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nanoBalkan2023 Foreword

On behalf of the Local, International and Technical Committees, we take great pleasure in welcoming you to Tirana (Albania) for the NanoBalkan International Conference (NB2023).

The 1st edition of NanoBalkan is being launched following the overwhelming success of the last 2 events organised in Albania i.e. TNT2021 and TNT nanoBalkan2022.

This high-level scientific meeting aims to present a broad range of current research in Nanoscience and Nanotechnology as well as related policies or other kind of initiatives such as nanoAlb. The NanoBalkan2023 structure will keep the fundamental features of the previous events organised in Albania, providing a unique opportunity for broad interaction. During NanoBalkan several specific sessions on hot topics will be organised: Graphene and 2DM, AI for Advanced Materials, nanobiosensors, nanomedicine, etc.

We are indebted to the following Institutions and Government Agencies for their financial support: Ministry of Education and Sports of Albania, Academy of Sciences of Albania and Constructor.

We also would like to thank all the exhibitors (SUSNANO, Netpore COST Action, PalmSens, ATLANT 3D, Constructor and Biotek Solutions), speakers and participants that join us in-person this year.

In addition, thanks must be given to the staff of all the organizing institutions whose hard work has helped planning this conference.

Hope to see you again in the next edition of NanoBalkan.

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NanoBioSensors School (TUE. Oct. 17)	Satellite Workshop Project Management (TUE. Oct. 17)
Satellite Workshop SUSNANO (WED. Oct. 18)	Satellite Workshop NETPORE (WED. Oct. 18)
Satellite Workshop Albania, Italy and Spain (WED. Oct. 18)	Satellite Workshop Albania, Japan and Spain (THU. Oct. 19)
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nanoBalkan2023 Speakers list

Virtual Staining of Label-free Tissue Using Deep Learning

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In this presentation, I will provide an overview of our recent work on using deep neural networks in advancing computational microscopy and sensing systems, also covering their biomedical applications. Specifically, I will discuss emerging opportunities to revolutionize tissue staining methods by digitally generating histological stains using trained deep neural networks[1-11], providing rapid, cost-effective, accurate and environmentally friendly alternatives to standard chemical tissue staining methods. These deep learning-based virtual staining techniques can successfully generate different types of histological stains,[1,11] including immunohistochemical stains,[7] from label-free microscopic images of unstained samples by using, e.g., autofluorescence microscopy,[1] quantitative phase imaging (QPI)[2] and reflectance confocal microscopy[10]. Our team also demonstrated similar approaches for transforming images of an already stained tissue sample into another type of stain, performing virtual stain-to-stain transformations [5,6,11].

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Micromotors Go In-Vivo: From Test Tubes to Live Animals

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Abstract
Nanoscale robots that can effectively convert diverse energy sources into movement and forces represent a rapidly emerging and fascinating robotic research area. Such nanoscale robots offer impressive capabilities, including greatly enhanced power and cargo-towing forces, multi-functionality, easy surface functionalization, and versatility. The new capabilities of modern nanorobots indicate immense potential for a variety of biomedical applications, and should have major impact on disease diagnosis, treatment, and prevention [1,2]. Recent *in vivo* applications using different types of biocompatible and biodegradable microrobots will be illustrated, including enhanced drug delivery towards enhanced treatment of stomach or lung infections, active vaccine delivery, autonomous gastric fluid neutralization, microrobot pills for oral delivery, or efficient intracellular delivery of functional proteins and nucleic acids.

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Biomarkers for health effects of exposure to advanced materials in mixtures

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Abstract
This presentation will discuss the recent developments in human biomonitoring efforts for early disease detection resulting from exposures to inhaled or ingested (engineered) nanoparticles in mixtures. Advanced materials have reached large scale production and have become widely used in consumer goods due to their superior technical performance. Workers and consumers are being exposed on a regular basis to these materials across the product life cycle, from synthesis to end-of-life. Newer scenarios that involve advanced materials and chemistries (e.g. hybrid surface functionalized nanoparticles in polymers) have gained interest due to the re-emergence of aggressive forms of old lung diseases such as acute lung failure, accelerated silicosis, COPD and asthma. We will draw from our group's research and major developments in the field to address four major themes: (i) innovative study designs that meet sample size/power needs and limited budgets; (ii) biomarker selection and its trade-offs, with an emphasis on three distinct options- a single biomarker, curated panels of biomolecular markers, or multi-omics; (iii) association vs causation, especially as it relates to the role of advanced materials in the observed outcomes; and (iv) interpretation of the clinical utility of biomarkers in the absence of upper normal clinical reference values. We will use examples from the commonly measured biomarkers of oxidative stress and inflammation to illustrate some of the challenges and progress to-date.

Figures

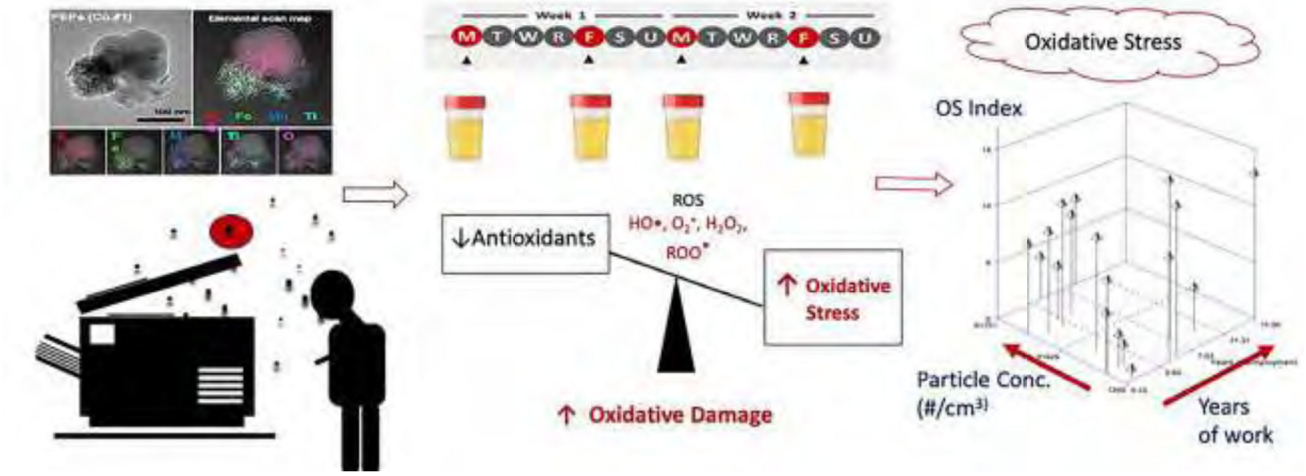

Figure 1: Example of urinary markers of oxidative damage in print shop operators.

Electrochemical Control of Solid-Contact Ion-Selective Electrodes

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Abstract
Elimination of the internal filling solution of polymer membrane-based conventional ion-selective electrodes (ISEs) in 1971 initially aimed at producing miniaturized, inexpensive and robust ion sensors [1]. Gradually, the importance of the ion-to-electron transduction process at the interface between the ionically conducting ion-selective membrane and the electronically conducting electrode substrate was realized [2]. Over the years, various ion-to-electron transducers, including conducting polymers, nanostructured carbon materials and other functional nanomaterials, have been explored to improve the analytical performance of solid-contact ion-selective electrodes (SC-ISEs) [3-5]. Extensive research in our group has resulted in new methods to electrochemically control the response behaviour of SC-ISEs using poly(3,4-ethylenedioxythiophene) (PEDOT) as the ion-to-electron transducer [6]. By utilizing the electrochemical properties of PEDOT it is possible to control and reset the standard potential of SC-ISEs [7, 8]. Furthermore, the redox (pseudo)capacitance of PEDOT can be used to convert a potentiometric signal into a coulometric one for SC-ISEs [9-15]. This latter coulometric transduction method allows amplification of the analytical response of SC-ISEs [9-12], resulting in improved precision compared to classical potentiometry [13]. The coulometric transduction method has been evaluated for determination of various cations and anions by SC-ISEs [14, 15]. Furthermore, Bakker's group has shown that the coulometric method can be used to detect very small pH changes, down to 0.001 pH units [16], and it also provides a route towards self-powered ion sensors [17].

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Our research centre of excellence 'IDUN' covers activities in nanosensors and microfabricated devices for oral drug delivery. This allows us to explore the synergy between sensor development and search for new pharmaceutical characterization/delivery tools and materials. I will show examples of recent findings and results within drug/polymer characterization, microdevices for drug delivery [1, 2] and diagnostics. Also, new applications within therapeutic drug monitoring using Surface Enhanced Raman Scattering [3, 4] will be presented as well as centrifugal microfluidics platforms for cell growth [5].

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Figure 1: Example of microdevice for oral drug delivery. This is a self-unfolding foil that aligns to the intestinal wall (rat or pig). Hereby, we have, among others, achieved oral delivery of insulin [2]

Thermal scanning probe-based greyscale nanopatterning applied to 2D materials

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Abstract

Thermal scanning probe lithography (t-SPL) that uses a heated AFM probe to induce locally thermal phase changes in materials has become a reliable nanolithography tool [1]. One distinct advantage of t-SPL is that it does not involve charged particle and resist development steps, thus enabling the patterning of fragile materials systems that would otherwise fail by conventional lithography methods. One further benefit of t-SPL is its excellent grey-scale patterning capabilities, thanks to the inherent closed-loop AFM-type of writing and reading. Such surfaces are of interest in photonics and nanofluidics, but also in the field of 2D material strain engineering.

This paper will present an overview of the current state of the art in t-SPL and probe design, and will show recent results obtained for t-SPL based deterministic patterning and straining of 2D materials [2, 3]. The latest improvements in a key nanomanufacturing step related to pattern transfer by dry etching from the thermal resist PPA into solid dielectrics such as SiO_2 is also shown [4].

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Figures

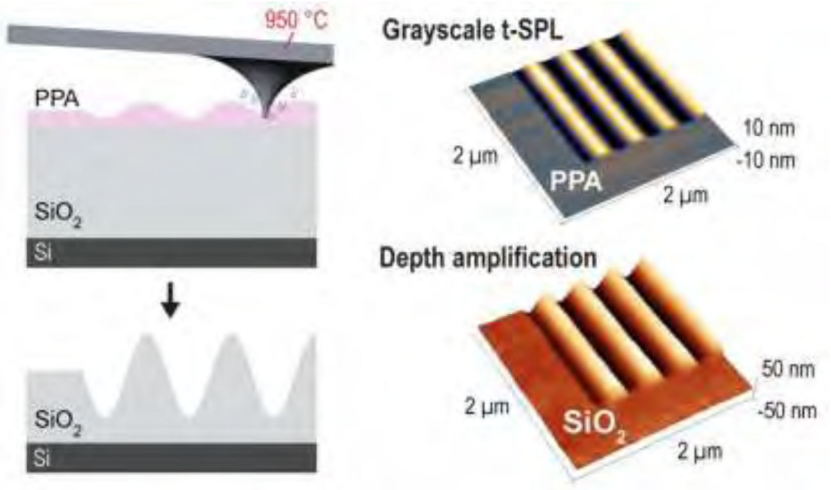

Figure 1: Schematics (left) and AFM profiles (right) of t-SPL patterns after writing in PPA and after etch transfer into SiO2. The sinusoidal surface profile can be amplified without shape distortion and without increasing surface roughness.

Empowering the genome, methylome and immune response with modern electrochemical biosensing: a new journey towards precision medicine

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The indisputable role played by genome, methylome and the immune system in the most prevalent diseases, such as cancer or neurodegenerative diseases, as well as in other unexpected ones, such as COVID-19, is clearer than ever. The interrogation of specific mutations and methylations in nucleic acids as well as the aberrant production of circulating immunoglobulins against self or external antigens associated with the onset and progression of cancerous, infectious and neurodegenerative diseases, among others, are considered highly predictable and valuable alarm signals about their triggering in the sophisticated machinery that makes up our organism. Moreover, since diseases are generally characterized by broad molecular marker profiles with considerable overlap between different diseases, the need for multiplexed molecular marker profiling approaches becomes particularly important.

Combining the unique opportunities offered by targeted proteomics for candidate antigen identification and state-of-the-art multiplexed electrochemical biosensing with the advantages of using magnetic materials and novel bioreceptors produced by modern technologies (HaloTag, Phase Display and targeted mutation), disruptive multiplexed and multi-omics technologies have been developed, allowing not only to discover but also to determine and evaluate the clinical potential of new molecular markers to advance both research and the implementation of precision medicine in cancer, Alzheimer's and viral infectious diseases. The biotools developed have allowed the detection of specific mutations and methylations in nucleic acids in cancers with high prevalence and mortality [1] and the discovery of new molecular signatures of autoantibodies against tumor antigens (circulating [2], exosomal [3] or proteoforms [4]) and against phage-display and aberrant peptides [5] for the early, accurate and minimally invasive diagnosis of colorectal cancer and Alzheimer's disease and of specific immunoglobulins against ectodomains of the SARS-CoV-2 spicule protein produced by targeted mutation [6]. The versatility of the latter bioplatforms to identify vulnerable populations from those with natural or acquired immunity, monitor infection, evaluate vaccine efficacy, and even identify the variant responsible for infection is remarkable.

The excellent results provided by the developed biotools, in terms of sensitivity, selectivity, ease of use and accessibility for all users, not only corroborate the potential genome, methylome and immune response-related molecular markers for advancing research and implementation of precision medicine but also reveal the great versatility and potential of the cutting-edge targeted proteomics-electrochemical biosensing-bioreceptor trio to provide relevant information on key aspects of known and unexpected diseases, as well as on their onset, severity and immune response, enabling their rapid, simple, affordable and precision management in diverse settings.

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Carbons dots as sensors, carriers and catalysts.

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Abstract
The paper will summarise the last decade of my team's research on carbon dots. Prior to 2014 the team worked on semi-conductor dots as sensors for water contaminants and markers in physical systems [1] but in 2014 realised that the perceived toxicity of such dots would hinder their acceptance into environmental and biomedical fields. As such we moved to carbon dots demonstrating in a seminal paper [2] in 2015 how by controlling precursors and the formation process carbon dotes could be formed with a controlled fluorescent across the visible light range from blue to deep red. Further it was demonstrated that the fluorescence was largely controlled by the surface groups on the dot particularly the oxygen and nitrogen containing groups. Worked advanced to demonstrated that the surface functional groups could be manipulated to allow the dots to act as sensors including for Copper ion and L-cysteine [3]. If the functional groups were correctly selected and formed, then they could be tuned to bind to specific analytes in solution. This binding would disrupt the passivity of surface and decrease the florescent. The degree of the fluorescent decrease was found to be proportional to the concentration of the analyte in solution. Additional work demonstrated that the carbon dots in appropriately doped and with the correct surface groups could act as catalyst. In one application [4] it was demonstrated that given a small concentration of hydrogen peroxide the dots could catalyse the formation of oxygen and hydroxyl radicals that could promote the breakdown on water contaminants such as dies including methylene blue. Iron doping was found to be particularly effective in enhancing this catalytic activity which may have been related to the development of a strong negative charge of the dot that attracted the contaminant. The most recent work has been the use of dots carriers of RNA-i into the leaves of plants . the dot/RNA-i complex can be sprayed onto the plant leaves where it penetrates the cells of the plane leaves and may act to reduce insect or microbial attack. The work has applications across the environmental (water sensors) , bio-engineering (numerous) and plant/food industries (RNA-I delivery) . Two additional bio -applications worthy of note are the impregnation of bandages with dots to both signal the onset of infections and to act as anti-microbial agents[5] and the use of dots to make fibres used in the human body as sinters and meshes more visible by X-ray post operation when they need to be removed. The science behind all these applications as well as the engineering will be outlined

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Photocatalytic nanostructures and nanocomposites: sustainable solutions for tackling environmental challenges

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In the last decades, increasing concerns have been arisen on environmental issues related to decontamination of environment from different pollutants, including organic compounds and microbial species. The development of effective and sustainable materials, methods and technologies is critical for tackling the needs of environmental protection.
In particular, the recent advances in the control of nanoscale materials and in the investigation of photocatalytic processes for degradation of organic pollutants and inactivation of bacteria and viruses in water envision a new scenario for nanoscience-inspired design, synthesis, and formulation of industrially relevant catalytic materials for water remediation. [1-2]
Original synthetic approaches have been developed to achieve diverse catalytically active nanoparticles, with peculiar size dependent optoelectronic and catalytic properties, with controlled size, shape, also coupled or doped with relevant compounds, and in multifunctional nanocomposites, providing flexible and versatile tools to access an innovative class of multifunctional materials with superior photocatalytic properties in the UV and visible range. In addition, realization and control of composite particle architecture over multiple length scales are fundamental for catalyst scale-up and large-scale manufacturing as well as for their exploitation in specific chemical processes, including design and realization of advanced reactors based on properly fabricated reusable and recoverable catalysts.[3]

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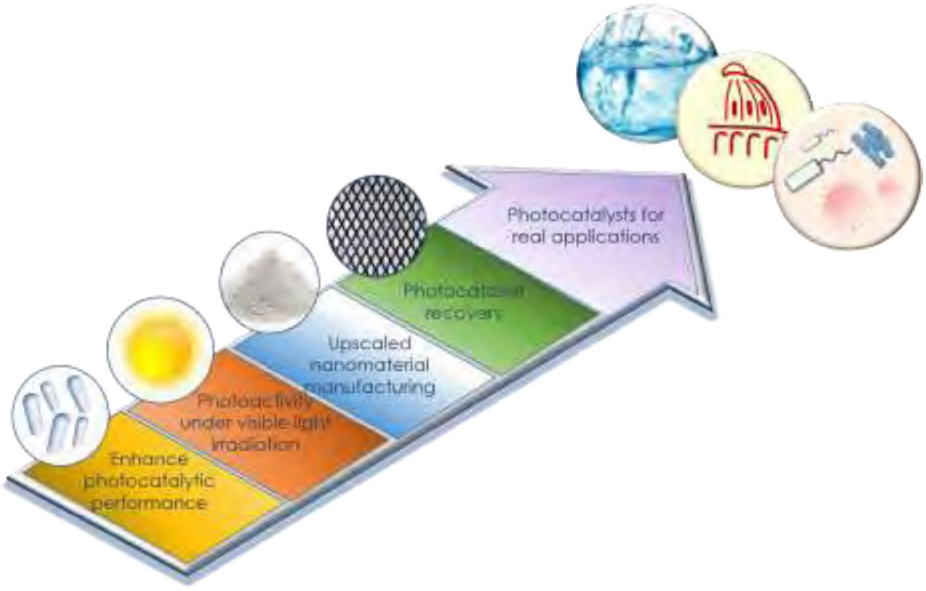

Figure 1: Sketch of strategies for photocatalytic nanomaterials development to improve performance and enable integration in real applications

Plasmonic Solid State Nanopores for single biomolecule identification

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Sequence identification of peptides and proteins is central to proteomics. Protein sequencing is mainly conducted by insensitive mass spectroscopy because proteins cannot be amplified, which hampers applications such as single-cell proteomics and precision medicine. The commercial success of portable nanopore sequencers for single DNA molecules has inspired extensive research on proteins based on electrical or optical readout. In this regard, a large variety of nanopores, both biological and solid state have been developed. The typical working principle consists in delivering DNA molecules into the pores and detecting the variations of ionic currents caused by the translocation of the molecule (in analogy with Coulter counter). Similarly, methods based on optical readouts have been developed. However, when moving from DNA to proteins some major challenges remain: (1) DNA bases are just 4 against the amino acids which are 20 hence their discrimination only by using electrical current levels or colorimetric readout is extremely difficult; (2) spatial and temporal resolution (sensitivity) to detect single amino acids within the same molecule; and (3) controlling the motion of proteins into the nanopores. In this context, the emergence of label-free optical analysis based on plasmonic enhancement shows great promises to address the first two challenges [1]. In fact, plasmonic nanopores can both confine and amplify the local electromagnetic field into the pore (challenge #2). The confinement improves the spatial resolution while the amplification helps to increase sensitivity. Notably, Raman spectroscopy provides unique molecular fingerprints to discriminate amino acids (challenge #1). Here we show our latest results on plasmonic nanopores combined with Raman Spectroscopy for single-amino-acid identification within single peptides. In fig 1 is reported a sketch representing the concept: a gold plasmonic nanopore is fabricated on silicon nitride membrane (passing through). Molecules in solutions are delivered into the pore by means of electrophoresis and detected by plasmonic enhanced Raman scattering. Notably, the system shows the ability to record and discriminate the twenty amino acids at a single-molecule level [2]. In addition, we discuss the manipulation of molecule translocation and liquid flow in plasmonic nanopores for controlling molecule movement and for enabling high-resolution reading of protein/molecule sequences [3]. We envision that a combination of Raman spectroscopy with plasmonic nanopores can succeed in single-molecule protein sequencing in a label-free way.

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Figures

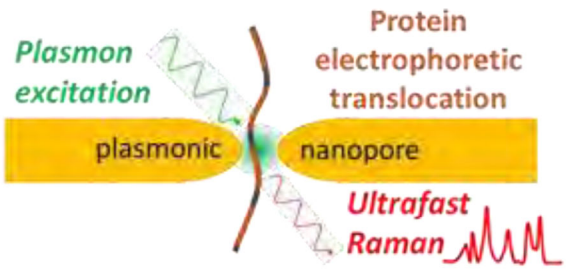

Figure 1: Sketch representing the concept of single molecule identification by means of Raman fingerprint.

Soft and Compliant Digital Materials for Wearable Healthcare Monitoring

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Wearable healthcare monitoring has the potential to revolutionize the way we approach healthcare, providing patients with real-time insights into their health and enabling doctors to access continuous monitoring of vital signs. However, to achieve this goal, we need to develop materials that are soft, compliant, and easy to integrate into clothing and other wearable devices.

In this presentation, we will discuss our work at BioEngine in developing digital materials that meet these requirements. Our research focuses on creating materials that are comfortable for patients to wear, while also providing accurate and reliable data on their health.

We'll discuss our findings on how novel materials can be used in medical implants, and how the soft and compliant properties of these materials make them ideal for wearable healthcare monitoring. We'll also explore how these digital materials can be integrated seamlessly into clothing, making it easier for patients to collect reliable data on their health, wherever they go.

Through this research, we aim to advance the field of wearable healthcare monitoring and create new opportunities for personalized healthcare

Electrochemical application of boron-doped diamond electrodes: Electrochemical sensors and CO_2 reduction

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Boron-doped diamond (BDD) electrodes are very attractive material, because of their wide potential window, low background current, chemical inertness, and mechanical durability.[1] In these years, we have reported several examples for electrochemical sensor applications including novel microsensing systems for in vivo real time detection of local drug kinetics.[2] Furthermore, applications for electrochemical organic synthesis[3] and electrochemiluminescence (ECL) systems[4] are also reported. Here, recent developments on electrochemical CO_2 reduction using BDD electrodes are presented.

In 2018, we investigated the electrochemical reduction of CO_2 in a flow cell using BDD electrodes. The faradaic efficiency (FE) for the production of HCOOH was as high as 94.7%. Furthermore, the selectivity for the production of HCOOH was more than 99%. The rate of the production was increased to 473 μmol $m^{-2}s^{-1}$ at a current density of 15 mA cm^{-2} with a FE of 61%. The FE and the production rate are almost the same as or larger than those achieved using Sn and Pb electrodes. In addition, the stability of the BDD electrodes was confirmed by 24 hours operation.[5]

Then, in 2019, we were able to control the selectivity and efficiency with which carbon monoxide (CO) is produced by optimizing certain parameters and conditions used in the electrochemical process with BDD electrodes, such as the electrolyte, the boron concentration of the BDD electrode, and the applied potential. With a BDD electrode with 1% boron used for the cathode and $KClO_4$ for the catholyte, the selectivity for producing carbon monoxide was high. On the other hand, with a BDD electrode with 0.1% boron used for the cathode and KCl for the catholyte, the production of formic acid was the most evident. *In-situ* ATR-IR measurements during electrolysis showed that $CO_2^{\bullet-}$ intermediates were adsorbed on the BDD surface in the $KClO_4$ aqueous solution. Here, switchable product selectivity was achieved when reducing CO_2 using BDD electrodes.[6]

Recently, in order to operate on a large scale for industrial applications, an intermittent flow cell system was presented. A stop-start motion of the flow conditions in the intermittent cell was created using a piston pump, and this considerably increases the rate of electrochemical conversion of CO_2 to HCOOH compared to a continuous flow system.[7] Furthermore, we found that an initial electrochemical CO_2 reduction reaction could significantly improved the reaction current and Faradaic efficiency of the CO_2 reduction on BDD electrodes.[8] The effect is referred to as the "self-activation" of BDD. Here, the mechanisms and the effect of self-activation is discussed.

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Nanomaterials enriched biosensors for electrochemical monitoring of nucleic acid interactions

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Abstract
The development of nanomaterials enriched biosensors could impact significantly the areas of genomics, proteomics, biomedical diagnostics and drug discovery since these nanomaterials have some advantages as unique electronic, optical, mechanical, and catalytic properties. Especially they hold a great potential for monitoring of sequence-specific nucleic acid hybridization related to clinical, environmental, or forensic investigations [1,2].
Numerous nanomaterials such as, carbon nanotubes, metallic nanoparticles, graphene and its derivatives, fullerenes, carbon nanofibers etc. have different applications in drug delivery, cancer therapy, tissue engineering and diagnosis including biosensors [3-5].
After the discovery of electroactivity in nucleic acids in 1959 [6], there has been a great interest to develop electrochemical methods for DNA analysis, including electrochemical biosensors. Electrochemical DNA biosensors have an inherent specificity of biorecognition reactions with the high sensitivity of physical transducers in order to analyze sequence-selective nucleic acid hybridization and the interaction of nucleic acids with drugs, proteins, DNA-targetted molecules [1-4,7-11]. Recent developments of electrochemical nucleic acid biosensors based on various nanomaterials have been overviewed herein, and discussed with their further prospects.

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Arzum Erdem express her gratitude to the Turkish Academy of Sciences (TÜBA) as the Principal member for its partial support.

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Micro swimmers-based collective biosensing for *in vitro* diagnosis: what is next?

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The utilization of self-propelled micromotors in (bio)chemical assays has led to a fundamentally new approach where their continuous collective movement around the sample and the mixing associated effect greatly enhances the target-receptor interactions and hence the performance of the bioassay [1-3].

In our lab, we are focusing on the design and development of micromotors which are constituted by (nanostructured) layers (tubular-based shape) and particles (Janus-based shape) that confer them self-propulsion using (photo)-catalytic propulsion and magnetic guidance with compatibility in biological media due its tremendous significance [4-6]. They also smartly incorporate nanomaterials and molecular recognition-based functionalization to obtain sensitivity and exquisite selectivity on board using electrochemical and fluorescence detection approaches. Also, we have explored the coupling of micromotors even with electrochemical microfluidics. In our experience, we humbly found that micromotor technology is an attractive alternative to performing fast, and reliable bioassays and diagnostic testing, especially when an extremely low volume of samples is available or when the analysis must be performed in a micro-size environment.

In this communication, selected micromotors-based bioassays with potential in diagnostics, and some future directions will be discussed. But ultimately, we try to answer the talk title's central and disturbing question.

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Skin-Interfaced Wearable Biosensors

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Abstract

The rising research interest in personalized medicine promises to revolutionize traditional medical practices. This presents a tremendous opportunity for developing wearable devices toward predictive analytics and treatment [1–3]. In this talk, I will introduce our efforts in developing wearable biosensors for non-invasive molecular analysis. Such wearables can autonomously access body fluids (e.g., human sweat) across the activities and continuously measure a broad spectrum of analytes including metabolites, nutrients, hormones, proteins, and drugs [4–10]. Laser engraving and inkjet printing are used to manufacture high-performance nanomaterials-based biosensors at large scale and low cost [6,7]. The clinical value of our wearable systems is evaluated through various human trials toward precision nutrition, stress/mental health assessment, chronic disease management, and drug personalization [4–10]. I will also discuss our research progress on energy harvesting from the human body and the environment to realize battery-free wireless wearable sensing [11–13]. These wearable technologies could open the door to a wide range of personalized monitoring, diagnostic, and therapeutic applications.

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Innovation in Nanomaterials Synthesis: from Lab to Commercialization

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Nanoengineering plays a pivotal role in optimizing nanomaterials to achieve enhanced performance and impressive mechanical stability, especially in challenging environments. Recent research has been dedicated to the creation of various novel composite materials, encompassing high entropy and multi-elemental nanoparticles, as well as the integration of stable single-atom catalysts onto robust supporting nanomaterials to ensure highly efficient catalytic performance. Effective catalyst design is essential not only for the advancement of chemical sensors but also for energy devices like lithium-air batteries, water-splitting, and CO2 conversion, and more. These active nanomaterials, including catalysts, must resist agglomeration, maintain high thermal stability during repetitive reactions, and necessitate minimal catalyst content for maximal performance. This presentation delves into diverse applications employing electrospun polymer fibers, metal oxide fibers, and carbon fibers. The presentation also outlines an expedited and optimal process for catalyst attachment onto electrospun nanofiber backbone structures. Lastly, a case study traversing the journey from laboratory research to commercialization spotlights the utilization of custom-made electrospinning equipment, roll-to-roll machines with nozzle arrays spanning 35 cm and 1.2 m widths. As electrospinning relies on solution-based processing, we can create a range of fiber types, including colorimetric, thermochromic, and antivirus fibers. Finally, I will conclude by offering insightful perspectives on innovative material synthesis using electrospinning and highlighting interesting case studies of device application.

Functional Materials for a Sustainable Innovative Industry

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Today science is essential to enable comfort and welfare, as well as prosperity to regions and countries. This implies fostering the creativity of scientists and consequent innovations to support the current societal challenges. In this respect, advanced materials offer a variety of solutions that are based on the idea that "Materials are everywhere even in our body!". Within these solutions, it is vital to consider the reuse of residues, recycling and circularity to serve a Green Agenda and bring an eco-sustainable environment, as we do not have a planet B as alternative solution!
In this regard, the future of our planet will have advanced materials at the heart of our progress and cannot be thought of as an isolated cluster. In fact, the role of advanced materials is to foster several economic sectors, by exploiting materials on their multiple latitudes to provide outstanding structural and functional applications of materials, particularly by understanding the nanoscale, as this is the scale by which the digital, bio and physical worlds can communicate and interact.
The aim of this presentation is to contribute towards the future, where advanced materials are the driven force for the societal and economic sustainable transformations required for a plethora of applications, namely in the fields of electronics, energy, and health.

Indirect electrochemical grafting of organic molecules

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Aryl diazonium salts are considered as excellent reagents for surface modification due to their ability, once electrochemically or chemically reduced, to create aryl radicals that strongly attach to a variety of material surfaces (ranging from all types of carbon, metals and metal oxides, semiconductors and polymers). [1] As very reactive species, aryl radicals are prone to tether the substrate surface or to attach to already grafted aryl moieties and form a multi-layer. A part of aryl radicals generated near the electrode surface, may undergo other reactions in the solution such abstraction of the hydrogen atom from the solvent, acetonitrile or methyl amine [2,3] a vinylic monomer or an alkyl or aryl halide RX, or RX. These H or X atom abstractions enable the formation of alkyl radicals that react immediately with material surface. Last reactions are particularly advantaged when aryl radicals are prevented to react with substrate surface due to the steric hindrance, as is the case with 2,6-dimethylphenyl radicals issued from 2,6-dimethylbenzen diazonium salt (2,6-DMBD), figure 1. [4,5] This approach is important as it permits the indirect electrochemical grafting of alkyl and aryl groups at mild conditions via a radical crossover reaction and there is a high positive potential shift, > 1.7 V compared with direct electrochemical reduction of RX or ArX. [6] Recently we have been able to graft acrylate monomers or vinyl ferrocene onto gold, iron, copper and different carbon types by abstracting a H atom from acrylate or vinyl monomer. [7]

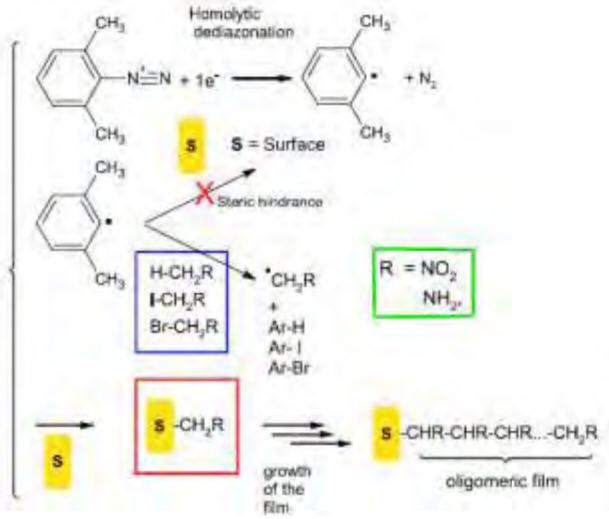

Fig. 1. Indirect grafting of solvent, alkyl or aryl halides through C-H, C-I, C-Br activation with 2,6 - dimethylaryl radical obtained by electrochemical reduction of the corresponding diazonium salt. [5]

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A nanometer scale perspective of soil reactions and processes occurring at mineral surfaces: Implications for contaminant fate and transport and carbon cycling.

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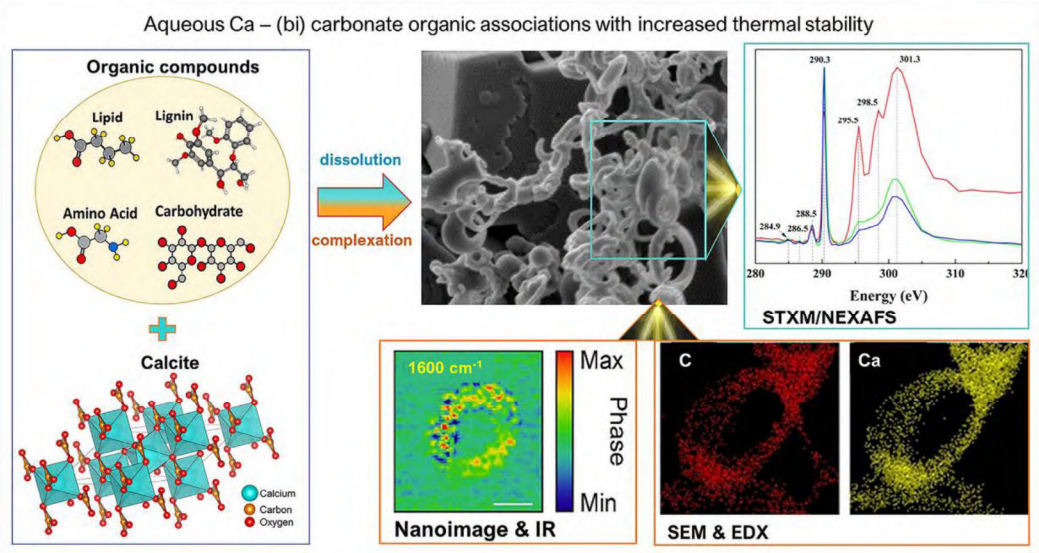
Significant advances have been made over the last years towards a better understanding of the reactions and processes occurring in soils at molecular and nanometer scales which affect and/or control contaminant interactions with minerals and organic matter transformation and persistence in soils. In this presentation, the focus will be, ***firstly***, on a paper published recently in Science about natural, incidental, and engineered nanomaterials and their impacts on the Earth system. ***Secondly***, a summary of recent publications on the role of soil minerals in controlling contaminant mobility (e.g., nano Fe oxides and calcium carbonate), which serve as hosts for different contaminants, will be presented. Iodine, chromium, and uranium are three contaminants of concern at the Hanford site in southeastern Washington (USA) and are part of the clean-up effort of the legacy waste at the site. Geochemically aided remediation by chemically trapping of iodine, chromium, and/or uranium in naturally occurring mineral lattices can help expedite and reduce costs involved in the cleanup and may be a reliable method for similar remediation efforts across the globe. ***Thirdly,*** the presentation will be focused on soil organic matter nano-scale interactions with minerals. With approximately 80% of Earth's terrestrial carbon being stored in soil, this carbon pool contributes significantly to the global scale carbon cycle. Soil organic matter can associate strongly with high surface area minerals, providing a mechanism for aggregation and organic matter stabilization. The presentation will summarize findings included in recent publications, which systematically probed physical, chemical, and molecular-level and nano-scale interactions at the organo-mineral interface, to directly quantify these interactions at the nanometer length scale and provide parameters for models to better predict the role of soil organic matter on the carbon global cycle. Data will be also presented on in-situ observations of soil mineral particles as they form aggregates in the presence and/or absence of organic matter using liquid cell transmission electron microscopy.



