



Book of Abstracts



SENERGY LABORATORY
Associated International Laboratory



WRASEA 2024

2nd SENERGYlab Workshop on Recent Advances in Sensors and Energy Driven Applications

12th April 2024

Venue: School of Public Health, University of the Western Cape

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Programme

Time	Talks	
8:30 – 9:00	Tea	
9:00 – 9:10	Opening	Prof Fanelwa Ajayi
9:10 – 9:20	Welcome	Prof Priscilla Baker
9:20 – 10:05	Plenary speaker	Prof Paul Van Loosdrecht <i>Impact of molecular alignment on the physical properties of π-conjugated systems</i>
10:05 – 10:30	Invited speaker	Dr Wafeeq Davids <i>Development and Implementation of Metal Hydride Materials and Technologies in South Africa</i>
10:30 – 11:05	Keynote speaker	Dr Keagan Pokpas <i>Electrochemical Immunosensing of SARS-Cov-2 Specific Antibodies: Strategies for Electroanalysis</i>
11:05 - 11:20	Tea break	
11:20 – 11:55	Keynote speaker	Dr Thanh-Tuân Bui <i>Design of hole transporting molecules for perovskite solar cells</i>
11:55 – 12:20	Invited speaker	Dr Grace Ngubeni <i>The development of quaternary semiconducting nanomaterials for solar cell applications</i>
12:20 – 12:45	Invited speaker	Cecile Jouanne <i>Metal oxide decorated CarboHIPE as electrode of supercapacitor</i>
12:45 – 13:10	Invited speaker	Leonard Rabelani Sithi <i>Preparation and modification of polyHIPE films for immunosensor development</i>
13:10 – 14:10	Lunch Break	
14:10 – 14:45	Keynote speaker	Prof Philippe Banet <i>Silver Nanoparticles in Electrochemical Biosensors</i>
14:45 – 15:10	Invited speaker	Dr Anh Thi Nguyet Nguyen <i>Palladium Nanoparticles Embedded in Anionic Polyelectrolyte as Low-Metal Content Electrocatalysts for Hydrogen Evolution Reaction</i>
15:10 – 15:35	Invited speaker	Prof Chris Arendse <i>Phase Stability and Crystal Orientation of 2D Hybrid Halide Perovskite Films grown by Vapour Transport</i>

15:35 – 16:00	Invited speaker	Dr Kevin Tambwe <i>Synthesis and construction of lead-free hybrid halide perovskite nanocomposites for use in high-performance humidity sensors</i>
16:00 – 16:15	Tea Break	
16:15 – 17:15	<u>Flash Talk presentations</u>	
Clementine Louw	Electrochemiluminescence biosensing of acute myocardial infarction biomarkers in microfluidic devices	
Alenzo Murray	Electro-analytical for the sensitive and selective reporting of spermine and spermidine as biomarkers for prostate cancer.	
Dhielnawaaz Abrahams	A Simple Electrochemical Sensing Platform based on poly-lysine modified electrode(s) for the detection of Antidepressant Drugs	
Nastaran Ghaffari	Electrochemically Reduced Graphene Oxide Multi-Pencil-Graphite-in situ Plated Bismuth- Mercury-film-Electrode Array for the Determination of Gallium and Indium by Anodic Stripping Voltammetry	
Andisiwe Ngwekazi	Highly organized cucurbituril functionalized redox active thin films for site-directed sensing of histamine.	
Teboho Moeketse	Uricase Biosensing and Optimised Electrochemical Transduction for the prototyping of biomedical devices on flexible substrates	
17:15 – 17:20	Closing Speech	Prof Priscilla Baker

Impact of molecular alignment on the physical properties of π -conjugated systems

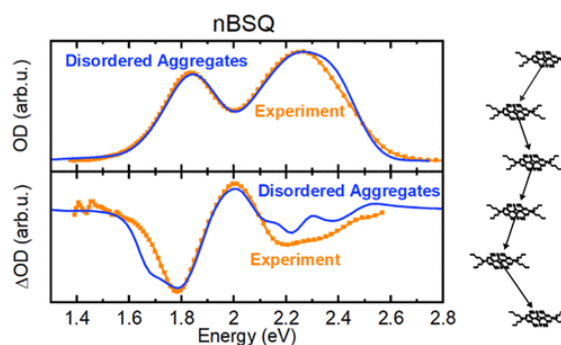
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Keywords: Molecular aggregates, excitons, optical properties

