina, N.; Grinyte, R.; Lidgi-Guigui, N.; Fazio, B.; Sutton, A.; Oudar, O.; Charnaux, N.; et al. High sensitivity, high selectivity SERS detection of MnSOD using optical nanoantennas functionalized with aptamers. *J. Phys. Chem. C* **2015**, 119, 15532–15540.

6. Yang, X.; Dou, Y.; Zhu, S. Highly sensitive detection of superoxide dismutase based on an immunoassay with surface-enhanced fluorescence. *Analyst* **2013**, *138*, 3246–3252.



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sciforum-089252: The Convergence of Technology and the Food Industry: Bionanosensors as a Potential Tool to Overcome Seafood Spoilage

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Seafood is known for its mineral, vitamin, and polyunsaturated fatty acid content, which means that its consumption is related to several health benefits. Moreover, fish products are characterized by their high water activity, pH, and nutrient content, especially non-protein nitrogen (NPN) compounds. Because of their composition, fish products are one of the most perishable foods, so the shelf life maintenance of these products is a challenge for the food industry. Seafood spoilage occurs because of biochemical reactions or/and because of the metabolic activity of naturally present microorganisms, producing alterations in the product that negatively affect its sensory characteristics and make it unsuitable for consumption. Moreover, the spoilage produced in fish products is the leading cause of fish losses globally, creating a sustainability problem. Despite the challenge of investigating the deterioration and degradation process of fish freshness, research related to biosensors as flexible and reliable devices to detect fish quality attributes in different scenarios has exponentially risen in the past few years. Among biosensors, bionanosensors stand out since they provide consumers with information in response to changes in internal or external quality and safety parameters of raw materials and/or their environment, ensuring food quality and safety. This communication is a review of how different nanobiosensors (bioreceptors, transducers, and optical biosensors) may help extend seafood shelf life, guaranteeing its quality and safety during storage, as well as the main challenges associated with these devices (e.g., the limited application in biological systems), together with the future perspectives to overcome these limitations. For this purpose, keywords were used in different databases and the data from the information collected were analysed.



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sciforum-088505: The Effect of the Microheater's Topology on the Performance of Carbyne-Based Ethanol Sensors

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In the realm of healthcare, gas sensors are utilized in medical devices and monitoring systems to measure physiological gases, such as oxygen and carbon dioxide, in patients' breath and blood. They also find applications in diagnostic equipment for detecting volatile organic compounds associated with various medical conditions, thereby aiding in disease diagnosis and management. As a gas-sensitive layer, carbyne offers unique properties that can significantly enhance sensor performance when volatile organic vapors like ethanol are detected. To ensure the reversibility of the response characteristics, the carbyne gas sensors must be equipped with a microheater. Surface acoustic wave (SAW) gas sensors have emerged as a promising technology for detecting and analyzing trace amounts of various gases. Lithium niobate (LiNbO₃) substrates were used to make the SAW structures. Platinum film with a thickness of 280 nm was vacuum-sputtered, and three topologies were fabricated with photolithography. The geometry of the interdigitated electrodes (IDTs) was as follows: width (in the range 300–450 μm for the different topologies), length (1.2 mm for all samples), and number of wires (1, 3 and 5), in order to provide the maximal heating temperature of 80 °C, taking into account that the adsorbed organic analytes are volatile. The meander microheater likely provides a more uniform temperature distribution across the sensing area, contributing to higher accuracy. The meander microheater exhibits more controlled and predictable heat transfer dynamics, leading to a more consistent and accurate response to changes in gas concentration. Meanwhile, the spot high-density rectangular filled micro-heater probably introduces unpredictable or non-linear heat transfer behavior, impacting accuracy to a greater extent. The small meander-shaped microheater exhibits slower response times and reduced sensitivity to changes in temperature. Its thermal design delays the heating and cooling process, impacting the sensor's ability to detect rapid changes in gas concentration, which can be the reason for its lower sensitivity.



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sciforum-081888: Ultrasensitive Detection of 3-Hydroxy-2-Butanone Biomarker at Low Temperatures through Trace Au Atom Enhancement in Mesoporous SnO₂ Spheres

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The development of semiconductor metal oxide gas sensors with high sensitivity and selectivity under low-temperature operating conditions remains a significant challenge. Herein, mesoporous SnO₂ spheres loaded with trace Au atoms are designed for the low-temperature detection of 3-hydroxy-2-butanone, a biomarker of *Listeria monocytogenes* frequently found in food. The designed sensing materials have a large pore size (~5.8 nm), high specific surface area (56.9–63.5 m²/g), and ultra-low Au contents (0.6 wt%). The fabricated gas sensors exhibit an ultra-high response (587.3) toward 2 ppm 3-hydroxy-2-butanone at 50 °C, which is 183.5 times greater than the sensor based on mesoporous SnO₂. The temperature range has been effectively reduced from 100 to 50 °C, while simultaneously achieving an impressive detection limit of only 10 ppb. The sensitivity is as high as 291.5 ppm⁻¹. The gas sensors could be further utilized for discriminating *Listeria* from other bacterial strains, including *E. coli*, *Salmonella*, *Thermophilus*, and *S. aureus*. The superior sensing performance can be due to the mesoporous framework with a low gas diffusion resistance, and the highly accessible Au-O-Sn sites with strong interactions toward the target gas. This work provides a reliable and facile method for the synthesis of noble metal single-atom-decorated mesoporous metal oxide spheres, which can be used in various fields, such as chemical sensing, energy, and environmental catalysis. The unique modification of noble metal single atoms on the mesoporous semiconductor metal oxides is an efficient strategy for the fabrication of high-performance gas sensors operated at low temperatures, which is expected to boost the development of high-performance sensors with low energy consumption for applications in environmental monitoring, food safety, smart homes, and intelligent agriculture.



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sciforum-085233: Ultrasensitive Detection of Biomarkers Based on Anisotropic Gold Nanorods and Dark-Field Imaging

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The detection of tumor markers in body fluids is crucial for the screening, diagnosis, and prognosis analysis of cancer. Hence, the sensitivity of tumor biomarker screening is highly demanded in detection. Currently, several detection techniques are available, such as a fluorescence analysis, surface-enhanced Raman scattering, electrochemical luminescence, and an electrochemical analysis. However, these methods have certain limitations, such as low sensitivity, poor stability, complex processes, and long reaction time. In recent years, the imaging technique combined with precious metal and dark-field microscopy has gained popularity in the field of highly sensitive biochemical detection due to its high spatiotemporal resolution and independence of signal reporter molecules. Gold nanorods (AuNRs) are anisotropic nanomaterials that show two types of plasmon resonance—longitudinal plasmon resonance and transverse plasmon resonance—in which the longitudinal LSPR plays a dominant role in the detection, while the transverse LSPR mode is always neglected. Herein, polarized light, which is perpendicular to the AuNRs, is designed to stimulate the transverse plasma resonance of the AuNRs to detect biomarkers in a microfluidic chip. In this work, Vascular Endothelial Growth Factor (VEGF₁₆₅) is used as the testing biomarker to demonstrate the feasibility of this method. With the presence of VEGF₁₆₅ in the sample solution, AuNRs will capture the gold nanoparticles due to the antibody–antigen–antibody switched structure, inducing the change in the polarized plasma resonance property. This method achieves a detection limit of 10 pg/mL for VEGF₁₆₅, which is lower than most of the reported methods. The results show that the method based on the combination of a microfluidic chip and dark-field microscopic image has excellent sensitivity and has significant potential in an early cancer diagnosis and prognosis analysis.



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sciforum-088665: Use of Hydrophobin RodA Protein for Modification of Gold Electrodes as Part of Glucose Biosensor

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Hydrophobins are proteins, consisting of approximately 70–130 amino acids and containing eight cysteines, linked by four disulfide bonds, which are characteristic of the entire hydrophobin family. The main advantage of hydrophobins is their ability to form amphiphilic layers on surfaces and thus to change their properties from hydrophilic to hydrophobic and vice versa. It is for this reason that hydrophobins can be widely used in a variety of applications to improve the properties of materials, such as hydrophilicity, activity and stability of immobilized molecules. In this work, the hydrophobin RodA of *Aspergillus fumigatus* and its properties were investigated. The gene responsible for the synthesis of the RodA protein was identified by molecular biology methods and used to design an expression system. The purified recombinant RodA protein was used to modify the surface of a gold electrode in order to investigate the effect of this hydrophobin as a matrix on the performance of the engineered glucose biosensor. The engineered biosensor with the RodA matrix was compared with a biosensor without the RodA matrix. The data obtained were fitted to Michaelis–Menten and linear models to calculate the K_M and the maximum current generated (I_{max}). In the case of Au/GOx, the K_M value was 6.99 mM and the I_{max} was $34.8 \mu A \cdot cm^{-2}$; in the case of the Au/RodA/GOx biosensor, the K_M value was 2.37 mM and the I_{max} was $0.432 \mu A \cdot cm^{-2}$. The lower I_{max} value for the Au/RodA/GOx biosensor could be explained by the possible formation of an excessively thick monolayer of RodA protein or by possible conformations of the protein that blocked the glucose oxidase molecules. However, the K_M value obtained for Au/RodA/GOx showed that for this biosensor, the immobilized glucose oxidase has a significantly higher affinity for the substrate, indicating that such a protein may be suitable for electrode modifications.



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sciforum-086949: Utilizing the High Sensitivity toward MMP-2 of an Electrochemically Reduced Graphene Oxide Aptasensor

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A fully electrochemical approach for fabrication and detection is employed to develop a simple, low-cost, and highly sensitive biosensor for matrix metalloproteinase 2.

Graphene oxide (GO) was deposited using the simplest technique, i.e., drop casting over the working electrodes commercially available in the form of an interdigitated electrode array. The GO monolayer uniform film was reduced using an electrochemical approach to obtain an electrochemically reduced graphene oxide (ERGO) ultra-thin film. The ERGO's conductivity and electrochemical activity were controlled by reduction process optimization, where the number of cyclic voltammetry cycles was determined to obtain a highly conductive ERGO film.