Taken from Qafoku et al., 2023 Environmental Science: Nano 10 (5), 1504-1517.

The gigantic energy consumption problem of our IT technologies… Artificial Intelligence at rescue?

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Abstract

In this talk, I will discuss some of the great challenges that our Information Technologies are facing today in terms of data storage and energy consumption. The gigantic needs for data storage facilities in a society of massive information processing and with the emergence of Artificial intelligence at all levels of technologies accelerate the crucial demand for developing low-energy dissipative devices, circuits and technologies together with the development of sustainable energy power sources.

Here I will illustrate the use of AI (machine learning) technique to boost the innovation in materials by presenting our simulation activities supported by SAMSUNG in the field of mircorelectronics. I will also mention our new project concerning the massive deployment of AI tools to boost the search for optimized van der Waals heterostructures achieving efficient spin-to-charge conversion for future non-volatile memory technologies, or our project to develop novel workflows to enhance the capability of STEM equipment towards predictive modelling and direct access to materials properties and device performances.

Acknowledgement
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Two birds with one stone: integrating exfoliation and biorecognition in multi-walled carbon nanotubes by functionalization with biomolecules

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The development of biosensors able to meet the current requirements of Clinical Chemistry is a very important challenge in the field of electrochemical sensors. Carbon nanotubes (CNTs) have demonstrated to be an excellent material to build innovative and versatile electrochemical (bio)sensing platforms due to their unique properties, the possibility of easy functionalization, and the excellent contributions for an efficient transduction of the biorecognition event. Different alternatives to reduce the strong tendency of CNTs to form bundles and to improve their compatibility with the solvent have been reported in the last decades. In this talk, I will present an overview of the "smart" strategies to functionalize CNTs reported by our group in the last years, based on the rational selection of functionalization agents that simultaneously allow the exfoliation of CNTs and provide them with particular (bio)recognition properties.

Typical examples will be discussed in this presentation in connection with the use of critically selected biomolecules as functionalization agents: i) site-specific anchoring proteins like *avidin*, to obtain a multipurpose platform for the development of any kind of biosensor by simply selecting the adequate biotinylated biorecognition element, and *concanavalin A*, to obtain useful building blocks for glycobiomolecule-based biosensors; ii) enzymes like *glucose oxidase* and pseudo-enzymes like *cytochrome c* to obtain enzymatic biosensors without additional enzyme immobilization steps; iii) immunoglobulins to develop very innovative and versatile immunosensing platforms; iv) cysteine to take advantage of its complexing capability, and v) critically designed ligands to mimic the glycobiomolecule-anchoring capability of concanavalin A.

In summary, the excellent results provided by the biofunctionalized CNT-based biosensors in terms of sensitivity, selectivity, reproducibility, and ease of use, corroborate the potential and versatility of the resulting biomolecule-CNT nanohybrids, and demonstrate the importance of the rational biomolecule selection to functionalize the nanostructures, paving the way for further label-free, friendly and efficient biosensing applications.

The authors acknowledge CONICET, ANPCyT, and SECyT-UNC for the financial support.

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Magneto-ionics for low-power memory and neuromorphic applications

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Voltage control of magnetism offers significant potential for enhancing energy efficiency in nanoscale devices. By utilizing electric fields instead of magnetic fields or electric currents, the detrimental effects of Joule heating and energy dissipation can be minimized. In recent times, we have demonstrated the ability to induce reversible and non-volatile alterations in the magnetic properties (such as coercivity and magnetic moment) of nanoporous films. These films consist of metal alloys (such as CuNi and FeCu) or oxides (like FeO_x and $CoFe_2O_4$). This manipulation is achieved by applying an electric field via a liquid electrolyte gate, even at room temperature [1,2]. Furthermore, significant progress has been made in the field of magneto-ionics, which involves voltage-driven ion transport in magnetic materials. Traditionally, this process relied on the controlled migration of oxygen or lithium ions. However, we have now demonstrated that the transport of nitrogen ions can also be triggered at room temperature in films composed of transition metal nitrides (such as CoN, FeN, and CoFeN) through liquid electrolyte gating [3,4]. Nitrogen magneto-ionics allows for reversible ON-OFF transitions of ferromagnetic states at faster rates and lower threshold voltages compared to oxygen magneto-ionics. This advantage arises from the lower activation energy required for ion diffusion and the lower electronegativity of nitrogen when interacting with cobalt, as compared to oxygen. Notably, nitrogen transport occurs uniformly through a plane-wave-like migration front, without the need for diffusion channels, which is particularly intriguing for the implementation of multi-stack memory devices. Moreover, both oxygen and nitrogen magneto-ionics can be utilized to replicate essential neuromorphic and synaptic functionalities, such as spike amplitude-dependent plasticity, spike duration-dependent plasticity, and long-term potentiation/depression. By employing DC and pulsed voltage actuation at frequencies ranging from 1 to 100 Hz, we can simulate learning, memory retention, forgetting, and self-learning through maturity (post-stimulated learning). This novel approach enables the device to decide between self-learning and forgetting emulation, as desired, following a voltage input. Consequently, this presents a ground-breaking method to emulate specific neural functionalities, including learning during deep sleep, which is challenging to achieve using other materials currently employed in neuromorphic computing applications.

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Cyclodextrin-based Nanosponges: Smart Nanocarriers for Various Applications

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Nanotechnology has been emerging as one of the most promising technologies of the 21st century with high applicability of the materials at the nanosize scale in many industrial fields ranging from electronics and ICT, energy, agriculture, and environment to the highly rewarding field of nanomedicine [1,2]. Recent advances in the fields of materials science, physic, and chemistry have presented many nanomaterials with distinctive properties capable of acting as nanocarriers [1]. Cyclodextrin-based nanosponges (CD-based NSs), with flexible and cost-effective production, have shown their full potential as the most promising, advanced, and biocompatible nanocarriers. CD-based NSs are cross-linked cyclodextrin-based polymers nanostructured within an insoluble three-dimensional network. They can easily be obtained by reacting the nucleophilic hydroxyl group of the selected cyclodextrin (CD) with a relevant cross-linking agent, containing two electrophilic sites using organic solvents or water. Having a highly porous nanomeric nature, CD-based NSs can encapsulate a variety of hydrophilic, lipophilic, large-sized, or small-sized substances. They are acclaimed to increase the solubility of poorly water-soluble compounds, prolonging their release, and improving their bioavailability and stability. Despite their potential for drug delivery, because of the unique features they possess, CD-based NSs are widely applicable for the delivery of genes, proteins, enzymes, gaseous compounds, etc. The list of their applications further widens in chemistry, environment, agriculture, cosmetics, food, biomedicine and biotechnology, biocatalysis, flame retardancy, additives for the preparation of mixed matrix membranes for gas separation, etc [3–7]. Therefore, it is no wonder that the demand and the need for an explosive scientific and technological revolution have increased over the years, and more advanced and innovative nanocarriers will come out year after year and outreach the market that has indicated strong growth of the nanotherapy sector.

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AI for material science: from data-driven to interpretable models of physical systems

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In this talk, we will explore the potential of AI in material science, focusing on data-driven and interpretable models of physical systems for 2D materials with defects. The presentation will cover various AI techniques, such as graph neural networks and autoencoders, and their applications in predicting material properties, generative design, and inverse design problems. Additionally, challenges such as the high cost of cutting-edge AI models, limited and diverse datasets, and interpretability in the context of physical systems will be discussed alongside ethical considerations related to the application of AI in material science.

Crystalline silica in construction: strategies to reduce exposures and to promote sustainable nanotechnologies in the workplace

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Abstract

Crystalline silica, a naturally occurring mineral, is a major component of numerous construction materials including sand, stone, granite, concrete, brick, and mortar. Occupational exposures to respirable crystalline silica (RCS) particles have been associated with silicosis, chronic obstructive pulmonary disease (COPD), and lung cancer [1,2]. In 2016, the US Occupational Safety and Health Administration (OSHA) promulgated a new RCS standard that contains provisions for using engineering controls in the workplace [3]. We present here the results of our field investigations conducted at several Massachusetts construction sites. The objective was to evaluate the efficacy of different engineering controls in reducing airborne exposures to RCS during demolition, crushing, and bridge repair. Personal breathing zone air samples collected among 51 workers were analyzed for RCS content with Fourier Transform Infrared Spectrophotometry (FT-IR) according to the National Institute for Occupational Safety and Health (NIOSH) Method 7602. Results suggest that a combination of wet dust suppression with respirator use is needed to comply with the new OSHA PEL of 50 $\mu g/m^3$ in the worst exposure scenarios [4]. Although these traditional exposure reduction measures continue to be important for reducing occupational health risks, the implementation of sustainable nanotechnologies must be promoted when applicable.

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Figures

Figure 1: National Institute for Occupational Safety and Health (NIOSH) Hierarchy of Controls

Harnessing the Power of DNA Nanotechnology for Activity-Driven Protein Detection

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The rapid advancement of DNA nanotechnology has enabled the development of highly controllable, programmable, and versatile nanoscale systems and devices. These systems harness predictable and reversible non-covalent interactions, offering an exceptional platform for molecular information processing. In this talk, we will showcase how DNA nanotechnologies can be engineered to create powerful sensing platforms for specific proteins. Our approach leverages engineered molecular processes that capitalize on the intrinsic biological activity of target proteins, thereby converting their presence into measurable signals.[1] One class of devices we will showcase is dynamic DNA structures that exploit high-affinity protein binding to generate binding-induced measurable signals. For instance, we will discuss the application of structure-switching DNA hairpins capable of detecting and quantifying transcription factors, as well as a structure-switching DNA aptamer targeting the SARS-CoV-2 Spike protein, integrated with carbon nanotube electrodes. [2,3] We will then present a more intricate challenge involving the design of a DNA-based mechanism responsive to the typical proteolytic activity of target proteases. This necessitates the creation of artificial communication between peptide- and DNA-based processes. To address this, we have developed a CRISPR-Cas-powered sensor for an oncogenic matrix metalloproteinase, which utilizes DNA-based amplification of proteolytic cleavage. Our system incorporates a chemical translator, combining a peptide bearing the substrate sequence of the target protease and a peptide nucleic acid (PNA) that converts the protein-based input, i.e., peptide cleavage, into a nucleic acid output. The nucleic acid output can then be processed and amplified. By introducing a rationally designed single-stranded DNA anchored to the PNA sequence of the translator, we can activate the nuclease trans-cleavage activity of a CRISPR-Cas12a system, resulting in the degradation of FRET-labeled DNA reporters. This process generates an amplified fluorescence signal. Remarkably, our strategy enables the detection of the protease MMP2 in the low picomolar range based on its enzymatic activity, surpassing the limits of detection of commercial peptide-based kits by several orders of magnitude. The implications of these studies extend beyond their immediate applications, highlighting the potential of engineered protein-responsive DNA nanotechnologies for transformative advancements in domains such as precision diagnostics and functional synthetic biology.

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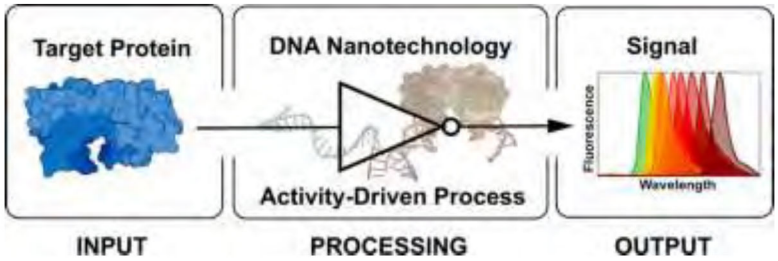

Figure 1: Engineered DNA nanotechnologies can convert protein biological activity into a measurable output.

1D and 2D Carbon Bioconjugates in Bio-Molecular Electronics and Biosensors

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Conjugates of biomolecules and carbon nanomaterials like graphene and carbon nanotubes can find a wide range of applications in electronics, photovoltaics, biosensors, regenerative medicine, etc. Most bioconjugates are actively studied in the application of point-of-care biosensors due to low cost, high sensitivity, selectivity, and usability. Due to chemical inertness of graphene surface and demand for preserve its surface intact immobilization of biomolecules is performed using hydrophobic reaction in most applications. Azide-based photochemistry is a novel tool for covalent immobilization of different biomolecules on carbon surface without disturbing its electronic structure [1]. Moreover, the proper conjugation itself can be the way of tuning properties of biocunjugates (Figure 1).
Field -effect transistors based on individual single-walled carbon nanotubes (SWCNT) photochemically modified with green fluorescent proteins (GFP) demonstrate wavelength selective response to light irradiation. Using genetically engineered proteins novel optoelectronic devices based on GFP and carbon nanotubes have been demonstrated [2]. Changing the attachment side of protein to SWCNT results in different mechanisms of charge transfer turning SWCNT/GFP conjugates to active optoelectronic devices like optoelectronic memory devices.
Graphene based field-effect transistors (GFETs) in conjugation with bioreceptors is considered as cost-effective, high-sensitive, easy in use devices for point-of-care biodiagnostics. Recently, GFET-based biosensors with immobilized aptamers were found as reliable tools for direct detection of small molecules (with mass less 1 kDa). In the assay the aptamer is considered as a larger molecular and detection mechanism is based on conformational changes in the structure of aptamer when it binds to small molecules [3]. Aptamer immobilization process becomes an important issue of the sensor performants. Photochemical binding of aptamer to graphene surface methods was developed to improve the stability and sensitivity of the graphene-based aptasensors in heart failure biomarker detection [4].

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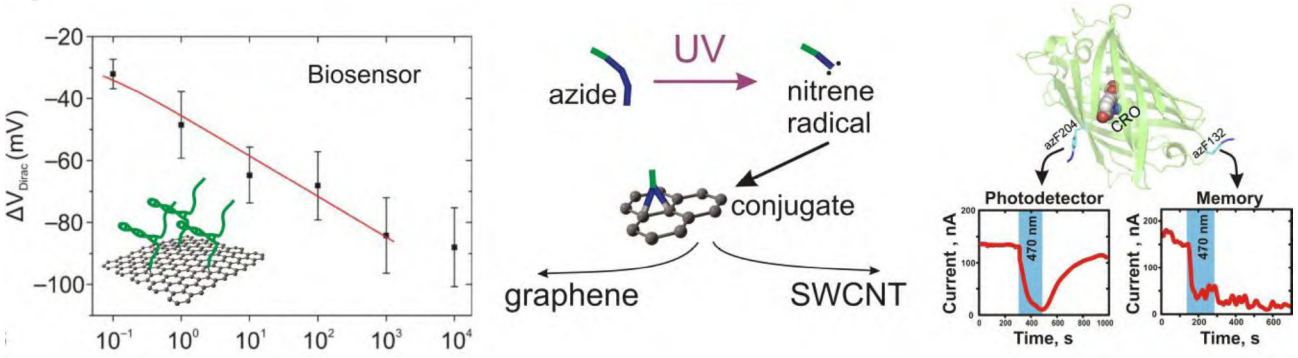

Figure 1: Photochemical immobilisation of aptamer (*left*) and protein (*right*) in development of graphene based aptasensors and SWCNT-based optoelectronic devices, respectively.

Supramolecular architectures for tailored drug delivery

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Over the past years, multifunctional nanotechnology has emerged as a novel approach to overcome the biopharmaceutical pitfalls of old and new drugs and optimize their therapeutic performance or provide for proper perspective to their development and application. As a result, last generation delivery nanosystems are capable of complex functions, which enable for sequential overcoming of multiple biobarriers following a certain time/site determined "logic" of events. These nanocarriers provide longer drug circulation times, higher tolerability, and site-specific delivery, factors that result in better patient outcomes.

Novel delivery approaches offer the possibility of enhanced therapeutic performance of old molecules and clinical translation of new drugs including small synthetic molecules, biotech macromolecules and nucleic acids, which suffer from their poor stability, poor bioavailability, off-targeting, and immunoreaction. Bioconjugation chemistry combined with the advances in biophysics and material science advancement allow for combination of biomaterials to produce new supramolecules with tailored in vivo behaviour.

An emerging need of new nanocarriers is related to the delivery of nucleic acid drugs, which include a wide range of molecules with different action mechanism and physicochemical features, namely, molecular weight, structure, and chemical composition. Although these new therapeutics are not new in the clinical practice, their exploitation has been limited by delivery issues. However, according to the rapid experience gained by the rolling over experimentation of mRNA-based vaccines used in Covid-19 pandemics, their development has been recently accelerated not only for prophylactic treatments but also for genetic diseases, metabolic disorders, cancer etc.

To date lipoplexes, polyplexes, and lipid nanoparticles have been shown to be efficient delivery systems for nucleic acid delivery and recently a few of them reached the market. However, despite successful results have been obtained, there are still unmet needs for efficient nucleic acid delivery to provide for cell targeting.

Novel carriers have been obtained, by exploiting supramolecular chemistry, which combines various biomaterials with different physicochemical, biopharmaceutical and biological function that physically or chemically assemble to form systems with targeting endosomal escaping ability.

An important aspect in the development of these supramolecular systems is their characterization and regulatory compliance. Indeed, these "complex non-biological systems", are intrinsically nonhomogeneous cluster of nanoformulations where each component may have different in vivo behaviour. Therefore, a new regulatory paradigm must parallel the development of these formulations.

Recent advances in preparation, characterization and applications of Titanium Oxide nanotube arrays

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Titanium Dioxide Nanotube Arrays (TNAs) represent a significant breakthrough in field of nanotechnology. TNAs possess remarkable chemical and physical characteristics and have proven to be flexible materials with broad-ranging applications in environmental and energy technologies [1-3]. The applications of TNAs have extend to various fields, such as photocatalysis, sensor technology, hydrogen production, and dye-sensitized solar cells relying on their outstanding specialties, which include a high specific surface area, admirable charge transfer abilities, and superior chemical stability. The electrochemical anodization of titanium sheet is a method to fabricate highly ordered TNAs, emphasizing the pivotal advantage of achieving high surface areas within a tubular structure. Compared to other TiO_2 nanostructures, TNAs demonstrate noteworthy performance electrochemically, owing to the augmented surface area and reduced diffusion length. This work presents an all-embracing summary of TNAs; outlining their methods of synthesis and application areas. Latest advances and developments in this field are also comprised.

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One probe to bring them all: integrated separation and analytical workflow for extracellular vesicles

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Extracellular Vesicles (EV), including a subtype called exosomes, are nano-sized biogenic particles that are released by almost any type of cells in various bodily fluids like blood, urine, and cerebrospinal fluid. These particles contain and expose different types of molecules like proteins, lipids, glycans and nucleic acids, which makes them highly attractive potential biomarkers for several diseases, such as cancer, neurological disorders, and infectious diseases. However, their small size, low refractive index, inherent heterogeneity, and high sensitivity requirements make it difficult for them to become a prominent choice for liquid biopsy. To address these challenges, new affinity-probes and digital techniques capable to detect disease-specific sub-populations with low abundance are urgently needed. In our recent work [1], we have introduced a new type of molecular ligands for integrated small EV isolation and analysis called membrane-sensing peptides (MSP). These peptides are derived from Bradykinin and are capable of recognizing and binding the outer membrane leaflet of small EVs through complementary electrostatic interactions while leading to subsequent insertion of hydrophobic residues into the membrane lipid packing defects. Small EVs have indeed unique lipid membrane features in the extracellular environment that can be used as a "universal" marker.
MSP outperforms antibodies in terms of capturing capacity while being pan-specific, interspecies, and interkingdom, resulting in a versatile class of ligands with additional advantages in terms of stability and synthetic versatility. They can also be applied to synthetic lipid nanoparticles.
Our research has integrated MSP into different platforms for EV analysis and isolation including paramagnetic beads for Single Molecule Immunoassays (SiMoA). We have applied these methods to different workflows in urine and blood providing examples of clinically relevant feasibility in EV phenotyping and liquid biopsy in various biological media.

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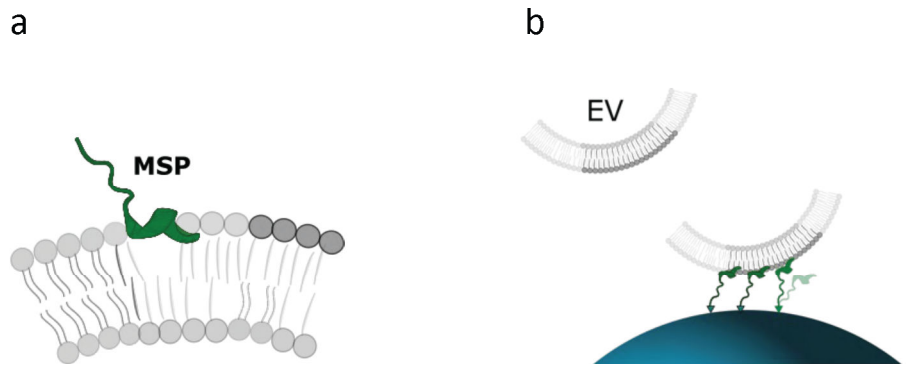

Figure 1: a) MSP are universal baits with affinity to small EV membrane and b) have been integrated into SiMoA paramagnetic beads for complete isolation and analysis workflows

Fabrication of 2D materials-based nanoarchitectures via innovative CVD processes

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The abilities to combine complementary two-dimensional (2D) materials and to introduce modifications at the nanoscale open compelling routes to engineer the material's properties and grant novel functionalities [1,2]. In this talk, I will introduce two innovative chemical vapour deposition (CVD) processes enabling flexible growth of atomically thin 2D materials and related heterostructures, such as borophene, hexagonal boron nitride (*h*BN) and graphene.
Specifically, the use of diborane as precursor gas yields large single-crystalline borophene domains (*i.e.*, an atomically thin layer made of elemental boron) on distinct metal supports. Subsequent addition of borazine as precursor in the process allows synthesizing *h*BN conjointly with borophene, which can selectively form lateral or vertical heterostructures. When combined laterally, borophene and *h*BN form uniform covalent lateral interfaces, while the vertically stacked configuration result in van der Waals structures that protect borophene from immediate oxidation [3]. On the other hand, the use of a single molecular precursor (borane tetrahydrofuran) providing boron and carbon enables the fabrication of 2D arrays of boron substitutional species in graphene. These are formed due to segregation of the boron atoms, which is guided by the naturally occurring moiré superstructures in Ir(111)-supported graphene [4].
Our findings are based on a comprehensive surface-science approach that combines atomic-scale and surface-averaged characterization techniques (*i.e.*, scanning tunnelling microscopy and spectroscopy STM/STS, low energy electron diffraction LEED and x-ray photoemission spectroscopies XPS/ARPES), together with first-principles calculations that provide insight into the material's structure, chemical and electronic properties, and interfacial interactions.

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Figures

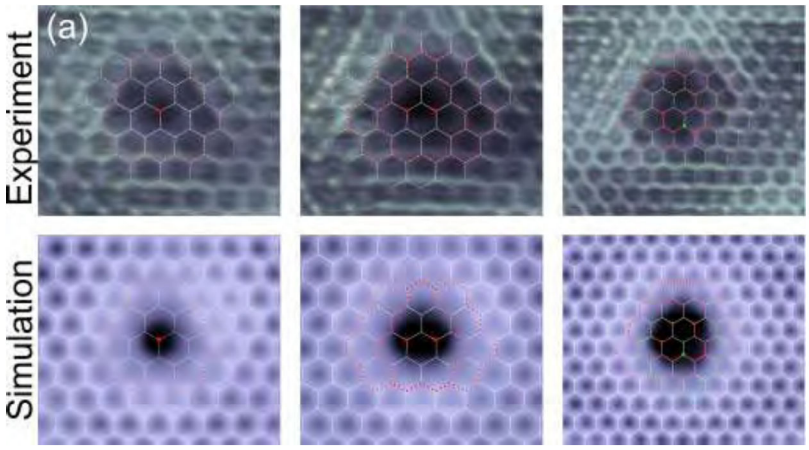

Figure 1: Comparison between experimental and simulated atomically resolved STM images of single and multiple substitutional boron heteroatoms in Ir-supported graphene.

From Nanobody Forests to Drug-producing MOFs: Designer Proteins for Designer Materials

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Proteins are found at the core of most biosensing platforms as well as in many recent nanotechnology devices or hybrid materials. However, too often this research relies on off-the-shelf, commercially available model proteins. The collaboration between protein engineers and material scientists can unlock applications that would be inaccessible to either side alone. In our work with the Inal team, we continue to improve a self-assembling nanobody architecture to build sensitive and rapid bioelectronic sensors that operate in unprocessed, complex samples [1]. The spyDirect biofunctionalization method creates ultra-high-density arrays of correctly oriented and fully binding competent nanobodies that are stably linked to a gold surface (Figure 1). SpyDirect biorecognition layers improve the long-term stability and lower the background noise of organic electrochemical transistors (OECTs) for the detection of SARS-CoV-2 in saliva or unprocessed waste water [2]. In our work with the Khashab team, we are combining their hierarchically engineered metal organic framework (MOF) nanoparticles with the *in vitro* reconstituted six-enzyme pathway for the biosynthesis of violacein [3]. Pathway-MOF nanoreactors produce violacein in amounts comparable to solute enzymes, but enable pathway reuse, lyophilisation and storage. MOF nanoreactors can deliver the entire multi-protein system into mammalian cells where it interfaces with the metabolic state of cancer cells leading to the enhanced production the cytotoxic violacein as an *in-situ* therapeutic (Figure 2). We believe that violacein nanoreactors may pave the way towards a novel class of intracellular protein systems therapies.

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Figures

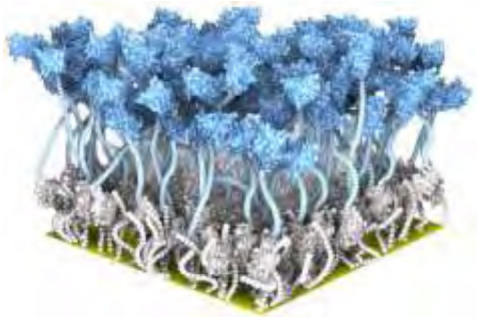

Figure 1: Rules-based model of a spyDirect nanobody-functionalized electrode surface.

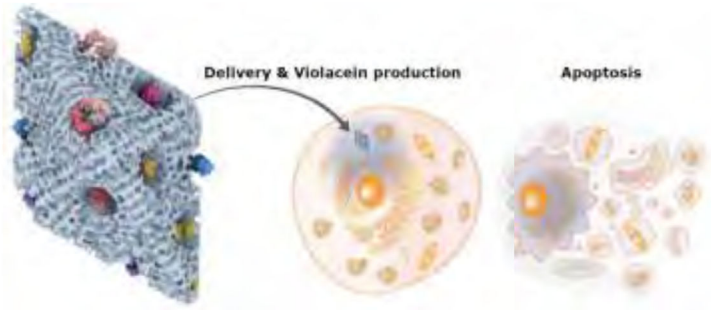

Figure 2: Illustration of eMIL - multi-enzyme nanoreactors and their delivery into mammalian cells.

3D Bioprinting and Nanotechnology Applications for Tissue Engineering: State of the Art

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Regenerative medicine and tissue engineering are two crucial technologies used nowadays. While regenerative medicine deals with the process of replacing, engineering or regenerating human cells, tissues or organs to restore normal functions, tissue engineering aims to develop biological substitutes that restore, maintain and improve the lost or damaged function of tissues. Three main components of tissue engineering are scaffolds, cells and signal molecules that may be added to the 3D structure to mimic better the natural tissue of interest. Scaffolds can be prepared as 2D or 3D structures through various methods such as freeze drying, phase separation, gas foaming, solvent casting and some nanofabrication techniques. As some of these methods do not fully mimic the inherent structure of the tissue, lately fabrication techniques that result in 3D structures such as 3D bioprinting and electrospinning have been used for tissue engineering purposes.

3D bioprinting has shown to be a promising strategy for preparing on-demand 3D models as it assembles biomaterials (with or without cells in it) to create various biomedical products. Some of the 3D bioprinting technologies used are inkjet-based bioprinting, extrusion-based bioprinting, laser-assisted bioprinting, and stereolithography bioprinting [1, 2]. With 3D bioprinting generation of highly complex cellularized constructs is possible. Combination of bioprinting and nano-biomaterials improves critical weakness of these manufacturing processes and enhances their efficiency by spatially arranging nano-features [1]. On the other hand, electrospinning is another method used to prepare three-dimensional nano-microfibrous structures. The process includes the use of electric forces to draw charged threads of polymeric solutions up to fiber diameters in the order of some hundred nanometers. It has found a wide range of applications for various tissues such as cartilage, tendon, bone, meniscus and skin [3].

Through this study we will highlight how the use of nanobiomaterials and polymeric scaffolds in 3D bioprinting and electrospinning techniques can lead to promising strategies for tissue engineering applications.

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Designing Trace Metal Sensors, Immunosensors, Genosensors, and Gas Sensors Using Screen-Printed Electrodes Modified with Various (Nano)Materials

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The proper selection, pretreatment, and modification of a supporting electrode are crucial steps for successfully fabricating an electrochemical sensor. In this context, screen-printed electrodes (SPEs) have been recognized as attractive substrates suitable for the deposition of various building blocks in the development of powerful electrochemical sensors, immunosensors, genosensors, gas sensors, etc. Particularly in environmental monitoring, clinical diagnostics, occupational health and food safety, cultural heritage preservation, homeland security, etc., there is an increasing need for low-cost, sensitive, and selective sensing devices for detecting numerous analytes of great importance. From this point of view, electrochemistry offers unsurpassed possibilities for the development of different sensing strategies in combination with advanced electrochemical techniques and countless modification (nano)materials that can be used as thin catalytic deposits, (bio)recognition elements, immobilization and anti-interference membranes, electrolytes, and analyte preconcentration and/or derivatization media. Different electrode configurations provide an excellent platform for developing simple and point-of-interest sensors, along with numerous miniaturization options [1].

We will summarize our recent research on developing SPE-based (bio)sensors for the detection of several important analytes in liquid and gaseous samples [2-4]. Since the reproducible response of the supporting electrode is a prerequisite in the fabrication of reliable electrochemical sensors, we will discuss selected strategies to improve the electrochemical properties of SPEs, along with a brief study of the effects of electrode surface pretreatments on protein binding kinetics and electrode surface stability. We will demonstrate the operation and performance of SPE-based sensors developed in our laboratory for the detection of trace metal ions, gaseous phenol and hydrogen peroxide, antibodies, antigens, and DNA/RNA.

Acknowledgments
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Synthesis, Characterization, and Application of Cyclodextrin-based Nanosponges as Drug Delivery Systems

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Nanomedicine is defined as nanotechnology-based delivery systems that can be utilized to prevent or treat various diseases at the molecular level [1]. Cyclodextrin-based nanosponges (CD-NSs) are one of the most promising nanocarriers to encapsulate therapeutic agents capable of delivering drugs and enhancing their bioavailability and efficacy. CD-NSs, with a three-dimensional nanoporous polymeric network, due to their biocompatibility and versatility have triggered extensive research and applications in various fields. CD-NSs are chemically cross-linked polymers obtained by reacting the cyclodextrin (CD) unit with a suitable multifunctional cross-linking agent at certain conditions. The final CD-NSs polymer network exhibits a cross-linking agent content-dependent behavior and the degree of cross-linking is a fundamental property of their applications as drug delivery systems. Taking into account the chemical composition and properties, CD-NSs can be classified in five consecutive generations beginning from the simple cross-linking reactions to more complex ones. Numerous surveys have shown that CD-NSs have emerged over the years heading towards greener processes such as the CD-NSs synthesis in natural deep eutectic solvents (NADES), and water [2-5]. Due to the peculiar physicochemical properties of CD-NSs, their complete characterization is a great challenge. Therefore, our research serves as an introduction to the extensive literature about the synthesis, characterization, and application of CD-based nano-delivery systems that will further meet the challenges of the twenty-first century for improving drug administration and lowering toxicity issues. Our survey is essential to research for tailoring novel nanocarrier systems with the prospect of increasing their exploitation in countless industrial applications.

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Figure 1: Synthesis of Cyclodextrin-based Nanosponges (CD-NSs).

Organic Electrochemical Transistors for Biochemical Sensing Applications

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Organic electronic materials provide a unique toolbox for establishing electrical communication with biological systems. In this talk, I will show how these materials are used at the interface with biological systems to detect biochemicals. I will introduce two types of organic electronic sensors; one that detects Alzheimer's disease-associated proteins with performance exceeding the state-of-the-art [1,2] and the other that detects coronavirus spike proteins at the physical limit. [3] Having challenged these sensors with patient samples, I will discuss areas where proof-of-concept biosensor platforms may fail. By tackling these problems, we improve device performance to a level that marks a considerable step toward biochemical sensing of infectious and noninfectious disease biomarkers. I will highlight how computational methods can aid sensor development and organic semiconductor research.

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Synthesis of Some Novel Chromandione Derivatives with Biological Activity

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The intense investigation in medicinal chemistry showed that many of the coumarin derivatives with expressed anticoagulant activity, are showing anticancer effects in the same time. Thus, very known and commercially available medicaments like Warfarin, Phenprocoumon (marcumar), Sintrom (acenocoumarol) and Bromadiolone are intensively studied for their cytostatic, apoptotic and antiproliferative activities. This triggered interest of design and synthesis of novel coumarin derivatives with high cytotoxic and antiproliferative potential. 2-Aminothiazoles were used in order to couple them with 4-hydroxycouamrin, and a series of novel chromandione derivatives were synthesized. The thiazolohydrazilidene-chromane-2,4-diones had shown to exhibit cytotoxicity on human breast cancer cell line MDA-MB-231. MDA-MB-231 cells are very sensitive to treatment with B-Raf kinase inhibitors blocking the RAF/MEK/ERK signaling pathway and affecting in this way the tumour growth. Among the three RAF isoforms in humans (A-Raf, B-Raf, and C-Raf), B-Raf is the most critical to mediate Ras activity. A significant fraction of melanoma, colorectal, thyroid and breast cancers have activating B-Raf mutations, particularly at valine 599. The compounds that were synthesized had shown significant B-Raf kinase inhibition.

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Smart Drug Delivery and Diagnosis Applications with Micro/Nanomotors in Breast Cancer

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Breast cancer is one of the most common cancer types, particularly in women which has severe effects and can cause still deaths. To prevent the fatal effects of this disease, its early detection is important. Even with its early detection and by the control of all risk factors, it is known that all these precautions may minimize the cancer development in low percentages [1-4]. Conventional treatments at advanced stages of breast cancer is currently not effective as desired. In addition to this, there is still need for the development of handy diagnosis systems to fight against breast cancer.

Engineered micro/nanomotors for different applications such as biomedical ones have been pointed out a substantial field of research. With efficient surface modifications and controlled propulsion mechanisms, synthetic motors can realize important tasks including smart drug delivery, phototherapy, (bio)sensing, and cell isolation [5-8]. Using the advances in materials science and nanotechnology, micro/nanomotors have been remarkable intermediates to assist cancer therapy and diagnosis. In this talk, applications of the polymeric and metallic motors (magnetic and catalytic) developed in our laboratory for potential breast cancer treatment and diagnosis will be presented. Such motors can response to physicochemical changes in their environment, and therefore serve as promising drug carriers. Furthermore, they can utilize as recognition platforms with effective prognostic antibody functionalization. Besides their biomedical applications, these functionalized motors will be introduced in terms of surface characteristics and viability studies.