In contrast to regular J- and H-aggregates, thin film squaraine aggregates usually have broad absorption spectra containing both J- and H-like features, which are favorable for organic photovoltaics. Despite being successfully applied in organic photovoltaics for years, a clear interpretation of these optical properties by relating them to specific excited states and an underlying aggregate structure has not been made. In this work, by static and transient absorption spectroscopy on aggregated n-butyl anilino squaraines, we provide evidence that both the red- and

blue-shifted peaks can be explained by assuming an ensemble of aggregates with intermolecular dipole–dipole resonance interactions and structural disorder deriving from the four different nearest neighbor alignments, in sharp contrast to previous association of the peaks with intermolecular charge-transfer interactions. In our model, the next-nearest neighbor dipole–dipole interactions may be negative or positive, which leads to the occurrence of J- and H-like features in the absorption spectrum. Upon femtosecond pulse excitation of the aggregated sample, a transient absorption spectrum deviating from the absorbance spectrum emerges. The deviation finds its origin in the excitation of two-exciton states by the probe pulse. The lifetime of the exciton is confirmed by the band integral dynamics, featuring a single-exponential decay with a lifetime of 205 ps. Our results [1] disclose the aggregated structure and the origin of red- and blue-shifted peaks and explain the absence of photoluminescence in squaraine thin films. Our findings underline the important role of structural disorder of molecular aggregates for photovoltaic applications.



Top: nBSQ thin film absorption spectrum together with a simulated spectrum.

Bottom: nBSQ thin film transient absorption spectrum of an nBSQ film together with a simulated transient spectrum. Right: nBSQ aggregation structure.

Development and Implementation of Metal Hydride Materials and Technologies in South Africa

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Keywords: metal hydrides, hydrogen storage, hydrogen compression

ABSTRACT

Metal hydrides (MH) offer promising solutions in several niche applications related to hydrogen storage, which is the most challenging problem and hinders the implementation of efficient and environment-friendly hydrogen energy technologies. Additional motivation for the development and implementation of MH materials and technologies in South Africa is the necessity to benefit from the vast mineral resources of the country, which include all the components used as raw materials for the manufacturing of primary kinds of practically important MH alloys, particularly, AB₂- and AB₅-type ones. This presentation overviews research, development and innovation (RDI) activities in South Africa in the field of MH materials and related technologies.

Applications of metal hydrides (MH) utilise a reversible interaction of a hydride-forming metal/alloy or intermetallic compound with hydrogen (either from gas phase or electrolyte). Due to the unique combination of their properties, MH found numerous applications belonging to three main groups [1, 2]:

- Gas phase applications (compact hydrogen storage; thermally-drive hydrogen compression and heat management; hydrogen separation and purification; catalysis; powder metallurgy; vacuum-plasma technologies).
- Electrochemical applications (NiMH batteries and fuel cells)
- Other applications (nuclear technologies; switchable mirrors; H₂ sensors).

MH technologies is a typical application-driven niche area able to provide very efficient solutions for hydrogen handling in a particular end-use application by tuning several parameters, including component and phase composition of the parent MH material, system layout, operating conditions, etc. For every particular case, success requires to pass whole way from material to system, including specification of the target composition of the MH material, its manufacturing in the necessary amounts, development and further manufacturing of non-standard system components based on MH materials, and further, the system as a whole.

This presentation overviews research, development, and innovation activities in South Africa in the field of MH materials and related technologies, mainly considering the works performed at the HySA Systems Centre of Competence hosted by SAIAMC / UWC.

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Electrochemical Immunosensing of SARS-Cov-2 Specific Antibodies: Strategies for Electroanalysis

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Keywords: WRASEA and EMS1 11 - 12 April 2024, Abstract, Conference.