In our approach, GO was reduced in a 1× PBS solution with a voltage range of -0.4 to -1.2 V and a scanning rate of 50 mV s^{-1} . We observed that 20 cycles of CV scanning produce stable and highly conductive ERGO. Furthermore, the biosensor was constructed using specific anti-MMP2 aptamers, which are covalently attached to the ERGO surface by pyrene-based chemistry. Initially, we tested the sensitivity in a buffer medium, finding a limit of detection of 3.32 pg mL^{-1} using electrochemical impedance spectroscopy (EIS), which is much lower than that of previously reported graphene-based devices of similar technology. Moreover, the MMP-2 biosensor showed a high specificity toward different similar proteins.

The wide range of active MMP-2 concentrations (10 pg mL^{-1} to 100 ng mL^{-1}) opens the potential for the development of point-of-care devices for the early prediction of different diseases, with an emphasis on cancer.

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sciforum-088448: ZnO Functional Nanomaterial in Green Microalgae Growth Advancement

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Nanomaterials are substances with unique properties due to their intrinsic confinement effect and high surface area that enable their use in biology and medicine for sensor applications. The key feature of nanomaterials in such applications is to provide sensitivity enhancement for sensors. On the other hand, nanomaterials possess the ability to change the biological function of cells or tissues; it is from this point of view that nanomaterials can be considered to be functional. As far as biosensor application is concerned, it is important to optimize the determination of the target molecule in spatial and temporal modes. The purpose of the presented work is to study the effect of functional nanomaterials on the growth (the temporal component) and morphology (the spatial component) of cell culture. The reason was to provide culture conditions where an increase in both the spatial and temporal components of configuration would be achieved for sensor needs to be optimized. Since microalgae have a wide range of possibilities for practical use in medicine, pharmacology and various industries, studying the effect of nanomaterials on their growth and development is very important. It was found that ZnO nanomaterial, which was obtained by volumetric electrospark dispersion, had a concentration-dependent effect on both the growth rate and the color intensity of *Chlamydomonas monadina* microalgae culture. ZnO functional nanomaterial thus performed the optimization of target molecule formation for biosensor applications. The obtained results will be used in astaxanthin research. Due to its special chemical structure, astaxanthin is an antioxidant of unique strength, which is 10 times more effective than beta carotene and 100 times more effective than vitamin E. This substance can be extracted from *Haematococcus pluvialis* microalgae culture. ZnO nanomaterial appears to be suitable for use in optimal sensor applications.



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sciforum-086866: Detection of Tetrodotoxins and Their Analogues in Pufferfish with a Single-Cell Biosensing Device

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Tetrodotoxins (TTXs) are one of the most potent marine neurotoxins known, and pufferfish are their main vector in nature. The toxicity of TTXs relies on the blockage of voltage-gated sodium channels (VGSCs) in neuronal or excitable cells, producing severe gastrointestinal and neurological symptoms that, in some cases, may be fatal. Until now, more than 30 TTX analogues have been described, but little is known about their role in poisoning. In this work, we propose the use of a high-throughput biosensing device for the detection of TTX and its analogues in pufferfish by assessing the electrophysiological activity of Neuro-2a cells exposed to fish extracts. The system showed an IC₅₀ value of 6.4 nM for TTX and, since detection was not affected by the presence of matrix components from different tissues of a TTX-free pufferfish specimen when analysed at 10 mg/mL, an LOD of 0.05 mg TTX equiv./kg was achieved (far below the Japanese regulatory limit of 2 mg TTX equiv./kg). The system was also used to evaluate the toxicity equivalency factors (TEFs) of five TTX analogues purified from the liver of a *Lagocephalus sceleratus* specimen fished near Crete (Greece). Then, naturally contaminated pufferfish samples were analysed using the single-cell biosensing device and compared with the LC-MS/MS quantifications after applying the TEFs, obtaining excellent correlations. Overall, the biosensing device presented in this work provides a rapid, highly sensitive and reliable toxicological method for the assessment of TTX and its analogues in seafood to protect consumers from TTX poisoning.



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sciforum-088221: Bio-Detection Dogs Sniff COVID-19 in Thailand

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Severe acute respiratory syndrome coronavirus (SARS-CoV-2) caused a pandemic COVID-19 disease worldwide, generating an urgent need to develop an early diagnosis approach. This work applied trained dogs to perform a sniff test for COVID-19 screening based on the detection of volatile organic compound (VOC) markers in sweat. Male and female Labrador Retrievers participated in this research as sniffer dogs. The samples were collected from the armpit sweat of PCR-positive (symptomatic/asymptomatic) and -negative patients admitted at Chulalongkorn University Hospital, Bangkok, Thailand. Two cotton rods were used to collect the samples from each patient and kept in 20 mL screw headspace glass vials closed with aluminum caps. The virus inactivation on the surface was performed under UV radiation and left at 25 °C inside a biosafety laboratory level 2 (BSL2) at Chulalongkorn University Hospital for 48 h. The cotton swabs from each patient were transferred from the glass vial into a stainless steel bottle with dimensions of 5 × 9.5 cm. The dog training process was based on positive reinforcement approaches, involving memorizing the COVID-19 positive and negative samples which were hanging in an I-shaped stand. A COVID-19 screening test evaluation (accuracy, sensitivity, and specificity) was carried out using a six-armed spinning wheel. The sniffer dogs successfully recognized VOC markers for SARS-CoV-2 patients with a success rate of 96% ($n = 300$). In conclusion, the COVID-19 sniffer dogs have the capability for participating in COVID-19 point-of-care testing in public areas in Bangkok, Thailand.



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sciforum-086962: Development of a Fully Automated Microfluidic Electrochemical Sensor on the ESSENCE Platform for Rapid Detection of Single-Stranded DNA

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This study presents a fully automated microfluidic electrochemical sensor for the detection of single-stranded DNA (ssDNA) on the ESSENCE platform. The sensor utilizes functionalized single-walled carbon nanotubes (SWCNTs) with short ssDNA strands immobilized through EDC-NHS coupling, placed between non-planar interdigitated electrodes. The detection process involves sequential flow of a background electrolyte and redox probe through the microfluidic channel before introducing the target DNA solution. The same solution is then circulated to enhance selectivity by removing non-specifically bound targets. Electrochemical impedance signals are acquired after the initial and final flow steps, utilizing changes in impedance spectra to quantify target DNA concentration. To streamline complex flow steps and eliminate manual interventions, the system integrates a fully automated fluid control system with syringe pumps, valves, and pressure sensors. Electrochemical impedance spectroscopy (EIS) data is acquired using the Analog Discovery 2 USB oscilloscope, and LabVIEW automation ensures a seamless transition from sample introduction to data acquisition. The transducer material's flow-through design enables efficient differentiation between different degrees of base pair mismatches, extending applicability to single nucleotide polymorphisms. The system exhibits high sensitivity, detecting single-stranded DNA at concentrations as low as 1 fM within a rapid 15-min detection time. Its compact design and automated data acquisition make it a promising candidate for point-of-care biomolecule sensing, including antigens and toxins. Future applications involve functionalizing SWCNTs with relevant antibodies to enhance the platform's capabilities for detecting a diverse range of target molecules in clinical settings.



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sciforum-088979: Military Training Dogs Sniff COVID-19 on Sweat

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Due to the SARS-CoV-2 pandemic, there were several techniques developed for COVID-19 diagnosis such as real-time polymerase chain reaction (RT-PCR) providing high performances of sensitivity, specificity, and accuracy. Several approaches such as biological detection were alternatively developed based on rapid, effective, and non-invasive. This technique of bio-detection used military trained dogs to differentiate between infected COVID-19 patients and non-infected COVID-19 by sniffing of body odors or human sweats by trained to recognize and respond to the unique VOCs patterns of COVID-19 patients' sweat samples, which provided fast and high sensitivity results. However, potential compounds suspected to be VOCs markers that training dogs recognized from sniffing had not been clarified enough. A challenge is to identify VOCs markers that dogs recognize and differentiate for SARS-CoV-2. Gas chromatography-mass spectrometry (GC-MS) has been widely used for VOCs identification coupled with the use of headspace-solid phase microextraction (HS-SPME) as an extraction method because of its ability to directly extract volatiles without solvent consumption. Potential biomarkers can be obtained from data analysis using alignment and statistic analysis program that can categorize all identified compounds into groups. The potential markers derived from this research included nonanal, and aromatic compounds. These biomarkers' production would relate to changes in metabolism pathways in the patient's body after COVID-19 infection. The researcher anticipated that this study would have practical implications for improving COVID-19 screening by training dogs in the future.



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sciforum-088951: Sweat-Based Volatile Organic Compound Identification of SARS-CoV-2 Detection

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Due to an outbreak of COVID-19 pandemic in recent years, the emerging variants of SARS-CoV-2 causing diagnostic challenges. The rapid, non-invasive diagnostic is an urgent need to differentiate between infected with asymptomatic or symptomatic individuals and uninfected with COVID-19 to control the silent virus spreading in the community. This research developed alternative method of detecting COVID-19, in these approaches mainly focused on volatile organic compound (VOCs) in armpit sweat samples derived from population in Thailand, during variants occurring between April 2021 to May 2023, including Delta and Omicron BA.1/BA.2. VOCs odor emission produced in response to inflammation and infection from SARS-CoV-2 infection body by Gerstel Multi-purpose sampler, headspace solid-phase microextraction coupled with gas chromatography-mass spectrometry (HS-SPME/GC-MS) technique with the total of 150 collected sweat samples with 75 negative confirmed COVID-19 and 75 positive confirmed COVID-19 cases (asymptomatic/symptomatic) used to identified potential biomarkers for COVID-19 related with peak areas of chromatogram results. The statistical analysis of ROC curves including classification rate indices of sensitivity, specificity and accuracy of the different potential markers for armpit sweat samples in GC-MS allowed potential VOCs biomarkers to discriminate the COVID-19 patients as nonanal and aromatic compounds (up to 92% sensitivity, 97% selectivity, and 96% specificity), respectively, and validated the results by comparison with the RT-PCR gold standard technique.



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sciforum-085788: Toward Plantar Pressure Evaluation in Real Time-Based Wearable Audio-Biofeedback

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Introduction

Wearable audio-biofeedback (ABF) is emerging to provide real-time feedback to heighten both biomechanical and physiological outcomes. A novel ABF prototype was developed to acquire the signals provided by a pressure-sensitive insole, measure the plantar pressure (PP), and offer biofeedback in real time. This study aimed to investigate the short-term effect of the ABF system on PP and linear acceleration.