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Exploring Long Noncoding RNA Dysregulation in Cancer Using Electrochemical Sensing Platforms

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One of the keys to reduce cancer mortality is its early diagnosis. Investigations on early detection of cancer should address in parallel two important issues: the identification of selective tumour biomarkers and the development of effective tests to clinically validate them. Long noncoding RNAs (lncRNAs) are part of the transcriptome that does not code for proteins but have important functions in different mechanism of gene regulation. They are deregulated in a number of cancers, with both oncogenic and tumour suppressive roles [1]. In consequence, lncRNAs have become new an important players in the clinical diagnosis of cancer and its treatment. But to effectively translate them to the clinical practice, it would be necessary to develop new and robust methods to detect the expression levels of lncRNAs in biological fluids and tissues.

The use of hybridization-based electrochemical biosensors results particularly appealing for the detection of lncRNA in clinical samples, with potential to meet the demands of selectivity, sensitivity, simple use, portability, and multiplexed detection, although their application to cancer-related lncRNAs monitoring is scarce [2]. Using this approach, we have developed bioelectrochemical platforms for the detection of different circulating lncRNAs overexpressed in prostate and colorectal cancer. These platforms have been combined with Molecular Biology tools to analyze total RNA extracts from tumour-derived cell lines, as well as accessible body fluids from cancer patients and healthy individuals, urine for prostate cancer and blood plasma in the case of colorectal cancer [3,4]. Our results, compared with those provided by real-time reverse transcription polymerase chain reaction (RT-qPCR) as a reference, demonstrated that these new tools would be useful as liquid biopsy test for cancer diagnostic.

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Some New Trends in the Development of Electrochemical Sensors and Biosensors

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Abstract
Some strategies for the development and the application of electrochemical sensors and biosensors will be shown together with illustrative examples. Nanosized materials have been used as the modifiers of electrode surfaces due to the high surface area and their catalytic effects ensuing in low detection limits and excellent analytical performance. The application of sensors for the detection of inorganic and organic analytes of interest will be shown [1-4]. The development of enzyme-based biosensors using oxidoreductases will also be shown due to the high specificity of the biological entity towards the substrate [5].

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Active Oral Drug Delivery Micromotor-based Systems

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Abstract

Tremendous progress has been achieved during the last decade towards the design of micromotors with high biocompatibility, multifunctionality, and efficient propulsion in biological fluids, which collectively have led to the initial investigation of in vivo biomedical applications of these synthetic motors. Six decades after Richard Feynman's visionary lecture, we are currently witnessing the creation and application of robotic pills that merge the distinct strengths of microrobotic and oral delivery technologies.

In this lecture, new developments towards the realization of clinical translation of this technology are reported. Firstly, by integrating synthetic micromotors with pharmaceutical pills for active and enhanced oral delivery applications. In vivo studies using a mouse animal model show that the micromotor pill platform effectively protects and carries the active micromotors to the stomach, enabling their release in a concentrated manner [1] [2].

Secondly, by utilizing Mg-based micromotors as microstirrers, due to their self-stirring built-in capabilities, to fabricate microstirring pills towards enhanced fluid dynamics of payloads and improved drug bioavailability. In vivo studies using murine and porcine models demonstrate that the localized stirring capability of microstirrers leads to enhanced bioavailability and therapeutic efficacy of drug payloads [3] [4].

Finally, this lecture provides a vision on the future applications of formulations with multiple active and responsive nanoscale and microscale robotic platforms that are capable of performing diverse biomedical tasks, such as diagnosis, sensing, imaging, biopsy, and drug delivery. Ultimately, research on such multitasking microrobotic pills that combine many functions into a single oral device may lead to autonomous theranostic closed-loop 'sense and act' systems that would provide tremendous benefits for patients in clinical applications. There is plenty of room in the pill and thus several opportunities to keep incorporating multiple capabilities into this versatile vehicle.

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Figures

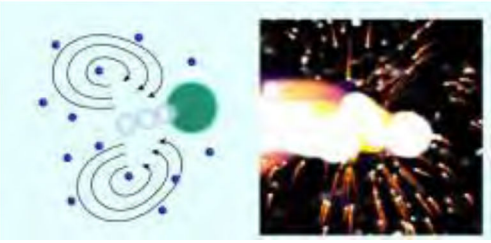

Figure 1: Mg-based microstirrer enhancing the fluid dynamics of a therapeutic payload.

Applications of Photocatalysis from Earth to Space

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Photocatalysts as photo-functional materials are able to convert photo energy to chemical one, thus the property gives wide range applications. In this presentation, new applications of photocatalysis in the field of earth and space are reported.

1) Development of switchable biodegradable plastics using photocatalysts. As marine pollution caused by microplastics intensifies, biodegradable plastics that can be decomposed by microorganisms are attracting attention. However, the biodegradability of plastics is in a trade-off relationship with durability, forcing an issue where biodegradable plastics are not suitable for long-term use. To overcome this, it is necessary to develop new biodegradable plastics that have a "switch function", whose plastics should remain stable and not degrade during use, but once they leak into the ocean or similar environments after use, this "switch" activates to promote their biodegradation. In this study, we focused on g-C_3N_4 (GCN) photocatalysts. GCN is a metal-free photocatalyst with high safety and exhibits antibacterial activity under visible light. Therefore, when GCN is applied to biodegradable plastics, it is expected to have a "switch function" that inhibits biodegradation under visible light due to the antibacterial activity of GCN, but promotes biodegradation in dark places such as sea and seafloor where the antibacterial activity does not occur because of dark environment. In this work, we have succeeded to develop new bio-plastics using GCN, showing anti-bacterial activity and less degradation ability for the bio-plastics, that is expected for switchable bio-plastics.

2) Synthesis and characterization of ZnO/CeO_2 photocatalyst for complete decomposition of methane under ambient condition. On the International Space Station, various organic compounds are generated from astronauts and equipment, with CH_4 being one of the most produced. Currently, it is being adsorbed and removed by activated carbon. However, for future long-term manned space exploration, a new material that can completely decompose CH_4 into harmless CO_2, without generating intermediate products and is reusable, is required. Photocatalysts, which can decompose organic chemicals by light irradiation under ambient conditions, are attracting attention from the perspective of safety and reusability. However, the current reported photocatalysts are not suitable for manned space exploration due to their low decomposition efficiency of CH_4. Therefore, a new photocatalyst that can decompose CH_4 with high efficiency is needed. Among many photocatalysts, ZnO has been reported to have an appropriate band structure for CH_4 decomposition and a characteristic that can activate the C-H bond of CH_4. Therefore, in this research, we focused on the porosification of ZnO and composition with CeO_2 as means to synthesize a ZnO-based photocatalyst that can efficiently decompose CH_4. And, we considered the use of oxalate-based co-precipitation as a way to achieve both. In this method, gases such as CO_2 are generated during calcination, thus it is expected to form fine pores that are believed to be useful for adsorbing CH_4. Furthermore, there are few examples of the composite of ZnO and CeO_2 by this method, and the detailed CH_4 decomposition activity are not clear. In this research, we have succeeded to synthesize a ZnO/CeO_2 photocatalyst using oxalate-based co-precipitation and clarify the CH_4 decomposition activity with high efficiency.

3) Air purification system using photocatalysis in the international space station. Currently, the Environmental Control and Life Support System (ECLSS) on the International Space Station operates devices that regenerate air and water, recycling and reusing resources. However, these devices are heavy and take up space, thus there is a demand for the development of lighter, more compact, and more efficient devices. We have succeeded to develop air purification system using photocatalysis and launched to the international space station.

Surface Functionalization of Graphene Materials and Their Applications

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Despite their remarkable properties, many challenges must be overcome to achieve practical applications of graphene-based materials. The primary obstacle lies in establishing a cost-effective method for producing high-quality graphene materials on a large scale, while ensuring good reproducibility. A trade-off relation exists between cost and properties, necessitating the selection of an optimal preparation method depending on the intended application.

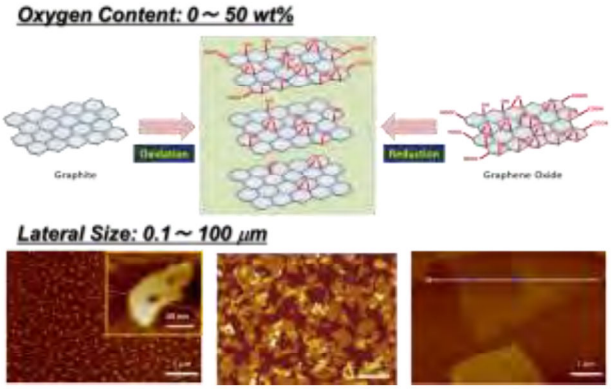

Figure 1. Strucuture control of GO.

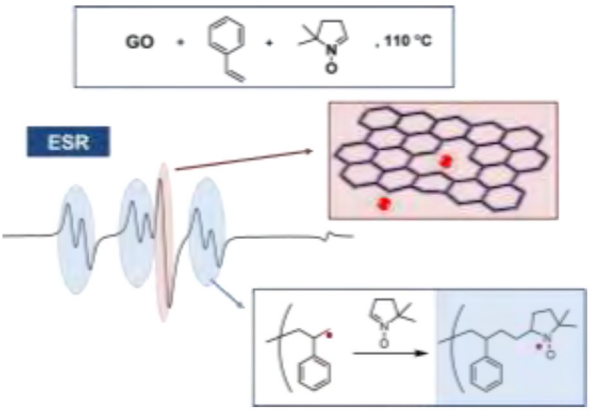

Figure 2. Polymer grafting on GO by radical.

During this presentation, we will explore the introduction of graphene oxide (GO) as an illustrative example, which is obtained through the oxidation and exfoliation of graphite. Through an optimized oxidation process utilizing $KMnO_4$ in H_2SO_4, we have successfully achieved the laboratory-scale production of 500 g of GO, and a prototype plant-scale production of 10 kg. The large-scale productions were possible by conducting mechanistic studies of the oxidation process using in situ analyses such as XRD and XANES. Our refined GO production processes controlled the size, degree of oxidation, and distribution of functional groups on GO (Figure 1).
By tailoring our GO, we have accomplished the grafting of polymers onto it via a radical pathway. The grafting mechanism was elucidated through in situ ESR measurements employing a spin trap reagent. During thermal treatment (Figure 2), the radicals were generated by cleaving C-O bonds of GO. In addition, redox-active molecules and polymers were grafted onto GO and utilized for supercapacitor applications.

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The bridge between DNA nanotechnology and Synthetic Biology as innovative biosensing approach

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Rapid and user-friendly diagnostic tests that are convenient, accessible, and well-suited for use at the point-of-care are essential for the early identification, tracking, and control of infectious diseases and other clinical needs. In this direction, in the last two decades, the advantages of synthetic nucleic acids (i.e., programmability of interactions, chemical versatility, low-cost and ease of synthesis) have been exploited by our group and many others to develop different classes of DNA-based sensors.[1] Synthetic nucleic acids are indeed highly versatile from a chemical point of view and they can be used as molecular scaffolds to conjugate different recognition elements (small molecules, proteins, etc.) and different signaling tags (optical or redox labels) thus leading to the detection of a wide range of targets, including nucleic acids, small molecules and proteins using optical and electrochemical approaches.[2] Mostly of the reported DNA-sensors provide several advantages compared to the current standard methods (i.e., immunoassays) in terms of time of measurement, cost and ease of operation convenience. However, due to the lack of a chemical or enzymatic amplification step the detection limit of these sensors is fixed by the intrinsic instrumental limitations of electrochemical or fluorescence detection and does not allow to measure the targets below nanomolar concentrations. Recently, the emerging field of synthetic biology has proposed cell-free transcription/translation biosensors as innovative analytical devices to overcome the above-mentioned limitations.[3] These systems are based on synthetic genes that can be activated in the presence of a specific target and trigger the *in-vitro* transcription of a signalling RNA strand or the translation of a signalling protein. By coupling the programmability of synthetic nucleic acids with the high sensitivity and specificity offered by the enzyme-machinery of RNA transcription, we have recently reported the first two examples of cell-free biosensors for antibodies detection.[4,5] Our approach of programming nucleic acid responsive units that can trigger the cell-free transcription of specific RNA in response to the presence of specific targets may have even broader applications than sensing. For example, we envision the possibility this strategy may be used to transcribe RNA therapeutics and to develop RNA vaccines.

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Perovskites meet 2D materials: A novel materials platform for efficient energy harvesting and neuromorphics

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An aggressive technological deployment will soon affect the planet's energy landscape, demanding a swift transformation from the predominant use of fossil fuels to that of renewable energy installations. With its concurrent arrival, the Internet-of-Things (IoT) deployment promises to create a largely distributed global network of wireless sensors and wearables connected to the ''cloud'': Humankind is exploiting new technological platforms able to impact sustainable development and prosperity toward Industry 4.0 revolution. These platforms will create a robust demand of energy for their power supply, making a battery-free operation mandatory together with the need of a low manufacturing cost and reduced environmental impact. 2D-material enabled ''harvesters'' span across a wide range of scales. The demonstrated prototypes include self-powered miniaturized IoT devices, to large scale renewable energy infrastructures.[1]

The heterogeneity of peculiar ions and carriers observed in hybrid organic/inorganic materials is the source of their emergent cross-coupled light and electric field tuneable functions with potential utility in novel opto-electronic applications. Mixed halide perovskites (HPs) have been used as active layers in high performing perovskite solar cells (PSCs) that led to efficient solar energy harvesting. The power conversion efficiency (PCE) of PSCs has rapidly increased and is now approaching the state- of-the-art PCE of 26.1% obtained by crystalline-silicon PVs.[2] However, this impressive PCE obtained on small-area cells and in laboratory conditions should be also valid to large-area PV panels in real outdoor conditions. Through interface engineering, the incorporation of the 2D materials improves the charge dynamics of the interfaces and most importantly protects the perovskite layer against degradation.[3] Graphene Flagship partners demonstrated the validity of this technology through the entire value chain, from materials development, perovskite modules and panels fabrication and their integration in an autonomous solar farm (of 5m^2 perovskite PV panels), to outdoor field tests, and assessment of the real energy production output. [4] The energy production of the solar farm was monitored for 12 months, demonstrating a remarkable 20% reduction (T_{80}) of the PV performance over 8 months of operation. The data analysis demonstrated that the perovskite panels enabled by 2D materials are promising for outdoor operation at elevated temperatures, such as in high-irradiance global locations.

Targeting beyond PV applications, HPs' rich dynamics enabled by inherently coupled ionic and electronic degrees of freedom have also led to the demonstration of optoelectronic memristors that emulate synaptic- and neural-like dynamics.[5] A single printable material stack fabricated with low manufacturing cost at low temperature, combining both efficient solar energy harvesting and memristive functionalities would constitute a transformational breakthrough. We have demonstrated that an inverted PSC with an average PCE of >17% with appropriate electric biasing procedure exhibits stable resistance switching characteristics at low voltages without losing its PCE performance even after thousands of switching cycles. Moreover, a high resistance state (HRS) to low resistance state (LRS) ratio of up to 10^5 and light-tunable switching cycles in the millisecond regime with an endurance of 3 x10^3 cycles with no detectable HRS/LRS ratio drop.

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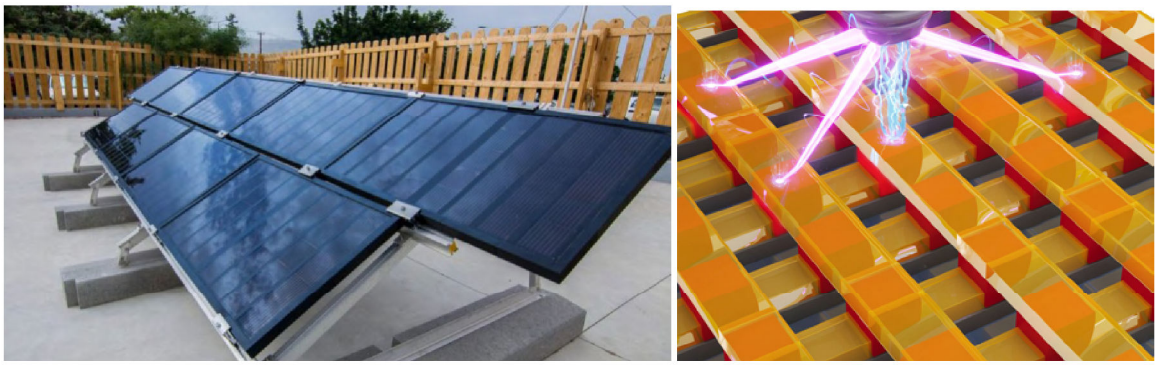

Figure 1: A) A photograph of the solar farm in HMU. B) Demonstration of a PSC operating simultaneously as an efficient, stable memristor and solar energy harvester.

Spin transport proximity phenomena in van der Waals heterostructures

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The vast collection of two-dimensional materials and their co-integration in van der Waals heterostructures enable innovative device engineering. Their atomically thin nature promotes the design of artificial quantum and topological materials by proximity-induced effects with physical properties not readily found in their single material forms [1]. Such a flexible design approach is especially compelling for the development of spintronic devices, which usually harness functionalities from thin layers of magnetic and non-magnetic materials and their interfaces. This talk will summarize recent experimental progress toward investigating proximity-induced phenomena in hybrid graphene-transition metal dichalcogenides systems through spin transport dynamics [2,3] and charge-spin interconversion experiments [4]. Particularly, I will focus on the relevance of crystal symmetries in the emergence of unconventional charge-spin conversion components and anisotropic spin dynamics [5], [6].

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PyzoFlex® matrix: How to combine printed ferroelectric sensors and organic transistors for vital parameter, tactile pressure and proximity sensing

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Flexible sensors impress with their outstanding properties; as they allow cost-effective and environmentally friendly production of large-area, flexible and, when fabricated on ultrathin, highly conformable or even stretchable substrates. These special properties enable an unprecedented integration possibility of sensor technology on complex-shaped objects, and pave the way for multi-stimuli responsive electronic skins used in human machine interfaces, soft robotics, prosthetics, implantable, wearable and physiological sensors, and sensor networks for the internet of things or structural health monitoring.

One transducer material that has proven to be very effective in many of the above-mentioned applications is the ferroelectric co-polymer P(VDF-TrFE). It can be printed at high resolution on various substrates in different form factors and is sensitive to pressure / force, strain, vibration / structure-borne sound as well as proximity / MIR radiation owing to its piezo- and pyroelectric nature [1].

An area where ferroelectric e-skins with low weight and high wearing comfort are of particular interest is the monitoring of human vital parameters such as pulse rate, blood pressure, tactile pressure or proximity signals at the point of care/living. Since vital parameter transducers should be highly conformable to the human body and provide a high spatial and temporal resolution, active addressing of the pixels in the ferroelectric transducer matrix in real time is inevitable. Such active addressing in e-skins is best achieved with organic thin film transistors, which, due to their compatibility with flexible, ultrathin or stretchable substrates, are the ideal counterparts for flexible ferroelectric transducers.

Here I will demonstrate several combinations of ferroelectric polymer transducers with organic thin film transistors on flexible substrates for tactile pressure sensing, proximity detection, pulse rate as well as blood pressure monitoring.

First, the basics of our printed ferroelectric sensor technology PyzoFlex® highlighting its scalable manufacturing and versatile application scenarios focussing on biosignal monitoring via the human pulse wave are presented [2]. Then I will show an ultra-compliant active-matrix tactile pressure sensor, where organic transistors are monolithically integrated with the ferroelectric transducers on a just 1 µm thin polymer substrate. More than 100 pixels at a pitch of ≈ 3 mm are addressed in this way. Advanced shadow-mask processes allow for a transistor channel length of < 20 µm and overlays < 100 µm, enabling operating frequencies in the 10 kHz regime and frame rates > 100 Hz [3].

Finally, I will demonstrate an in-pixel amplified actively addressed flexible proximity-sensing surface for process control, work security and robotics based on the integration of an all-printed organic thin film transistor backplane with an all-printed pyroelectric sensor frontplane. The system can detect a human hand approaching from different directions and track the position of a movable heat source up to a distance of around 0.4 m at a readout speed of 100 frames per second [4].

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Electrochemiluminescence-based biosensor: from academic curiosity to an industrial success

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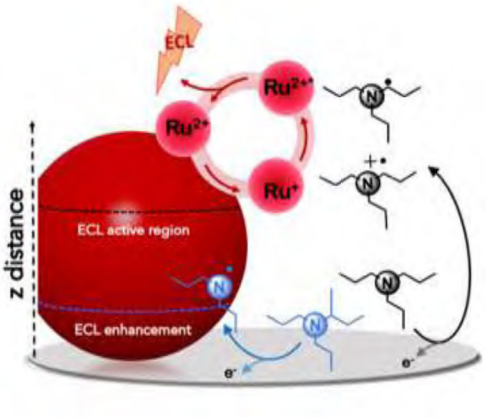
Electrochemiluminescence (ECL) is a leading technique in bioanalysis.[1] Since the excited species are produced with an electrochemical stimulus rather than with a light excitation source, ECL displays an improved *signal-to-noise* ratio compared to photoluminescence.[2] The electrochemically-induced way to generate luminescence signal allows to obtain sensors with low background, high sensitivity, good temporal and spatial resolution, robustness, versatility, and low cost. The unique analytical performances in terms of high detectability of conventional chemiluminescence (CL) are retained and, in addition, the electrochemical trigger of the reaction allows controlling the time and position of light emission. As a matter of fact, ECL has become a powerful analytical technique widely studied and applied both from the academic and industrial point of view. If we have a look at the last 20 years, the number of scientific publications focused on ECL research has been exponentially increased and commercial clinical analyzer, Elecsys®, is an industrial success with more than 150 immunoassays based on ECL technologies.

In the quest for ever-increasing sensitivities, ECL can ideally be coupled to nanotechnology for developing new systems and strategies for analyte determination. In this context, thanks to the combination of different nanomaterial we were able to *"fuel"* the generation of the ECL reagents and optimize its interaction with the dye reaching very competitive limits of detection in complexes matrix such as blood and urine. [3] Our last efforts have been focused also in the combination between ECL and microscopy for single cells analysis with high throughput and low detection limit [4] and for the point of care PCR-free Hepatitis B Virus determination.



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Modification of carbon based sensors with rGO doped with metal nanoparticles

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Abstract
Carbon nanomaterials are considered as potentially promising sensing materials for fabrication of high-performance electrochemical sensors for different applications [1]. However, it is highly required to investigate the structure effect of carbon supports on electrochemical sensing performances. In this work reduced graphene oxide (rGO) dopped with metal nanoparticles [2] are selected as modifier of carbon paste electrodes which were subsequently used to construct electrochemical sensors for three typical water pollutants: i)antibiotics; ii)pesticides, and iii)heavy metals. Characterization of modified carbon paste using characterization techniques [3] such as SEM, EDS, FTIR, XPS and TEM will explain that the presence of these modifiers (rGO/npMe), effect the morphology and microstructures of the electrode material and consequently the electrochemical response. It was observed that the presence of hybrid modifiers rGO/Me-np in the CPE improve analytical performance of the electrochemical sensors in terms of sensitivity and linear range. Consequently, CPE modified with these nanostructures (rGO/Me-np) can be used for development of high-performance sensors for interested analyts such as water pollutants. The aim of this work is to enhance the applications of carbon based hybrid structures as modifiers for the designing of new electrochemical nanosensors with wider applications.

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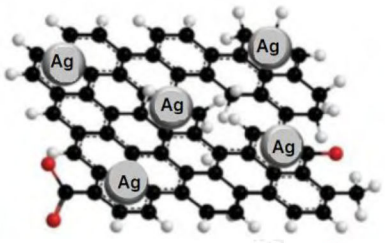
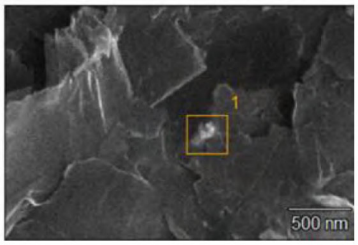
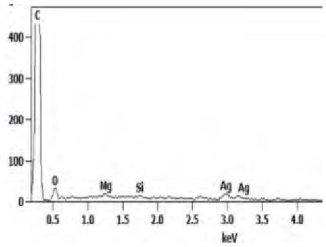
Figure: Reduced Graphene Oxide doped with Ag-np



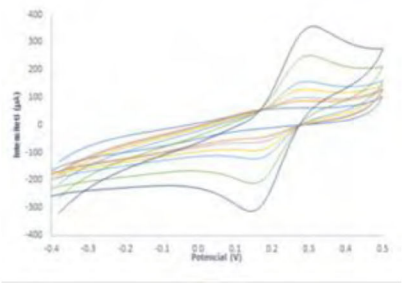
Schematic structure (-C, -O, -H);



SEM of CPE-Ag@rGO composit



EDS of CPE-Ag@rGO composit



Electrochemical characterization: CV in the presence of redox couple Fe(+3)/Fe(+2)

Different Approaches for Antibiotic Quantification using Electrochemical Sensors and Nanomaterial's

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Abstract

Antibiotics are pharmaceutical substances that have saved many lives since they began to be used as medications for the treatment of infections. But over the years their use has multiplied, increasing the number of genes resistant to antibiotics. As a result, antibiotics now are included in the group of environmental pollutants and in the list of chemicals that must be monitored in food products. This fact has stimulated the interest of scientists and funding organizations to increase research in finding a fast, sensitive and accurate way to identify and monitor antibiotics.
Macrolides (Azithromycin and Erythromycin) and Glycopeptides (Vancomycin) are two of the antibiotic classes which have been used as a target for presented research work.
SPCIE (Screen Printed Carbon Ink Electrodes) modified with TiO_2 NPs are used as a working electrode in electrochemical analysis of Azithromycin (AZM). SEM analysis was performed to determine the physical and surface properties of the sensor. SPCIE/ TiO_2 NPs sensor using Cyclic Voltammetry performed well with a low limit detection (LOD) of 0.93 µM, limit of quantification (LOQ) 3.1 µM, sensitivity 7.36 µA μM^{-1} cm^{-2} (S/N = 3) and linear range 0.05–50 µM towards determination of AZM. The sensor was applied successfully in urine and water samples. However, the sensor was not specific toward other Macrolide antibiotics such as Erythromycin, Clarithromycin etc.
To overcome the specificity issue of the sensor, electro-active molecularly imprinted polymers nanoparticles (e-MIP NPs) were developed for antibiotic quantification. Solid phase synthesis of e-MIP NPs was used to produce electro-active polymer. Together with other functional monomers, Ferrocene methyl methacrylate (FcMMA) was included as a redox-active monomer enabling the polymer to be a recognizer and reporter vs. specific targets in the same time (Fig. 1). Synthesized e- MIP NPs were applied on Screen Printed Electrodes (SPE) and showed an oxidation peak of FcMMA at about 0.3 V in Differential Pulse Voltammetry (DPV) using DropSens potentiostat. The further optimization of the method is developing in the lab.
Those new approaches for Antibiotic quantification may contribute in the attempts to find good alternatives for the determination and monitoring of antibiotics in environmental, food and human samples.

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Figures

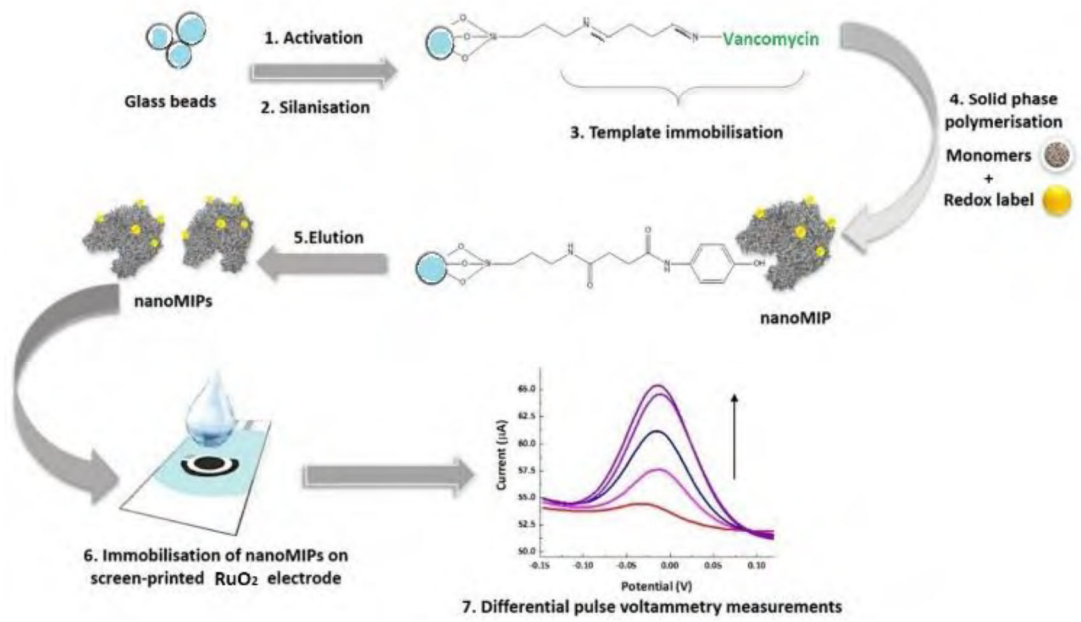

Figure 1: General principle for Electroactive Molecularly imprinted polymers Nanoparticles (e- MIP NPs) on SPE

Graphene transparent electrodes for POCT devices based on ECL immunoassay

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Our group aims to fabricate CVD graphene-based devices such as transparent antennas [1] and biosensors for point-of-care (POC) testing [2].

POC devices that allow rapid diagnosis and early treatments are in great demand for monitoring infectious diseases. While the outbreak of COVID-19 led to the widespread use of rapid test kits using lateral flow immunoassay (LFIA) for visual detection, there was a growing demand for rapid test kits with higher sensitivity and quantitative measurement. Electrochemiluminescence (ECL)-based immunoassays are recognized as more reliable analytical methods, although they are very rarely used in rapid test kits. CVD-grown graphene films are suitable materials for ECL-based analytical platforms for POCT because they can be used as disposable transparent electrodes. The use of transparent electrodes allows the photodetector to be placed directly below the electrode, which increases the light collection angle and facilitates the placement of other electrodes.

So far we have demonstrated that CVD-grown graphene films transferred onto quartz glass by the PMMA method exhibit better ECL performance than glassy carbon and ITO electrodes and enable ECL-based immunoassays for a tumor marker, carcinoembryonic antigen (CEA) [2].

In this study, porous nitrocellulose/graphene stacked films were fabricated as a platform for biochips for ECL analysis for POCT. Porous nitrocellulose is used as a support material for biomolecules such as antibodies, including membranes for LFIA. When fabricating CVD graphene transparent electrodes, a transfer process from the catalyst metal (Cu) to the transparent substrate is essential, and PMMA is commonly used as a transfer support material. We performed graphene transfer using a porous nitrocellulose membrane as an alternative to PMMA. By optimizing the preparation conditions of cellulose membranes, a porous membrane with sufficient electrolytic solution permeability and strength to be used as a transfer supporting material was successfully fabricated (Fig. 1). Furthermore, ECL-based immunoassay was successfully demonstrated using the cellulose/graphene stacked films loaded with anti-CEA antibody (Fig. 2).

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Figures

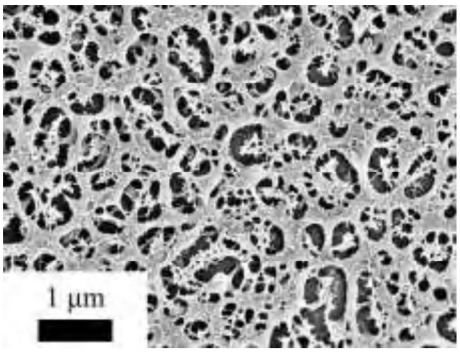
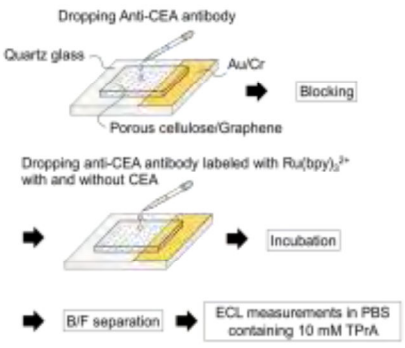


Figure 1: SEM image of porous cellulose.



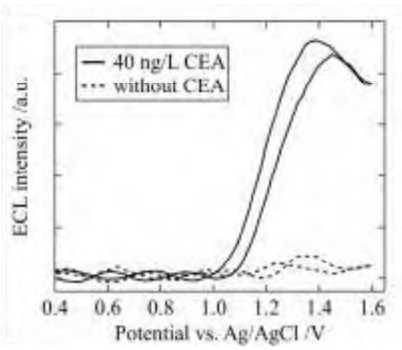


Figure 2: ECL-based immunoassay using cellulose/graphene films.

The Ex-situ Electrochemical Determination of Bioactive Compounds: The Influence of Surface and Nano-modifiers

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Abstract

The hormone Estradiol has significant study interest as a bioactive compound responsible for the reproduction [1-3]. This study focuses on the *ex-situ* electrochemical determination of estradiol and investigates the influence of surface and nano-modifiers on the analytical performance. Bare carbon paste electrodes, including expanded carbon, CR-2, and CR-5, were used for comparison. Silicon oil served as the pasting liquid. The response of CR-2 and CR-5 electrodes was superior to expanded carbon for the same estradiol concentration of 1 µM, indicating the importance of the conductive carbon type. A consistent optimal adsorption time of 5 minutes was observed for all electrodes.

The introduction of surface modifiers yielded notable changes in the electrode response. Substituting 5% of CR-5 weight with amorphous carbon and cyclodextrin led to decreased responses and performance, respectively. In contrast, the inclusion of 5% and 10% Halloysite nano-clays resulted in slightly improved responses, associated with a prolonged extraction time of 10 minutes. Moreover, increasing the nano-clay content in the paste further enhanced the response. Incorporating 5% carbon multiwall nanotubes in the paste displayed a lower response and longer adsorption time (10 minutes) compared to bare CR-2 and CR-5 carbon paste electrodes. The highest response among the considered surface modifiers was observed when functionalized carbon multiwall nanotubes were used, with an optimal adsorption time of 15 minutes.

Furthermore, changing the pasting liquid from silicon oil to ionic liquids yielded significantly improved responses compared to most of the modifiers used, with an optimal adsorption time of 10 minutes. These results demonstrate the impact of surface and nano-modifiers on the electrochemical determination of bioactive compounds, highlighting the importance of careful selection and optimization of these modifiers for enhanced analytical performance.

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Fabrication of cleanroom free, low-cost nanoband electrodes with low zM limits of detection

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Nanoscale electrodes have been a topic of intense research for many decades. Their enhanced sensitivities, born out of an improved signal to noise ratio as electrode dimension's decrease, means that they are ideal for the development of low concentration analyte sensors. [1,2] However, to date, nanoelectrode fabrication has typically required expensive equipment and exhaustive, time consuming fabrication methods that has rendered them unsuitable for widespread use and commercialization.[3,4] Herein we report a method of nanoband electrode fabrication using low cost materials and equipment commonly found in research laboratories around the world. The materials cost to produce each nanoband are less than €0.01 and fabrication of a batch takes less than 1 hour. The devices can be made on flexible plastics and their designs can be quickly and easily iterated. Facile methods of combining these nanobands into powerful devices, such as complete 3 electrode systems, have also been displayed. As a proof of concept, the electrodes were functionalized for the detection of a DNA sequence specific to SARS-cov-2019 and found to display low zM limits of detection.