The urgent need for rapid, affordable, and portable diagnostics along with efficient and timely monitoring of vaccine efficacy for SARS-CoV-2, especially in resource-limited settings, has prompted innovative approaches to improve binding efficiency and sensitivity in the field of electrochemical immunosensing as an effective alternative to conventional molecular spectroscopic approaches. Herein, two novel strategies to monitor SARS-Cov-2 specific antibodies are proposed, namely (i) electrolyte-gated organic field effect transistor (EGOFET)-based, and (ii) carbon nanostructured paper-based sensing. The developed early-detection devices leverage the selective interactions between SARS-CoV-2-specific Spike (S) and Nucleocapsid (N) Protein receptor binding domain (RBD) antigens and IgG anti-SARS-CoV-2-specific S and N-protein antibodies. The sensors rely on the bio-affinity of immunocomplexes formed at the paper-based and electronic gate surfaces resulting in the interruption of the redox reactions and gate modulation, respectively decreasing the current response. Increased active surface area, conductivity, and binding efficiency via EDC/NHS cross-linking chemistry were achieved due to the formation of self-assembled monolayers and low-oxygen content carbon nanomaterial inclusion, with 5 nm, blue luminescent GQDs offering the best results. The p-type organic semiconductor EGOFET platform successfully integrated electrolyte-mediated sensing capabilities with low-cost electronic devices and was successfully applied to SARS-Cov-2 specific Nucleocapsid antibody detection with remarkable sensitivity and a dynamic detection range, spanning from 0.01 ng/mL to 1.25 ng/mL. In a second approach, the reported low-cost μ PED immunosensors fabricated on (i) chromatographic, (ii) photographic and (iii) adhesive-backed sticker paper by inkjet printing and craft-cutting approaches demonstrated good conductivity with resistance measurements in the low Ω range for applicability in resource-limited settings. The photographic and sticker μ PED SARS-CoV-2 immunosensors were proven to be specific for SARS-Cov-2 Spike Protein antibodies with a LOD of 0.128 and 0.1468 ng/mL, respectively comparable to the findings of solid electrode substrates showing an LOD of 2.028 ng/mL. This research shows for a good grounding to research alternative POC paper devices, specifically μ PEDs, to reduce cost in obtaining sensing devices and time consumption when expecting results. The novel immunosensors suggest a possible application for monitoring of IgG antibody production in SARS-CoV-2-vaccinated patients to study immune responses, vaccine efficacy, and lifetime to meet the demands for POC analysis in resource-limited settings.

Design of hole transporting molecules for perovskite solar cells

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In this talk, I'll present our recent advances in development of small molecule hole transporting materials (HTMs) for halide perovskite solar cells (PSCs). We report the design and synthesis of different series of conjugated molecules for use as charge transporting materials in PSCs. The thermal, morphological, optical and electrochemical properties of all prepared compounds have been investigated in detail and a comparative discussion has been presented. Their characteristics have suggested that these molecules could be suitable for use as HTM in perovskite photovoltaic devices. The preliminary photovoltaic application have given devices with power conversion efficiency (PCE) around 17 %. Selected molecules have been subjected for further device optimization and in deep interface engineering (between the perovskite and hole transport layers) improving PCE to higher than 23 % and this champion PCE is even higher than that of the Spiro-OMeTAD-based device. Thermal stability test at 85 °C for over 1000 h showed that the PSC employed novel HTM retains 86% of initial PCE, while the Spiro-MeOTAD-based PSC degrades unrecoverably. Time-of-flight secondary ion mass spectrometry studies combined with Fourier transformed infrared spectroscopy reveal that novel HTM shows much lower lithium ion diffusivity than spiro-MeOTAD due to a strong complexation of the lithium ion with HTM, which is responsible for the higher degree of thermal stability. Under optimized condition, the perovskite solar cells employed additive-free HTM gave a PCE of ca. 16%. This work delivers an important message that capturing mobile Li⁺ in hole transporting layer is critical in designing novel HTM for improving thermal stability of PSCs. In addition, it also highlights the importance of interfacial engineering on the non-conventional HTM.

Recent related publications:

Nanographene Coupled with Interfacial Pyrene Derivative for Thermally Stable Perovskite Solar Cells. S.-G. Kim, T. de Monfreid, J.-H. Kim, F. Goubard, J. J. Berry, K. Zhu, **T.-T. Bui**, N.-G. Park, *ACS Energy Letters* **2023**, 8, 5, 2267–2275.

Tetraphenylpyrrolo[3,2-*b*]pyrroles: Synthesis, Thermal, Optical, Electrochemical Properties and Photovoltaic Applications. T.-T. Dang, M. Spence, S. K. Thomas, M. Carnie, **T.-T. Bui**, *Journal of Materials Science: Materials in Electronics* **2022**, 33, 17773 – 17779.

Capturing Mobile Lithium Ion in Molecular Hole Transporter Enhances Thermal Stability of Perovskite Solar Cells. S.-G. Kim, T. H. Le, T. de Monfreid, F. Goubard, **T.-T. Bui**, N.-G. Park, *Advanced Materials* **2021**, 33, 2007431.