Methods

The ABF system based on Arduino micro (sample rate 34 Hz) was made with 10 force-sensing resistors (FSR402), an MPU-6050 triaxial accelerometer (ACC), and a headset for posture control based on ABF. Also, TRIGNO™ Wireless System assessed postural control using 10 triaxial ACC sensors (27 × 37 × 15 mm, with a sample rate of 148 Hz) placed on the spinous process of C7 and L5, the deltoid tuberosity of the humerus, the midpoint between the anterior superior iliac spine and the upper border of the patella bone, 15 cm above the lateral malleolus, and the anterior midpoint of the head of the III, IV, and V phalangeal metatarsus.

Results

Four participants (aged 29 ± 3.92 years) performed standing trials with the ABF system both ON and OFF. A significant improvement in posture control was shown based on PP and linear acceleration with the ABF ON. Higher PP ($p = 0.001$) was detected when the stimulus was ON, particularly in the middle and final right foot of the task. Notably, a significant modification of linear acceleration was observed in most sensors. Participants reported comfort in wearing the ABF device, highlighting its potential for practical use. The linear acceleration of the low-cost ABF system showed similar performance with that of the commercial system.

Conclusions

Our findings underscore the potential practical use of the ABF device for enhancing postural proprioception in outpatient clinical and home-based rehabilitation.



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Abstracts

Session H. Paper-Based Biosensors

sciforum-086936: A Lab-on-Paper Biosensor for ATP Quantification via a Chemiluminescent DNA Nanoswitch Assay

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Water is indispensable for life, yet many lack access to clean drinking water, resulting in fatalities from waterborne bacterial infections. Precise assessment of microbial abundance and viability in natural aquatic environments is vital. Adenosine triphosphate (ATP) serves as a parameter for viability assessments due to its presence in viable bacterial cells as an energy carrier. Traditional ATP detection methods involve chemical or enzymatic extraction, followed by measurement of light emission via the Luciferin–Luciferase complex. However, these methods are costly, present a low stability, require specialized equipment, and entail complex sample pretreatment. To overcome these limitations, we developed a biosensor based on aptamers, nucleic acid sequences with specific target-molecule-binding capabilities. Aptamers offer advantages such as an enhanced stability, a lower cost, and ease of design compared to antibodies. Recently, ATP has been used for aptamer selection testing. Our proposed biosensor utilizes a structure-switching ATP-binding DNA nanoswitch with two functional domains: a catalytic DNA-zyme domain and an ATP-binding aptamer domain. In the presence of ATP, its binding to the aptamer domain triggers the activation of the DNA-zyme domain, which is exploited for chemiluminescence (CL) detection. Integrating functional DNA biosensors with microfluidic paper-based analytical devices (μ PADs) holds promise for point-of-care (POC) applications. However, achieving proper DNA binding on paper remains challenging, often requiring solution-based assay protocols, leaving μ PADs for final signal readout. Here, we introduce an origami μ PAD with preloaded dried reagents, allowing for on-paper assay execution upon sample addition and proper folding. Paper functionalization strategies and assay protocols were optimized to ensure simple and straightforward detection of ATP, employing a portable charge-coupled device (CCD) camera for CL detection. Calibration curves plotted against the logarithm of ATP concentration in the range of 1 to 500 μ M facilitated determination of the assay's limit of detection (LOD), which was found to be 3 μ M.



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sciforum-086998: A Simple Paper-Based Microfluidic Device for the Rapid Detection of Inorganic Chemicals

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Microfluidic technology, also known as lab-on-a-chip, enables the fabrication of low-cost, user-friendly, and portable detection devices. Microfluidic chips can be utilized for detecting biological and chemical analytes in various liquid samples, including water or biofluids such as urine, blood, and sweat. The specific and quantitative detection of ions has garnered increased attention in recent years due to their potential harm to environmental and human health. Inorganic ions are special chemicals that hold positive or negative charges with relatively small molecular weights. Among the various types of microfluidic platforms, paper-based systems are favored as simple analytical tools that rely on the generation of hydrophilic–hydrophobic contrast on filter paper. In this study, a paper-based microfluidic device was developed as an analytical tool for quantifying several ions, such as iron (Fe^{3+}). The reaction spot was created by simply melting a wax crayon to form hydrophobic barriers that define hydrophilic zones. After spotting Fe^{3+} samples and potassium thiocyanate (KSCN) as a detection reagent on the reaction zone, an immediate and obvious color change was observed with different ion concentrations ranging between 50 and 500 ppm. While the naked-eye detection of color change was easy at high concentrations, quantifying ion concentrations in samples required the use of a smartphone camera. The captured images were then analyzed using ImageJ software. The developed paper-based microfluidic device exhibited good performance in quantifying Fe^{3+} ions in samples. Indeed, this simple platform is easy to store and transport, and allows the transportation of aqueous solutions without the need for external pumping or a power supply.



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sciforum-087040: Advancing Early Diagnosis of Alzheimer's Disease: An Artificial Intelligence-Driven Paper-Based Aptasensor for Detecting A β (1–42) and p-tau181 from Plasma Using CdTe Quantum Dots

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Alzheimer's Disease (AD), characterized by a gradual onset and a lack of exact therapeutic interventions, underscores the imperative for the development of uncomplicated and cost-effective biosensors capable of detecting its biomarkers. This necessity arises in anticipation of a projected surge in the incidence of AD. Quantum dots (QDs) represent the promising new generation of luminophores owing to their size, composition and desired optical properties. In this study, an Artificial Intelligence-driven paper-based QD aptasensor for the early detection of AD by targeting amyloid beta (A β -42) and p-tau181 proteins using Förster Resonance Energy Transfer (FRET) is developed. The sensor employs a Whatman paper with six sensing wells, integrating hydrophobic and hydrophilic regions, hydrophobic parts created through wax. Blood samples are placed in the inlet, dispersing into six sensing wells containing QD-aptamer-AuNP complexes. Target proteins induce conformational changes in aptamers, leading to fluorescence quenching in CdTe QDs due to FRET. Two wells target p-tau181, two target A β -42, and two serve as references. Fluorescence emission spectra from each well are recorded showing a linear correlation between fluorescence quenching and analyte concentration. Values from each pair of wells are then averaged, and the average values from the pairs targeting A β -42 and p-tau181 are compared to the average value of the reference wells. Subsequently, the performance of the sensor is enhanced with the Convolutional Neural Network algorithm and a user-friendly app for real-time results which takes the sensor images as input and outputs the biomarker levels of patients is developed. This facilitates monitoring and enabling long-term management of the disease and opens the avenue of personalized medicine for the diagnosis of Alzheimer's.



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sciforum-088442: Clinically Deployable 3D Cascade-Based Sensing Device for Diagnosing Kidney Disease

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Chronic kidney disease (CKD) has emerged as a significant contributor to morbidity and mortality in the 21st century. A bioengineered paper device has been created for the purpose of quantifying albumin in physiological samples. The paper surface was activated, and antibodies that are specific to the targeted biomarker were immobilized on the modified paper surface. Following the change, each subsequent step was characterized using FTIR, XPS, SPM, and optical analysis. Additionally, the device model was created via CAD files, and a three-dimensional cascade device was manufactured with an integrated continuous light source in order to establish a suitable and regulated environment for picture processing. Following the introduction of the sample onto the bioengineered paper, the subsequent occurrence involves the antigen–antibody reaction. The study of the image involved the utilization of an optical method, which entailed the identification of the image's area and the intensity of its color. The developed immunosensor's linear dynamic range has been reported to be 1–60 mg/mL, with a detection limit of 0.049 (± 0.002) mg/mL, spanning both the clinical and normal range of albumin in physiological samples. Furthermore, an assessment was conducted to determine the specificity of the immunosensor toward various compounds present in serum. The outcomes of this evaluation demonstrated a low level of cross-reactivity and a high level of performance. The device exhibited high precision and accuracy in determining the levels of albumin in the serum sample with the recovery % being between 88.14 and 97.70. The developed device has the potential to be employed in primary health care centers.



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sciforum-087039: Development of a Rapid Test for Tetrodotoxin Detection in Seafood

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Introduction

Intoxication by marine toxin tetrodotoxin (TTX) through the consumption of contaminated seafood has been consistently reported in Asia, and its recent emergence in Mediterranean Sea waters has been alarming. TTX impairs nervous signals, with the lethal dose for humans being 1–2 mg, and no antidote is known. A simple test for the rapid, cost-effective, and simple analysis of potentially contaminated food is thus required. The accurate detection of TTX relies on costly and time-consuming techniques due to its small size and the potential interferences from seafood components. Biosensors exploiting single-stranded DNA aptamers as bioreceptors have garnered increasing interest recently due to their high affinity and specificity, especially toward small-molecule targets. Our group previously reported the selection of novel TTX-binding aptamers for use in a hybrid sandwich assay in combination with an antibody. Herein, we report the development of a rapid lateral flow device (LFD) for the rapid and facile detection of TTX.

Methods

A TTX aptamer bioreceptor was immobilized on a nitrocellulose membrane, and an anti-TTX IgG antibody-gold nanoparticle conjugate was prepared for detection. Several parameters were optimized for enhanced sensitivity, and the device's stability was evaluated via an accelerated stability study. Finally, the device was used to detect TTX in extracts from contaminated pufferfish.

Results

The developed LFD successfully detected TTX in buffer and in contaminated pufferfish extracts in less than 30 min, exhibiting a limit of detection of ~0.3 ng/mL, suitable for TTX detection in seafood below the 2 mg TTX equivalents/kg limit established in Japan. No interferences were observed from other marine toxins, whereas the stability of the device was more than 1 year when stored at 4 °C.

Conclusions

The LFD based on an aptamer–antibody hybrid sandwich assay exhibited high sensitivity, specificity and stability, and its application in the rapid analysis of contaminated seafood was demonstrated.



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sciforum-087027: Dipstick Test for DNA-Based Identification of Olive Oil Cultivar Origin

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Introduction

We describe the first DNA biosensors for the identification of the cultural variety of olive oil, which is an important agricultural product. Because the varietal origin affects the quality characteristics, monovarietal olive oils with protected designation of origin are the focus of consumers and producers. Contrary to other tedious and costly methods, such as real-time PCR with fluorometric detection and capillary electrophoresis, the proposed biosensors enable visual detection by the naked eye without sophisticated instrumentation. Also, the proposed method is based on unique DNA markers rather than small metabolites and is therefore not affected by environmental/climatic changes, geographic origin, soil composition, harvesting period and storage conditions.