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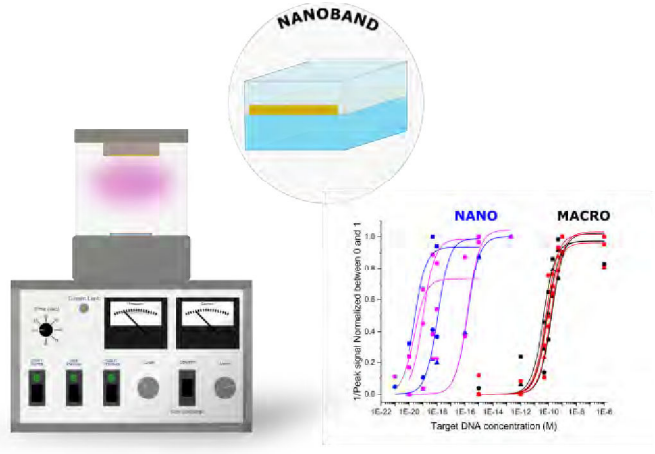

Figure 1: Schematic illustration of a nanoband electrode and calibration curves from the macro and nano electrode for DNA sensing

Bioinspired nanoparticles for glioblastoma treatment

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Nanotechnology has enabled many improvements in cancer therapy, in terms of increased efficacy in selective drug delivery, allowing to limit systemic toxicity. In particular, extracellular vesicles (EVs) have attracted great deal of interest as theranostic tools, presenting features that make them feasible drug delivery systems. However, the application of EVs in drug delivery is hampered by several issues like the high heterogeneity and batch-to-batch variation caused by the lack of efficient GMP protocols, possible contamination from residual genetic material, difficulty in drug loading, low production and isolation yield hindering scalability [1,2].
Recently, cell membrane-derived nanoparticles have emerged as innovative theranostic tools which allow to retain the complexity and versatility of the cell membrane, overcoming the limits of the traditional surface modification approach. Therefore, the purpose of our project is to develop a safe biomimetic nanosystem able to target parent malignant tumor cells, exploiting its cancer-mimetic characteristics. To this aim, primary glioblastoma cell homogenates underwent sequential centrifugations leading to the isolation of cell membrane fragments, which were extruded through polycarbonate filters. The obtained nanovesicles were characterized for their chemical-physical properties by photon-correlation spectroscopy; the protein content was evaluated by proteomic analysis, and the presence of detrimental residual genetic material was ruled out by gel electrophoresis. Then, the selective internalization in cancer cells was studied through confocal microscopy (Figure 1) and fluorescence activated cell sorting analysis.
To further improve the production yield, ongoing studies are dedicated to the preparation of hybrid vesicles, obtained by the fusion of the cell-membrane derived vesicles with biocompatible synthetic lipids. Future studies will involve the loading of the nanosystem with an active anticancer compound, and the preparation of analogous cell derived nanosystems from different types of cancer cells.

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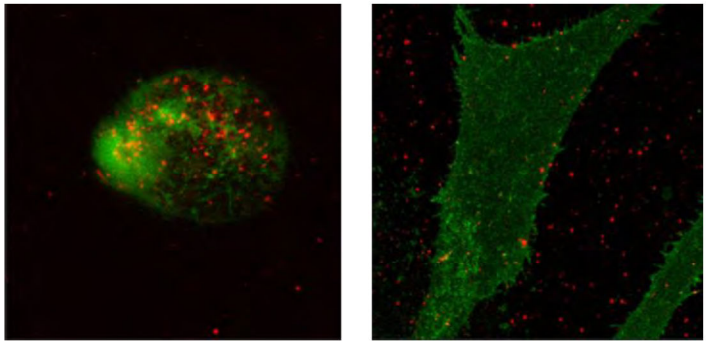

Figure 1: On the left, internalization of the cell-derived vesicles in the parent glioblastoma cells, after 30 min incubation; on the right, scarce internalization of the nanovesicles in healthy oligodendrocytes after 30 min incubation.

Electrochemical device for the detection of Alzheimer's disease protein markers

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Alzheimer's disease (AD) is a neurodegenerative disorder that causes progressive cognitive impairment and memory loss in one out of every ten people over the age of 65. AD is not curable yet, and treatment may be ineffective if identified later in the disease's progression. Early detection is imperative to improving the efficiency of existing treatment, delaying or slowing symptoms, and thus providing the patient a better quality of life while navigating the disease. Electrochemical sensing is a promising approach for early detection of AD [1,2]. In this work, we present an electrochemical sensor design capable of detecting proteins, such as Tau and glial fibrillary acidic protein (GFAP), recently shown to exist in high concentrations in the blood of patients with AD [3]. To build biosensing electrodes, we use two types of bioreceptors, an antibody and a recombinant fusion protein (nanobody) developed for these protein markers. We evaluate how gold-based electrodes' performance in detecting the biomarkers depends on the bioreceptor type selected and suggest a sensing mechanism (Faradaic or potentiometric) and device type (electrode or transistor) that leverages the functionality of each surface.

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Electrochemical determination of heavy metals using hybrid nanosheets of Au@rGO

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Abstract

Heavy metals (HMs) are considered crucial pollutants of the environment as they are very toxic, easy to be accumulated, and nondegradable in environment [1]. Therefore, the main goal of this study is to develop a graphene based sensor, suitable for the monitoring of Heavy Metals in environment. Herein, based on advantages of graphene oxide and metal nanoparticles, we used a single-step technique to produce reduced graphene oxide (rGO) conductive films integrating gold NPs. This method is based on the coreduction of graphene oxide and metal cations (Au^{3+}) by CO_2 laser plotter [2]. The production procedure has been optimized, and the obtained nanomaterials are fully characterized; the hybrid nanosheets have been easily transferred onto lab-made screen-printed electrodes [2]. The electrochemical characterization of integrated Au@rGO- sensor was accomplished via Cyclic Voltammetry (CV) and Square Wave Anodic Stripping Voltammetry (SWASV) as typical techniques for HMs dedection [3]. A well-visible shift of the lead reoxidation peak was observed in the case of modified sensor Au@rGO-. Based on obtained results, this sensor can be used for determination of Heavy Metals in environment.

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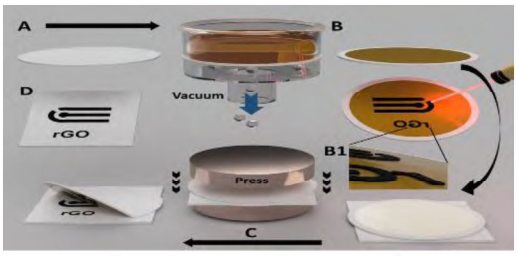

Figure 1: Schematic presentation of rGO-sensor

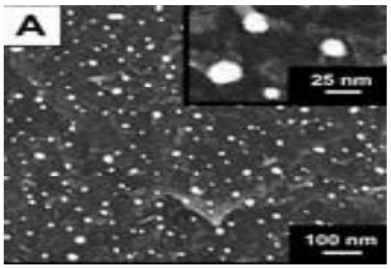

Figure 2: SEM of Au@rGO- films

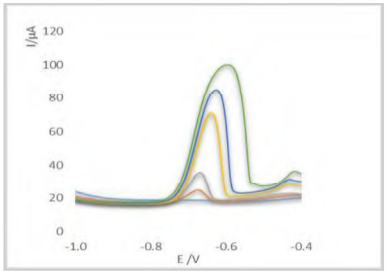

Figure 3: Typical SWASVs of Pb^{2+} using Au@rGO- sensor

Electrochemical Paper Analytical Device for nitrite and nitrate determination

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Abstract (Calibri 12)

The new voltammetric method for the determination of nitrites [1], which has been shown to be successful in the detection of meat products, is based on the formation of the electroactive product 2-methylfuran cation. Through the reduction of nitrates to nitrites with metallic zinc, and derivatization with ranitidine in the formation of the electroactive product, it has been possible to determine nitrate ions indirectly. A cathodic reduction at −0.210 V of 2-methyl-2H-furan-3-one at the electrode covered with a thin layer of ERGO and adsorbed SDBS surfactant has given a good sensitivity and the possibility of minimal interference from the sample matrix components. The incorporation of zinc metal particles in cellulose (zinculose)[2] for reduction of nitrate ions and the reaction of product formation has successfully resulted in the indirect detection of nitrate and nitrite in model samples.

Keywords: Electrochemical sensor, Voltammetry, ePAD's, Nitrite, Nitrate.

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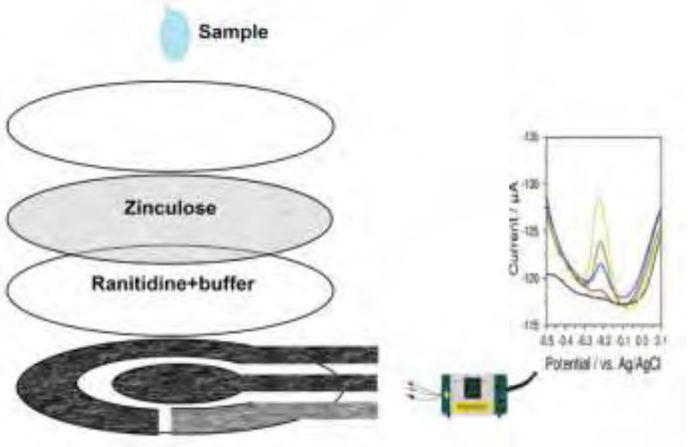

Figure 1: Electrochemical paper analytical device for nitrate determination.

Enhancing therapeutic efficacy through optimizing drug delivery from nanoparticles

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Abstract
Nanoparticle-based drug delivery systems offer exciting new approaches due to their small size and special characteristics, which enable precise control over drug distribution, targeted delivery, improved solubility, sustained release, and protection against degradation. To take advantage of their unique properties the size, shape and/or surface chemistry of nanoparticles need to be optimized, allowing their functions to be modified for various biological applications.
The aim of this study is to provide a comprehensive overview of optimization strategies for nanoparticles, with a focus on enhancing targeting efficiency and optimizing drug release rates.
Articles from the last decade were identified and reviewed to address the advancements in understanding the structure of nanoparticles.
Several studies report that drug release is influenced by elements like the drug's encapsulation, size, shape, and composition of the nanoparticles. Modification techniques and stimuli-responsive nanoparticles are identified as effective means to achieve controlled release. Optimization strategies, such as formulation techniques and surface engineering, are presented to improve drug release profiles and enhance therapeutic outcomes.
The review concludes by emphasizing the significance of optimizing drug release from nanoparticles and proposing future research directions in this field, with the aim of further advancing the capabilities of nanoparticle-based drug delivery systems.

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Tomato Brown Rugose Fruit Virus in Albania: Detection and Characterization Using SANGER Sequencing and Nanopore Technology

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Abstract

Tomato (*Solanum lycopersicum L.*) is one of the most economically valuable fruit or vegetable crops worldwide, valued at 93.9 billion US dollars in 2018, with a yield estimated at 180.8 million tons in 2019 [1]. Tomato production is affected by numerous diseases and, among them, viruses are considered an important production-limiting factor. It has been estimated that nearly half of emerging crop diseases can be attributed to plant viruses [2], which could amount for about a quarter of overall achievable yields in major crops, including tomatoes [3]. Among many important tomato viruses, undoubtedly tomato brown rugose fruit virus (ToBRFV) is a new emerging viral pathogen that is spreading widely within greenhouses of tomato crops of several countries and recently it was found to be present on tomato plants from a commercial greenhouse in Albania [4].

Two ToBRFV isolates (Al-B and Al-F) were selected for Sanger-type sequencing and subsequent BlastN analysis of their partial nucleotide sequences (accession numbers OL763429 and OL763428) revealed more than 99% identity with homologs reported in the GenBank database.

To determine the incidence of ToBRFV in the country, 160 samples were collected from different tomato growing regions during 2022-2023. The preliminary results of qPCR applied on collected samples showed an infection rate of 18 %; whereas the Oxford Nanopore Technology (MinION) applied on the previously Sanger-sequenced samples confirmed the sequence variations found on the two Albanian isolates. Additional MinION sequencing is ongoing to determine the full genome sequence of several isolates showing severe symptoms. Gaining further molecular information on Albanian ToBRFV isolates would help to draw a precise scenario on the origin of the infection and help to prevent further spread in the country.

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Figure 1: Fruit symptoms of ToBRFV.

Figure 2: Oxford Nanopore (MinION).

CRISPR/Cas12a based portable and low-cost Inkjet printed platform for one-pot pathogen detection

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Infectious diseases associated to pathogenic bacteria are spreading worldwide, particularly in developing countries. The rapid diffusion of infectious disease urges for rapid and portable devices for the detection of pathogens. Biosensors, because of their low-cost, portability, ease of use and availability for point-of-care/need applications, represent a valid alternative to traditional techniques, that are instead time consuming, expensive and do not allow for a point-of-need analysis [1]. In this work we present an electrochemical portable, sensitive and specific biosensor device for the detection of pathogens. A low-cost platform is fabricated using inkjet printing technology on a plastic substrate using Gold and Silver nanoparticles-based inks and it includes electrode and microfluidic channels. The pathogen DNA target is detected by coupling the recombinase polymerase isothermal amplification (RPA) with the CRISPR/Cas12a system. This last is specifically designed and integrated into the inkjet printed platform. The trans-activity of the CRISPR/Cas12a system triggered after the specific DNA recognition process is used to electrochemically transduce the information by using a smartphone readout. In particular, a rationally designed ssDNA reporter labelled with methylene blue (ssDNA-MB) is functionalized on the working electrode surface and detected by using square wave voltammetry (SWV) electrochemical technique. The trans-activity is triggered when the CRISPR/Cas12a system detects the pathogen target sequence and the reporter ssDNA is cleaved; as a result, the SWV MB associated signal decreases [2]. The performances of the biosensor are assessed and the use of this device for point-of-need applications in real clinical and drinkable water samples are evaluated.

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Electrochemical detection of azithromycin based on modified carbon paste electrode

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Abstract

Antibiotics are widely used today to treat many antibacterial diseases. They are often discharged into the environment in an uncontrolled mode, risking pollution of aquatic habitats. Determinations with sophisticated instrumental methods of these analyte often require time and high costs. In this paper, is studied the possibility of developing a sensor to determine by electrochemical methods the antibiotic azithromycin, which is used the most compare with other antibiotics. The sensor is based on carbon pastes and suitable nanomaterial modifier, ZnO, reducing the detection limit and analysis time and increasing the selectivity. Characterization of modified carbon paste using electrochemical characterization techniques explain the presence of these modifiers. From the assessment of the performance parameters of the sensors, the modifier ZnO by 16% (wt/wt) and 10% (wt/wt) of graphene oxide in the carbon paste, gives the best results, with a correlation coefficient according to Regression Analysis, $R^2 > 0.9$ of the calibration curve.

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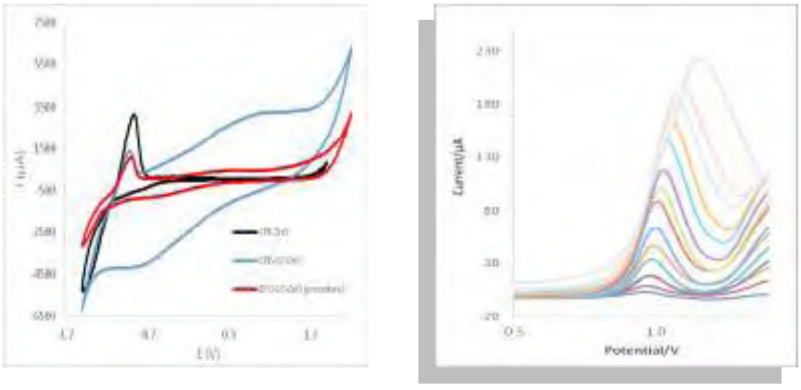

Figure 1: Voltammograms of CV (left-E=1.5:-1.5 V) for three types of modified electrode in acetate puffer, pH 5; and Voltammograms of DPV (right- E=1-1.8 V, teq=10 s, scan rate=0.05v/s) for CPE modified with graphene oxide and ZnO, in different concentration of AZI.

Unravelling the Multi-Enzymatic Activity of Platinum Nanoparticles

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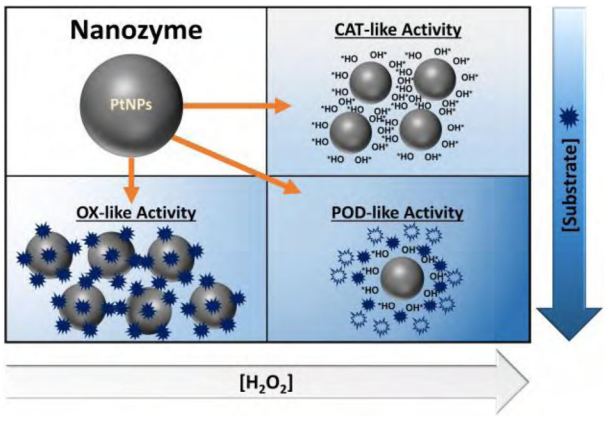
Nanozymes are a new class of nanomaterials exhibiting catalytic activities similar to natural enzymes.[1] Thanks to their versatility, robustness, low manufacturing costs, and long shelf life, they have been widely applied in diagnostics, environmental remediation, and nanomedicine.[2] However, the differences between the catalytic mechanisms of nanozymes and biological enzymes are often overlooked in literature, and some nanozymes have recently been questioned as catalysts due to their low activity and specificity.[3] Hence, studies aiming at clarifying the specific catalytic mechanisms and the advantages/drawbacks of nanozymes with respect to their natural counterparts are extremely important, especially for emerging nanomaterials. In this framework, platinum nanoparticles (PtNPs) possess multi-functional enzymatic activity, displaying oxidase- (OX), peroxidase- (POD), catalase- (CAT), and superoxide dismutase-like (SOD) activities, which attracted great interest for reactive oxygen species scavenging,[4] antioxidant detection,[5, 6] and antimicrobial activity.[7] Nevertheless, there is still much to disclose concerning the mechanisms underlying PtNP activities and their dependence on chemical/physical and environmental parameters. Such lack of knowledge hinders the development of new effective applications. Here, we systematically investigated the OX, POD, and CAT activities of citrate-capped PtNPs, as a function of pH, temperature, buffer media, and substrates. We observed that PtNPs are generally more active at acidic pH, and their activity increases with temperature. Different colorimetric assays, commonly used to test nanozymes' activities, were found to generate misleading results, due to the instability of the chromogenic probes and/or interference of the solvents, employed to solubilize the substrates even in commercial kits. The mechanisms underlying the PtNP catalytic properties were investigated using detection reagents with high selectivity for specific radicals. The three different enzyme-like activities resulted deeply interconnected: they occur simultaneously, but one can be favoured over the others tuning the relative concentration of reagents and catalyst. Eventually, the performances of the nanozyme were compared with three natural enzymes (one for each catalytic activity) proving that PtNPs are as active as their natural counterparts in physiological conditions and even more efficient in harsh conditions. In summary, the present study provides a comprehensive characterization of PtNP multi-enzyme functionalities and important insights on their catalytic mechanisms, which are of pivotal interest for the implementation of Pt-based nanozymes in sensing and nanomedicine applications.



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UV-Induced Photodegradation of Rhodamine B Dye using TiO2-Based Nanocomposites

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In this study, an investigation is conducted to compare the photocatalytic efficacy of of Copper (Cu) and Silver (Ag) doped TiO_2 supported on Graphene oxide sheets, wherein TiO_2 is synthesized in both anatase and rutile crystal structures. Pure anatase and rutile TiO_2 are effectively obtained during the synthesis process. The capability of the synthesized materials to degrade the organic pollutant Rhodamine B is evaluated under UV light. The findings demonstrate a significantly improved photocatalytic activity of Ag-TiO_2/GO composite, achieving up to 100% degradation within duration of 40 minutes. Additionally, SEM-EDX and XRD analyses are performed to characterize the samples.

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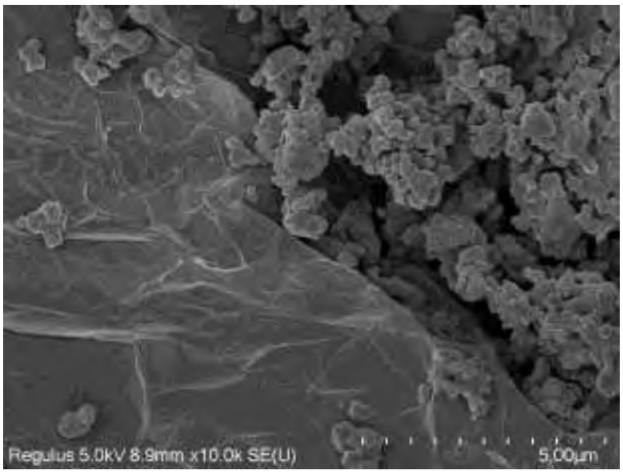

Figure 1: Rutile TiO_2/GO SEM image

Biopolymer Coated Magnetic Nanoparticles as a Carrier for Controlled Drug Delivery Systems

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Abstract

Drug delivery systems have superior features that can release drugs in the target area of the body at a sufficient dose and at the appropriate time. In controlled drug release systems, the target drug is continuously released at the optimum value over a long period [1]. Among the polymers, materials are mostly preferred as drug carriers which should be non-toxic, allow easy removal from the living system (≤ 45 kDa), and have a long residence time in the body [2]. In recent years, biomaterials sensitive to stimuli such as pH, temperature, magnetic field, and photons, known as intelligent polymers, have started to attract much attention in drug release systems [3].
The magnetic polymers are called smart polymers provide the mobility of the polymers to the desired region thanks to the externally applied magnetic field [4]. Fe_3O_4 nanoparticles are often used in the core in magnetic polymers or materials [5]. The most crucial advantage of magnetic materials is that they can be easily removed from the environment or moved toward the target area with the effect of the magnetic field. A magnetic drug delivery system is directed to the damaged area with the effect of the magnetic field and releases it only in this region. Thus, it is aimed to minimize the side effects of chemotherapeutic drugs in healthy cells.
For this respect, in this study it is aimed to prepare a magnetic drug carrier that can provide effective drug release in the target region in a short time. Magnetic alginate nanoparticles, which are both magnetic and pH-sensitive composite, was easily synthesized at mild conditions. The physicochemical properties of the obtained nanoparticles were investigated using FTIR, SEM/EDS and VSM techniques. However, the usability of the magnetic biopolymer as a carrier for chemotherapy drugs was investigated using 5-Fluorouracil as a model drug. The drug was immobilized around the magnetic alginate, surrounded by polyethyleneimine, and the drug release was controlled. In addition, biocompatibility of drug-immobilized magnetic drug carrier were determined, and the effect of magnetic field on drug release behaviour was also investigated.

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Carbon Coated Magnetic Nanoparticles Based Assay for Electrochemical Detection of Hepatitis B virus DNA

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Abstract

Magnetic particles have gained significant popularity in the field of biotechnology, medicine, and analytical biochemistry for their effective use in immobilizing and separating proteins, enzymes, and other bioactive agents. The iron oxide core has the potential to serve as nanoscale magnetic particles exhibiting superparamagnetic properties. These nanoparticles can form stable suspensions in aqueous media and can be easily dispersed again after agglomeration when subjected to a magnetic field [1,2]. Electrochemical DNA biosensors are anticipated to play a vital role in point-of-care diagnostics under medical supervision in the future [1-3]. Furthermore, there has been a significant increase in biotechnological investigations employing magnetic particles for the analysis of nucleic acids, specifically focusing on the detection of sequence-specific nucleic acid hybridization using electrochemical sensors [4-8]. Our study [8], aims to develop amino-functionalized carbon-coated magnetic nanoparticles (cc-MNPs) and utilize them for electrochemical detection of Hepatitis B virus (HBV) DNA sequence. Under this aim, sequence selective DNA hybridization related to HBV gene sequence have been carried out at the surface of cc-MNPs. After the sequence-selective DNA hybridization detached from the surfaces of these nanoparticles, the electrochemical detection of full DNA hybridization was investigated using pencil graphite electrodes (PGE) in combination with differential pulse voltammetry (DPV) technique by measuring the guanine oxidation signal. In order to improve hybridization efficiency, experimental parameters affecting all assay steps (i.e. DNA probe concentration, hybridization time, target DNA concentration) are studied and the analytical performance of the sensor was tested and the selectivity of this assay was examined. The detection limit was found to be 1.15 µg/mL [8]. Our magnetic nanoparticles-based assay offered a chemically and electrochemically stable, powerful, cost-effective, selective, sensitive, and rapid technique for nucleic acid detection related to HBV DNA resulting in a low detection limit.

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Area-selective atomic-molecular layer deposition of lanthanide thin films on graphene

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Area-selective atomic-molecular layer deposition (ALD/MLD) is a promising "bottom-up" alternative to the current nanopatterning techniques [1,2]. Due to the inherent 2-dimensional (2D) nature, the surface of graphene and other 2D materials do not provide sufficient reactive sites for chemisorption of ALD/MLD precursors compared with traditional microelectronics. Functionalization of certain surface areas is required to provide the selective growth of insulating materials. Recently, we overcame the chemical inertness of graphene to ALD precursors by local activation using direct femtosecond laser two-photon oxidation (TPO) [3] for selective ZnO deposition [4].
In this study, we guided the growth of Eu-organic thin films on top of single-layer graphene via TPO. We achieved high homogeneity (Figure 1a) and close to 100 % selectivity in locally activated predefined regions for Eu films up to 15 nm. The polymer used for graphene transfer highly affects the selectivity of the ALD/MLD process, as it might leave residues and promote unnecessary deposition in pristine graphene areas. The fabricated graphene/Eu-organic thin films exhibited high photoluminescence at 625 nm even when excited with a green laser (Figure 1b). These films are suitable for various applications such as fluorescent sensors or organic light-emitting diodes with small pixel sizes.

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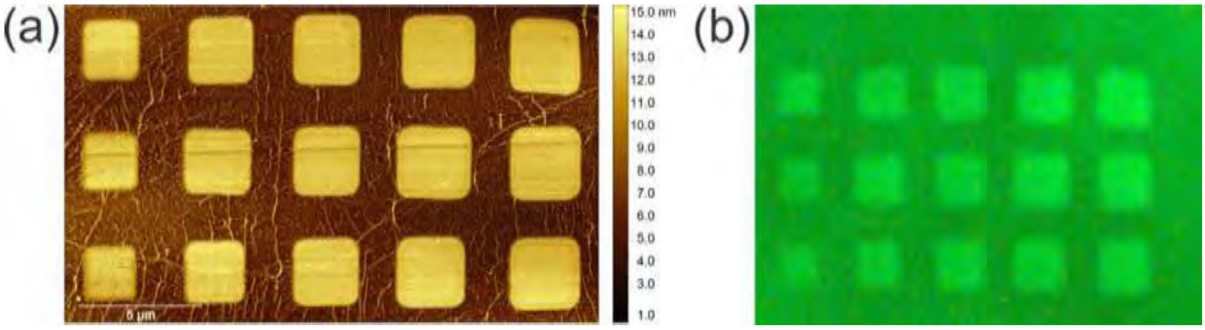

Figure 1: (a) AFM height image of Eu-organic film selectively deposited on predefined oxidized graphene patterns. (b) FLIM image of the same area excited by 514 nm laser with 20 µW power.

Nanotechnology Applications for Brain-Computer Interfaces: Enhancing Communication and Mobility

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Brain-computer interfaces (BCIs) hold tremendous potential for revolutionizing communication and mobility for individuals with neurological disorders or disabilities. By leveraging nanoscale materials and devices, BCIs can be made more efficient, durable, and compatible with the human brain. Recently, it has been clear that incorporating nanotechnology into BCIs is a viable way to raise their effectiveness, biocompatibility, and overall performance. This study provides an overview of the key applications of nanotechnology in BCIs and their impact on enhancing communication and mobility. First, better electrical contact with neurons has been made possible by the use of nanomaterials as electrode materials, such as carbon nanotubes, graphene, and nanowires [1]. This has increased signal quality and permitted more effective communication between the brain and external devices. Additionally, the creation of miniature, flexible brain probes through the use of nanotechnology has made it possible to precisely and selectively record or stimulate cerebral activity, making accurate and dependable BCIs possible [2]. Additionally, nanotechnology-based biocompatible coatings have been crucial in reducing immunological reactions and inflammation, improving the long-term stability and effectiveness of implanted BCI devices [3]. Furthermore, the targeted drug delivery to particular brain regions made achievable via nanotechnology provides potential therapeutic advantages, particularly for the treatment of neurological conditions linked to impairments in speech and mobility [4]. While these developments showcase the enormous scope of nanotechnology in BCIs, it is crucial to keep in mind that further research, clinical trials, and safety assessments are needed to ensure their applicability and effectiveness in actual environments. The incorporation of nanotechnology in brain-computer interfaces poses ethical concerns about acquiring participants' informed consent and protecting the confidentiality and security of the sensitive neurological data that BCIs collect and handle. However, the incorporation of nanotechnology in BCIs shows promise for improving autonomy and the quality of life for those with neurological conditions by transforming communication and movement.

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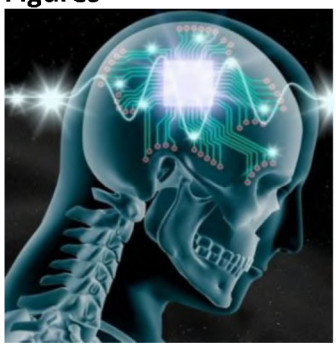

Figure 1: Neuralink's Nanotechnology Unleashing the Potential of Brain-Computer Interfaces

Electrochemical sensor for HMF based on glassy carbon electrode modified with nickel graphene carboxylate

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Abstract

The product of the Maillard reaction, 5-hydroxymethylfurfural (5-HMF), is formed under acidic conditions by the dehydration of sugars in foods during heating and storage. The concentration level of HMF is not only an indicator of the freshness of honey but also of the duration and conditions of storage. The sensitive and selective voltammetric method using glassy carbon modified with nickel carboxylate graphene showed high performance on determination of HMF. Through the oxidation reaction between HMF and nickel ions on the surface of the electrode, the electrochemical signal was recorded for 5-hydroxymethylfurfural (HMF), and the working conditions for the quantitative determination of HMF were optimized on hydrodynamic amperometry. After studying the electrochemical reaction mechanism at electrode surface using cyclic voltammetry technique, the optimal conditions of sensor operation such as reaction time, pH of the solution, concentration of the modifier, as well as analytical parameters: linear range, and detection limit were found using the hydrodynamic amperometry technique. The linear range of the method is up to 2 µM, with 70 nA/µM a sensitivity with a correlation coefficient R2= 0.9956. From the tests, it was found that the method is suitable for quantitative determination even in real samples, compared with the reference method for determination of HMF. The electrochemical sensor showed successful application in the determination of HMF in the matrix of real samples.

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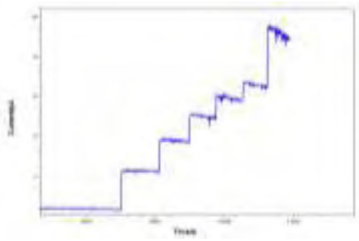

Figure 1. The amperogram obtained ate GCE-GrCOONi electrode after injection of the HMF. Operating potential 0.6 V, pH=12 (KCl+NaOH).

This research was financed by the Academy of Sciences of Albania through the project "Development of a new electrochemical sensor for the determination of HMF, for honey quality control" in the framework of the call "NanoAlb Ignite projects 2022-2024".

Maximizing the adsorption efficiency in electrochemical determinations: Insights into electrode surface modifications

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Abstract

The precise assessment of antioxidants in wine is crucial for evaluating its quality and health benefits. Catechins, prominent antioxidants found in wine, significantly contribute to its overall antioxidant capacity. These polyphenolic antioxidants also play a vital role in maintaining the color stability of wine during aging. Electrochemical measurements provide a reliable method of quantifying catechins in wine due to their sensitivity and specificity. However, it is essential to optimize the efficiency of catechin adsorption onto electrode surfaces to enhance the accuracy and precision of these measurements.

This study aims to explore strategies for improving the adsorption efficiency in electrochemical determinations of catechins in wine. Various approaches are investigated to maximize the adsorption of catechins onto the electrode surface. These include evaluating the impact of different types and sizes of graphite, assessing the influence of binding oil and its concentration, investigating the optimal adsorption time, and optimizing other experimental conditions such as electrode material, pH, temperature, and scan rate. A comparison is also drawn between the in-situ method, which entails the direct measurement of a solute within a solution, and the ex-situ method, wherein the electrode is immersed in the analyte solution, subsequently withdrawn, and transferred into the measuring solution. Once the method optimizations are completed, real wine samples sourced from different regions of Albania are tested. The quantification of catechins in these wine samples is performed using the differential pulse voltammetry (DPV) technique, which offers high sensitivity and selectivity in detecting and measuring these antioxidant compounds. The successful implementation of the investigated adsorption enhancement strategies demonstrates a significant improvement in the accuracy and precision of catechin determination in wine samples.

Selective Electrochemical Detection of Doxorubicin Using Molecularly Imprinted Polymer-Modified Boron Doped Diamond Electrodes

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Drug detection in biological solutions is crucial for tracking pharmacokinetics in the body. Electrochemical detection methods are promising for accuracy and rapidity, but measuring multiple drugs that react at similar potentials is difficult. Therefore, molecularly imprinted polymers (MIPs) were modified onto the electrode surfaces. The MIP has specific cavities whose shape fits template molecules and enables selective detection. Boron doped diamond (BDD), known for its high functions, was chosen as an electrode material [1]. In this study, doxorubicin (DOX), an anticancer drug, was used as the template molecule, and an electrochemical sensor that can detect DOX specifically and with high sensitivity was developed. In electrochemical measurements of DOX using an unmodified BDD electrode, a maximum reduction current from the background current was observed at -0.52 V *vs.* Ag/AgCl [2] (Signal-to-background ratio (S/B) = 123 (300 nM)). Other drugs, an antiepileptic drug, clonazepam (CZP), for instance, exhibited a reduction reaction (S/B = 35.2 at -0.67 V *vs.* Ag/AgCl)) when a similar potential was applied (Figure 1(a)). When their mixed solution was measured using the unmodified BDD electrodes, it would be difficult to only measure the concentration of DOX. In a similar measurement using the MIP-BDD electrodes, DOX reduction current increase was observed (S/B = 8.14 (300 nM at -0.56 V *vs.* Ag/AgCl)), but CZP reduction current increase decreased (S/B = 4.35 (300 nM at -0.75 V *vs.* Ag/AgCl)) (Figure 1(b)). This suggests that the MIPs using DOX as template molecules inhibited the reduction of CZP and enabled selective DOX measurements. The DOX in plasma was measurable using the electrochemical DOX-sensor based on the MIP-BDD electrodes. It exhibited the DOX concentration-dependent current increase in plasma. This MIP-BDD sensor may be helpful for therapeutic drug monitoring (TDM) in human patients.

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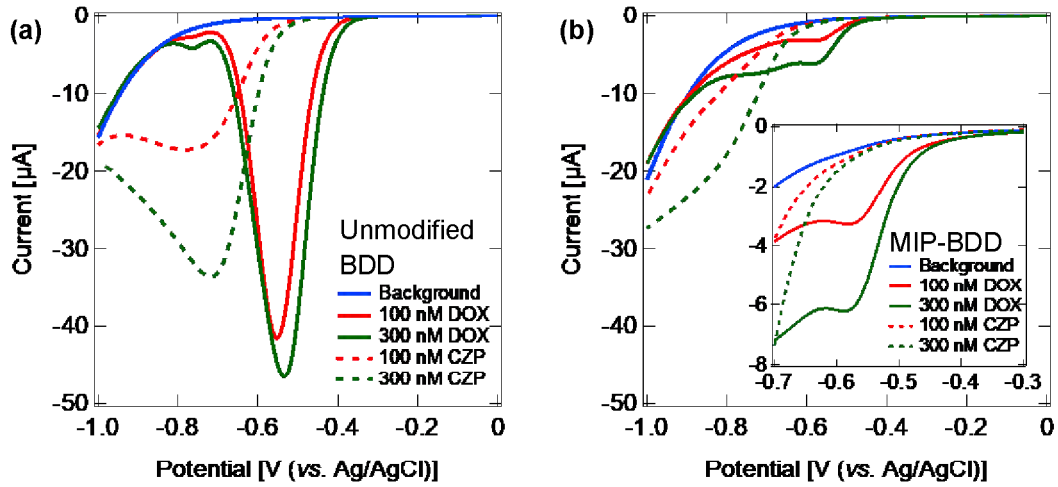

Figure 1: Linear Sweep voltammograms of DOX and CZP in PBS using (a) an unmodified BDD electrode and (b) an MIP-BDD electrode.