The development of quaternary semiconducting nanomaterials for solar cell applications

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Keywords: quaternary semiconducting nanomaterials, C/L/NZTS, counter electrode, DSSC.

Platinum's (Pt's) high cost and poor abundance have prevented widespread use, despite the metal's excellent electrocatalytic qualities. Additionally, due to Pt's stability—or lack thereof—in the triiodide/iodide electrolyte, the use of Pt as a counter electrode (CE) in a dye-sensitized solar cell (DSSC) has come under criticism [1]. Considering this, efforts have been made to discover substitute electrocatalysts that don't contain rare or noble metals, outperform crystalline silicon/quaternary nanomaterials in terms of the power conversion efficiency (PCE), and remain stable in extreme environments.

To alter the CZTS characteristics even more and maybe boost solar cells' efficiency, scientists have investigated substituting metal in a +4-oxidation state for the monovalent and divalent cations. I₂-II-IV-VI₄ is the typical formula for copper chalcogenide quaternary nanoparticles. Cu₂FeSnS₄, Cu₂ZnGeS₄, Ag₂ZnSnS₄, and numerous additional modifications have been documented in this regard [2–4]. Transition metals are used in all these alterations, together with the element replacement of II and IV respectively.

In terms of PCE, the doping of VI elements and these materials with alkali materials has attained stagnancy (12.3%–12.6%). Herein, the use of alkali metal lithium (Li) and sodium (Na) for the monocationic copper is suggested. Lithium and sodium have shown high conductivity in battery applications; as such, the premise is that Li₂ZnSnS₄ (LZTS) (Figure 1) and Na₂ZnSnS₄ (NZTS) can potentially be good candidates as CE for DSSCs.

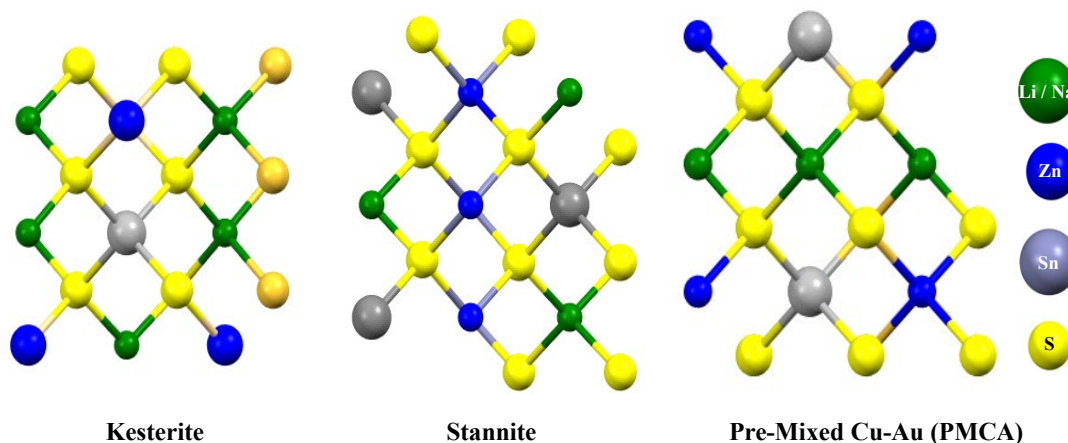


Figure 1: crystal phase representation of L/NZTS.

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Metal oxide decorated CarboHIPE as electrode of supercapacitor

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Keywords: PolyHIPE ; porous carbon material ; metal oxide ; energy storage ; supercapacitors

PolyHIPEs are highly porous polymers synthesized from High Internal Phase Emulsion (HIPE) that can be used in various applications: biomedical, tissue engineering, sensing or energy storage.^{1, 2} Indeed, they are porous materials possessing interesting surface area (200 - 900 m².g⁻¹), a low density and a hierarchical and open-porosity but they are also limited by their conductivity and relatively low specific capacitance for potential use in electrochemical storage systems.^{4,5,6} To overcome these drawbacks, pristine PolyHIPE could serve as precursors and template for generating conductive carbon foams⁷, so-called CarboHIPEs, which are good materials to promote hierarchical porous structuration of electrode material with high electrical conductivity. Consequently, the resulting pyrolyzed materials provide highly accessible ion channels to electrolyte for EDLC-type supercapacitors.³