Methods

We performed simultaneous genotyping of four single-nucleotide polymorphisms corresponding to eight alleles. The steps are DNA extraction, quadruplex PCR of cycloartenol synthase and lupeol synthase, octa-plex genotyping by DNA polymerase (20 min) and application to the biosensor without prior purification. The biosensor is immersed in developing buffer and the detection requires 20 min.

Results

A red spot appears when an allele is present. The combination of red spots from eight alleles provides the genetic identity. The biosensors were applied, accurately and reproducibly, to the identification of seven olive varieties using DNA isolated from leaves and olive oil. The results were in full concordance with sequencing data. As low as 5 ng of extracted olive oil DNA can be used for PCR. The CVs were in the range of 0.5–9%.

Conclusions

Because of their simplicity and practicality, we anticipate that the proposed biosensors will find wide applicability in determining the authentication and traceability of olive oil.

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sciforum-089075: Hybrid Paper–Fabric Sandwich Structure-Based Micro-Analytical Device for Detection of Iodine

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This study presents a novel method for manufacturing microfluidic paper–fabric hybrid analytical devices (μ PFADs), which play a vital role in conducting diagnostic tests at the point of care (POC), especially in resource-limited environments. By circumventing the need for complex machinery or highly skilled operators, our method presents a practical solution for scaling up these POC devices. The approach involves the utilization of a folded paper structure featuring a specific pattern like a circular well or liner microchannel on either side of the fold as a mirror image, followed by inserting a piece of fabric in between the paper fold, thereby creating a sandwich-like structure. Subsequently, a PDMS (polydimethylsiloxane) elastomer with base and curing agents in a 10:1 ratio would be coated over the entire top paper and allowed to settle, enabling the penetration of PDMS down to the bottom paper through the sandwiched fabric. When sufficient PDMS penetration is achieved through visual changes on the back side of the paper, the sandwiched assembly is heated for polymerization of the PDMS. An embedded fabric-based POC device is obtained within the paper whose structure is defined by the designs on the folded paper itself. This micro paper–fabric hybrid analytical device (μ PFAD) offers several noteworthy advantages as it boasts rapid fabrication times and is cost-effective, without the need for any printing machines, thereby further enhancing its suitability for no- or low-resource environments. Experimental studies with these μ PFADs were conducted for the colorimetric detection of iodine, whose deficiency is a leading cause of thyroid disorders, particularly hypothyroidism. Here, starch acts as the chromogenic agent, which forms a blue-colored complex that shifts the color from purple to deep blue–black with increasing iodine concentration. The initial experimental results reveal contrasting color changes for varying levels of iodine using the proposed μ PFADs, which would be useful for the early diagnosis and management of thyroid disorders



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Abstracts

Session I. Optical and Photonic Biosensors

sciforum-087016: Monitoring Salivary Biomarkers in Astronauts during Spaceflight: A Versatile and Reusable Portable Microfluidic Biosensor Based on Functionalized Superparamagnetic Microbeads for Performing Multiplex Chemiluminescent Immunoassays

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Introduction: Portable and simple analytical devices to be used for routinary self-diagnostic applications are particularly attractive for space applications since the crewmembers must live in a microgravity environment for several months. The proposed work in the project APHRODITE (financed by Italian Space Agency) focused on the optimization of a dual-chemiluminescent immunoassay implemented onto a portable and easy-to-use platform for the quantification of two salivary hormones, cortisol and dehydroepiandrosterone (DHEA).

Methods: The method is based on the use of immunological techniques combined with chemiluminescent (CL) detection by exploiting a microfluidic channel integrated with a dedicated detector. Two aliquots of magnetic beads functionalized with anti-cortisol and anti-DHEA antibodies, respectively, were entrapped by magnets in two different areas along the microchannel. A solution containing the sample and the peroxidase conjugates of both DHEA and cortisol was injected to enable competition for binding the antibodies immobilized on MB surfaces. By adding the proper CL substrate, it was possible to monitor the CL signal in real time by employing an array of hydrogenated amorphous silicon (a-Si:H) photosensors. Once the assay was completed, by removing the magnets and performing the washing step, the microchannel was clean and ready to run a new assay.

Results: With this system, taking advantage of the possibility of magnetically confining the immunoprobes, chemiluminescence detectability, and photosensor sensitivity, the accurate quantification of target analytes down to 0.1 ng mL⁻¹ for cortisol and 0.05 ng mL⁻¹ for DHEA were obtained with high specificity and multiplexing ability.

Conclusions: Results confirmed the good detection capabilities and assay applicability of the proposed system, prompting the development of innovative universal tools used for multiplex assays that allow a health-related panel of biomarkers to be simultaneously monitored through a single analysis.



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sciforum-087026: Development of a Chemiluminescent Immunoassay for the Detection of Dehydroepiandrosterone in Counterfeit Cosmetic Products

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Introduction

Many countries have developed regulatory lists of banned or restricted cosmetic ingredients for ensuring the safety of cosmetic products. Among the banned substances, dehydroepiandrosterone (DHEA) is an hormone which can affect the biological processes in humans even at a very low level, but it is often illegally added to cosmetic formulations since it has an anti-ageing effect. The aim of this study is to develop a chemiluminescent (CL)-based immunoassay for the detection and quantification of DHEA in cosmetics.

Methods

The method involved the development of an integrated lab-on-a-chip platform, the assay was carried out in solution, and the detection was performed inside microwells coupled to a dedicated CL detector.

In this approach, magnetic beads (MBs), used as platform for the competitive immunoassay, were functionalized with anti-DHEA antibodies and were incubated with a solution containing the sample and the peroxidase conjugates of DHEA to provide competition for binding the antibodies. After the washing step, the MBs were added into a black microwell plate with a transparent bottom which was aligned with an array of hydrogenated amorphous silicon photosensors. After the addition of the proper CL substrate, it was possible to monitor the CL signal in real time.

Results

The developed method allowed for the accurate quantification of DHEA down to 20 ppb, and tests were performed on spiked cosmetic samples and suitably pre-treated.

Conclusions

The proposed assay demonstrated the possibility to exploit a rapid and simple CL-immunoassay for detecting counterfeit at very low level in complex cosmetic matrices. The method can be optimized in the future for different kinds of banned ingredients, allowing the number of target analytes that can be detect into a single analysis to be increased by exercising a multiplexing approach.



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sciforum-089167: Numerical Investigation of a D-Shaped Fiber-Optic Biosensor Utilizing Surface Plasmon Resonance for Early Cancer Cell Detection

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The field of biosensors has found great use for surface plasmon resonance (SPR), which has attracted attention for its multiple applications. With the goal of early cancer detection at the level of a single living cell, this research numerically investigates a very sensitive D-shaped fiber-optic biosensor based on surface plasmon resonance (SPR). The titanium oxide (TiO₂) is coated on gold (Au), which is utilized as a thin-film plasmonic material in the suggested biosensor structure. The guiding of light in the fiber is modeled using the finite element technique (FEM) when six different types of healthy human cells and their malignant counterparts are exposed to its sensitive region. Refractive index (RI) differences between cancer cells and healthy cells are found through the analysis of the optical spectra and their amplitudes. This enables us to identify small changes in the optical characteristics of cells that could be a sign of pathogenic alterations. In this work, we concentrated on three forms of cancer: skin cancer (basal cell) and breast cancer (MDA-MB-231 and MCF-7). The results show which parameters are optimal to ensure that the sensor performs well when used to detect the three types of cancer under study. When the suggested sensor's performance is compared to SPR sensors that have previously been published in the literature, it becomes clear that our sensor offers great promise for early cancer detection.



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sciforum-088272: A Spicy Recipe for At-Home Diagnostics: A Smart Salivary Edible Sensor for the Point-of-Care Diagnosis of Jaundice

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Introduction

Even though significant advances have been made, there is still a lack of reliable sensors capable of non-invasively monitoring bilirubin and diagnosing jaundice as the most common neonatal disease, particularly at the point-of-care (POC) where blood sampling from infants is accompanied by serious challenges/concerns. Aiming to address this utmost important necessity, we herein introduce a smart, easy-to-fabricate/use sensing bioplatfrom that enables the non-invasive optical monitoring of bilirubin in saliva at the POC.

Methods

Herein, the high sensing capability of curcumin as a natural edible pigment is demonstrated in paper-based assays for the optical monitoring of bilirubin in saliva. To measure and quantify the fluorescence signals of the developed sensing bioplatfrom, we fabricated an Internet of Things (IoT)-enabled hand-held optoelectronic reader, enabling the smart POC diagnosis of jaundice and its therapeutic monitoring by clinicians remotely.

Results

The sensing mechanism behind the selective response of our developed sensor for bilirubin is based on bilirubin photoisomerization under blue light exposure, resulting in the selective recovery of the bilirubin-induced quenched fluorescence of curcumin. The sensor exhibited a linear range (0.5–20.5 μM) with $r^2 = 0.984$, LOD = 0.2 μM , and intra- and inter-day RSDs between 1.8% and 4.9%. The clinical analysis of the saliva of eleven jaundiced infants using our developed sensor strongly proved that it is amenable to be widely exploited in POC applications for bilirubin monitoring as there are excellent correlations ($R = 0.994$, and $R = 0.99$) between its results and those of reference methods for saliva and blood. We also recommended an IoT-based model capable of meeting the Healthcare 4.0 prerequisites.

Conclusions

The developed smart salivary sensor is believed to be highly promising for exploitation in the ultra-low-cost, non-toxic, easy, and non-invasive smart diagnosis and therapeutic monitoring of jaundice, hepatitis, and other bilirubin-induced neurologic diseases at the POC and in patient/home-centric healthcare systems, since it meets all of WHO's REASSURED criteria for ideal diagnostic devices.



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sciforum-089010: An In-Depth Analysis of Peritoneal Dialysate Effluent Composition with a Deep-UV-LED-Based Affordable Optical Chromatographic Sensor

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Introduction

It was shown earlier that the use of Fast Protein Liquid Chromatography (FPLC) and low-cost deep-UV-LED-based optical chromatographic sensors with PD-10 desalting columns can facilitate monitoring of patients on peritoneal dialysis (PD). Previously, we established that the first peak in FPLC chromatograms is responsible for proteins and could be used for the assessment of peritoneal protein loss in patients with PD, while the origin and clinical significance of the other two peaks still remain unclear.