A fully wearable conductive yarn-based potentiometric ion sensor, self-powered by TENG in shoe sole for analysing sodium in sweat

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Abstract

Sweating during vigorous aerobic workouts leads to sustained loss of water and electrolytes from the human body (hypohydration). This is known to increase physical and cardiovascular strain and thereby degrade the performances of athletes [1]. Since the rate and composition of sweat loss vary among and within individuals [2], a wearable continuous sweat monitoring system will be an invaluable resource for athletes to analyse their electrolyte loss during workouts and to get personalized fluid and electrolyte replacement suggestions [3]. Moreover, the usage of batteries to power these sensors is known to make them rigid, bulky and less wearable and importantly, reduce the devices' life span [4]. The incorporation of wearable energy harvesters can overcome this challenge. Herein we fabricated a wearable potentiometric sweat sensor based on carbon ink-coated cotton yarns as a conductive electrode, functionalised with an ion-selective membrane, and powered by a soft and flexible PDMS-based triboelectric nanogenerator. Due to their flexible and highly mouldable nature, the TENG was incorporated into the heel portion of the shoe sole to generate energy from the motion of the foot during workout and the proposed potentiometric sensor was attached towards the opening of the socks, facing the skin. Using a low-power BLE module the collected data was transmitted to an external user interface for easy data display. This system has potential applications beyond monitoring sodium ions and can be seamlessly integrated into fabric, making it a promising technology for future wearable biosensing devices.

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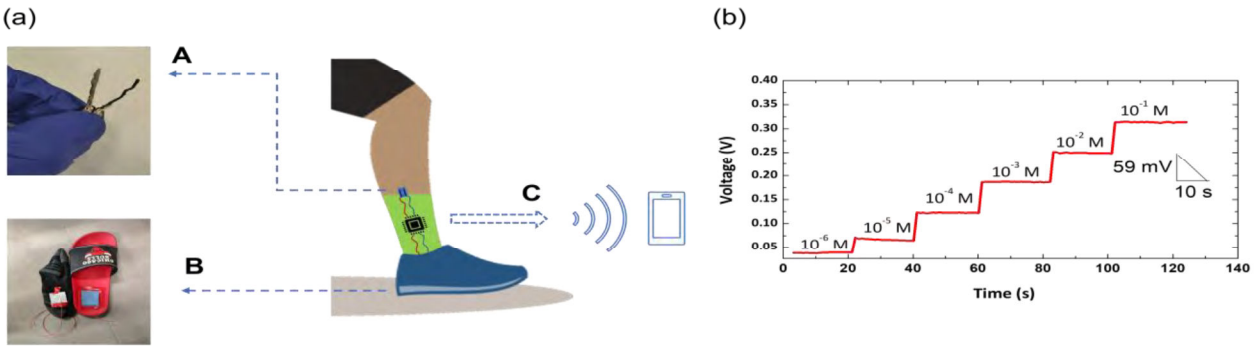

(a)Illustration of self-powered Na^+ wearable sensor with (**A**) conductive ink-coated cotton yarn-based sensing unit, (**B**) shoe sole based TENG and (**C**) BLE module. (b) Response obtained when different concentrations of Na^+ were added to the sensor.

Fabrication and Effective Sorption Behavior of Electrospun *Cystoseira barbata*/PAN fibers

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Abstract

With the recent rapid development of cities and industries, toxic heavy metal ions release into groundwater and critically pollute the aquatic environment. Heavy metal ions are a serious threat to human health because they cannot be degraded in the aquatic environment [1] Lead (Pb(II)) ions are one of them that are difficult to remove from waters. Among the numerous methods (biological, chemical precipitation, ion exchange, and sorption) used for the sequestration of Pb(II) ions from wastewater, sorption has clear benefits such as ease of use, high efficiency, and reusability [2]. Therefore, it is crucial to develop low-cost and high-performance sorbents. Algae are biological sorbents with high metal retention potential due to their functional groups such as carboxyl, hydroxyl, amine, and sulfonyl [3]. Nanomaterials are well known for metal ion sorption as they have a high surface area/volume ratio, high strength/weight ratio, and interconnected porosity [4, 5].

In this study, polyacrylonitrile (PAN) fibers containing *C. barbata* were used for the first time to remove Pb(II) ions from the aqueous media. For this purpose, *C. barbata*/PAN fibers were fabricated by electrospinning, and their morphological, structural, and mechanical properties were determined. Then, the sorption of Pb (II) metal ions was studied using *C. barbata*/PAN sorbent. The effect of shaking time, percentage of algae, sorbent amount, pH, temperature, and initial metal ion concentration on the sorption behavior was investigated by batch method. Accordingly, 5 mg of 5% doped *C. barbata*/PAN has a high sorption percentage (88.89%) for Pb (II) metal at 60 min, pH 4.0, 100 µg L^{-1} initial ion concentration. Furthermore, the nature of the sorption process was described using thermodynamic parameters, kinetic and isotherm models. After sorption, the presence of lead ions in the EDX analysis of the nanofibers confirmed the sorption behavior. According to FTIR analysis, carboxyl, and sulfonyl groups presented by algae and polymer played an active role in metal sorption.

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Comparison of Polymerization Techniques for the Development of Molecularly Imprinted Polymer-Based Electrochemical Sensor Used for Anticancer Drug Determination

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Olaparib (OLA; 1-(Cyclopropylcarbonyl)-4-[5-[(3,4-dihydro-4-oxo-1-phthalazinyl)methyl]-2-fluorobenzoyl]piperazine), a significant anticancer drug, is used for the treatment of ovarian, prostate, breast, and pancreatic cancers. The mechanism of action of OLA is described as the inhibition of poly(ADP-ribose) polymerase (PARP) [1,2]. This study describes the first molecularly imprinted polymer (MIP)-based electrochemical sensor used for the determination of OLA. This sensor combines the high sensitivity, cheapness, and easy-use advantages of electrochemical sensors with the superior selectivity of MIPs. Because lack of selectivity can be a major issue in electrochemical sensors, MIPs have specific recognition ability thanks to the functional monomer and template-assisted polymerization process. In this work, two different polymerization techniques, photopolymerization (PP) and thermal polymerization (TP), were utilized. For both techniques same functional monomer, 4-aminobenzoic acid (4-ABA), was used with other necessary constituents such as ethylene glycol dimethacrylate (EGDMA), 2-hydroxy-2-methylpropiophenone, sodium dodecyl sulfate (SDS), tetraethyl orthosilicate (TEOS), etc. While UV light was used in the PP process, an oven was used to reach the desired temperature in TP. The surfaces of both developed sensors were characterized electrochemically and morphologically. In electrochemical measurements performed with MIP-based sensors, the indirect method was preferred, and a solution of 5 mM $[Fe(CN)_6]^{3-/4-}$ was used as the redox probe. The linear working range for both sensors was determined between 0.1 and 1 nM for the standard solution and the commercial human serum sample. The LOD values for the standard solution for PP and TP methods were found as 4.2 pM and 28.6 pM, respectively. Good recovery and RSD% values as a result of serum and tablet applications were obtained, and the sensors' accuracy was confirmed. Interference and imprinting factor studies demonstrated high selectivity. Finally, the non-imprinted polymer (NIP) was used to check MIP-based sensors' performance.

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Graphene quantum dots based optical biosensor system for rapid detection of *Salmonella spp*

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Abstract

Globally, contaminated food is responsible for 600 million cases of foodborne illnesses each year, nearly 1 in 10 people, resulting in 420,000 fatalities [1]. It is estimated that tainted food costs approximately USD 110 billion annually in terms of lost productivity and medical expenses [2]. Rapid detection of foodborne pathogens is crucial for protecting supply chains and public health [3,4]. However, the current approach involves labor-intensive laboratory work and extended processing times [5,6]. To address these challenges, a novel nanomaterial-based lateral flow immunoassay (LIFA) integrated with an optical detection system utilizing the exceptional properties of graphene quantum dots (GQDs) was introduced. This innovative system is designed for the detection of *Salmonella spp.*, the most common foodborne pathogen responsible for severe illnesses and disruptions. The synthesized GQDs have been incorporated into the LIFA kit, which is integrated into an optical system developed by our project team. Beyond enabling rapid detection and quantitative analysis, our system facilitates image processing and allows for the transfer of test results to smartphones. This optical biosensor system boasts remarkable attributes, including fast (<20 min), portability (200 g), point-of-care functionality, and high sensitivity (1-10 cfu/mL).

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Figures

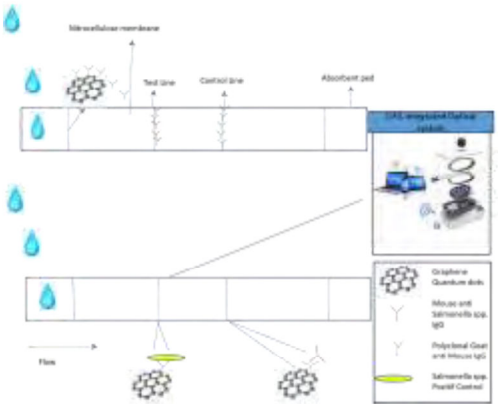

Figure 1: Scheme illustrating GQDs based LIFA integrated optical system for *Salmonella spp.* detection

Electrospun nanofiber-based assay design for pathogen detection

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Enterohemorrhagic *Escherichia coli (*EHEC) serotype O157:H7 is a food-borne pathogen that younger children are most prone to this microorganism. Hemolytic Uremic Syndrome (HUS) caused by EHEC, leads to the destruction of red blood cells and kidney failure. I most cases, the infection is self-limited in young children and aged population, it may cause HUS. Therefore, several investigations are performed to offer effective therapies and vaccines, which can prevent and treat the infection in appropriate time. As the pathogenesis of this infection is complicated, so new biotechnology methods are required[1]. Diagnostic techniques based on biomolecules, have many application areas that can be used. Immobilization of biomolecules to conductive surfaces is necessary to increase these properties. Electrospinning is one of the common biotechnological method that it can be used[2]. Nanofibers which are formed by electrospinning technique, in the immobilization of biomolecules to surfaces; is using due to its advantages such as morphology and pore size. Polycaprolactone (PCL), is a non-hazardous, hydrophobic, semi-crystalline and biocompatible polymer[3]. One of the essential strategies for improving mechanical properties and time of degradation of PCL-based materials can be the incorporation of nanostructures in PCL in the form of blend materials or as a copolymer[4]. Poly(amidoamine) (PAMAM,) which can be prepared with a few successive generations of synthetic reactions, has a structure that can be easily controlled due to its high density of cationic charges display electrostatic interactions with nucleic acids.

In this study, nanofiber was formed by electrospinning technique using polycaprolactone (PCL) and polyamidoamine dendrimer generation (PAMAM G5). Aptamer bonded using the surface binding potential of nanofibers. An assay was developed for the detection of *E.coli* O157:H7 by conjugation using the target-specific binding property of the aptamer.

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Enhancing the Antioxidant and Anticancer Potential of *Lavandula angustifolia* Essential Oil through Nanoformulation and Storage Evaluation

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Lavandula angustifolia, commonly known as lavender, is a well-known medicinal plant with numerous therapeutic benefits. Its essential oil is rich in bioactive compounds, including antioxidants and phytochemicals that exhibit promising anticancer/cytotoxic activities.
The study aims to optimize the therapeutic efficacy of *L. angustifolia* essential oil by employing a nanoformulation approach (liposomes and nanoemulsions). Nanoformulations have gained considerable attention in recent years due to their ability to enhance the bioavailability and stability of therapeutic agents. By encapsulating the essential oil within nanoparticles, its bioactivity can be preserved, and potential issues such as volatility and degradation can be minimized.
The presentation discusses the nanoformulation of *L. angustifolia* essential oil-loaded nanoparticles using biocompatible and biodegradable materials. Various characterization techniques, including particle size analysis, zeta potential determination, and encapsulation efficiency evaluation, were employed to assess the physicochemical properties and stability of the nanoformulation. Additionally, *in vitro* human cancer cells viability studies were conducted to investigate the controlled release behaviour of the essential oil from the nanoparticles.
Furthermore, the storage stability of the nanoformulation was evaluated under different conditions to assess its long-term stability. The changes in particle size, zeta potential and encapsulation efficiency of the essential oil were monitored over time to determine the impact of storage conditions on the nanoformulation.
The results indicate that the nanoformulation successfully encapsulated *L. angustifolia* essential oil, preserving its antioxidant and anticancer potential. Moreover, the stability studies revealed the importance of proper storage conditions to maintain the integrity and bioactivity of the nanoformulation.
Overall, this oral presentation highlights the potential of nanoformulation as a strategy to enhance the antioxidant and anticancer properties of *L. angustifolia* essential oil. The findings contribute to the development of innovative and efficient delivery systems for natural products, opening new avenues for their therapeutic applications in the field of cancer treatment and prevention.

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Development of GCE modified with graphene derivatives for detection of paraquat

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Abstract

Paraquat (PQ) is a well-known herbicide that is widely used in agriculture but it is highly toxic, negatively influencing the respiratory system, damaging livers, heart, kidneys and resulted in death [1].Therefore, the main goal of this study is to develop sensitive and selective electrochemical sensing platform suitable for the monitoring of the concentration of this herbicide in the environment. Here, we present novel electrochemical sensor based on state-of-the-art graphene derivates[3][4] which can be equipped with different functional groups that results in enhanced conductivity as well as selectivity. To prove that, two graphene derivatives (nitrogen doped graphene labelled as GN3 and "graphene acid" modified with iron nanoparticles) [2] were selected and tested as potential candidates suitable for PQ determination. The sensor characterization was accomplished via electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and square wave voltammetry (SWV). Obtained results indicate that such derivatives possess sufficient electrochemical response against PQ giving the sensitivity 0.0702 (μA/mM), correlation 0.984 and linear range 0.05 - 1.25 mM, respectively. Moreover, there is well-visible shift of the potential during the sensing of PQ for both derivatives, which was obtained at -0.65V. Such findings imply, that would be possible to build multiplex sensing platform suitable not only for the determination of PQ but also for the determination of herbicides with the similar structure (imidacloprid and thiamethoxan).

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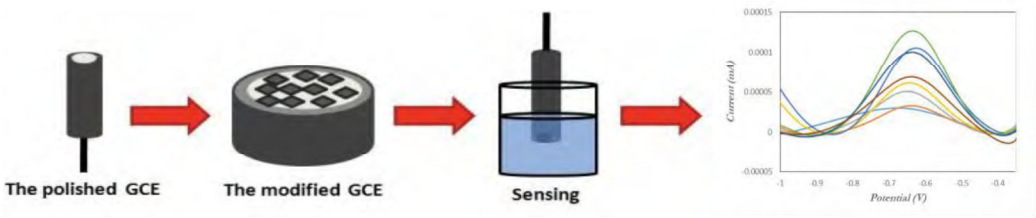

Figure 1: Typical SWVs of paraquat obtained using GCE modified with GAFe in BRB pH 7.04

Crucial Parameters to Obtain a High-Performance Supercapacitor from Plastic Waste

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Activated carbons (ACs) find common use in electric double layer capacitance (EDLC) supercapacitors. One sustainable approach to produce ACs involves repurposing plastics as a raw material, effectively addressing plastic waste management.
In our research, we introduce a two-step procedure comprising pyrolysis followed by chemical activation. This method successfully converts conventional plastic waste into activated carbons suitable for use as electrode materials in supercapacitors (Figure 1). In addition to established parameters like specific surface area and micropore volume, our study underscores the significance of several crucial factors, including the polymer's glass transition temperature, compatibility between the polymer and activating agent, the ratio of the activating agent (K_2CO_3) to ACs, and the stability of ACs when dispersed in water. By fine-tuning these parameters, we achieved ACs with competitive electrochemical performance metrics. Specifically, the ACs exhibited a specific capacitance of 220 F g^{-1} (at a current density of 1 A g^{-1}), energy and power densities of 61.1 Wh kg^{-1} and 36.9 kW kg^{-1}, respectively, along with outstanding cycling stability (95% retention after 30,000 cycles).
Incorporating recycled plastic into the production of supercapacitors has the potential to reduce manufacturing expenses when compared to traditional feedstocks for active carbon. This, in turn, can promote enhanced resource efficiency and a more sustainable approach to the manufacture of supercapacitors. Our findings pave the way for transforming plastic waste into valuable electrode materials for supercapacitors.

Figure 1: The process sequence, starting from polymer waste, through the creation of activated carbons (ACs), and ultimately leading to the assembly of a supercapacitor device.

First PEDOT NPs based electrochemical MIPs sensor for the sensitive determination of Milrinone

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Molecularly imprinted electrochemical sensors have been generated with the use of molecularly imprinted polymers (MIPs) in electrochemical sensors, which provide several advantages in terms of specific target analyte recognition, sensitivity and selectivity, high chemical/mechanical stability, easy preparation, miniaturization, and reusability in the electrochemical analysis [1,2]. Since cardiovascular diseases are one of the most common causes of death in the world, their treatment is very important. Phosphodiesterase 3 inhibitors from the inotropic agent class are frequently used in the treatment of these diseases, which generally develop due to congestive heart failure. Milrinone (MIL) is commonly used in treatments as an inhibitor of the phosphodiesterase-3 enzyme. However, adverse reactions with PDE inhibitors might include increased liver enzymes, thrombocytopenia, and electrolyte abnormalities [3]. In this work, a new sensitive electrochemical sensor has been developed by electropolymerization of molecularly imprinted polymer with poly(3,4-ethylenedioxythiophene) nanoparticles (PEDOTNPs) on a glassy carbon electrode (GCE) in aqueous solution using cyclic voltammetry (CV) in the presence of Milrinone (MIL) as template molecules. Surface morphology and electrochemical characterization of MIP/PEDOTNPs/GCE were characterized by electrochemical impedance spectroscopy and cyclic voltammetry, respectively. 5 mM *o*-Phenylene diamine, (*o*-pDE) and 0.1 mM MIL was prepared in acetate buffer solution (ABS, 0.1 M, pH 5.2) and electrochemical polymerization utilized on GCE. Polymerization was performed with 30 numbers of CV scans between 0.0 V and +0.8 V at 50 mV/s. To remove unbound monomers or MIL, GCE/MIP washed with an ethanol/water mixture. The same polymerization method was then used to form non-printed polymer (NIP), that is, without MIL molecules. All electrochemical analysis of the designed molecularly imprinted electrochemical sensor were completed with CV and DPV using 5 mM $[Fe(CN)_6]^{3-/4-}$ solution in 0.1 M KCl solution as a redox probe. The electrochemical behaviour of MIP/PEDOTNPs/GCE with MIL revealed that, in comparison to bare GCE, the signal of MIL's oxidation current obtained with MIP/PEDOTNPs/GCE was much higher. This indicates that the modified electrode has excellent selectivity for MIL and may accelerate electron transport. Under optimal conditions, MIP/PEDOTNPs/GCE showed a good linear relationship between 10-100 fM and MIL oxidation peak current and MIL concentrations and limit of detection (LOD) 2.77 fM (S/N=3). The modified electrode had great repeatability and stability. Finally, MIP/PEDOTNPs/GCE has been effectively used to determine MIL in serum samples and ampoule dosage forms.

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Biomedical applications of graphene and new 2D-nanomaterials

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Photothermal therapy (PTT) using 2D nanomaterials (2DnMat) has recently emerged as a promising alternative treatment for cancer, a major global health challenge. High surface area, high extinction coefficient in near infra-red region, responsiveness to external stimuli like magnetic fields, and the endless possibilities of surface functionalization, make 2DnMat ideal platforms for PTT. Most of these materials are biocompatible with mammalian cells, however, each material must be comprehensively characterized physiochemically and biologically, since small variations can have significant biological impact. Highly efficient and selective PTT for the treatment of cancer has already been achieved, using different 2DnMat concentrations and incubation times. Despite the promising results, some challenges remain, such as improving 2DnMat conjugation with drugs, understanding their biodegradation, and refining the evaluation criteria to measure PTT effects. A general perspective on the work of our team will be presented, focusing on applications of 2DnMat, with emphasis on graphene-based materials for phototherapy, immunotherapy, and 3D-printing for tissue regeneration [1-3].

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Enhancing Resistive Humidity Sensors with rGO Resistors for Thermal Compensation

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Environmental measurements often require monitoring ambient humidity, with sensors commonly employing capacitive or resistive technologies. While capacitive sensors are commonly used, implementing resistance measurement at the circuit level offers distinct advantages, including greater sensitivity and ease of quantification. However, resistive sensors introduce a significant challenge: their resistance values not only vary with humidity but also fluctuate with temperature. In the case of silver printed sensors, this variation in resistance is due to the positive thermal coefficient of the material. In contrast, carbon-based materials, including reduced graphene oxide (rGO), exhibit a negative thermal coefficient. In most scenarios, temperature-induced resistance variations are negligible. Yet, in extreme environments like deserts, characterized by wide temperature fluctuations, or during measurements in volcanic areas, thermal effects can become substantial. Consequently, it becomes imperative to apply correction or compensation techniques. In this study, we explore the application of rGO resistors in series circuits to counteract the thermal changes observed in silver tracks. Through this innovative approach, we aim to develop humidity sensors that remain temperature-independent, ensuring their accuracy and reliability in environmental monitoring applications.

Innovative Simultaneous Aptamer Selection Strategy for ACLF-Associated Small Molecules

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Decompensation of liver cirrhosis and its further progression to ACLF causes 1.2 million yearly deaths. The deregulation of the intestinal microbiota triggers the development of cirrhosis, i.e., altering the gut microbiome composition would have an inherent effect on the concentration of several metabolites, including kynurenic acid (KA), quinolinic acid (QA) and phenylalanine (Phe), which have caught attention as potential biomarkers for diagnosis and prognosis [1]. A well-known in vitro selection method called Systematic Evolution of Ligands by EXponential enrichment (SELEX) can be used to isolate aptamers —single-stranded DNA (ssDNA) or RNA oligonucleotides with high specificity and affinity for their target molecules— which have emerged as a promising alternative to antibodies [2]. SELEX involves multiple selection rounds where a ssDNA library with up to 10^{60} random sequences interacts with target molecules. Aptamers bound to the target are isolated, amplified via PCR, and purified. Stringency increases with each round, gradually enriching the library for sequences with high target affinity and specificity. Ultimately, sequences with the strongest affinities dominate and can be sequenced to identify optimal aptamer candidates [3].

In our research, we conducted two parallel and independent SELEX approaches, including a novel Joint One-Pot method to simultaneously isolate aptamers for QA, KA, and Phe, thus expediting aptamer selection for multiple targets. We compared this novel approach with a conventional bead-based selection strategy, which focused solely on isolating aptamers for Phenylalanine (Phe). Our findings aim to validate the feasibility of our proposed method while highlighting the importance of various optimizations and considerations to enhance the likelihood of successful aptamer selection.

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The safety of using nanotechnology in cosmeceuticals and their availability in the albanian market

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Abstract
Nanoparticles are nowadays used from all major cosmetic industries leading to the development of so-called nanocosmetic products. The different types of nanoparticles employed in cosmetics include liposomes, niosomes, SLNs, fullerenes, TiO_2, ZnO etc. Due to their novel properties mainly derived from the reduction of particle size up to the nano size, nanocosmetic products have brought novelties in antiage treatment and prevention of age signs. Many scientists consider these products as cosmeceuticals. Recently, a number of concerns have been raised regarding the safety of these products. Researchers believe that nanoparticles may enhance penetration through the skin layers and may gain access to the blood stream and from there they can be transported to the various organs. Other concerns are the exposure of workers and the release of such particles in the environment. The purpose of this work is to review the scientific literature which sustains the efficacy and safety of nanocosmetic products and to conduct descriptive survey in the city of Tirana in order to assess the presence and knowledge level on nanocosmetic products in this district. 100 pharmacists participated in this survey during a period of 3 months. Participants were asked about their knowledge about the subject and asked their opinion regarding the presence of nanocosmetics in Albanian pharmacies.

Key words: nanoparticles, cosmeceuticals, nanocosmetics, anti age treatment, study.

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Selective Transformation of Cumene in Electrochemical Batch and Flow Reactors

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Electro-organic synthesis has attracted attention from the viewpoint of sustainability because reactions can proceed well even at ambient conditions [1]. However, in a generic batch reactor, long reaction time is generally required, leading to a poor product selectivity due to side reactions. On the other hand, in a flow reactor, products flow outside the reaction system, which improves the selectivity by suppressing side reactions. Herein, we report selective molecular transformation of cumene in electrochemical batch and flow reactors.

A solution of cumene (**1**) and Et_4NClO_4 (0.1 M) in MeCN was transferred into the undivided electrochemical reactors equipped with boron-doped diamond (BDD) anode and cathode. A constant current electrolysis was performed at room temperature.

In the batch reactor, **1** was electrochemically converted into cumene hydroperoxide (**2**), acetophenone (**3**), and cumyl alcohol (**4**). The main product was **3**, and the isolated yield was 34% under the optimum condition with the current density (*j*) of 2.1 mA/cm^2 and the amount of charge (*Q*) of 5.0 F (referring to mole of **1**) [2]. On the other hand, in the flow reactor, **4** was obtained as the main product with the GC–MS yield of 44% under the optimum condition: *j* of 0.25 mA/cm^2, *Q* of 1.0 F (referring to mole of **1**), and flow rate of 0.375 mL/min (**Table 1**). Obviously, the product selectivity in electro-conversion of cumene can be controlled by changing electrolysis modes. This is especially because an overoxidation of **4** into **3** was suppressed in flow electrolysis.

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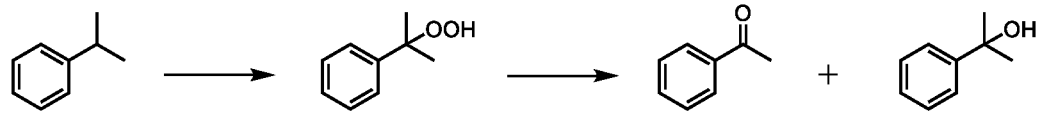
Table 1. Screening of flow electrolysis conditions.



1 **2** **3** **4**

Entry [a]	*j* (mA/cm^2) [b]	*Q* (F) [c]	*v* (mL/min) [d]	Yields (%) [e]		
				1	**3**	**4**
1	2.0	1.0	3.0	30	n.d.	17
2	2.0	3.0	1.0	14	14	10
3	2.0	5.0	0.6	3	7	6
4	3.0	1.0	4.5	1	3	3
5	1.0	1.0	1.5	trace	3	20
6	0.5	1.0	0.75	52	n.d.	42
7	0.25	1.0	0.375	36	n.d.	44

[a] Reaction conditions: BDD cathode and anode, 5 mM **1**, 0.1 M Et_4NClO_4, MeCN (30 mL), undivided flow cell, rt. [b] Current density. [c] Amount of charge (referring to mole of **1**). [d] Flow rate. [e] Determined by GC–MS. n.d.: not detected.

Graphene Functionalization for Sensing

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Graphene emerges as a very interesting material with a range of potential sensing applications. Introducing covalent chemical functionalities to graphene promises materials that yield valuable sensing responses. While direct functionalization of graphene poses challenges due to its innate inertness, the chemistry of fluorographene represents a breakthrough enabling an alternative avenue for creating a diverse and wide spectrum of graphene derivatives with covalently mounted chemical functional groups from small chemical moieties (e.g., nitre of carboxyl groups) up to enzymes and aptamers. Notably, their low resistivity renders them exceptionally suitable for electrochemical sensing. This presentation will offer insights into the spectrum of graphene derivatives, exploring their roles in electrochemical and optical sensing. Additionally, future perspectives of this intriguing class of graphene derivatives will be presented.

Determination of Famotidine as antiulcer drug in serum samples with high selectivity using a MIP-based electrochemical sensor by photopolymerization

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Abstract
Famotidine (FAM) is an efficacious competitive drug and a reversible inhibitor of H2-histaminergic receptor action used to manage acid production in the stomach [1]. Electrochemical methods are widely used for analyzing or detecting target analytes from various samples. A molecularly imprinted polymer (MIP) is produced by polymerization in the presence of a target molecule. The polymerization comprises a monomer, initiator, cross-linker, and target molecule. MIP aims to form artificial receptors for target molecules [2]. In this study, a new molecularly imprinted polymer (MIP) based sensor was developed for the selective detection of FAM by the photopolymerization of 4-aminobenzoic acid (4-ABA) in the presence of FAM on the glassy carbon electrode (GCE). The surface characterization was performed with cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and scanning electron microscopy (SEM). The conditions such as monomer: template ratio, dropping volume, photopolymerization time, removal solution, removal, and rebinding time for a successful MIP system were tested. The analytical performance of the NIP (non-imprinting polymer) based sensor was also evaluated to control the MIP-based sensor. The selectivity of the developed sensor was also tested with similar compounds with FAM. The results showed that the developed sensor could achieve to detection of FAM from synthetic serum samples. The analytical performance of the sensor was evaluated, and it seems a good correlation between the concentration of FAM and currents.

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Dual electrochemical immunoplatform for the determination of epithelial glycoproteins associated with colorectal cancer aggressiveness

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Advances in cancer care and prevention include studying the role of candidate markers and the identification of new ones seeking the implementation of precision cancer medicine and minimal residual disease (MRD), to improve patients' survival, quality of life, and commitment to self-care and guarantee significant savings in healthcare costs. This progress depends to a great extent on the development of new disruptive technologies, including cutting-edge electrochemical bioplatforms, with the versatility of design and application required both to further explore the role of certain biomarkers and to identify new ones, and capable of meeting current pressing demands in terms of simplicity, reduced assay time, compatibility with multiplexed and/or multi-omics determinations, and applicability at the point-of-care (POC).

Mucin (MUC) proteins not only provide a suitable microenvironment to prevent hypoxia, acidity and other biological conditions that promote cancer progression, but also their composition and structure allows them to mimic the surface of normal epithelial cells, enabling tumour cells to escape immune surveillance [1]. The study of mucins' structure and function is an expanding field due to their clinical relevance, and their prospective use as potential therapeutic targets [2]. Among the mucin proteins family, transmembrane mucins 1 (MUC1 or CA15-3) and 16 (MUC16 or CA125) have been the most well-studied in terms of their clinical importance in tumorigenesis [3]. These two mucins are overexpressed in different types of cancer, including colorectal cancer (CRC), the second leading cause of cancer-related mortality worldwide, becoming particularly relevant in their progression [4].

In this work, the dual determination of MUC1 and MUC16 in extracts of CRC cells (1.0 µg per determination) with different metastatic potential is demonstrated. A disposable amperometric sandwich immunoplatform is used, it involving magnetic microsupports (MBs), a set of specific antibody pairs to intercalate each target protein (a capture antibody, cAb, and a biotinylated detector antibody b-dAb further labelled with a streptavidin-horseradish peroxidase, Strep-HRP, polymer), and amperometric detection on dual screen-printed carbon electrodes (SPdCEs) using the hydroquinone (HQ)/horseradish peroxidase (HRP)/H_2O_2 system. Under the optimised experimental conditions, this dual immunoplatform allows reaching limit of detection (LOD) values of 1.81 and 50 pg mL^{-1} (or mU mL^{-1}) for MUC16 and MUC1, respectively, and selectivity suitable for the determination of the two targets in clinical samples. These features together with its simplicity, multiplexing capacity, miniaturisation, and compatibility with POC devices, confirm that the developed bioplatform can be potentially employed to assist in both the early diagnosis of CRC and MRD detection, and demonstrates its competitiveness compared to ELISA and blotting technologies commonly used for the determination of these two mucins.

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Practical Detection of COVID-19 by Personal Glucose Meter and Signal Nanoplatform

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Abstract

For the COVID-19 pandemic, which is constantly on our agenda, it is possible to control the infection rate, minimize the risk of transmission and start early treatment of sick individuals by rapid detection of this disease. While PCR-based methods performed in the hospital for the detection of COVID-19 provide results with a high accuracy rate in the early stages, serological-based kits allow individuals to test themselves at home [1]. In this study; this is the first time a nucleic acid-based signal nanoplatform capable of in situ analysis (POC) for COVID-19 detection with high accuracy was developed. Another basic feature of this technology is that the strips of the existing glucose meter device, which is easily accessible to everyone, can be used for the detection of COVID-19.
For this aim, firstly, 3 target genes were selected from the regions with the lowest mutation rate and the lowest probability of matching within themselves, and probe DNAs were determined by taking the conjugates of the target gene sequences. The signal nanoplatform (MAP) was obtained by binding these DNAs to magnetite nanoparticles (MNP) modified with amine groups (Figure 1A). On the other hand, invertase enzyme was bounded to target DNA probes (Figure 1B) with the method suggested by Xiang and Lu [2]. For COVID-19 detection, the designed MAP was interacted with samples with and without viral genome (target DNA), and after the liquid phase was separated, invertase-DNA conjugate was added to the MAP. Different signals were obtained from the glucose meter depending on the target DNA concentration as a result of the reaction between the MAP with sucrose.
It was revealed by SEM, EDX, and FTIR analyses that MNPs were modified with amine group. Qubit measurements revealed that approximately $887^{\pm 170}$ ng of probe DNA was attached to the modified MNPs, and the 3 different probe DNA sequences did not interact with each other. It was clearly seen in the agarose gel that the target and probe DNAs did not match within themselves but hybridized with their conjugates to form dsDNA. In the experiments performed in phosphate buffer, the signal value for the negative sample (without target DNA) was found to be 344 mg/dl, and the signal value for the positive sample (including 361 ng of target DNA) was found to be 101 mg/dl. In the samples taken from individuals who were revealed to be COVID-19 positive and negative by PCR results, high signal values (>600 mg/dl) for negative case samples, and values below 358 mg/dl were obtained for positive cases as expected. The developed MAP also has a qualification to be used in other infectious diseases, cancer, pathogen, and GMO analyses by simply altering the probe DNA sequences.

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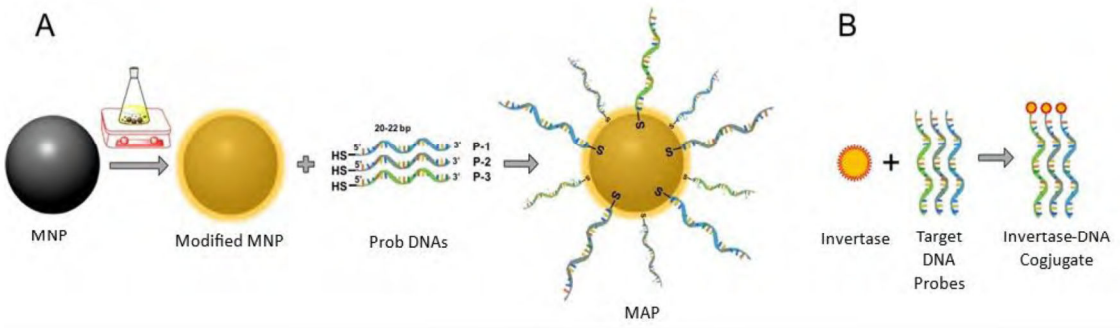

Figure 1: A) Designed signal nanoplatform (MAP), B) enzyme bounded target DNA probes.

Colorimetric point-of-care devices for rapid detection of salivary biomarkers and drugs

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Point-of-care testing (POCT) is drawing increasing attention in the diagnostics market, representing a valuable tool for the early detection and quantification of key biomarkers related to specific pathologies and to increase the chance of successful treatment.[1] The integration of noble metal nanoparticles, like gold (AuNPs), in POC devices strongly increases the stability and sensitivity of the test, enabling the detection of analytes also in non-invasive fluids where their concentrations are typically very low. Moreover, the remarkable plasmonic properties of AuNPs and their simple manipulation allow for a naked-eye readout that is cost-effective and flexible.[2] In particular, exploiting a target-induced morphological change of multibranched AuNPs, we developed a novel strategy aimed at detecting glucose in saliva.[3] The rapid color change associated with the particle shape variation and the successful technological transfer on a solid substrate enabled the realization of a dipstick prototype for the early and non-invasive home testing of hyperglycemia. Extending the same strategy to several targets, we realized a low-cost monolithic paper-based device for the simultaneous detection of three salivary biomarkers (cholesterol, glucose, and lactate), showing excellent selectivity and multiplexing ability.[4] Moreover, taking advantage of the POC technology, we realized two innovative devices for the assessment of anticancer drug contaminations both in occupational environments and in urine samples of healthcare workers, aimed at reducing the risk of the exposure.[5] We developed two lateral-flow assays based on the pharmacological action mechanism of the drugs for the recognition step, avoiding the use of costly antibodies. Particularly, we exploited the intercalation in the dsDNA probe and the competition with folic acid for the detection of doxorubicin and methotrexate, respectively.[6] The highly sensitive strategies were successfully adapted to a real urine sample, without resorting to complex pre-treatment procedures.

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Figures

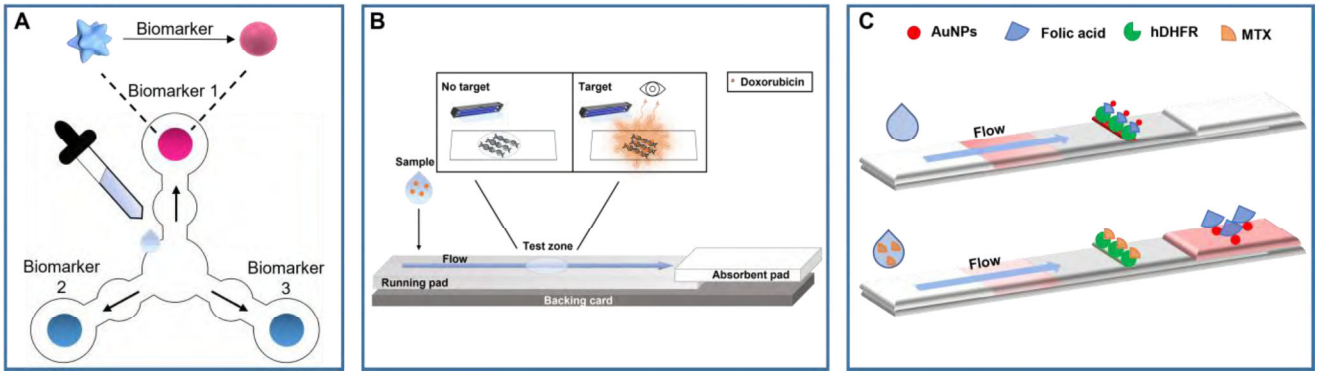

Figure 1: Schematic illustrations of the multiplexed paper-based device for the simultaneous detection of three salivary biomarkers (A), doxorubicin POC device (B), and methotrexate (MTX) lateral flow device.

Microfluidic production of biomimetic liposomes for personalized therapy of metastatic melanoma

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Nanoparticles (NPs) modified by cell membranes represent an emerging biomimetic platform that can mimic the innate biological functions resulting from the various cell membranes in biological systems. Many research investigations have demonstrated the potential utility of biomimetic NPs in the treatment of cancer. As a simple and effective approach, delivery vehicles consisting of cell membranes are extensively researched and found to have various merits, such as prolonging the circulation time, alleviating immunogenicity, and accomplishing active targeting [1].
In this study, we investigated the use of microfluidic technology to produce biomimetic liposomes (hybrid liposomes) by fusing synthetic lipids directly with cell membranes (CM) obtained from a metastatic melanoma cell line (MM) extracted from a patient biopsy material. Here, a microfluidic sonication strategy for one-step and continuous generation of liposomes and hybrid liposomes is proposed to address the challenge of breaking the CM by purely hydrodynamic forces in microchannels. (Fig. 1). Two polypropylene microfluidic devices fabricated using 3D printing technology with different geometries were tested. Due to their complex internal structures, both geometries produced high-quality monodisperse hybrid liposomes by passively mixing the two phases containing lipids and CM, respectively. [2,3].
To evaluate the best hybridization conditions, we produced three hybrid liposomes formulations starting by three different amounts of CM. First, we demonstrated the effective fusion of the CM with liposomes through dynamic light scattering, nanoparticle tracking analysis, fluorescence resonance energy transfer (FRET) and flow cytometry characterizations. To explore the homotypic targeting strategy, 2D and 3D *in vitro* uptake studies were performed, showing that the hybrid liposomes had a stronger affinity for its source MM cancer cells than for hepatocellular carcinoma cancer cell line, with an 8- fold higher cellular uptake compared with liposomes. Moreover, to candidate this biomimetic nanosystem as a potential therapeutic tool for the personalized treatment of metastatic melanoma, cobimetinib and lenvatinib, were efficiently loaded, demonstrating an in vitro higher antitumor efficacy referred to the free drugs administration.

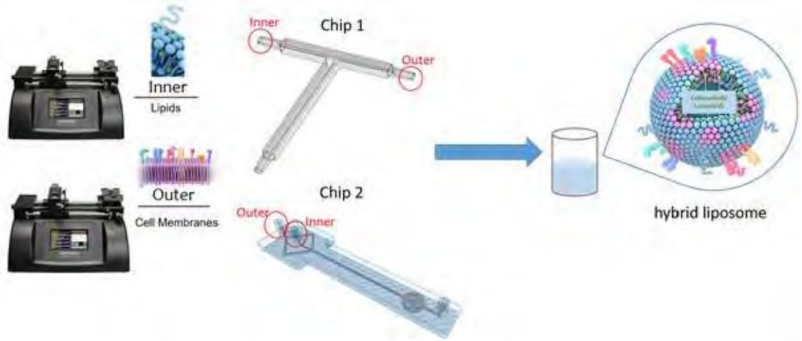

Figure 1: Schematic representation of setup producing hybrid liposome through microfluidics.

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Advancing Electrical Metrology with Graphene and Topological Insulators

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Since 2017, epitaxial graphene (EG) has been the base material for the US national standard for resistance. Nanoscale devices based on EG have been expanded to include specially designed arrays to rapidly expand access to quantized resistance at values other than $h/2e^2$ via mathematical star-mesh transformations. In addition to these developments, an alternative research avenue in electrical metrology has also formed around the use of magnetically doped topological insulators (MTIs), which seek to replace graphene as a standard due to its exhibition of the quantum anomalous Hall effect (or zero-field quantized resistance) [1-3]. Here we present results on both material systems to show the benefits gained by the metrology community, along with benefits applicable to many research endeavours focused on the fabrication of small-scale devices.

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Figures

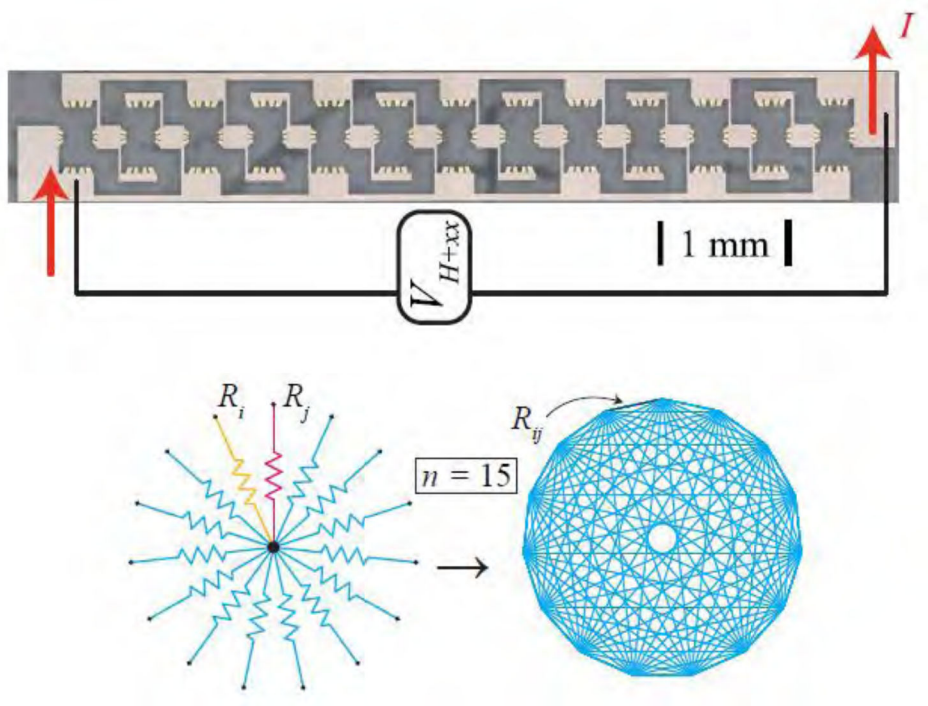

Figure 1: (Top) An example 13-element graphene-based array for obtaining quantized resistances other than $h/2e^2$. (Bottom) A mathematical star-mesh transformation for a 10 GΩ quantum electrical standard is illustrated, representing a possible configuration that is within fabrication capacities.

Organelle-derived genome electroanalysis applicable to low-resource settings for foodomics support

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Today nutrition's key role in health and wellness is fully accepted. In addition to moving forward to close food/health loop through accurate and personalized nutrition, emerging issues including climate change, access to sustainable land and water, inflation, and war-related food shortages need to be faced. In this sense, the ongoing progress of analytical tools has led to raise more ambitious goals using a wider outlook, triggering the birth of "foodomics" as new discipline, it being based on the study of food/nutrition nexus and its scope, by integrating leading-edge omics technologies to promote food safety and consumer wellness[1][2]. In this field, genomic studies have contributed to nutritional comprehension and follow-up as pathway to prevent and treat modern diseases such as diabetes, allergies, and chronic nutritional disorders. In this context, due to genomic material integrity during food processing, nucleic acid-based methodologies have been postulated as reliable alternative to protein-based assays. Indeed, foodomics aim can be extended to the interrogation of scarcely explored genes found in some abundant organelles as mitochondria and chloroplasts, small size genomes, which are easily handled and provide a more sensitive detection[3].
In this context, we are working on the set-up of amperometric genosensors for the sensitive and selective interrogation of food allergy-relevant genetic targets derived both from animals or plants, implying the selective capture of DNA/RNA heterohybrids onto magnetic microcarriers and their ultrasensitive detection with a specific antibody tagged with n-enzymatic bioconjugates for signal amplification purposes. These bioplatforms have been successfully implemented in the identification of genomic DNA from tomato[4] and mustard[5], and pioneeringly for the interrogation of organelle-derived genomic targets, such as chloroplast and mitochondrial DNA for the detection of peanut or meat adulterations using raw mitochondrial lysates[6], respectively. Currently, in addition to exploiting the isolation of organelles to enhance throughput and simplify gene extraction procedures, the biosensing pathway simplification for the set-up of single step bioelectronics approaches applicable to low resource settings with minimal handling and free of stirring and/or heating devices is being evaluated. The flexibility of the proposed methodology to easily and sensitively detect any type of nucleic acid, regardless of its nature (DNA or RNA), organelle type (nucleus, mitochondria or chloroplast) and origin (plant or animal) make them very promising tools for foodomics support and for advancing genome interactions with improved crop yield, nutritional quality, stress resistance or on-demand recombinant protein production in the desired food host.

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Noble metal nanoparticle-based lateral flow devices for colorimetric nanodiagnostics

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Lateral flow devices (LFDs) represent efficient paper-based methods for the evaluation of a variety of target analytes in the context of rapid and portable point-of-care testing technologies.[1] In particular, colorimetric assays allow instrument-free and naked-eye evaluation of the biomarker of interest.[2] Here, we present two noble metal nanoparticle-based strategies to develop LFDs for colorimetric diagnostics. First, a dual-color plasmonic immunosensor for the evaluation of salivary cortisol was developed combining two differently shaped gold nanoparticles (35 nm nanospheres and 60 nm nanostars).[3] Such strategy facilitated an easy and immediate evaluation of cortisol levels, providing a blue-to-pink color change of the detection area. The second assay involved 5 nm platinum nanozymes (PtNPs) for the assessment of total antioxidant capacity in human saliva or in food matrices.[4] The LFD was engineered with a multi-line PtNP-based detection zone, relying on three sequential test lines with increasing amounts of Pt nanocatalysts, able to provide a competitive colorimetric response depending on the antioxidants content of the sample. Notably, both methodologies can be applied as rapid (10 min), non-invasive and accurate monitoring systems, allowing an easy discrimination of various target concentrations.

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Figures

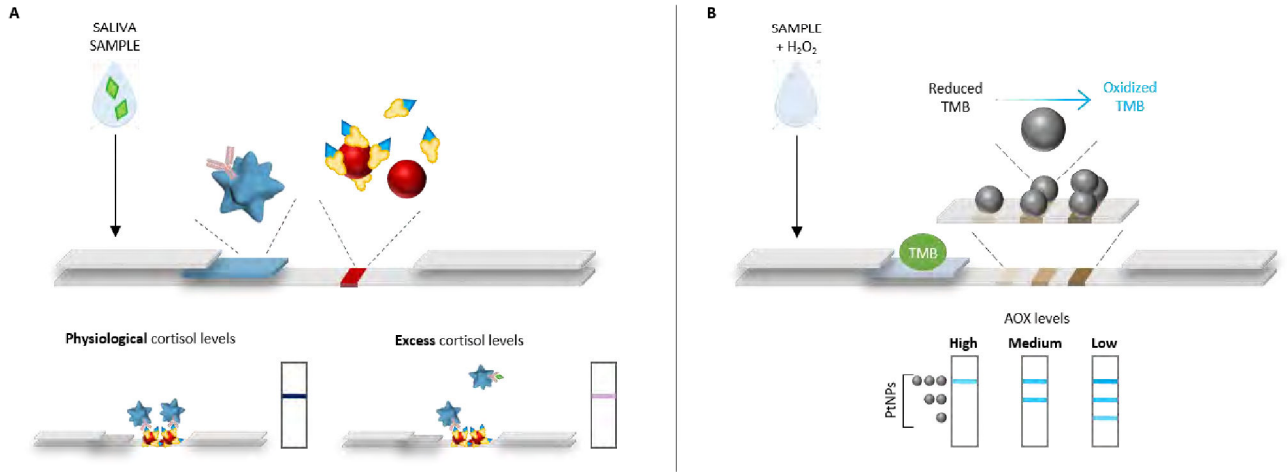

Figure 1: Scheme and working principle of the two colorimetric LFDs. (A) competitive dual-color plasmonic immunosensor for salivary cortisol evaluation, providing a blue-to-pink color change of the test line depending on the hormone's levels. (B) competitive multi-line PtNP-based LFD for antioxidants species assessment, providing a number of blue test lines inversely proportional to the antioxidants content of the sample.

Carbon nanofibers modified eight-channel array of electrodes for detection of lysozyme

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Abstract

Carbon nanofiber is a nanomaterial with graphene layers stacked in different shapes [1]. Due to their unique structure, physical and chemical properties, carbon nanofibers have applications in materials science, nanotechnology, energy storage, environmental science, biosensing, biomedicine and many other fields [1 – 3]. An impedimetric aptasensor was developed in this study [4] for the label-free detection of lysozyme. In this context, 8-channel array of carbon nanofiber modified screen-printed electrode (8-CNF-SPE) was used for the determination of lysozyme in order to show the application of the developed aptasensor in simultaneous multiple analyzes. Amino linked lysozyme specific aptamer was immobilized onto the electrode surface. After the interaction of lysozyme with aptamer at electrode surface, the measurement was done by electrochemical impedance spectroscopy (EIS) technique. An increase in Rct value was obtained proportionally with increasing concentration and lysozyme was determined quantitatively. The limit of detection was obtained as 0.38 µg/mL under optimum conditions. In addition, the determination of lysozyme was performed with a simultaneous multiple analysis system with a good reproducibility.

Acknowledgements: A.E. would like to express her gratitude to the Turkish Academy of Sciences (TUBA) as a Principal member for its partial support.

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Lateral flow assays for on-farm bovine veterinary monitoring

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Abstract

Accurate supervision of animal health and livestock management have a high impact on the productivity of meat and dairy industry. Thus, the development of Point-of-care (POC) diagnostic devices is highly demanded to bring the accuracy of molecular diagnosis into the farm. Lateral flow assay (LFA) is a popular POC test thanks to its user-friendly, time- and cost-effective design.[1] Gold nanoparticles (AuNPs) have been widely used as LFA labels by virtue of their plasmonic properties, which allow for naked-eye assessment of the test result. Herein, we developed two independent lateral flow immunoassays to enhance the ability of farmers and veterinaries to monitor two relevant veterinary parameters in cattle farming. The first test is a competitive immunoassay, to detect the level of progesterone. In the exact time window of bovine estrous, which is the optimal time for a successful insemination, the level of progesterone in blood is lower than 2 ng/mL.[2] On the other side, bovine mastitis is the inflammation of the udder due to infection or trauma. It is a disease with one of the highest economic impacts on the dairy industry. Hence, the second device classifies udder health in three levels: healthy, subclinical mastitis, and clinical mastitis. The test is based on a multiplexing strategy, targeting two biomarkers present in milk: haptoglobin and bovine immunoglobulin G. Haptoglobin is an acute phase-protein, and its concentration in milk increases hours after infection, which makes it suitable as early biomarker.[3] Immunoglobulin G is a convenient late biomarker, because its concentration increases during the secondary inflammatory stage of the disease.[4] Both in the devices were validated with their respective biological matrices. Finally, to assess the two devices' performances, an extensive on-farm validation is underway with real cow's blood and milk samples.

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Figure

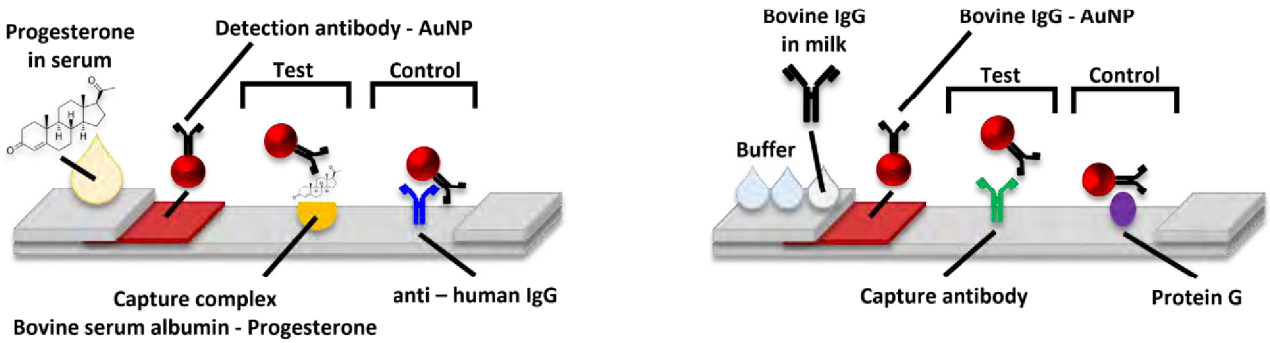

Figure 1: Lateral flow assays detection schemes for estrous determination in serum (left) and inflammatory latte mastitis phase detection in milk (right).

The impact of AI and recent developments in the pharmaceutical R&D steps

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Abstract

During recent months & years, our daily reality was "stormed" by the presence of AI (artificial intelligence) models and applications, with a massive impact on our working and living routine. Modern medicine and the pharmaceutical system must be included in AI's essential impact and rising importance.

Today, many healthcare professionals consider the "AI role" as one of the most critical factors that can change our way of developing modern drugs with the highest level & standard of quality, safety, and efficacity.

Many ongoing examples perfectly describe the importance of AI applications in procedures, the methodology of pharmaceutical research, and final development steps (R & D), with constant and continuous updates. We are facing new unique features and characteristics, but at the same time, there are many new challenges, including scientific, clinical, economic, ethical, regulatory, and political ones.

This presentation would like to focus on a detailed overview of recent developments related to AI applications (ChatGPT, et others) and their specific aspects, impacting R&D phases, pharmaceutical drug development, and pharmacist-patient everyday interactions. Discussions will include critical elements such as clinical trials, regulatory & legal aspects, pharmacovigilance, and special attention to our Albanian reality, its status, with local characteristics, problems, findings, and possible solutions.

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Figures

Figure 1: ChatGPT logo

Multistep optimization of Point-of-Care Microscopy in Microfluidic Settings

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Abstract

Microscopy is one of the most important fields of the medical science. Over the last half century, eventhough significant improvements have been accomplished, still several limitations of the physical components indicate the limits of the imaging technique [1]. Recently an increased focus is observed in settings that require rapid and accurate image acquisition and analysis of large data throughput and this is made possible with optimized experimental instruments in point of care microscopy [2, 3]. Sometimes the physical limitations could be overcome by using computational imaging. Fourier Ptychography microscopy is a relatively new branch of microscopy, but in the short time since its introduction, the benefits that it has brought have been enormous. The essence of this method lies in the reconstruction of images that go up to gigapixels using series of low-quality images. The traditional microscopic technique involves illumination by white light of the samples that are fixed on uniform glass slides. Here we report results of Fourier Ptychography while operating on microfluidic chambers which imply unique challenges. Images of the same sample using different illumination sources with different optical pathlengths are fused in the reciprocal domain and then a higher resolution image is acquired. The first improvement that we propose is the refocusing for every different light source. Secondly, we tested whether the quality of the reconstructed image depends on the illumination wavelength. We conclude that the refocusing improved the quality of the image and a shorter wavelength leads to a higher resolution of the images that are reconstructed.

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Production of lipids by *Rhodotorula* yeasts

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Abstract

The global need for energy supply indicates the urgent need to find renewable-based alternatives to fossil fuels [1]. Microbial oils have recently attracted attention in a move towards sustainable energy generation. Presently, oleaginous yeasts are being evaluated as oil factories, they have a short life cycle and are less affected by seasons and climate, require less labor and microbial oil production is easier to scale up [2-4]. Among them, *Rhodotorula* species have proved to have a biotechnological advantage over other oleaginous yeasts because of their ability to grow on inexpensive substrates [5]. *Rhodoturula toruloides* SBY29, *Rhodoturula toruloides* CBS14, *Rhodoturula babjevae* DVBPG 8058 were grown in a medium containing 10 % and 50 % of hydrolysate of logging residue for 5 days at 25°C on an orbital shaker at 130 rpm. The three strains showed growth in 10 % and 50 % of the logging residue. In 10 % of logging residue hydrolysate SBY29 showed highest growth (OD_{600}=23.5) and CBS14 lowest growth (OD_{600}=16). The same behavior of the strains was observed in 50 % of logging residue hydrolysate, SBY29 (OD_{600}=28.5), DVBPG 8058 (OD_{600}=27.5), CBS14 (OD_{600}=17). The study continued with 90 % dilution of this hydrolysate but none of the strains didn't grow in this media. The cultivation of the yeast strain SBY29 was performed in 500 mL bioreactor in pH=6 DO=21 % O_2 and temperature=25 °C. Most of the total sugars were depleted within the first three days of fermentation and yielded 85 % of total lipid content.

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Assessing the Impact of Gamma Irradiation on the Microbial Characteristics and Overall Protein Content of Dried *Agaricus bisporus* Edible Mushrooms

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Abstract

One of the extensively cultivated mushrooms in Macedonia is the Agaricus bisporus species. Nonetheless, the considerable susceptibility of mushrooms to decay poses a challenge to the advancement of this sector. Microbial contamination stands out as a significant issue in the realm of food preservation.
The presence of various microorganisms in food besides leading to disruption of organoleptic and nutritional properties, can directly threaten the health of the consumer. Treatment by irradiation emerges as a possible conservation technique that has been tested successfully in several food products. The purpose of this research was to investigate the effects of different doses of ionizing radiation on the microbial quality and the protein content of the dried mushrooms of the common cultivated species *Agaricus bisporus.*

Samples from *Agaricus bisporus* were gamma irradiated with doses of: 0.5 kGy, 1 kGy, 3 kGy, 5 kGy, 10 kGy, and 12kGy. Microbiological analyses were performed with standard plate count method. Protein content was determined by Kjeldahl method.

Applied irradiation resulted in a decreasing number of the total cell count of microbial cells with increasing the radiation dose. Total protein content ranged from 25, 05 % - 29,36 %. Analyses of total protein content revealed an increase of proteins in irradiated mushrooms compared with the unirradiated control sample.
The obtained data show that gamma irradiation might provide a useful alternative to ensure the quality of the *Agaricus bisporus* edible mushrooms.

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SELEX FOR APTAMER SELECTION AGAINST SMALL MOLECULES ASSOCIATED WITH ACUTE-ON-CHRONIC LIVER FAILURE: DESIGN, OPTIMIZATION, AND DEVELOPMENT

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Acute-on-chronic liver failure (ACLF) is a life-threatening syndrome that may present in patients with underlying chronic liver disease, characterised by poor patient outcomes and high short-term mortality (28 days), culminating in different grades of multi-organ failure[1]. To address the need for early diagnosis and accurate prognosis, the MICROB-PREDICT Consortium has identified three small molecules as potential biomarkers of ACLF: Quinolinic Acid (QA), Kynurenic Acid (KA), and Phenylalanine (Phe). Aptamers, single-stranded DNA or RNA oligonucleotides with high specificity and affinity for their target molecules, have emerged as a promising and viable alternative to antibodies for small molecule detection, and may be identified through a well-established in vitro selection technique known as Systematic Evolution of Ligands by EXponential enrichment (SELEX)[2,3]. It is an iterative process of several selection rounds, where a nucleic acid library of up to 10^{60} random sequences is exposed to the target molecules, and target-bound aptamers are isolated, amplified by PCR, and purified[2,3]. Stringency is increased after each selection round, leading to a progressive enrichment of the initial library towards sequences with high affinity and specificity towards the target. Ultimately, the sequences with stronger affinities will have dominated the pool and can be sequenced to identify optimal aptamer candidate.

Herein, we report the design and optimization of two parallel independent SELEX strategies, introducing a novel variation of the One-pot SELEX to simultaneously isolate aptamers against QA, KA, Phe, speeding up aptamer selection for multiple targets[4]. Our novel approach was compared with a well-established conventional bead-based selection strategy, which was carried out to isolate aptamers against only one of the targets, phenylalanine (Phe).

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Electrochemical sensing platform based on carbon paste electrodes modified with natural nanomaterials for Beta-Blocker determination

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Abstract

Beta-blockers (β-blockers) are a special type of medicine that are prescribed for a wide range of health problems including cardiovascular diseases [1]. There is a narrow border between the therapeutic and toxic levels of β-blockers and at high dosages. Therefore, developing a rapid, simple, economic and accurate method for analyses of different receptor blocking agents is very important [2]. The electrochemical behaviour of Propranolol (PRO) at the surface of composite carbon paste nanosensors modified with natural zeolite (CPE/Ze) and rutile (CPE/R) is described. The prepared nanocomposite sensors shows a good electrocatalytic activity toward the oxidation of Propranolol, which is leading to considerable improvement of sensitivity (anodic current) [3]. The cyclic voltammetry (CV) and square wave voltammetry (SWV) were used for determination of PRO, in 0.1 M H_2SO_4 using CPE/Ze and CPE/R. The effect of supporting electrolyte, pH, frequency, amplitude, loading of modifier and particles size, on voltammetric response of both sensors was studied. Under optimal condition, the analytical performance of the modified nanosensors toward propranolol, resulted with a linear range of 0.6 -15.7 mM and 0.2-8.9 mM and with detection limits of 0.45 mM and 0.08 mM for CPE/Ze and CPE/I, respectively. The proposed sensors were applied for detection of this drug (PRO) in pharmaceutical tablets. Finally, the obtained results indicate that the composite nanosensors CPE/R and CPE/Ze could be a good alternative method for the selective measurements of the propranolol in complex matrices [4].

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Figures

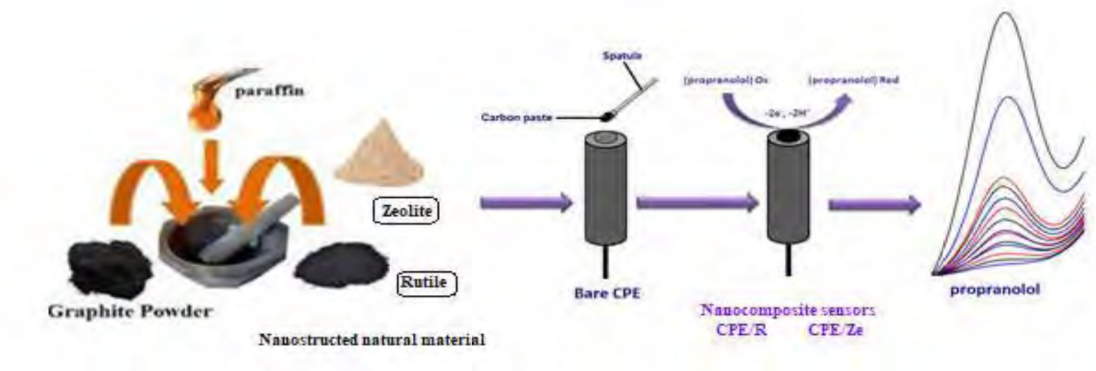

Figure 1: Schematic preparation of nanosensors for electrochemical sensing of PRO

Development of molecularly imprinted polymer-based electrochemical sensor for the selective and sensitive detection of Selexipag

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Persistent and rare pulmonary arterial hypertension (PAH) disease can lead to significant cardiovascular problems and even death. Selexipag, a new non-prostanoid prostacyclin receptor agonist, is used to treat this disease [1]. For the first time, we aimed to develop a molecularly imprinted polymer (MIP)-based electrochemical sensor for selexipag's selective and sensitive quantitative determination. The MIP-based electrochemical sensor was designed to identify the drug selectively and sensitively, and photopolymerization technique was used for MIP formation. The developed sensor optimized the dropping amount, template/monomer ratio, removal solution and time, and rebinding time. Surface and morphological characterizations of the MIP-based electrochemical sensor were performed using cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), scanning electron microscopy (SEM), and energy distribution X-ray spectrometry (EDX) methods. It has also been tested under optimized conditions compared to an unprinted polymer (NIP) based sensor. For the quantitative analysis of selexipag, the tablet dosage form was successfully applied to standard solution and commercial serum samples. The linearity of the MIP-based electrochemical sensor developed for the drug analysis was found in the concentration range of 0.75 pM-7.5 pM. A recovery study was performed to prove the accuracy of the sensor, and it was calculated as 99.7% for the tablet dosage form and 101.3% for the serum solution. Also, the selectivity of the sensor has been proven by experimentation with interference agents (KNO_3, $MgCl_2$, Na_2SO_4, uric acid, ascorbic acid, dopamine, and paracetamol). The imprinting factor was calculated using famotidine, zonisamide, loperamide, and acetazolamide substances with molecular structures similar to selexipag. Based on the results obtained, the developed electrochemical sensor has proven to be sensitive, selective, fast, inexpensive, and specific for the quantitative analysis of selexipag.

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Per- and polyfluoroalkyl (PFAS) contamination of irrigation waters in Albania

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Abstract

Per- and polyfluoroalkyl substances (PFAS), known as "forever chemicals", represent a large and complex class of man-made chemicals widely used in consumer and industrial products, such as fire suppressant foams, pesticide, non-sick cookware, leather, coating, glass cleaners and many more [1]. PFAS are persistent in the environment, they bioaccumulate, and are highly toxic to humans. Exposures to PFAS have been associated with neurobehavioral development, immune system impairment, endocrine disruption, disruption of lipid metabolism, diabetes and cancer [2]. PFAS are now found everywhere and almost on everyone [3]. *The status of PFAS environmental contamination in Albania is not known.* Our team is collaborating with the UMASS Lowell researchers to generate baseline data and identify PFAS contamination hot spots with focus on irrigation waters sources in Albania. We will collect samples (n=100) from surface waters (e.g. rivers, streams and reservoirs) and ground water systems (e.g. wells) utilized by large farms and greenhouses with high water consuming plants (e.g. strawberries). Samples will be analyzed at Dr. D Bello laboratory, UMASS Lowell, with liquid chromatography tandem-mass spectrometry (LC-MS/MS). Statistical analysis will be performed with SAS software to characterize PFAS concentrations and potential sources. We plan to extend our collaboration with other groups to investigate development of nanosensors including ion-selective electrodes, electrochemical sensors, fluorescence sensors and smartphone app-based monitoring systems that are both reliable and feasible [4-6]. *This work is funded by Research Expertise from the Academic Diaspora Fellowship (READ) program.*

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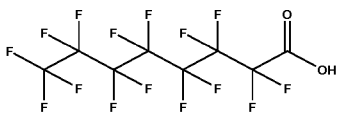

Figure 1. Chemical formula of perfluorooctanoic acid (PFOA)

Synthesis, structure and properties investigation of complex perovskites with manganese

Besarta Çeliku Ramadani

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In the last few decades, perovskite type compounds (ABX_3) are probably the most researched group of compounds. The great scientific interest in these compounds is due to the flexibility in their composition and structure, which results in a number of important and unique properties. Among the large number of different perovskites, of particular interest are the oxide perovskites containing manganese in the B position and some lanthanides in the A position. This is because of their properties which are very interesting from scientific and applied point of view. This abstract presents the initial research related to the attempt to synthesize and characterize new complex perovskites with the general formula $GdMn_{0.5}M_{0.5}O_3$ (Ln=Gd; M=Cr,Fe,Co). The assumption that compounds with this composition would have a perovskite structure was confirmed by calculating the so-called tolerance factor. The solution combustion method was chosen for the synthesis of these compounds and all the assumed perovskites were obtained according to this method using glycine as fuel. The obtained precursors of the indicated perovskites were annealed at 800 °C in a muffle furnace for 8 hours. For the identification and characterization of the obtained samples, X-ray powder diffraction (XRPD) was applied. The comparison of the diffractograms of the synthesized compounds with the diffractograms of known perovskites, showed perovskites with general formula $GdMn_{0.5}M_{0.5}O_3$ (M = Cr, Fe, Co). The perovskites are isostructural to each other, and according to the appearance of the diffractograms, it can be assumed that they have orthorhombic structure. The composition was also established by vibrational spectroscopy and by EDX analysis. The EDX analysis confirmed the 1:1 ratio of Mn/M, and accordingly the general formula $GdMn_{0.5}M_{0.5}O_3$ (M = Cr, Fe, Co). In order to determine the impact of the method of synthesis on the morphology and the size of the particles, SEM was employed. Results show that the compounds within the series are of same polycrystalline porous morphology, typical for perovskites obtained by solution-combustion method.

Molecularly imprinted electrochemical sensor based on surface-printed polymerization and nanomaterial affinity for the selective and sensitive detection of abrocitinib

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Abstract

An electrochemical molecularly imprinted polymer (MIP) sensor was developed for the sensitive and selective detection of abrocitinib (ABR) used in the treatment of atopic dermatitis [1] on the glassy carbon electrode (GCE) surface using differential pulse voltammetry (DPV) for the first time. 4-aminobenzoic acid (4-ABA) was used as a functional monomer to form a molecularly imprinted polymer (MIP) by photopolymerization on GCE. A wide variety of nanomaterials, such as graphene, carbon quantum dots, carbon nanotubes, and metal-organic frameworks, are often used in the fabrication of electroanalytical sensors. These nanomaterials have many advantages on electrodes, including high conductivity and the effect of increasing the surface area. Moreover, when combined with selective and sensitive methods such as MIPs, since it improves electrode performance, its use was increased recently [2]. Nanoflower (NF), an organic-inorganic hybrid nanomaterial, was used in this study. It is known that NFs have a high surface area/volume ratio and show high activity in many activities [3]. A flower-shaped nanomaterial was synthesized (RME-NF) using methanol extract (RME) obtained from the roots of *Alkanna cappadocia* Boiss. et Bal. as organic structure and zinc phosphate structure as inorganic structure. Graphene oxide (GO), due to its high surface area of approximately 2600 m^2g^{-1}, exceptional chemical stability, and distinctive electronic and mechanical properties, exhibits significant potential for utilization in a diverse range of applications such as nanoelectronics, composites, and sensors [4]. Therefore, the synthesized RME-NFs were modified with GO. The MIP film was synthesized in the presence of 2-hydroxyethyl methacrylate (HEMA) and ethylene glycol dimethacrylate (EGDMA) to form the ABR/4-ABA/RME-NFs@GO@MIP/GCE sensor. The developed ABR/4-ABA/RME-NFs@GO@MIP/GCE sensor was investigated with atomic force microscopy (AFM), Fourier Transform Infrared Spectroscopy (FT-IR), scanning electron microscopy (SEM), cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The produced ABR/4-ABA/RME-NFs@GO@MIP/GCE sensor performed a linear detection range of 0.1-1.0 pM and a limit of detection (LOD) of 0.022 pM. The selectivity studies were also shown against the possible interfering compounds in commercial serum samples. The reproducibility of fabricated MIP-based sensors obtains a relative standard deviation (RSD) of 2.86%. The practicability of the sensor was examined by determining commercial serum samples, and satisfactory results and recovery (101.04%) were achieved. These results demonstrate the molecular imprinting approach's potential as the newly developed sensor for detecting ABR.