Methods

Optical absorption and fluorescence spectroscopy in the UV and visible regions 240–720 nm was used for the analysis of PD effluent fractions obtained with a chromatographic sensor with photometric detection at 280 nm; chromatograms of five samples were processed.

Results

The absorption and fluorescence spectra of the first fraction demonstrated peaks at 280 nm and 330 nm, respectively, which are characteristic of proteins. The absorption spectrum of the third fraction has maxima characteristics of creatinine and uric acid, while the second fraction surprisingly revealed no distinctive absorption bands. When it exited at 280 nm, the second fraction showed a single fluorescence maximum at 300 nm, while for the third fraction, there are maxima at 300, 300, 375 nm—the latter is characteristic of indoxyl sulfate.

For all three fractions, two fluorescence emission peaks are observed at longer excitation wavelengths, 300–320 nm, with the Stokes shifts of about 50 and 150 nm. The ratios of their amplitudes depend on the fraction. These peaks could probably be responsible for ascorbic acid, uridine, 3-indole acetic acid, and other metabolites.

Conclusions

It was demonstrated that deep-UV-LED-based affordable chromatographic sensors could provide sufficiently more information about PD effluents than just protein concentration, including the content of clinically significant metabolites, e.g., indoxyl sulfate. Moreover, the introduction of fluorescence detection could significantly improve the capabilities of such devices.



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sciforum-087017: An Innovative and Versatile Reconfigurable Sensor for Biomolecule Detection via Metal-Ion-Mediated Recognition

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Introduction

Reconfiguration of chemical sensors, meaning the capacity to adapt the sensor to new target analytes, is potentially game changing and would enable rapid and cost-effective reactions to dynamic changes occurring at different levels, although this is still a challenge. Here, we report on a reconfigurable label-free optical sensor leveraging versatile immobilization of a metal ion chelating agent on a nanostructured porous silica (pSiO₂) optical transducer for the detection of different biomolecules.

Methods

pSiO₂ scaffolds were functionalized with a modified silane, GLYMO-IDA, preliminarily derived from a condensation reaction between 3-glycidoxypyltrimethoxysilane (GLYMO) and iminodiacetic acid (IDA). When exposed to aqueous solutions of metal ions (e.g., Zn²⁺, Ni²⁺, Cu²⁺, Fe³⁺), GLYMO-IDA exhibits the ability to chelate them. The as-modified silane was employed as a receptor for biomolecules, leveraging the metal ions as pivotal points. The metal ion on GLYMO-IDA was easily switched by treating the pSiO₂ samples with a complexing agent.

Results

Successful functionalization of pSiO₂ scaffolds with the artificial receptors for various biomolecules was corroborated via UV-VIS spectroscopy and XPS analysis. After switching the metal ions from Cu²⁺ to Zn²⁺, the sensor was used in carnosine detection tests, proving its ability, in both configurations, to detect the target in a concentration range between 0.1 and 1 mM. Alternatively, by switching Cu²⁺ with Fe³⁺ ions, the sensor was successfully used for adenosine triphosphate (ATP) detection. A satisfactory sample-to-sample reproducibility was obtained (RSD: ~15%), along with an excellent repeatability (RSD: 2.5%) and stability (30 days).

Conclusions

A reconfigurable sensing platform was developed, and sensor reconfiguration was achieved by switching the metal ions from Cu²⁺ to Zn²⁺ and testing its ability to detect the dipeptide carnosine. Additionally, by switching Cu²⁺ with Fe³⁺ ions, the sensor was able to detect the target ATP, demonstrating effective reconfiguration of the sensor with the proposed surface chemistry.



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sciforum-087019: An Innovative Vapor-Phase Synthesis Approach to Obtain MIP-Based Optical Sensors for Label Free Detection of Quercetin

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Introduction: Quercetin (QU) stands out as the most abundant dietary bioflavonoid supplement, renowned for its anti-inflammatory, anti-oxidative, and anti-carcinogenic properties. However, the potential for harmful effects with excessive use necessitates vigilant monitoring. Consequently, continuous screening of QU assumes paramount importance. Various analytical techniques are employed for QU detection but simple and rapid approach are needed. Here, we proposed the use of an innovative vapor-phase polymerization approach to obtain polypyrrole (PPy)-based molecularly imprinted polymers (MIPs) for QU, within the nanostructure of porous silicon (pSi) photonic crystals, used as interferometers. The aim is to combine the recognition abilities of the MIP receptors with the optical properties of pSi to obtain a robust, selective and reusable sensor for QU.

Materials and Methods: Porous silicon (pSi) photonic crystals were initially fabricated through an electrochemical etching procedure on p++ silicon wafers. Subsequently, pSiO₂ layers were obtained via thermal oxidation of pSi at 1000 °C for 10 min. In a subsequent step, the QU target was anchored within the pSiO₂ layer, employing an imidazolidine-mediated coupling reaction. Afterwards, a vapor-phase polymerization of Py, developed by our group, was performed to obtain a thin film around the target. Successive removal of QU molecules from the polymer matrix produced the imprinted cavities and then the MIP.

Results and Conclusions: The functionalization steps were monitored by UV-VIS spectroscopy, which demonstrated the effectiveness of the MIP synthesis on pSiO₂. Preliminary detection tests showed that the sensor can detect QU in aqueous solutions in a dynamic concentration range between 0.005 to 0.1 mM. Moreover, the sensor selectivity was tested upon exposure to other antioxidant agents such as gallic acid and vanillic acid recording in each case a higher sensor response for the target molecule. Repeatability and stability tests along with QU detection tests in real matrices are in progress.

References

1. Mansour, F.R.; Abdallah, I.A.; Bedair, A.; Hamed, M. Analytical Methods for the Determination of Quercetin and Quercetin Glycosides in Pharmaceuticals and Biological Samples. *Crit. Rev. Anal. Chem.* **2023**, 1–26. <https://doi.org/10.1080/10408347.2023.2269421>.
2. Mazzotta, E.; Di Giulio, T.; Mariani, S.; Corsi, M.; Malitesta, C.; Barillaro, G. Vapor-Phase Synthesis of Molecularly Imprinted Polymers on Nanostructured Materials at Room-Temperature. *Small* **2023**, 19, 2302274. <https://doi.org/10.1002/SMLL.202302274>.



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sciforum-086939: Application of Random Forest ML Algorithm to Spectral Recognition of MD Vibrational Spectra of Nucleotides SERS Sensor Model

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The research on DNA/RNA and protein identification down to the single oligomer level has significant advances. Nanopore-inspired systems have been extensively developed for applications in genome sequencing and are being adapted for protein sequencing. The surface-enhanced Raman scattering (SERS) method has the detectability of single oligomers but includes spectral variations related to environments and conformations. The machine learning (ML) methods were successfully applied in the spectral measurements. Molecular dynamics (MD) can provide us with simulated vibrational spectra in various environment. Identification of oligomers can be done by an ML Random Forest (RF) algorithm that has shown high accuracy for the experimental SERS. We investigate the applicability of the RF algorithm to identify nucleotides by vibrational spectra in MD sensors. The ring-averaged vibrational spectra of the DNA nucleotides were used. The spectra were obtained in interaction with the system of Au nanoparticles attached to a graphene sheet with nanopore. The first step was to apply the baseline correction to the decay component of the velocity correlation function present in the MD vibrational spectra to adjust intensities because the intensity of the peaks becomes comparable with the subtracted decay component at low frequencies. The 20 points b-spline and piece-wise linear baseline corrections have been tested. The frequencies f , amplitudes I , and differences for adjacent grid points were used as training test for RF algorithm that has shown accuracy of 93–96% on the grid of some 170 spectral points. The RF algorithm identifies the methylated forms of cytosine and reproduces differences in nucleotide spectra. Still, the lower frequency part of spectra [1000 cm^{-1}] is reproduced with higher validity as compared to the higher frequency part above 1000 cm^{-1} for nucleotides.



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sciforum-089747: Blood Serum Clinical Chemistry through Spectroscopy—An Assement Case Study towards Direct Clinical Chemistry in a Single Drop of Blood

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Blood serum clinical chemistry is an essential part of clinical pathology diagnosis. Diagnostic parameters such as bilirubin (BIL), triglycerides (TRIG), uric acid (UA), urea (UR), creatinine (CRE), and myoglobin (MIO) are currently measured using reagent-based methods and wet lab chemistry, either at the clinical pathology laboratory by automated clinical chemistry machines (ACC) or at the point-of-care (POC). The use of reagents and fluids in technologies, such as chemo/biochips, restricts the application of POC technology to controlled environments and the need to manage consumables. Furthermore, blood is still collected by traditional venipuncture, centrifugation, or filtration to remove the cellular fraction, which increases the complexity of the operation and makes it less attractive for emergency or harsh scenarios. The current state-of-the-art limitations imposed by wet chemistry can be overcome using Spectral POC technology. In this study, we assessed blood serum chemistry using ultraviolet, visible, and near-infrared spectroscopy to relate spectral information to blood serum composition using self-learning artificial intelligence. This preliminary study demonstrated the feasibility of the direct detection of BIL, TRIG, UA, UR, CRE, and MIO. These parameters were determined with significant statistical agreement in terms of correlation (R) and total error (TE) with the ground-truth methods used in the clinical pathology laboratory, where (i). BIL: R = 0.99 and TE = 10.4%; (ii). TRIG: R = 0.84 and TE = 22.6%; (iii). UR: R = 0.82 and TE = 32.3%; (iv). CRE: R = 0.88 and TE = 20.9%; and (v). MIO: R = 0.96 and TE = 42.65%. These results show that it is possible to perform clinical chemistry in the blood serum without any reagents. Further research is necessary to enhance the detection of constituents with less absorbance and expand the range of parameters investigated to develop a system that can perform blood chemistry directly in a drop of blood without using reagents or with the need to remove the cell fraction.



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sciforum-088004: Colorimetric Methods of Magnesium Detection for Point-of-Care Heart Failure Management

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Heart failure (HF) continues to represent a leading cause of hospitalization and mortality worldwide, with an increasingly high prevalence as a result of population growth and ageing. HF patients are at higher risk of sudden cardiac death (SCD), which is frequently associated with the cardiac arrhythmias that can stem from electrolyte imbalances such as magnesium (Mg^{2+}) and potassium (K^+) deficiencies. Therefore, the regular monitoring of electrolyte levels can enable a timely identification of these depletions, improving patient management and outcomes.