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Point-of-Care Haemoglobin Detection for Anaemia Diagnosis

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Anaemia is a blood-related disease affecting people of all ages, genders, and ethnicities. It is caused by the reduction of the number of erythrocytes or haemoglobin concentration in blood, resulting in a deficiency in oxygen transport. Anaemia is often a symptom of other diseases, which can make its diagnosis difficult [1]. Anaemia can be classified into different phenotypic groups, such as: haemolytic, microcytic, macrocytic, hypochromic, and Iron Deficiency Anaemia (IDA), among others [2,3]. These have different causes and treatments and can be identified by measuring the levels of different biomarkers in patients' blood, such as haemoglobin (Hb) concentration, erythrocytes' physical parameters, serum iron and serum ferritin. Current methods for anaemia diagnosis rely on blood analysis and a complete haemogram. Herein, we are comparing two different strategies for the electrochemical detection of Hb based on nanotechnology: on one hand, the interaction between methylene blue (MB) and Hb and, on the other hand, the complexation of Hb with its aptamer. This detection methods could be used for developing a Point-of-Care (PoC) biosensor, which will be user-friendly, fast, and less invasive, requiring only a small drop of blood. Additionally, it could serve as a screening and monitoring tool for other disease states in which anaemia is a symptom.

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MTs - potential biomarkers used in well-designed environmental monitoring programs

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The use of stress indices has been recently proposed to evaluate the effects of pollutants, such as heavy metals on marine organisms. This contaminant can produce alterations of biochemical and physiological processes that can be quantified by estimating biological parameters (often reported as stress indices or biomarkers) whose variations may be related to the physiological status of the animals. Whereas general stress indices reveal a stress syndrome characteristic of the response of the organism to a wide range of environmental stressors, specific stress indices are those which mainly reflect responses to particular classes of contaminants.

Metallothionein are low molecular weight, cysteine- rich (20-30 %), metal binding proteins whose neosynthesis represents a specific response of the organisms to pollution by heavy metals. SF procedure takes into account precautions to obtain a complete metallothionein precipitation and to avoid the oxidation of sulphydryl groups (SH), the contamination by soluble low molecular weight thiols and enzymatic protein degradation which can occur during sample preparation. In the extract the concentration of MTs, denatured by low pH and high ionic strength, was quantified spectrophotometrically utilizing Ellman's SH reagent (DTNB-5,5 dithiobis-2-nitrobenzoic acid) reagent.

Bioindicator organisms that have been commonly employed in the application of MTs as biomarkers are mollusks. Mussels has been collected from three coastal areas: Butrint, Qeparo and Shengjin. In conclusion, this spectrophotometric method allows the simple, repeatable and low-cost detection of minimal concentration (nmol) of metallothionein in biological samples.

Keywords: mussel, metallothionein, digestive glands, biomarker of exposure

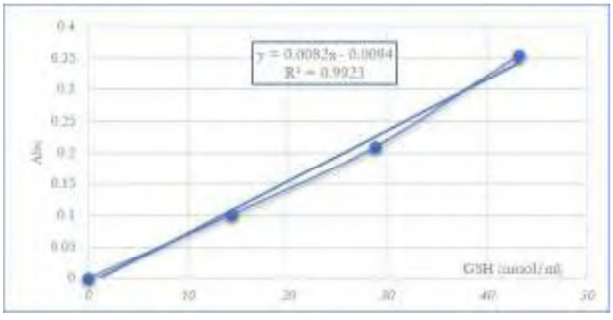

Figure 1. Standard curves obtained by spectrophotometric evaluation of equimolar -SH concentration of GSH from rabbit liver- in 0.5 N HCl, 2Mm EDTA; DTNB – in 2 NaCl, buffered with 0.2 M Na-phosphate.

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Determination of Heavy Metals in water using printed electrodes

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Abstract
Heavy-metal pollution poses severe threat to ecological systems and presents a great challenge for global sustainability.[1] The electrochemical method for heavy metal detections has attracted intensive attention due to its capability for achieving better quantitative results, more rapid analysis, and higher sensitivity.[1] The main goal of this study is to develop a sensor, suitable for the monitoring of Heavy Metals in environment. We used a single-step technique to produce reduced graphene oxide (rGO) conductive films integrating gold NPs.[2] The rGO- , Au@rGO- based electrodes and AuNPs –Inkjet printed electrodes have been challenged to detect heavy metals in water. The electrochemical characterization of integrated sensors was accomplished via Cyclic Voltammetry (CV) and Square Wave Anodic Stripping Voltammetry (SWASV). Bare and modified electrode surfaces were carried out with a 5 mM $K3Fe(CN)_6$ redox probe in 0.1 M KCl aqueous solution using cyclic voltammetry. Well-defined anodic stripping peaks were obtained for Pb^{2+} and the calibration curves of the tested electrodes showed a line correlation R^2 = 0.9957 for AuNPs – Inkjet printed electrodes and R^2 = 0.9436 for Au@rGO- based electrodes. Based on obtained results, AuNPs –Inkjet printed electrodes show better analytical performance than Au@rGO- based electrodes for determination of Heavy Metals in environment.

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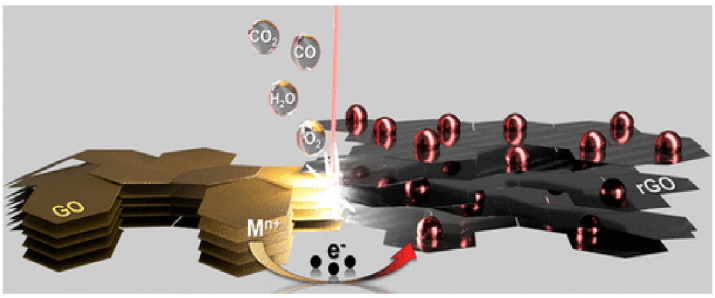

Figure 1: Sketch of the proposed MNPs@rGO mechanism of nanostructured film formation.[2]

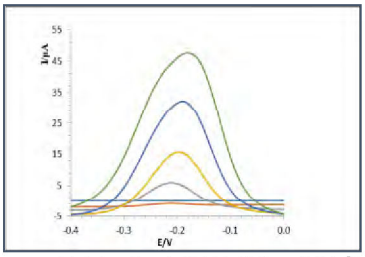

Figure 2: Typical SWASVs of Pb^{2+} using AuNPs-IjP sensor

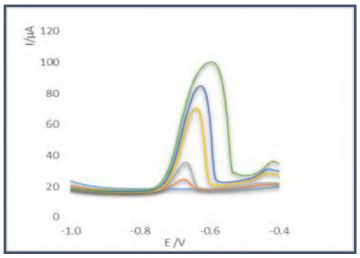

Figure 3: Typical SWASVs of Pb^{2+} using Au@rGO- sensor

Influence of doping with carbon and nitrogen on photoactivity of TiO_2 thin films by PVD

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Abstract

Titanium dioxide is well known as a photoactive material to be activated under ultraviolet irradiation and is either employed as a photocatalyst or exhibits superhydrophilic behavior after reducing the surface energy under illumination for self-cleaning or anti-fogging surfaces. For increasing the reactivity of the thin films under solar illumination, a reduced band gap is desired. Doping with transition metals or with nitrogen has been reported in the literature. However, the incorporation of nitrogen into the growing film, is a much more complex process which is presently not completely understood. TiO_2 thin layers were produced by metal plasma immersion ion implantation and deposition at room temperature at a pulse voltage of 0 to 5 kV and a duty cycle of 9 % for an apparently amorphous layer. An auxiliary rf plasma source was employed to increase the growth rate at low gas flow ratios. By adjusting the geometry between incident ion beam, sputter target and substrate, independently from the primary ion energy and species, a controlled deposition of samples was possible. Conventional ion implantation was employed to implant either carbon or nitrogen ions below the surface for bandgap engineering. The resulting thin films have subsequently been investigated for optical properties, stoichiometry, structural properties, surface topography and photoactivity.

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Figures

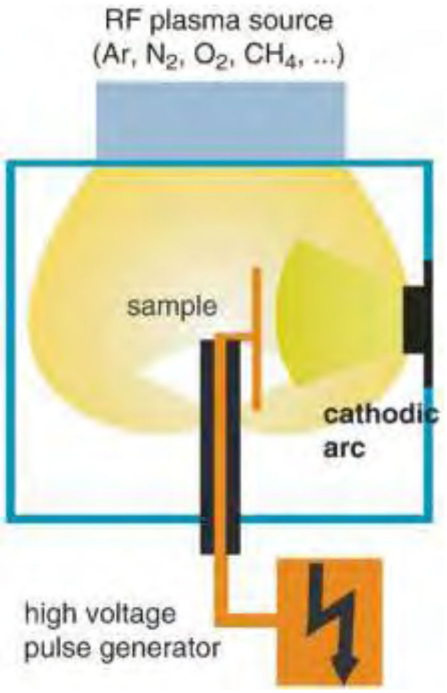

Figure 1: Schematic of the MePIIID deposition system with auxiliary plasma source

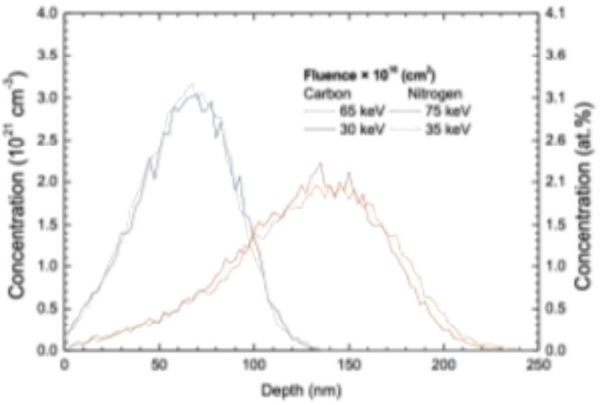

Figure 2: Concentration profiles of Carbon and Nitrogen

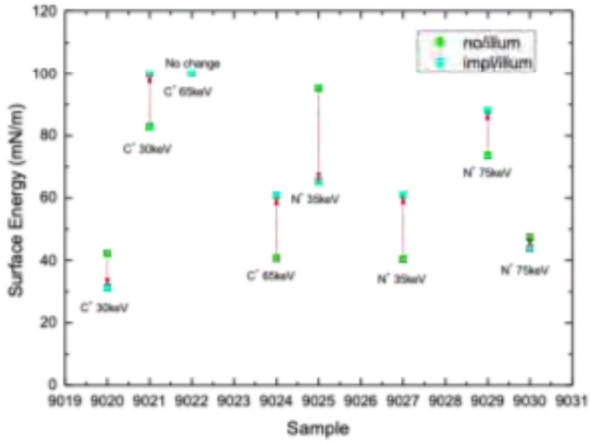

Figure 3: Surface energy of selected samples before and after implantation with/without UV-illumination

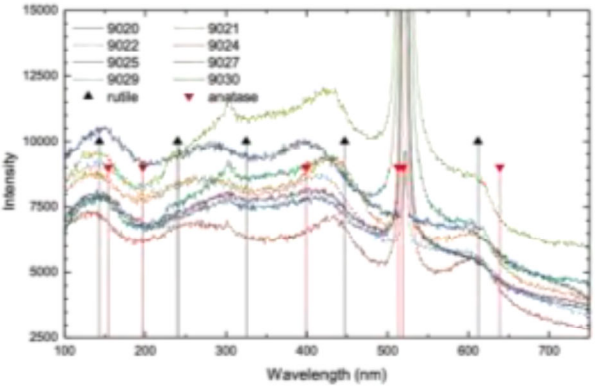

Figure 4: Raman spectra of selected samples after implantation, together with reference spectra of a rutile thin film and anatase powder (APS 32 nm, Alfa-Aesar).17 The prominent peak at 520 cm–1 arises from the Si substrate

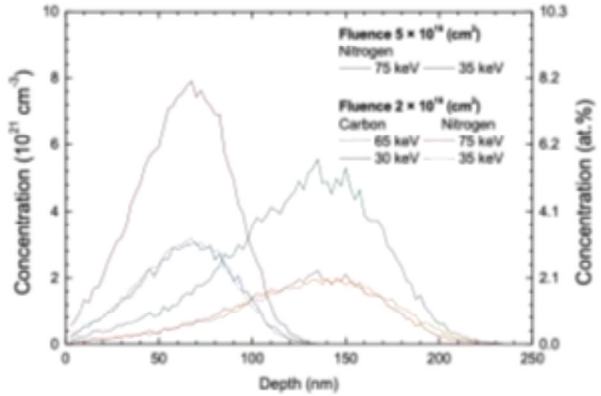

Figure 5: Concentration profiles of carbon and nitrogen by SRIM

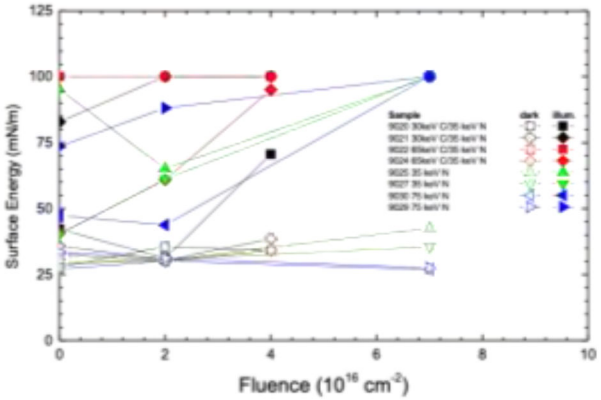

Figure 6: The variation of surface energy with ion fluency before and after illumination

Beyond the Microscopic: Advancing NanoToxicology through Cutting-Edge *In Vitro*, *In Vivo*, and *In Silico* Models

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Abstract

Nanotechnology has revolutionized numerous industries, but concerns surrounding the potential adverse effects of nanomaterials on human health and the environment necessitate the development of comprehensive NanoToxicology approaches. Recent advancements in the field have led to the integration of advanced *in vitro* and *in vivo* models, with an emerging emphasis on incorporating *in silico* methods to enhance our understanding of nanomaterial toxicity. Amphibian erythrocyte, as an *in vitro* cell model, enables more accurate evaluation of nanoparticles toxicity and their effects on cellular responses. Erythrocyte morphological alternations provide a fingerprint for NPs-induced cito and genotoxicity assessment. Limited systemic complexity of in vitro cell models necessitates the use of *in vivo* models to understand nanomaterial toxicity in the context of whole organisms. Amphibians and zebrafish provide a good in vivo model to study nanoparticle biodistribution, metabolism and molecular mechanisms of their long-term effects. Nowadays, *in silico* methods, which involve computer simulations and modeling, have emerged as powerful tools to complement *in vitro* and *in vivo* approaches. By leveraging molecular dynamics simulations, molecular docking modeling, and systems biology approaches, in silico methods facilitate the prediction of nanomaterial properties, toxicity, and potential interactions with biological systems. These computational models aid in the prioritization of nanomaterials for further experimental investigation, reducing the time and cost associated with traditional trial-and-error approaches. By combining these multidisciplinary approaches, we can enhance our understanding of nanomaterial toxicity and accelerate the responsible development and safe utilization of nanotechnology.

Keywords: *nanotoxicology, erythrocyte, molecular docking, zebrafish, toxicity fingerprint*

Nano-Biomimetics: Harnessing Nature's Strategy to Design Efficient Antiviral and Antimicrobial Agents

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Currently, a problem is being faced in the treatment of infectious disease. Common antibiotic resistance has lowered the number of therapeutic choices available against bacterial diseases. On the other hand, recurring viral pathogen emergence also offers a serious concern.

Biomimetics is the utilization and application of natural notions and principles in the development of novel materials, devices, and systems. Biomimetic nanotechnology has also been used in the development of drug delivery systems, where nanoparticles can be generated to mimic the functioning of cells and target specific tissues or organs. This review delves into the innovative realm of Nano-Biomimetics. In this context, our objective is to provide a current review of the latest developments in biomimetic and bioengineered nano-therapies for the treatment of infectious diseases. By utilizing principles discovered in natural systems, innovative nanotechnology techniques are developing nanoscale materials and structures with exceptional antiviral and antibacterial properties. Nano-biomimetics shows significant promise in producing unique and effective treatments for fighting viral and bacterial infections through the application of biomimetic design concepts such as surface patterning, hierarchical structures, and bioactive molecules.

Keywords: biomimetics, biomimetic-nanotechnology, drug delivery system, bioactive molecules, bioengineered nano-therapies.

- Rrona Pozhari and Fatbardha Halilaj contributed equally to the presented Review.

Mimoza Basholli-Salihu, Aida Loshaj-Shala, Toskë Kryeziu, Fatbardha Halilaj, Rrona Pozhari are members of NANOALB research group.

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A new spectrophotometric method for determination of 5-hydroxymethylfurfural in food products

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Abstract

The determination of 5-hydroxymethylfurfural is a very important parameter to show the quality of honey and products containing this compound. The development of the new spectrophotometric method for the determination of HMF is based on derivatization of HMF using the compound N-naphthylethylenediamine dihydrochloride (NEDD). The reaction of HMF with NEDD forms a new product with pink colour, which is assumed to be an imine. The maximum absorption wavelength of this product is set at 500 nm. The reaction parameters of the method were optimised using the experiment design with Response Surface Design. The determined amount of HMF in the honey samples with the new method has given good results comparing it with the reference White method. Preliminary tests have shown good results for the possibility of application of the method using paper microfluidics and digital colorimetry for the determination of HMF.

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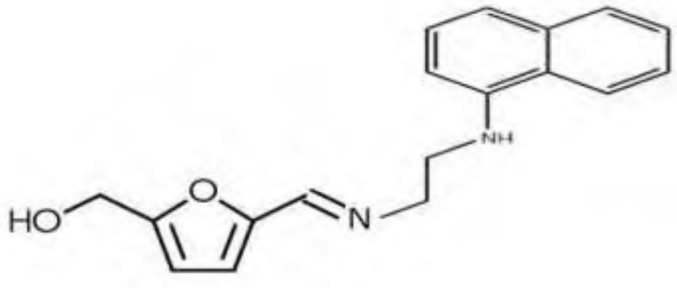

Figure 1. The assumed structure of the new product (imine).

This research was financed by the Academy of Sciences of Albania through the project "Development of a new electrochemical sensor for the determination of HMF, for honey quality control" in the framework of the call "NanoAlb Ignite Projects 2022-2024".

The use of coal modified with alkyl-aryl layers for the preparation of heterogeneous asymmetric membranes

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Abstract

Coal surface is tethered with alkyl molecules by diverting the reactivity of aryl radicals derived from aryl diazonium salts during their reduction. Diazonium salts are reduced chemically by using potassium iodide or under sonication. [1] When we have used 4-nitrobenzene diazonium tetrafluoroborate salt and 3,5-bis-threefluoromethylbenzene diazonium tetrafluoroborate salts we obtained mixed alkyl-aryl layers grafted on coal surface. In order to prepare only alkyl layers we used 2,6-dimethylbenzendiazonium salt, (2,6-DMBD) which does not graft due to steric hindrance but permits to abstract an halogen atom from alkylhalides and to generate alkyl radicals. [2-3] We have used 6-bromohexanoic acid as reagent that gives alkylcarboxylic radicals after the removal of bromine atom by 2,6-DMBD.
Modified coal is used to prepare heterogeneous asymmetric cellulose acetat modified coal membranes. In the past we have shown that coal modified with aryl layers issued from aryl diazonium salts have shown better performance than unmodified coal. [3] Here we show the results that we obtained with heterogeneous asymmetric cellulose acetate modified coal membranes where coal that was modified with alkyl layer. These membranes are prepared in the weight proportions (1:1.5) of celullose and modified coal respectively. The reverse osmosis data confirm the improved performance of membranes (i.e. enhanced product rate and separation) of modified membranes. We obtained a high separation efficiency of up to 97 % and a product rate of 33.57g/h for the system NaCl-H_2O.

Keywords: tethered coal, aryl diazonium salts, 6-bromohexanoic acid, reverse osmosis, heterogeneous membranes

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The effect of different amount MMT in PVA properties

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Abstract

A series of nanocomposite hydrogels were prepared by evaporation-induced assembly with the introduction using polyvinyl alcohol (PVA) as the polymer matrix and natural hydrophilic Albanian montmorillonite (MMT) 0–10 wt %. quantity, without any changes, in the form of composite aggregates. The effects of nanoclay content and sonication on the microstructure and morphology of the nanocomposite as well as its properties (physical, mechanical and thermal) were investigated. Microstructure and morphology were studied by Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), differential scanning calorimetry (DSC), and water absorption kinetics. The results show that MMT acts as a shader and this effect is analogue to the amount of MMT. Also, the water uptake kinetics deviate slightly from Fick's law due to slow relaxation of glassy polymer matrix, with or without MMT. Based on the results obtained, the PVA/MMT nanocomposite hydrogel has emerged as a viable candidate for biomedical applications.

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Beyond the Microscopic: Advancing NanoToxicology through Cutting-Edge In Vitro, In Vivo, and In Silico Models

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Increased use of nanoparticles in medicine and industry, in addition to the positive aspects, certainly represents a threat to the organisms that populate our Planet. Since they are part of the products we use, we must also consider the effects they have on human beings. Regarding ethical issues, we cannot use for research studies human beings or their cellular organelles, hence we study organisms and the cells as prescribed in the "Guide for Use and Care of Laboratory Animals". In this paper we have integrated *in vivo* and *in silico* experiments to comprehend how nanoparticles, specifically CuO-NP, can be involved within the organisms under study. To elucidate this, we used *Danio rerio* and *Carassius carassius* as model organisms. These organisms were exposed to environmentally realistic CuO-NPs doses (*D.rerio* to 1; 5; 10; 25; 50 mg/L while *C.carassius* to 0.5 and 1.0 mg/dL). The *in silico* methodology, molecular docking, presented for the first time in Albania, has aided to reinforce the results obtained from *in vivo* experiments, based on the binding energy. The results show that CuO-NP interacts with the enzymes that affect the degradation of the egg coat in *D. rerio*, He1a (favorable binding energy -2.30 kcal/mol), blocking their activity and thus delaying the hatching time of the embryos. Copper nanoparticles also interact with erythrocyte band 3 (favorable binding energy -2.07 kcal/mol) inhibiting the activity of this protein and causing erythrocyte cytotoxicity, based on the abnormalities in erythrocyte morphology. Molecular binding analysis showed that CuO-NPs, despite having low molecular mass, bind to the minor groove of DNA in an energetically favorable manner (-2.13 kcal/mol), suggesting a direct interaction with the genetic material, instead of secondary events caused by ROS.

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Figures

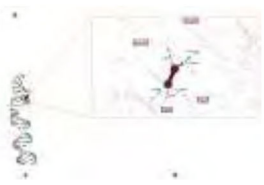

Figure 1: A best-ranked conformation of the intermolecular interaction between CuO NP and crystallographic DNA

Monitoring and evaluation of electromagnetic fields near some base stations for telecommunication systems in some areas of Tirana

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Abstract
The widespread use of electronic devices, especially mobile phones, is accompanied by the ever-increasing interest of the public and researchers in the possible occurrence of adverse effects on people's health, which may be caused by exposure to the electromagnetic fields that accompany these devices. The improvement of the service or the addition of mobile operators has been accompanied by an increase in the number of the base stations located mainly in residential areas. It is of great interest to measure and evaluate the electromagnetic field near these base stations located near urban centers and residential areas. The purpose of this study is monitoring and evaluation of high-frequency electromagnetic fields near one or several base stations for wireless communication systems in several urban centers and residential areas in Tirana (near 21 Dhjetorit and Zogu I Zi), by measuring the intensity E of the electric field using the SRM-3006 (Selective Radiation) device Meter) for electromagnetic fields up to 6 GHz and comparison with the permitted exposure levels for the population, determined by the International **C**ommission on **N**on-**I**onizing **R**adiation **P**rotection (ICNIRP). The process of making the measurements was done according to a standard procedure, based on the European recommendations for several base stations [1], which is applied in those cases where we have more than one transmission station in a certain area.

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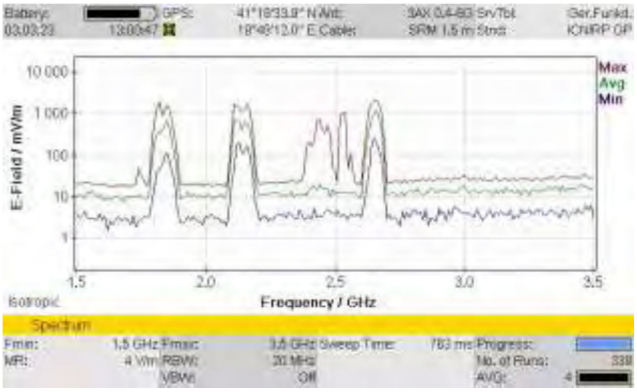

Figure 1. The maximum, average and minimum values of the electric field near the base stations on 21 Dhjetorit

Performance evaluation of electrochemical sensors modified with functionalized graphene

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Abstract

The aim of this study is to develop an electrochemical sensor for detection of Paraquat in water. Paraquat is a pesticide of great interest in research because of its severe acute toxicity and neurotoxicity after long-term exposure [1]. The electrochemical sensor is based on a graphene-acid-modified glassy carbon electrode functionalized with iron nanoparticles (GA-Fe) [2]. In this study, the following electrochemical properties of GA-Fe: high conductivity, selectivity and accelerated electron transfer on the electrode surface, are adapted to improve the analytical performance of the sensor [3][4]. Electrochemical measurements were performed using the following electrochemical methods: cyclic voltammetry CV, square wave voltammetry SWV and electrochemical impedance spectroscopy EIS. Moreover, the operating conditions for the cyclic voltammetry technique, square wave voltammetry technique and pH value have been optimized. The obtained results, indicate that the GCE/GAFe-based sensor exhibits a significant electrochemical response at potential value E= -0.65V with linear range 0.25-1.25 and sensitivity of 0.0744μA/mM. The sensor has also been tested on structurally similar to Paraquat pesticides such as Imidacloprid and Thiamethoxam.

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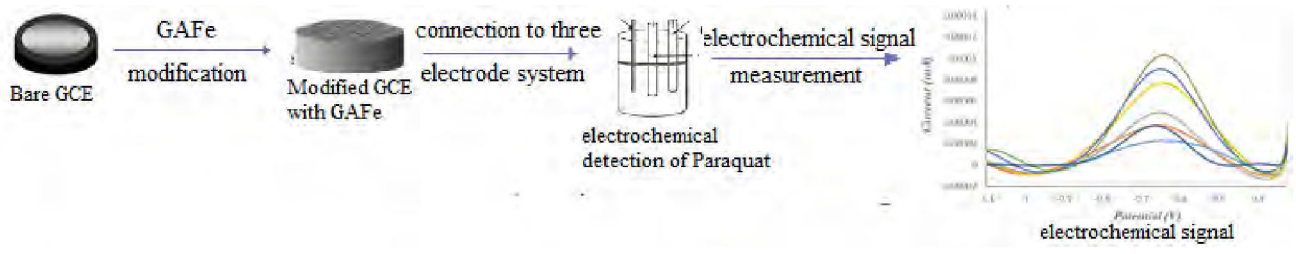

Figure 1: Electrochemical detection of Paraquat using glassy carbon electrode modified with GA-Fe.

Seasonal variability on the Air Pollution in Korça City

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Abstract

Air pollution, even in low concentration, is a big environmental threat to the human health. The mayor sources of urban air pollution are industrial activities, transport vehicles and heating with wood. PM2.5, PM10, NO_2 and CO_2 have been analyzed in Korça City, in two seasons, winter and summer, during 2022. The data obtained indicate a significant difference on the concentrations of these contaminants in the measurement periods. All the parameters, in the winter season, clearly exceed the maximum allowable levels, defined in national and international standards. However, the levels of four contaminants in the summer season are significantly diminished compared to winter, being in average for PM10 and PM2,5 almost 10 times lower, for CO_2 reduced more than 2 times, whilst for NO_2 lowered by around 24%. From the analyzed data in the winter season, a good correlation has been observed between PM10 and PM2,5 (0,897) and between them and CO_2 (0,618 and 0,634 respectively), which indicates that they have similar emission source. The surpassing levels of such contaminants in the winter season are related with the vast use of wood burning for communal heating, which seems to be the mayor contributor in the urban air pollution in Korça City.

Key words: Air Pollution, PM2.5, PM10, NO_2, CO_2, Korça City.

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Optimizing the Physicochemical Properties and Antioxidant Activity of Linalool through Nanoencapsulation

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The focus of this study is the encapsulation of Linalool, the principal constituent of *L. officinalis* essential oil, using optimal liposomal nanoformulations and nanoemulsions to augment its physicochemical features and antioxidant activity.
The encapsulation was executed via the ethanol injection method for liposomal nanoformulations and a high-speed homogenizer for nanoemulsions. To quantify the antioxidant activity, the DPPH technique was used. The physicochemical properties were assessed using parameters like vesicle size, Zeta potential, polydispersity index (PDI), encapsulation efficiency, viscosity, and surface tension, with the microstructure examined through AFM.
The encapsulation of linalool led to a high encapsulation rate and significantly boosted the preservation and amplification of antioxidant activity. The resulting nanosystems showed enhanced physicochemical properties and sustained stability post 2-month storage at 4ºC and 25ºC. Conclusively, nanoencapsulation of Linalool in nanoliposomes and nanoemulsions represents a promising approach to improving stability and efficiency, thereby addressing the challenges in its application in the food and pharmaceutical industries.

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Amir Makolli, Donjeta Spahiu, Mimoza Basholli-Salihu, Aida Loshaj-Shala and Toskë Kryeziu are members of NANOALB research group.

Impedimetric detection of Activated Protein C by carbon nanofibers based composite modified electrode

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Abstract

Carbon nanofibers, which are an advanced form of carbon nanomaterials, possess comparable conductivity and stability to carbon nanotubes. Due to their distinctive chemical and physical properties, carbon nanofibers have found extensive application as electrode material and immobilization substrate [1]. APC is the key enzyme of the protein C pathway and is a serine protease derived from the inactive precursor protein C (PC). Following the discovery of an association between decreased endogenous protein C and APC levels and worsening disease progression in sepsis, recombinant human APC (rhAPC) has been developed for use in the treatment of these patients. [2,3].

In this study [4], the selective and sensitive impedimetric detection of human activated protein C (APC) was performed using graphite electrode modified with the composite of carbon nanofibers (CNF) and ionic liquid (IL). Electrochemical behaviour of CNF-IL modified electrode was firstly investigated. Under the optimized experimental conditions, the detection of interaction between APC and an APC-specific DNA aptamer was performed by using electrochemical impedance spectroscopy (EIS) technique. Additionally, electrochemical detection of interaction process was explored in the absence /presence of antidote pair. The selectivity of our assay to APC contrast to other proteins was also tested.

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Assessment of air pollution using mosses as a bio-indicator in some localities in Kosovo

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Abstract

The aim of research is assessment of air pollution with heavy metals through air depositions by using mosses as bioindicators in some localities. Samples of mosses of some localities were collected along Prishtina – Mitrovica axis, spread out relatively equally. Sample collection was taken in eleven sampling points, each containing three to five subsamples within 50 X 50 m surface area. Levels of heavy metals (Pb, Cd, Zn, Cu, Ni, Cr, Mn and Fe) are analyzed by using flame and oven atomic absorption spectroscopy (AAS). Statistical analyses were used for processing of experimental data. Concentrations of Pb, Cd, Cu and Ni in some sample points are high. The main emissions of these elements for a long time are mine industry, coal sources of energy and traffic overloaded with vehicles. The findings of this research provide accurate data for potential sources of pollution with metals for polluted areas which can serve to respective institutions and future researches for the implementation of strategies to reduce this pollution.

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Figures

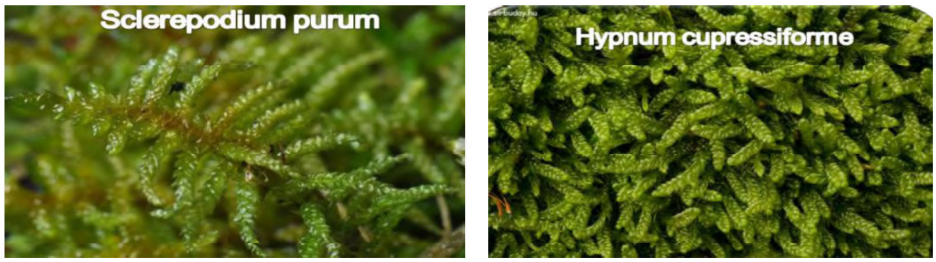

Figure 1: Mosses Sclerpodium purum dhe Hypnum cupressiforme

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Advancing Therapeutic Proteins Through Nanosized Delivery Systems

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Therapeutic proteins present a powerful class of biopharmaceuticals with the potential to treat various diseases. However, limitations like short half-lives, diminished stability, and inadequate target specificity have restricted their clinical efficacy. The development of nanosized delivery systems has offered transformative solutions, elevating the potential of these proteins. This review sheds light on the current breakthroughs in leveraging nanotechnology for enhanced delivery of therapeutic proteins. It outlines the numerous nanosized delivery mechanisms, which offer advantages including enhanced stability, prolonged circulation durations, and the capability time and the ability to encapsulate a variety of therapeutic proteins. Notably, these delivery systems possess the unique potential for precise site-specific targeting, thereby reducing undesired interactions. Additionally, the review emphasizes the challenges in scaling, adherence to regulatory requirements and potential toxicities. It accentuates the necessity for an all-encompassing strategy to facilitate a smooth transition to clinical applications. As a summary, this review critically assesses the advancements, challenges, and future horizons of nanoscale delivery systems for therapeutic proteins, emphasizing their pivotal role in transforming patient care.

Keywords: therapeutic proteins, nanosized delivery systems, targeted delivery, drug delivery, scalability, regulatory compliance, toxicity, clinical translation.

- Rrona Mehmeti and Stina Morina contributed equally to the presented Review.

Mimoza Basholli-Salihu, Aida Loshaj-Shala, Toskë Kryeziu, Rrona Mehmeti, Stina Morina are members of NANOALB research group.

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Conjugation of titania and silver nanohybrid: a new label for enhancing lateral flow biosensors

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Paper-based lateral flow (LF) biosensors are a very significant tool, providing a low-cost and rapid diagnostic evaluation of the result by the naked eye, with high sensitivity, good selectivity and low amount of sample volume being required [1]. Ongoing research seeks to utilize novel and innovative nanomaterials able to achieve a better limit of detection (LOD), thus improving the analytical performance of traditional lateral flow immunoassays, typically based on gold nanoparticles [2]. For this purpose, a novel nanohybrid system was developed through the direct conjugation of commercially available titania anatase nanoparticles with silver nanoparticles (TiO_2-AgNPs). This nanoplatform has great potential to be used, for the first time in LF, to detect human immunoglobulin (HIgG), which serves as a model protein for the study. To obtain the nanohybrid, first the surface of 25 nm-sized TiO_2NPs was covalently functionalized with the linker 3-(mercaptopropyl)trimethoxysilane (MPTMS), a bifunctional ligand that provides terminal -SH groups suitable for attachment to the silver (Ag) surface. The quantification of free -SH groups on titania surface was quantified by using a rhodamine-based dye. Then, *in-situ* formation of silver nanoparticles occurred in the presence of TiO_2NPs bearing -SH groups. In this process, different amounts of Ag^+ precursor were used and just one TiO_2NPs/Ag weight ratios was chosen based on the best size, stability and darker colour for the final lateral flow application, i. e., TiO_2-AgNPs = TiO_2NPs:Ag 1:2.5 wt/wt. Thus, silver nitrate interacted with sodium borohydride as reducing agent and 3MPS (3-mercapto-1-propanesulfonate) as a stabilizer. The 3MPS imparted negative surface charges to the nanoparticles preventing their aggregation, resulting in a hydrophilic nanohybrid. Extensive characterization techniques were employed to investigate structure-property correlations, colloidal stability, and the extent of titania surface decoration, including UV-vis, ATR, SEM-EDX, DLS, and ζ-potential. The obtained results demonstrate the successful silanization of TiO_2NPs and the subsequent *in-situ* decoration of AgNPs-3MPS on their surfaces. Lastly, the interaction between TiO_2-AgNPs and goat anti-human IgG-HRP (HIgG-HRP) was investigated before considering its potential as a new label in LF assays. A colorimetric reaction between the enzyme horseradish peroxidase (HRP) and the substrate 3,3',5,5'-tetramethylbenzidine (TMB) was used to evaluate this interaction. The substrate oxidizes from TMB to TMB^+ in the presence of HRP, turning from colorless to blue. To stop the HRP-mediated oxidation reaction, the oxidative conversion of TMB^+ to $TMB2^+$ was then induced by H_2SO_4 (0.1M), again changing the color from blue to yellow. Different concentrations of HIgG-HRP, ranging from 2 to 30 ug/mL, were tested to optimize the conjugation process. The performance of TiO_2-AgNPs nanohybrid in LF assays is currently under evaluation.