In this work, calmagite (1-(1-hydroxy-4-methyl-2-phenylazo)-2-naphthol-4-sulfonic acid) was employed as a direct dye-complexing method to determine the concentration of Mg^{2+} in a sample. In an alkaline medium, calmagite is blue but, in the presence of Mg^{2+} , it forms a metallized reddish complex, whose color is concentration dependent. This method provided a fast response, which was determined using both a UV-Vis spectrophotometer and a smartphone camera for RGB (Red, Green, Blue) analysis. With an increasing Mg^{2+} concentration (0.005–0.3 mM), the ratio between the light absorbance at 620 nm and at 520 nm decreased, while the Red value increased, enabling detection. The specificity of the assay was tested using different ionic solutions that are present in body fluids, namely sodium chloride, calcium chloride and potassium chloride, with EGTA (ethylene glycol-bis(β -aminoethyl ether)-N,N,N',N'-tetraacetic acid) used to dampen calcium interference.

This research paves the way for this method's application at the point of care to monitor Mg^{2+} levels by demonstrating its rapid response, low limit of detection and simple instrumentation, aiming to improve HF management and prevent SCD.



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sciforum-086973: Detection of Aflatoxin M1 in Milk with a Mach–Zehnder Interferometric Immunosensor

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Aflatoxin M1 (AFM1) is the hydroxylated form of Aflatoxin B1 (AFB1) and is expelled in the milk of both humans and animals following the consumption of AFB1-contaminated food. AFM1 has been categorized as a Group 1 carcinogen by the International Agency for Research on Cancer. Consequently, the European Commission has established a maximum allowable concentration of 50 pg/mL for AFM1 in dairy products and milk. Here, a rapid and sensitive approach for detecting AFM1 in bovine milk is presented. The analytical setup comprises a broad-band white LED, a spectrophotometer, and a silicon photonic probe, all interconnected by a bifurcated optical fiber [1]. Additionally, a laptop powers the system and facilitates signal monitoring through specialized software. The silicon photonic probe is equipped with two Mach–Zehnder interferometers: one functionalized with AFM1-bovine serum albumin conjugate, and the other with bovine serum albumin to serve as a blank. The analysis involves immersing the probe directly into a mixture of anti-AFM1 antibodies and the sample, followed by sequential immersion into biotinylated anti-rabbit IgG antibody and streptavidin solutions. The entire assay process takes 12 min, and the limit of detection in undiluted milk is 20 pg/mL, below the EU maximum allowable limit of 50 pg/mL. The assay demonstrates accuracy, with %recovery values ranging from 87.5 to 112%, and repeatability, with intra/inter-assay coefficients of variation below 7.6%. Given its analytical performance and compact instrumentation, the proposed immunosensor proves to be an ideal solution for precise on-site determination of AFM1 in milk samples.

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Reference

1. Angelopoulou, M.; Makarona, E.; Salapatias, A.; Misiakos, K.; Synolaki, E.; Ioannidis, A.; Chatzipanagiotou, S.; Ritvos, M.A.; Pasternack, A.; Ritvos, O.; et al. Directly immersible silicon photonic probes: Application to rapid SARS-CoV-2 serological testing. *Biosens. Bioelectron.* **2022**, *215*, 114570.



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sciforum-089825: Detection of Interleukin 6 in a Sprague Dawley Rat's Blood Plasma Using a Fiber Optic Biosensor with Long-Period Grating

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The severity of various diseases is related to the concentration of interleukin 6 (IL-6), a proinflammatory cytokine crucial for the proliferation and differentiation of immunocompetent and hematopoietic cells. In ischemic cerebrovascular disease, it is known that, after traumatic injury, increased plasma levels of IL-6 are associated with neuronal inflammation and brain death. Research has shown that elevated plasma IL-6 levels within the first 12 h after an ischemic vascular event are strong predictors of early mortality. Therefore, developing a device that can detect the presence of IL-6 in a murine model of induced ischemic disease could be beneficial for monitoring the disease and selecting the appropriate treatment in the future. This study aimed to detect IL-6 using biosensors developed within optical fibers; the biosensors were assembled using a self-assembled monolayer technique. Subsequently, detection was carried out using samples from rats (Sprague Dawley strain) with an induced ischemic disease. Samples were left to interact with the sample for 2 h to characterize the changes in the sensor's transmission response. Both the response of the biosensor to IL-6 and the self-assembly steps were characterized by transmission spectroscopy at wavelengths of 1250–1450 nm and micro-MIR spectroscopy. Spectral changes were observed at different stages of the assembly and detection processes. By performing a PCA on the experimental data, it was possible to observe the clustering of the different assembly stages and the final detection. This allowed for discrimination not only at the stage of the biosensor's construction but also in its detection of IL-6.



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sciforum-086784: Investigation of a Camera-Based Contactless Pulse Oximeter with Time-Division Multiplex Lightning on Piglets for Neonatological Applications

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Objective

The purpose of the study is to create the basis for non-contact monitoring of premature babies in neonatal intensive care units.

Methods

A contactless pulse oximeter is presented which measures the arterial oxygen saturation and heart rate with a monochrome camera and a time division multiplex controlled illumination with three wavelengths (660 nm, 810 nm and 940 nm). The related hardware setup and the signal processing is described in detail. The newly developed technology as prototype was used for the first time on an animal model.

Results

Using the camera system and our new designed algorithm for further analysis, the detection of heartbeat and calculation of the oxygen saturation was evaluated. Under ideal conditions, heartbeat and respiration were separated clearly by flat breathing and only minor intervention. In this case, the saturation can be determined with an mean difference of 0.7%.

Conclusions

The general functionality of the sensor can be guaranteed by the results of the presented experiments under ideal conditions. The results allow a systematic improvement for the further development of contactless vital sign monitoring systems.

Significance

The results presented here are a major step towards the development of an incubator with non-contact sensor systems for use in the neonatal intensive care unit.



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sciforum-089749: Non-Invasive Hemogram Analysis: A Step towards an Optical Bracelet Wearable Device

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Blood hemograms are an essential part of the clinical pathology diagnosis. This is especially important for chronic or acute conditions that require blood transfusions (e.g., anemia, cancer, hemophilia, and kidney and liver diseases). The capacity to monitor hemogram parameters using a wearable device without blood withdrawal is evaluated in this study using ultraviolet, visible, and near-infrared spectroscopy transmittance measurements simulating the wrist vein. Tylose gel and catheter tubes representing internal and near-surface wrist veins were studied to simulate different anatomical characteristics (e.g., skin tone, thickness, and depth of the monitored vein). The results showed that diffusive transmittance through the anatomical surrogate can correctly quantify the hemogram in terms of red blood cells (RBC), hemoglobin (Hgb), and discriminate levels of total white blood cells (WBC), achieving the following correlation (R) and total error (TE) against laboratory automated hematology machines: (i). RBC: $R = 0.85$ and $TE = 5.9\%$; (ii). Hgb: $R = 0.81$ and $TE = 5.25\%$; and (iii). WBC: $R = 0.78$ and $TE = 12.0\%$. These results demonstrate the possibility of performing a hemogram analysis without blood withdrawal using diffuse reflectance spectroscopy and artificial intelligence. Further research is necessary to evaluate the efficiency of different optical designs to be incorporated into a wearable bracelet system for noninvasive blood hemogram analysis.



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sciforum-089212: Nonspecific Staining of Protein Receptor Layers as a Quality Control Method for SPRi-Based Multiplexed Biosensing

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Surface Plasmon Resonance Imaging (SPRi) is a versatile biosensing platform for protein microarrays. It enables high-throughput, label-free analysis of various analytes in a multiplex format. However, the critical process of protein immobilization poses challenges, particularly in ensuring a reliable and reproducible receptor layer formation, which is essential for the validity of analyte determination. In the SPRi technique, protein immobilization on the chip occurs *ex situ*, making it challenging to monitor and resulting in an undetermined surface density of immobilized receptors. An optimal protein receptor layer requires reproducible fabrication with controllable density and homogeneous distribution of proteins while preserving their biological activity. A method of protein microarray quality control is yet to be developed, which emphasizes the need for a reliable assessment approach.

This study utilized commercially available protein dyes (Coomassie Brilliant Blue G, Amido Black, and Ponceau S) to map and characterize the quality of protein receptor layers by means of SPR and SPRi studies. Various factors influencing dye–protein binding were investigated using covalently immobilized model proteins (rabbit IgG and transferrin) on mixed -COOH monolayers or carboxylated PEG. Additionally, DNA-directed immobilization, allowing for protein–DNA conjugate immobilization through hybridization with complementary sequences, was explored. This study examined the appropriate pH and ionic strength for efficient protein staining and tested the effect of buffer composition on DNA double helix stability and dye intercalation. The association and dissociation constants of the dyes, along with the correlation between dye–protein and protein–antibody interactions, were determined. The results contribute valuable insights for developing a versatile quality control method for protein receptor layers immobilized using varied procedures. The presented approach seems to be very promising for evaluating the reliability of SPRi biosensors.



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sciforum-085127: Novel Thiophene-Derived Schiff Base as a Fluorescent Sensor for the Highly Sensitive and Selective Relay Recognition of Zn^{2+} and Fe^{2+} Ions

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Chemosensors based on Schiff bases are pivotal in environmental and biological applications, serving to identify specific metal ions at trace levels. Despite the distinctive importance of thiophene-based molecules in medicinal contexts, the number of reported chemosensors utilizing these moieties remains limited.

In this study, we present the synthesis and characterization of a novel Schiff base sensor (TBH), derived from thiophene-2-carboxaldehyde and benzil. We investigate its application as a selective relay probe for the detection of Zn^{2+} and Fe^{2+} ions.