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Design of Boron Nitride Nanosheet/Polymer Electrospun Nanofibers

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Abstract

Nanofibers are widely used industrial and biomedical fields. Various synthetic or natural polymers such as polyvinyl alcohol (PVA), polyacrylic acid (PAA), chitosan, and alginate are commonly fabricated by electrospinning technique. PVA, a hydrophilic polymer, can easily produce as nanofiber by electrospinning. However, poor mechanical properties and water resistance are disadvantages of PVA [1]. Until now, PVA has been combined with different polymers and reinforcing agents to improve its properties and be used in different application areas [2]. Among polymers, gelatine, chitosan, carboxymethyl cellulose, pullulan, and PAA are widely preferred [3]. The PVA/PAA system is a well-known mixture due to its interpolymer hydrogen bond interactions and its miscibility at the molecular level. Recently, studies in biomedical field focused on the nano-sized reinforcement materials such as graphene [4], graphite, multilayer carbon nanotubes [5], and boron nitride [6] to improve weak mechanical strength, uncontrollable degradation, and insufficient biocompatibility of polymeric materials [7].
In this study, the effect of boron nitride nanosheets on the properties of biodegradable PVA/PAA nanofibers produced by electrospinning was investigated. For this purpose, boron nitride exfoliated by ultrasonication in ethanol medium. The boron nitride nanosheet reinforced-PVA/PAA composite nanofibers were produced by electrospinning at different boron nitride nanosheet ratios and annealed at 130 °C for 80 min. FTIR and SEM/EDS results determined that boron nitride nanosheets was homogeneously dispersed in the PVA/PAA nanofiber. However, it was determined that composite nanofibers were not toxic for L929 cell line and showed good antibacterial activity against to *E. coli* and *S. aureus*.

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Comparison of solar energy prediction models with experimental data for solar output

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Abstract

In this work it is discussed the assessment of solar potential, feasibility analysis for a specific region in Albania. Statistical evaluations are made in terms of technical parameters, capacity for power installation, generation and generalization on economic parameters. Forecasting the power production of grid-connected photovoltaic (PV) power plants is essential for both the profitability and the prospects of the technology. Artificial Neural Networks will be analyzed for the prediction of the energy produced by comparing it with the experimental data. represents a common approach in calculating the expected power output from numerical weather prediction data. The model selection has a high effect on physical PV power forecasting accuracy, the calculations are made to evaluate the difference between the models in terms of mean absolute error (MAE), root mean square error (RMSE) for a PV plant.

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Complex in vitro models and advanced drug delivery systems as a complementary strategy for improving drug transport across bacterial barriers and maximizing bacterial bioavailability

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Abstract

The increasing antimicrobial resistance has dwelled the attention to hitherto almost unnoticed biological barriers such as the biofilm matrix, the bacterial cell envelope, and intracellular bacterial metabolism [1]. Overcoming these biobarriers requires thorough in vivo studies that are often difficult from a physiological, regulatory and ethical point of view. Therefore, in vitro models are needed as a test platform for advance drug delivery systems. The new paradigm is to increase bacterial bioavailability and minimize bacterial resistance [2].
A recent model of our group employs bioprinting of the bacterial biofilms on air-interface cultured lung cells as a viable strategy to obtain read outs from both the bacteria and the host [3].
Complementary, calcium peroxide nanoparticles were developed to co-deliver tobramycin as an antibiofilm strategy. The particles displayed not only increased biofilm susceptibility but also potential antimicrobial activity. In clinical settings however, tobramycin is often administered with a β-lactam antibiotic to synergistically increase the bactericidal efficiency. Nevertheless, this strategy is not sustainable as it contributes to increased antibiotic resistance. To reduce the risk, a potential strategy is to take advantage of the so-called cell-penetrating peptides that facilitate drug uptake via membrane permeabilization.
Predictive models can also be a utility in the context of delivery systems and novel anti-infective development. By coating Transwells® membranes with polymeric hydrogels or outer membrane vesicles we could simulate the drug transport across the Gram-negative cell wall. Additionally, a simple but yet effective anti-infective degradation assay was developed to evaluate the anti-infective inactivation capabilities of bacterial lysates. Such assay can be applied to a wide range of bacteria and in a timely manner, AI machine learning trained with an adequate input of data could produce meaningful read outs leading to an in silico predictive model and aid the development of novel anti-infectives.

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Click and Detect: Versatile Ampicillin Aptasensor Enabled by Click Chemistry on a Graphene–Alkyne Derivative

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Addressing the impending crisis of antimicrobial resistance (AMR), which poses significant dangers to global health, requires swift, economical, and efficient approaches for controlling and identifying antibiotics within diverse samples at the point of interest. Economical, disposable, electrochemical biosensors for point-of-care applications present an especially appealing solution. However, the demand persists for versatile and conductive carbon-based materials and inks that enable effective bioconjugation under mild conditions, thereby facilitating the creation of durable, sensitive, and selective devices. This work describes a straightforward and rapid methodology for constructing an aptasensor using a novel graphene derivative equipped with alkyne groups, synthesized via fluorographene chemistry. Through the utilization of click chemistry, an aptamer is immobilized and serves as a successful platform for the selective determination of ampicillin in real samples, even in the presence of interfering molecules. The electrochemical aptasensor exhibits a detection limit of 1.36 nM, exceptional selectivity among other antibiotics, the capability for storage over 4 weeks, and effectiveness in real samples. Additionally, structural and docking simulations of the aptamer illuminate the binding mechanism of ampicillin. The versatility of this platform opens up a wide range of possibilities for the design of a new category of aptasensors based on disposable screen-printed carbon electrodes usable in point-of-care devices.

Figures

Figure 1: Reaction scheme depicting click chemistry between GA-NH-YN and a DNA aptamer bearing an azide moiety.

Exploring the advantages of the ex-situ electrochemical determination compared to the in-situ: the case of catechin

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Abstract

Electrochemical determination methods play a crucial role in multiple fields like analytical chemistry, pharmaceuticals, and food science. The focus of this research is to compare the benefits of ex-situ electrochemical determination with in-situ techniques, specifically regarding the analysis of catechin in wine. Catechin is a natural polyphenolic compound found widely in plants and beverages, known for its health benefits and antioxidant properties.
Conventional in-situ electrochemical measurements involve directly analyzing samples at the electrode surface, providing real-time information. However, this approach presents challenges such as electrode fouling and interference from complex sample matrices. On the other hand, ex-situ electrochemical determination indirectly measures an analyte in a solution that does not contain it. This method offers several advantages, including improved sensitivity, selectivity, and reduced matrix effects. Our findings indicate that ex-situ electrochemical determination exhibits higher sensitivity and selectivity for detecting catechin, enabling accurate quantification even in complex sample matrices.
In summary, this study demonstrates the advantages of ex-situ electrochemical determination compared to in-situ techniques for analyzing catechin in wine. These findings emphasize the potential of ex-situ approaches in enhancing the accuracy and reliability of electrochemical analysis for catechin and similar compounds in various applications.

Rapid Plasma Molecular-Targeted Drug Monitoring with Boron-Doped Diamond Electrode

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Compared to conventional cytotoxic anti-cancer drugs, molecular-targeted medications exhibit reduced toxicity. These drugs are administered to patients at fixed doses, without the need for adjustments based on biomedical indices such as body surface area. However, this therapeutic strategy gives rise to significant variability in plasma concentration among individuals, often resulting in notable adverse events that require dosage reduction. Recent clinical investigations have aimed to quantify the relationship between drug concentration and clinical efficacy or toxicity. To enable personalized administration of molecular-targeted drugs, it is essential to directly determine plasma concentrations at the clinical site. In recent years, advancements in medical engineering have led to the development of various portable or wearable biosensors capable of rapid on-site monitoring. Nevertheless, the widespread adoption of these devices has been hindered by inadequate evaluation of accuracy using clinical samples, sensor-to-sensor variability, and the necessity for complex and expensive fabrication processes. To overcome these challenges, we propose a straightforward approach utilizing untreated boron-doped diamond (BDD), an electrochemical material known for its sustainability. As a proof-of-concept, we have chosen pazopanib, a molecular-targeting anticancer drug recommended for monitoring. By utilizing a BDD plate chip with a size of approximately 1 cm2, our sensing system accurately detected pazopanib concentrations in rat plasma samples within the clinically relevant range. Moreover, the chip's response remained stable throughout 60 consecutive measurements, demonstrating excellent repeatability. When we analyzed plasma samples collected from orally administered healthy rats and cancer patients using our system, the measured concentrations closely corresponded to those obtained through liquid chromatography with mass spectrometry. Furthermore, we assessed the reproducibility of the BDD chips. Finally, we developed a portable system comprising a palm-sized sensor housing a chip to facilitate practical implementation. This setup successfully determined drug concentrations from approximately 40 µL of whole blood obtained from dosed rats within a short turnaround time of around 10 minutes. This "reusable" sensor-based approach can expedite point-of-care drug monitoring, advance personalized medicine, and potentially reduce medical expenses.

Development of a rapid diagnostic test for diagnostic and prognostic of malaria

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Introduction. Malaria is the leading cause of fever in international travelers and in the 2-23% of the cases produces severe symptoms (including death)[1]. Although appropriate treatment can almost entirely reduce mortality, current methods for prognosing malaria, which assess the risk of developing severe symptoms, are not reliable. A tool able to precisely prognose malaria during the initial visit would allow for a better patient management. In order to provide a solution for this need, we developed a lateral flow assay (LFA) for the detection of two prognostic biomarkers: angiopoietin-1 (ANG1) and angiopoietin-2 (ANG2)[2].
Methods. First, in order to identify the cut-off levels of host biomarkers (ANG1, ANG2 and sTREM) associated with severity[2], we analyzed a retrospective cohort of 132 patient samples using commercially available ELISA kits. Then, following a recently published protocol[3], we developed a LFA using gold nanoparticles for the detection of ANG2 and ANG1, whose ratio provided the best prognostic performance. To optimize the assay, we tested 12 different antibodies, 3 nitrocellulose membranes, 3 running buffers, and their specificity.
Results. From the analysis of the biomarker levels, the ANG2/ANG1 ratio provides the best performance with an area under the ROC of 0.82, which is similar to the values obtained by the current gold-standard methods. The measurements of the developed LFA was able to detect concentrations of ANG1 between 50 ng/ml to 1000 ng/mL and of ANG2 between 40 ng/ml and 1000 ng/ml[4], concentrations respectively within the clinical relevant range of ANG1 (5-200 ng/mL) and just above the one of ANG2 (2-15 ng/mL). The results confirmed that the developed LFA is specific for both targets. The use of the ImageJ software was feasible for the quantification of the biomarker concentrations.
Conclusions. We believe that developing and implementing more point-of-care prognostic devices is essential to shift from the common 'one-size-fits-all' approach to precision medicine, which allows for personalized patient management and optimizes available healthcare resources.

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Figures

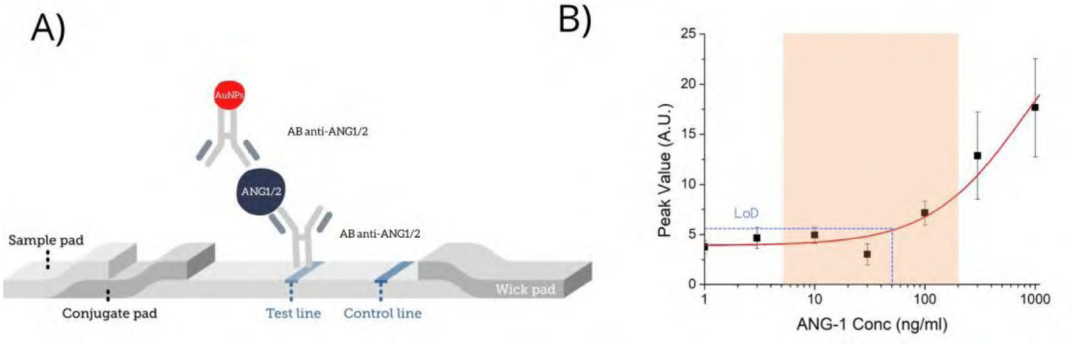

Figure 1: A) Representation of the main components and operation of a LFA schematic of the procedure based on immunosandwich recognition, with a positive sample testing B) Final prototype results with their limit of detection and the clinical range of ANG-1 Ab4/Ab7.

Designing a highly sensitive and selective molecularly imprinted polymer-based electrochemical sensor for the detection of ipratropium bromide in pharmaceutical formulation and commercial serum samples

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Abstract

A new electrochemical sensor based on molecularly imprinted polymer (MIP) film is presented for the determination of ipratropium bromide (IPR), which is used in the treatment of chronic obstructive pulmonary disease (COPD) [1]. MIP film was prepared for the first time by photopolymerization of methacrylate aspartic acid (MAAsp) as monomer and IPR as target molecule on a glassy carbon electrode (GCE). The morphological characterizations of the developed IPR/MAAsp@MIP/GCE sensor were carried out using atomic force microscopy (AFM), Fourier Transform Infrared Spectroscopy (FT-IR), energy-dispersive X-ray spectroscopy (EDX), and scanning electron microscopy (SEM) and electrochemical characterizations of the developed sensor were performed using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). Under the optimum conditions, the calibration curve linear range was 1.0 -10.0 pM. The quantification (LOQ) and the detection (LOD) limits were calculated as 0.28 pM and 0.93 pM, respectively.
Moreover, this sensor exhibited good repeatability and reproducibility, satisfactory stability, and excellent measurement performance in commercial serum samples and pharmaceutical formulations. The IF values were determined by taking the ratio of ΔIp values of MIP to NIP, and IF' values were calculated as the ratio of IF values for MIP to NIP. The IPR/MAAsp@MIP/GCE sensor showed high IF' values for IPR, confirming that the sensor was selective for determining IPR. These results show that the molecular imprinting method for detecting IPR in the novel sensor system is very successful.

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Nano-Biomimetics: Harnessing Nature's Strategy to Design Efficient Antiviral and Antimicrobial Agents

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Currently, a problem is being faced in the treatment of infectious disease. Common antibiotic resistance has lowered the number of therapeutic choices available against bacterial diseases. On the other hand, recurring viral pathogen emergence also offers a serious concern.

Biomimetics is the utilization and application of natural notions and principles in the development of novel materials, devices, and systems. Biomimetic nanotechnology has also been used in the development of drug delivery systems, where nanoparticles can be generated to mimic the functioning of cells and target specific tissues or organs. This review delves into the innovative realm of Nano-Biomimetics. In this context, our objective is to provide a current review of the latest developments in biomimetic and bioengineered nano-therapies for the treatment of infectious diseases. By utilizing principles discovered in natural systems, innovative nanotechnology techniques are developing nanoscale materials and structures with exceptional antiviral and antibacterial properties. Nano-biomimetics shows significant promise in producing unique and effective treatments for fighting viral and bacterial infections through the application of biomimetic design concepts such as surface patterning, hierarchical structures, and bioactive molecules.

Keywords: biomimetics, biomimetic-nanotechnology, drug delivery system, bioactive molecules, bioengineered nano-therapies.

- Rrona Pozhari and Fatbardha Halilaj contributed equally to the presented Review.

Mimoza Basholli-Salihu, Aida Loshaj-Shala, Toskë Kryeziu, Fatbardha Halilaj, Rrona Pozhari are members of NANOALB research group.

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Production of ceramic monoliths from diatomaceous earth

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Abstract

The natural diatomaceous earth (DE) from around city of Bitola (North Macedonia) expressed low bulk density (0.62–0.67 g/cm^3), high-water absorption (73–82%) and porosity (67–71%). For the determination of the chemical composition ICP-MS was employed, providing the following results for the DE: SiO_2 (63.59 wt%), Al2O3 (11.65 wt%), Fe2O3 (5.94 wt%), MnO (0.14 wt%), TiO2 (0.68 wt%), CaO (1.59 wt%), MgO (2.29 wt%), P2O5 (0.15 wt%), K2O (1.69 wt%), Na2O (0.95 wt%), LOI (11.29 wt%). XRPD results of the examined sample show prevalence of crystalline phase with small amount of amorphous behavior. The crystalline mineral phases present are the following: silica (quartz), feldspars (plagioclase), mica (muscovite), chlorites and dolomite. Microscopic analysis (SEM and TEM) results show presence of micro and nanostructures with pores ranging from 260 to 650 nm. The sintered diatomaceous earth (at three temperature intervals 900, 1000 and 1100°C, for a period of 1 h) showed alteration of the silica phase. Namely, sintered samples at 1100°C expressed thermal stability and formation of new phases (mullite and tridymite). Samples showed high compressive strength of 22 MPa and bulk density of 1.16 g/cm^3.

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Electrochemically exfoliated Graphene/MIP electrode for electrochemical detection of Isoproturon

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In this study, an original method for elaboration of 100% graphene electrodes has been developed. This consists firstly in electrochemical exfoliation of graphene at negative potentials in a single step and then in preparing electrodes by temperature compression of graphene on a polystyrene substrate. After testing different design methods for graphene electrodes, their electrochemical properties were evaluated using redox probes. XPS, Raman, IR methods and four-point probe conductivity measurements are used to finely characterize the surface chemistry and nanostructure of graphene electrodes and correlate them with their properties.
In a second part, the electropolymerization of ISO-MIPPy films has been successfully carried out onto graphene and their potential for the determination of isoproturon in water has been demonstrated. The electrochemical preparation procedure includes two small steps: electropolymerization performed by cyclic voltammetry and chronoamperometry where ISO template molecules were successfully trapped in the PPy film where they created artificial recognition cavities. After the electrochemical extraction of the template, the PPy film acted as a molecularly imprinted polymer (MIP) for the selective recognition of isoproturon whereas the non-imprinted polymer (NIP) film, made in the same conditions except for the presence of isoproturon, did not exhibit any interaction. ISO-MIPPy films made on graphene electrodes were found to selectively detect isoproturon. Its limit of detection (LOD) in milli Q water, achieved via square wave voltammetry was as low as 13.6 µg L^{-1}.

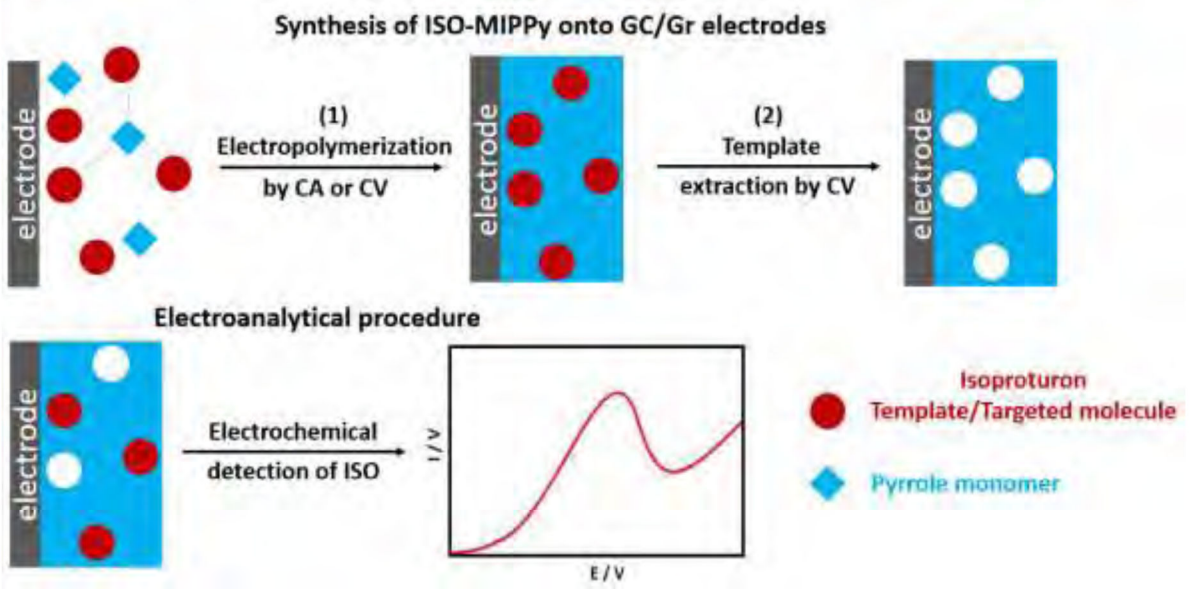

Figure 1: Schematic representation of the procedure used for the preparation of ISO-MIPPy films onto exfoliated graphene electrodes, including two steps: 1) electropolymerization of MIPs by CA and/or CV, and 2) the CV extraction of ISO molecules.

Application of Screen Printed Carbon Paste Electrode for Monitoring of Adsorption of Erythromycin on Inactivated Clay

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Abstract

The pollution of surface waters with antibiotics nowadays is a common occurrence. Antibiotics are introduced in the environment through municipality water discharges, pharmaceutical industries, health care institutions, and veterinary activities. Therefore, there are already many polluted water treatment methods, intended to remove pollutants - such as antibiotics – in order to prevent pollutants to reach natural waters. In this regard, the treatment methods are very important as well as the analytical methods applied to measure the concentration of the pollutant [1]. In this work, natural clay was used to remove Erythromycin (ERT) from water, and the efficiency of the removal was monitored by cyclic voltammetry, performed on screen printed carbon working electrode (SPCE) [2]. Six mass values were applied to ERT adsorption process. ERT solution was left in contact for a predetermined time and clay mass. Afterwards the suspension was centrifuged and the solution was put in an electrochemical cell equipped with SPCE and a platinum contra electrode as well as the Ag/AgCl reference electrode. In Fig. 1. Is shown how 0.5 g of clay decreased the concentration of ERT substantially. Almost complete ERT removal was achieved for 3.5 and 5 g of clay at 1h of contact time.

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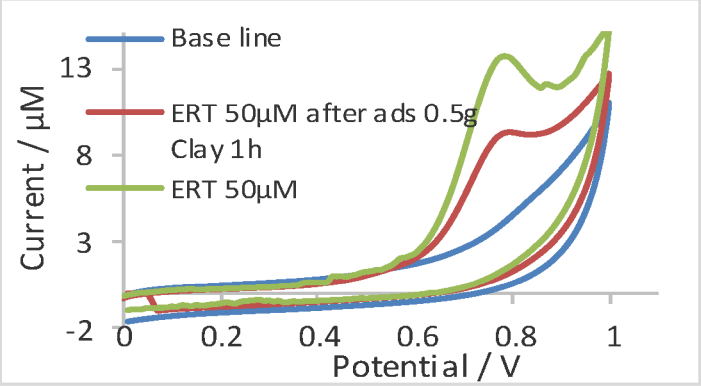

Figure 1: Cyclic voltammetry of ERT before and after the adsorption process on inactivated clay.

Enhancing the Bioavailability and Stability of Naringin and Naringenin through Nanoencapsulation

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This research elucidates the effectiveness of encapsulating Naringin and Naringenin, two vital natural flavonoids, in nanoliposomes and nanoemulsions to strengthen their physicochemical characteristics and antioxidant performance. Adopting ethanol injection for liposomal nanoformulations and high-speed homogenization for nanoemulsions, the process showcased significant enhancements in preserving and heightening the antioxidant activity of these polyphenols.
Evaluation metrics, including vesicle size, Zeta potential, polydispersity index (PDI), encapsulation efficiency, viscosity, and surface tension, were measured for comprehensive physicochemical characterization, accompanied by AFM for to reveal their microstructure.
Resulting nanosystems maintained Naringin and Naringenin properties and stability post 2-month storage at 4°C and 25°C. Consequently, this exploration proves that the bioactivity of Naringin and Naringenin is amplified by encapsulation in nanoformulations, presenting a viable solution for the efficient utilization of polyphenols in the food and pharmaceutical sectors.

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Donjeta Spahiu, Amir Makolli, Mimoza Basholli-Salihu, Aida Loshaj-Shala and Toskë Kryeziu are members of NANOALB research group.

Probing ZnONPs Cytotoxicity: Insights from Human Erythrocyte “in vitro” Model

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Abstract

Zinc oxide nanoparticles (ZnONPs) have garnered significant interest for their potential applications in the field of medicine. Their unique physicochemical properties make them suitable for various biomedical purposes such as drug delivery, antibacterial and antifungal activity, wound healing, anticancer applications, and anti-inflammatory effects. However, it is crucial to consider their potential toxic effects to ensure safe use. In this study, we explore the hidden potential of human erythrocytes as an innovative in vitro model system to investigate the cytotoxicity of ZnONPs and establish important connections with human health. Human erythrocytes, or red blood cells (RBCs), play a critical role in maintaining human health by facilitating oxygen transport and maintaining overall physiological balance. Thus, studying the cytotoxic effects of ZnONPs on erythrocytes provides insights into their potential impact on human health. The unique characteristics of erythrocytes, such as their abundance in the bloodstream and membrane composition, make them an attractive model for evaluating nanoparticle interactions with cells in circulation. Our findings reveal dose-dependent cytotoxic effects of ZnONPs on human erythrocytes, mirroring the potential adverse effects on circulating red blood cells in vivo. The observed cytotoxic effects on erythrocytes, coupled with alterations in membrane integrity and morphology, emphasize the need for a comprehensive understanding of the potential risks associated with ZnONP exposure. Ultimately, this research contributes to the development of strategies to mitigate adverse effects and protect human health in the context of emerging nanotechnologies.

Keywords: Zinc oxide nanoparticles, Human erythrocytes, Cytotoxicity, Cell viability, Membrane integrity

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Electrochemical Studies: Elucidating the Interaction Between the Antiviral Drug Molnupiravir and Calf Thymus dsDNA

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Molnupiravir (MLP) is a promising antiviral drug that is a natural nucleoside molecule analog called cytidine. RNA viruses use it to form the RNA strand. In the presence of molnupiravir, the virus turns to molnupiravir instead of cytidine, thus leading to an error in the formation of the RNA chain key. It is an effective agent in the treatment of COVID-19.[1] In order to design new pharmaceuticals, it is crucial to explore the mechanism of drug interaction with DNA. These interaction studies aid in understanding the response process. Because of its predictable chemical and functional groups, three-dimensional structure, and use as a principal therapeutic target, DNA is a biomolecule.[2] The aim of this study was to determine the interaction of MLP with calf thymus double-stranded DNA (ct-dsDNA) by electrochemical methods. In this study, the interaction between MLP and ct-dsDNA was investigated for the first time by electrochemical techniques. Investigation of these interactions was carried out by differential pulse voltammetry technique (DPV)[3] in two different ways. Firstly, ct-dsDNA was immobilized on the GCE surface, and the interaction was evaluated on the biosensor surface. Secondly, MLP-ct-dsDNA interaction was investigated by bare GCE in a solution that included ctdsDNA and MLP. Changes in ct-dsDNA between deoxyguanosine (dGuo) and deoxyadenosine (dAdo) oxidation signals were examined before and after the interaction. Moreover, the ct-dsDNA-MLP interaction was confirmed by the DPV of the systems MLP –dGuo and MLP – dAdo in the solution phase. The MLP-dAdo binding mode is responsible for the decrease in oxidation signals observed after incubation with various concentrations, as determined by differential pulse voltammetry. All measurements were carried out in pH 4.7 acetate buffer medium, and experimental parameters were optimized such as interaction time, concentration of MLP, ct-dsDNA, and dAdo solutions. Under optimum conditions, each investigation showed that MLP interacts with dAdo and decreases dAo oxidation signals. The dAdo oxidation peak currents were linearly proportional to the concentrations of the MLP in the range of 50-200 µM. The limit of detection (LOD) and limit of quantification (LOQ) were found to be 13.91 µM and 46.37 µM, respectively. It is believed that, elucidation of this mechanism will shed light on the development of drugs for the diagnosis and treatment of existing conditions and pandemic conditions that may occur later.

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Removal Of Phosphorus From Wastewater Using Various Adsorbents

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Abstract

Phosphates are widely used in many industries such as food, agriculture, beverage and detergent. The excessive use of phosphorus has resulted in a large amount of pollution and environment problems, such as severe eutrophication which contributes to aquatic species death, algal bloom and parasite infections. Therefore, it has become a crucial need to eliminate phosphates with minimal environmental impact. Adsorption technique is the most widely employed method for removal of phosphates due to its environmentally safe process, simple and fast operation, and low cost. Developing new adsorbents with high adsorption capacities is of great significance for the effective adsorption and removal of phosphate from the environment. The present study aims to investigate the performance of different adsorbents (ZnO, TiO_2, zeolite and $nCaO_2$-AC) used for phosphate removal from water and wastewater. Batch adsorption studies were performed to evaluate the effects of adsorbent type, dosage, initial phosphate concentration, contact time, and pH on removing phosphate from aqueous solution. The obtained results indicated that phosphorus adsorption was strongly dependent on the surface area of adsorbent, adsorbent dosage and contact time. $nCaO_2$-AC exhibit higher phosphorus adsorption capacity (97%) compared with other materials used in this study.

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Figures

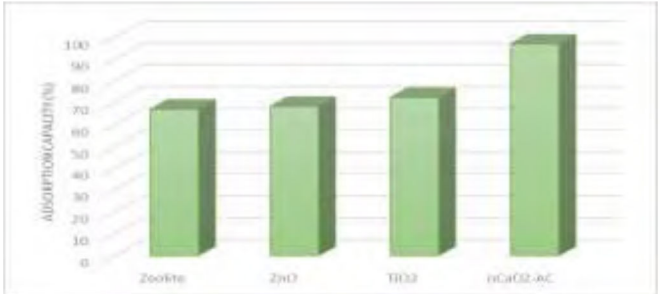

Figure 1: Comparison of different adsorbents used for phosphorus removal

Deleterious effects of metallic nanoparticles in in-vitro models

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Abstract

Nanoscience is one of the novel fields in science that is highly developing in the last decade. It has found its application in many distinct areas ranging from industry, agriculture, environment monitoring and human health. Great interest has been shown for metallic nanoparticles that have been extensively used especially in biomedicine as antibacterial agents, in anticancer therapy, for bio-imaging and biosensors. The efficiency of nanoparticles in these areas has been demonstrated in several studies, putting them in the center of cancer treatment strategies as well as drug delivery systems, as the most investigated areas related to human health. It is however, important to emphasize that the rapidly increased use of nanoparticles is associated with a potential toxicological effect in organisms. Several studies have shown that metallic nanoparticles can induce oxidative stress related mitochondrial membrane abnormalities that can lead to activation of apoptotic pathways and cell death. Even though it is not completely understood, there are many in vitro and in vivo approaches showing a genotoxic effect of metallic nanoparticles. In this study we explore the metallic nanoparticle induced genotoxicity in in vitro models, their deleterious effects and the severity of these damages.

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Zeolite synthesis from clay and study of the acetic acid adsorption on it

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Abstract
This paper presents the experimental results of the removal of acetic acid from aqueous solutions through adsorption on synthesized zeolite. The montmorillonite clay from Prrenjas area, Albania was used as the primary material for zeolite synthesis. Zeolite was synthesized through alkaline treatment of clay. The influence of temperature, acid concentration, amount of zeolite and contact time were investigated. The obtained results showed that the increase of the temperature, concentration of acetic acid and amount of zeolite lead to the improvement of acetic acid removal efficiency as a water pollutant.

Keywords: *montmorillonite, zeolite, acetic acid removal, water pollution.*

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Evaluation of quality radiologic devices using RTI evaluation method and comparing the results with international standards

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Abstract

The diagnostic and radiological service, which is rated as a primary service, for the examination of internal diseases and the consequences of Covid-19, played a crucial role in examinations of patients with corona-virus. In this study, we aim to evaluate the important role that diagnostic imaging has played in dealing with the pandemic situation where, by means of X-ray imaging technologies, it has been possible to identify the severity of the disease in patients affected by Covid 19. With support of NASRI, under project "*Development of simulation and forecasting models and integration with the TCIA database of medical images*", we analysed the diagnostic system in several diagnostics centres in Albania. We used Piranha Multi (RTI Group) to verify the accuracy of the voltage (kV), the stability of the repetition of the values of the voltage dependence of the power voltage change, the overall filtering and the exposure time. We have presented a general picture of the situation of diagnostic equipment in Albania compared to OECD and COCIR indicators. The study shows that diagnostic imaging in Albania uses a large variety of equipment, but compared to the OECD standard, the ratio of units per 1 million inhabitants in Albania is below the average number. We found a low level of compliance with the COCIR standards ("Golden Rules") where more than 65% of the basic equipment installed is between six and ten years old, 20% is less than five years old and 15% of the installed equipment is more than ten years old.

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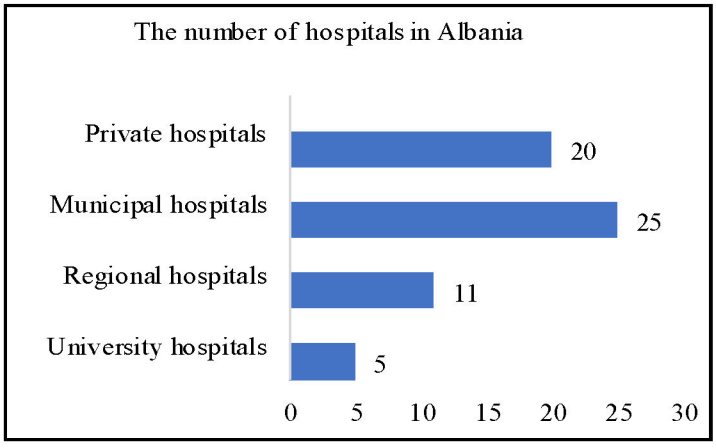
Figures



Figures: In the left: Map of regional hospitals in Albania, Health system in Albania, Ministry of Health
In the right: The number of hospitals according to the number in Albania

Halloysite nanotubes -ionic liquid based nanosensors for cancer diagnosis

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Abstract

The integration of molecular biology and nanomaterials has facilitated the usage of novel technologies in the application of electrochemical biosensors for health and environmental analysis [1]. Nanoclays have a tube-like structure and strong hydrogen interactions. Halloysite nanotubes (HNT), a specific type of nanoclay, possess several advantages such as a wide aspect ratio, high functionality, ease of use, and good biocompatibility [2]. This study [3] presented a novel nanocomposite consisting of halloysite nanoclay and an ionic liquid (HNT/IL). HNT, a new nanomaterial for the modification onto the surface of PGE, was presented to the literature for cancer diagnosis. The HNT/IL nanocomposite has been successfully modified onto the surface of the pencil graphite electrode (PGE). Following the modification, characterization studies were carried out using both electrochemical techniques and microscopic techniques. Optimization studies were applied for the determination of miRNA-21, a biomarker in various cancers, such as liver cancer, breast cancer, lung cancer. The detection limit for miRNA-21 was calculated as 0.17 µg/mL. Due to the higher expression of miRNA-21 in cancer cells contrast to healthy cells, total RNA samples isolated from a breast cancer cell line (MCF-7) were used in our study while using human embryonic kidney cell line (HEK-293) as a control group.

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