The introduction of Zn^{2+} to TBH resulted in a significant enhancement in fluorescent intensity, attributed to the formation of a 1:1 TBH- Zn^{2+} complex, with no response observed for other cations, including Mg^{2+} , Ba^{2+} , Cd^{2+} , Cu^{2+} , Co^{2+} , Mn^{2+} , Cr^{3+} , Hg^{2+} , Sn^{2+} , La^{3+} , Ca^{2+} , Na^{+} , K^{+} , and particularly Fe^{2+} . Furthermore, Fe^{2+} induced fluorescence quenching in the TBH- Zn^{2+} system, forming a 1:1 MY- Fe^{2+} complex. The TBH- Zn^{2+} complex demonstrates potential as a secondary sensor for Fe^{2+} ions. The sensor's signal change is based on the chelation-enhanced fluorescence (CHEF) effect of TBH- Zn^{2+} , coupled with the inhibition of photoinduced electron transfer (PET).

Moreover, the rapid and selective features of the proposed sensor make it promising for the precise monitoring of Zn^{2+} and Fe^{2+} in biological and environmental research.



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sciforum-089185: Optical Detection of Uric Acid Using Bimetallic Co-Doped NaYF₄:Er³⁺/Yb³⁺ as Fluorescence Probe

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Uric acid (UA) optical biosensor was developed in this study. Nanocomposites were synthesized using NaYF₄: Er³⁺/Yb³⁺ as the matrix and iron, cobalt, and copper (as dopants) at different ratios, in a one-pot hydrothermal treatment. Nanocomposites were prepared with different ratios of Co and Cu while concentration of Fe was constant for all the variants. The detection of UA is based on measuring change in fluorescence signals of the nanocomposites in presence and absence of UA. Fe, Co, and Cu shows peroxidase-like activity which was used for oxidation of o-phenylenediamine (OPD) to 2,3-Diaminophenazine (DAP) in presence of uricase (UAO) to catalyze UA. The co-doped NaYF₄: Er³⁺/Yb³⁺ nanoparticles emit upconversion fluorescence with four typical emission peaks centered at 490 nm, 540 nm, 660 nm, and 800 nm under 980 nm near-infrared (NIR) irradiation which are attributed to transition from ²H_{9/2}, ⁴H_{11/2}, ⁴F_{9/2} and ⁴I_{9/2} to ground state ⁴I_{15/2}. DAP shows absorbance near 450 nm, the emitted fluorescence at 490 nm gets quenched due to the inner filter effect. All the variants show quenching of fluorescence signal at 490 nm with different intensities. Intensity of blank signal with respect to (I_{490(o)}/I₄₉₀) were measured and are in proportion to UA concentration. Under optimized conditions, colorimetric and ratiometric linear range sensing for UA was 0.1–1 mM. Ratiometric fluorescence detection limit (S/N = 3) was 0.66 μM. These results shows that the synthesized nanocomposites have great capability for the detection of UA using colorimetric and ratiometric dual-readout assay methods.



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sciforum-089203: Optical Enzymatic Biosensor for the Determination of Heavy Metals in the Lagoon of La Paz, Baja California Sur, Mexico

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An optical crystalline silicon biosensor was developed for the detection of heavy metals in surface water, deep water, mollusks and sediment in the lagoon of La Paz, Baja California Sur, Mexico, to monitor the presence of heavy metals, the biosensor was built using self-assembled monolayers, the silicon supports were cut with a diameter of 0.5 cm × 0.5 cm, chemical modifications were made on the surface by adding KOH to obtain Si-OH groups, for the functionalization this was carried out by 3-aminopropyltrimethoxysilane to add NH₂ groups on the surface of the biosensor, the activation was with EDC/NHS as a crosslinking agent, Finally, the urease enzyme was immobilized on the surface of the biosensor in an orbital shaker at 100 rpm in PBS and proceeded to detect each of the concentrations of standard heavy metals methylmercury chloride, cadmium, lead, chromium oxide VI, arsenic oxide III and silver iodide at different concentrations. Subsequently, detection was performed on biological samples by taking the internal part of tissues placed in PBS under refrigeration and water samples were measured without treatment. The self-assembly and detection was characterized by FTIR in the region from 370 to 4000 cm⁻¹ taking the region from 1000 to 1200 cm⁻¹, 1500 to 1700 cm⁻¹ and from 2800 to 3100 cm⁻¹ as the most important regions for the principal component analysis, showing that in these regions the characteristic bonds of silicon are present, The functionalization showed the region of the primary and secondary amide and finally the detection was taken as the inhibition of the enzymatic activity, the principal component analysis showed the region where the detection of each heavy metal is performed and corroborates the results obtained in FTIR.



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sciforum-089065: Optical Sensor-Based Assessment of Bio-Waste Levels for Home Water Safety Monitoring

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Access to clean water is a pressing global challenge, particularly in households where water quality is compromised by various factors, including bio-waste contamination. This issue is especially acute in developing countries where clean water access is limited. In response, this study introduces a novel multispectral sensing approach tailored for assessing bio-waste levels in household water, thus enhancing water safety monitoring capabilities.

The method leverages cutting-edge optoelectronic technology and microelectronics to detect and quantify bio-waste particles in liquid water. Through the integration of optical sensors with advanced electronic circuits, the system enables the seamless collection, processing, and analysis of optical data, providing a cost-effective and user-friendly solution for effective water quality monitoring.

Real-time monitoring facilitated by optical sensors allows for timely interventions to mitigate health risks associated with bio-waste contamination in water consumption. The utilization of electronic circuits ensures the reliability and accuracy of data, empowering users to make informed decisions regarding water usage and consumption habits.

Ultimately, the primary aim of this research is to empower households to safeguard the health and well-being of their family members by ensuring access to clean and safe drinking water, particularly in the presence of bio-waste contamination. By addressing the urgent need for localized bio-waste-related water safety management, this approach offers a practical solution to a critical issue.

Furthermore, the study underscores the importance of leveraging technology to tackle bio-waste contamination challenges, especially in resource-constrained environments where traditional monitoring methods may fall short. By harnessing the power of optical sensing and microelectronics, scalable solutions for clean water access at the household level are developed.

In conclusion, the integration of optical sensor-based assessment of bio-waste levels represents a promising avenue for enhancing home water safety monitoring capabilities, thereby significantly contributing to improving public health outcomes.



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sciforum-087038: Raman Detection of Algae on a Silica Substrate

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The imperative to accurately monitor algae growth and composition stems from their pervasive impact on ecosystem dynamics. Algae serve as early indicators of environmental changes, making their precise assessment crucial for identifying shifts in ecological balance. The information gleaned from such monitoring is pivotal for implementing targeted conservation efforts and sustainable practices, thereby safeguarding the delicate equilibrium of ecosystems. As integral components within the intricate tapestry of ecological processes, algae play indispensable roles in environmental health by facilitating crucial functions such as oxygen production and carbon dioxide absorption, and serving as the cornerstone of aquatic food chains. Positioned as stewards of ecosystem equilibrium, the accurate monitoring of algal growth and composition becomes paramount for comprehending the intricacies of ecosystem dynamics and fostering sustainable environmental practices.

This paper initiates a comprehensive exploration of the revolutionary potential inherent in Raman spectroscopy, with a specific focus on its application to a silica substrate. The distinctive attributes of Raman spectroscopy, marked by its non-invasive nature, rapid data acquisition, and label-free analytical capabilities, position it as a formidable tool poised to unlock intricate molecular insights into the composition of algae. In this context, the research methodology entails a meticulous experimental setup designed to harness the unique capabilities of Raman spectroscopy for the detection and characterization of algae on a silica substrate. By ensuring the uniform deposition of the algal samples, the study seeks to guarantee consistent and reproducible analysis.



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sciforum-088485: Rapid Colorimetric Detection of *Xanthomonas oryzae* pv *oryzae* Using Unmodified Gold Nanoparticles and Target-Specific DNA Probes

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Xanthomonas oryzae pv *oryzae* (*Xoo*) causes bacterial leaf blight, a devastating disease in rice crops worldwide. Early diagnosis is critical to limit economic losses. We report a rapid, cost-effective colorimetric biosensor using unmodified gold nanoparticles (AuNPs) and a novel *Xoo*-specific DNA probe for visual detection of the pathogen. The detection strategy exploits the surface plasmonic property of AuNP solutions that shifts their color to purple/blue upon probe–target binding-induced nanoparticle aggregation. AuNPs were functionalized with probes complementary to a conserved *Xoo* genomic sequence. Genomic DNA was extracted from pure *Xoo* cultures and infected rice leaf samples. Aggregation was evaluated after mixing probe-functionalized AuNPs with DNA samples. The color change from red to purple was visually observed within 5 min of mixing probe AuNPs with as little as 5 ng/μL of purified *Xoo* DNA and 0.5 g of infected leaf tissue. No color change occurred using DNA from healthy plants or other pathogens, indicating a high specificity. This assay offers a simple, rapid, and field-deployable colorimetric method for visual detection of *Xoo* with a high sensitivity and specificity. The unmodified AuNPs and specific probe provide a cost-effective alternative to PCR-based methods. This biosensor has immense potential for on-site diagnosis and management of bacterial leaf blight in rice plants.



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sciforum-089472: Single-Cellular Electroanalytical Chemistry at Micro-Nano Interfaces

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Knowledge on the behavior of an individual cell is of critical importance because even genetically identical cells showed large variation. It has become an essential project to design and develop single-cell in-situ analysis techniques with high sensitivity, high selectivity, and high spatiotemporal resolution in the field of analytical chemistry. Aiming at urgent challenges in the field of single-cell analysis, such as the low sensitivity and background interference, we proposed many new mechanisms for electrochemical analysis and constructed a lot of high-sensitive optoelectronic micro-nano interfaces. With these new optoelectronic micro-nano interfaces, the applicant developed a series of single-cell imaging techniques to solve scientific problems. For example, the applicant proposed Fermi level-charge theory that straightly decreases the detection limit of faraday current to attoampere level, six orders smaller than current methods, which allows for the observation of single-molecular level electron transfer events. we elucidate the intracellular factors that determine this output limit by monitoring the respiratory-driven shrinking kinetics of a single magnetite nanoprobe immobilized on a single *Shewanella oneidensis* MR-1 cell with plasmonic imaging. We proposed label-free structural color microscopy and demonstrated that *Shewanella oneidensis* MR-1 cells show unique structural color scattering, changing with the redox state of cytochrome complexes in the outer membrane. it provides a potential platform for further exploring the electron transfer mechanism of subcellular structure.



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sciforum-089744: Spectroscopy Human Hemogram Analysis—A Feasibility Case Study

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Blood hemograms are an essential part of the clinical pathology diagnosis. These are currently performed in the clinical laboratory using automated hematology machines (AHM) to discriminate blood cells by capillary laser scattering technology. Despite all the efforts in this miniaturization through microfluidics, this approach may not be appropriate for use at point-of-care (POC) under harsh or non-ideal operational conditions. AHM already uses low volumes of blood samples, but the blood is still collected by traditional venipuncture, and quantification of cells and hemoglobin still requires the use of reagents. A way to allow POC technology to be used in the harsh conditions of emergency medicine is to remove both venipuncture procedures and reagents. Research in canines and felines has demonstrated that hemogram analysis using reagent-less spectral technology at the point-of-care (POC) with an ultra-portable device that requires a single drop of blood is feasible for quantification with analytical-grade quality red blood cells (RBC), hemoglobin (Hgb), and hematocrit (HTC). Such POC uses solely ultraviolet, visible, and near-infrared spectroscopy to unscramble spectral information related to blood composition using self-learning artificial intelligence, providing unequivocal advantages in terms of convenience, real-time results, pain-free procedure, and reduced risk of infection. Herein, we demonstrate the feasibility of direct detection of RBC, Hgb, and HTC counts in human blood using spectral POC technology for medical applications. The results showed excellent agreement in terms of correlation (R) and total error (TE) against the ground-truth method, where (i). RBC: $R^2 = 0.84$ – 0.77 , $TE = 7.3$ – 5.7% ; (ii). Hgb: $R = 0.74$ – 0.85 and $TE = 4.9$ – 6.4% ; and (iii). HTC: $R = 0.74$ – 0.80 and $TE = 5.5$ – 7.6% . Spectral POC demonstrates promise as a method for conducting rapid and simple point-of-care hemogram analyses in human patients. Further research is necessary to enhance and confirm the instrument's accuracy and to expand the range of parameters examined.



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sciforum-089134: The Development and Standardization of a U-Bent LSPR Fiber Optic Biosensor to Screen for Parvovirus B19 IgM

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Introduction

Nearly 50% of the adult population has been exposed to parvovirus B19 (B19V). B19V has an elevated risk of transmission through blood and blood products as it is resistant to common inactivation procedures. Multiple studies have documented high IgM seroprevalence among blood donors that were recently exposed to B19V which could pose a risk to blood safety programs. This study aimed to develop a lateral surface plasmon resonance (LSPR) U-Bent *fiber optic biosensor (fob)* that could screen B19V IgM.

Methods

Linear epitope against B19V was identified using Bepipred2.0 and commercially synthesized. The epitope was validated using ELISA against synthetic IgM control and then was tested against clinical B19V IgM samples. A label-free method was employed to mount the biotinylated epitope on the LSPR *fob* and then test the absorbance against B19V IgM. A bump in spectral absorbance curve indicated the sample was positive for B19V IgM. The *fob* was calibrated at each step measuring the pre- and post-wash absorbance reading to accommodate the different buffers.

Results

The epitope demonstrated suitable reactivity against B19V IgM as demonstrated by ELISA. The label-free method was suitable in the identification of low levels of synthetic B19V antibody with similar detection indices to B19V ELISA.

Discussion

Individuals who screen B19V IgM-positive (that indicates recent infection) can then be screened for B19V DNA. The transfusion of B19V DNA-positive blood and blood products can lead to severe consequences for individuals who are hematologically stressed or immunocompromised. Multiple studies have documented the importance of screening for B19V especially among blood donors by the introduction of routine screening into their national blood safety programs. A sensitive and specific rapid test such as this LSPR *fob* would be very beneficial in the B19V screening.



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sciforum-089751: Towards On-Site Dairy Cow Mastitis Diagnosis in Your Pocket

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Mastitis has a significant impact on animal welfare and dairy industry profitability (regular losses 5–25%, outbreaks 85%), which is the main reason for antibiotic use (risk to the food chain). Diagnosis is based on clinical observations and measures of the inflammatory response by somatic cell counts (SCC) in milk (crucial in quality and salubrity, with limits of 400,000 cells/mL in the EU and 750,000 cells/mL in the US). SCC is a late indicator of mastitis in milk, while early diagnosis is possible by an increased WBC count in the blood, suggesting probable mastitis (prevention). WBC react to inflammation, are released into the bloodstream, and migrate to the mammary gland to fight infection. Furthermore, the SSC value does not discriminate which cells are being counted, as this value can comprise the number different types of white blood cells and mammary gland cells. In this preliminary study, we recorded spectra of fresh milk obtained from 50 cows during milking. The milk collected was sent to a certified laboratory for butyric acid (TB), total protein (TP), urea (U), and SSC. This preliminary test using a spectroscopy point-of-care system provided the following metrics for on-site quantification: (i). TB: $R = 0.79$ and $TE = 10.0\%$; (ii). TP: $R = 0.94$ and $TE = 2.8\%$; (iii). U: $R = 0.73$ and $TE = 12.0\%$; and (iv). SSC: $R = 0.72$ and $TE = 12\%$. These results demonstrate the possibility of performing a direct measurement of both milk quality and mastitis detection using reagentless POC spectral technology. Further research is necessary to evaluate the efficiency of POC in large-scale studies, as well as its capacity to discriminate between mammary and immune system cells and the presence of bacteria in milk.



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sciforum-088909: Ultrasensitive Lateral-Flow Immunoassay Based on Magnetically Modulated Fluorescent Nanodiamonds and Machine Learning Enhancement

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Fluorescent nanodiamonds (FNDs) now underlie cutting-edge quantum precision measurements, owing to the rigorous spin qubit out of their negative-charged nitrogen vacancies (NV^-) that are manipulable and scalable at ambient conditions (the DiVincenzo criteria). Though the FND-based ODMR (optically detected magnetic resonance) technique has already achieved an ultimate sensitivity down to the subcellular organelle or even monomolecular levels, confocal microimaging as a benchmarked setup must cohere microwaves with the Zeeman-split ± 1 states (3E in spectral terms) of a rare single particle in a programmed pulse sequence. It is not easy to integrate such intricate instrumentation into some transportable benchtop devices, and then adapt these devices for point-of-care testing (POCT) scenarios in dire needs, for instance, a PCR-free dipstick reader that can be used for inspection during the COVID-19 pandemic in a resource-limited community.

The individual quantized eigenvectors of multiple NV^- spins in an FND ensemble can actually be modulated in unison once subjected to a strong alternating magnetic field (≥ 50 mT in our case), which would provide not only a nanofabricated chip-set for microwave coherence, but also the lens group for feeble signal amplification. By surface chemistry, biotinylated FNDs of a uniform size (~ 10 nm) were tagged with the model SARS-CoV-2 N-protein antibodies as a probe upon the Conjugate Pad of a lateral flow test strip. Following the standard LFA protocol, well-dispersed FNDs mounted on the T line, where their blinking photoluminescence emissions ($\lambda_{em} = 632$ nm, excited at 543 nm) were routed out via an optical fiber, were recorded and further processed with machine learning quantum computation for lock-in enhancement of timelapse captures in a swift and streamlined fashion.



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sciforum-086870: Ultrasensitive Surface-Plasmon-Resonance-Based Biosensor for Efficient Detection of SARS-CoV-2 Virus in Near-Infrared Region

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The COVID-19 pandemic has motivated scientists to delve deeper into this area and create cutting-edge biosensors that have the potential to enhance sensing beyond the current state of the art in terms of cost and accuracy. Several sensors for virus detection have been developed using chemical and electrochemical approaches as their foundations. Nevertheless, achieving high performance and accurate identification is not trivial. Surface plasmon resonance (SPR)-based optical biosensors are one method to capture very minute changes accurately via label-free sensing. This work offers a numerical approach for an ultra-sensitive multilayered SPR-based biosensor that uses angular interrogation in the near-infrared (NIR) region to detect the novel coronavirus (SARS-CoV-2). The multi-layered biosensor consists of a plasmonic metal, a dielectric layer (MgF_2), and optimized 2D nanomaterial (MoS_2) layers. In order to achieve high sensitivity, the figure of merit (FoM), and detection accuracy, the proposed plasmonic sensor was engineered using the transfer matrix method and finite element method after a thorough investigation. This includes the selection of plasmonic metal and optimization for the different layers. Using the strong binding efficiency of the MoS_2 layer and the high dielectric constant of the MgF_2 layer, the biosensor configuration comprising a glass prism/ $\text{Al}/\text{Au}/\text{MgF}_2/\text{MoS}_2$ /sensing sample is observed to exhibit the highest sensitivity of $372^\circ/\text{RIU}$, FoM of 1690 RIU^{-1} , and detection accuracy of 4.54 degree^{-1} . According to the investigation's findings, the proposed biosensor numerically exhibits excellent performance in the NIR region, making it easier to employ in the field of biomedical sensing applications.



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sciforum-089748: Urinalysis without Reagents—A Case Study

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Urinalysis is a noninvasive clinical chemistry method that is essential for human diagnosis. It is one of the most convenient body fluids that can be regularly monitored. Parameters such as urea (UR), uric acid (UA), creatinine (CRE), total protein (TP), and amylase (AMY) are commonly used in urinalysis. Urine analysis is now commonly performed at the point-of-care of test strips using colorimetric reactions. Similar reactions are used in the wet-lab approach in the clinical pathology laboratory. Spectral Point-of-Care can eliminate the use of reagents, allowing simple, fast, and consumable-free measurements. Herein, we present a case study of urinalysis using ultraviolet, visible, and near-infrared spectroscopy to relate spectral information to urine composition using self-learning artificial intelligence. This preliminary study demonstrated the capacity for direct detection of UR, CRE, TP, and AMY. These parameters were determined with significant statistical agreement in terms of correlation (R) and total error (TE) with the ground-truth methods used in the clinical pathology laboratory, where (i). UR: R = 0.79 and TE = 15.5%; (ii). UA: R = 0.82 and TE = 25.1%; (iii). CRE: R = 0.77 and TE = 24.6%; (iv). TP: R = 0.74 and TE = 25%; and (v). AMY: R = 0.9 and TE = 14.5%. These results demonstrate the possibility of performing clinical chemistry on urine without any reagents. Further research is necessary to enhance the detection of constituents with lower absorbance and expand the range of parameters investigated to develop a system that can perform urinalysis with a drop of urine.



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