In this context, our objective was first to control and optimize the synthesis of the CarboHIPE for achieving optimal electrical conductivity and specific surface area. We have therefore optimized the synthesis a styrene (St)/divinylbenzene (DVB)-based PolyHIPE that we later functionalized by sulfonation in concentrated sulfuric acid. This specific step allows the formation of a hyper-crosslinked sulfonated PolyHIPE that further serve as raw material for preparing the graphitized carbon foam by pyrolysis at 800 °C. Such a procedure produces a free-standing electrode with designable geometry and enhances the specific surface area of the resulting CarboHIPE up to 370 m².g⁻¹ and, therefore the specific capacitance up to 80 F.g⁻¹ measured by cyclic voltammetry at 5 mV.s⁻¹ in aqueous medium. In a second step, we successfully functionalized and improved their storage performance by means of electrodeposition by chronopotentiometry of manganese dioxide (MnO₂). The deposited layer of conductive metal oxides decorates the surface of the CarboHIPE and, interestingly, it increases its specific capacitance by 40% thanks to the additional contribution of pseudocapacitance from electroactivity of MnO₂.

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Preparation and modification of polyHIPE films for immunosensor development

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Keywords: High internal phase emulsion (polyHIPE), films, conducting polymer, nanoparticles

Among many diagnostic methods, biosensing devices have emerged as one of the most advantageous due to their ability to perform instant and highly sensitive detections using small amounts of analytes. Composites of several materials and methods are required for the design and construction of such devices. Chemical or physical modification of novel porous materials results in porous material-based composites which are perfect candidate materials for portable sensing devices owing to their light weight, and large surface area, which makes for efficacious chemical processing. Porous materials are characterized by large specific surface area and a variety of novel features. Porous polymers can be engineered to exhibit large surface area and explicit porosity, and their potential to combine the characteristics of both porous materials and polymers they have gained an elevated level of research interest. One of such porous polymers is polyHIPEs, which are porous emulsion-templated polymers synthesized within high internal phase emulsions (HIPEs). The characteristics of polyHIPEs make them a suitable candidate for sensor development. However, polyHIPEs are scarcely reported in literature as sensor construction materials. In this work, we present preparation of styrene-co-divinylbenzene polyHIPE films on ITO substrate, modification of polyHIPE films with a conducting polymer and gold nanoparticles for development of a sensing device for application in the healthcare field.

Silver Nanoparticles in Electrochemical Biosensors

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Keywords: Electrochemical biosensor, AgNPs, Hepatitis B Virus, Tuberculosis.

Nanomaterials are widely used in the field of biosensors to develop new platforms with an increased specific surface, enhanced electron transfer or improved sensitivity and/or sensibility [1]. Among them silver nanoparticles, Ag-NPs, are less used than gold nanoparticles or carbon nanotubes although they exhibit conductive and electroactive properties that can be advantageously exploited to develop original electrochemical biosensors. Some of these aspects will be presented here based on an overview of our recent works on the use of Ag-NPs in electrochemical biosensors.

We focused more on the ability of Ag-NPs to be electrochemically oxidized [2] and therefore, to be used as electroactive labels to enhance sensitivity of electrochemical biosensors. With this goal, we have synthesized zwitterionic polymer-grafted Ag-NPs that were functionalized with biotin [3]. The addition of poly(N,N'-dimethyl(methacrylamidopropyl)ammonium propanesulfonate), PSSP, as the zwitterionic polymer grafted onto AgNPs surface, induces an excellent colloidal stability in high ionic strength medium like physiological ones and the functionalization with biotin ensures biorecognition. These properties open the way to prepare sandwich type biosensors with Ag-NPs labels in physiological media. We prepared such sensor using avidin as a model target. The sensing tests proved the direct electrochemical oxidation of Ag-NPs enhances the detection signal and that the oxidation of Ag-NPs is quantitative and proportional to the concentration of avidin in the medium. A limit detection of 1,5 nM was obtained.

In another work that deal with an electrochemical immunosensor for hepatitis B surface antigen, HBsAg, Ag-NPs were used as redox probes immobilized on modified screen-printed electrode, SPE, before biofunctionalization to avoid a labelling step after the biorecognition of the target [4]. This configuration allows an easier handling of biosensor by end user. We will show the synergetic effect of the combination of Ag-NPs with other nanomaterials on the intensity of the electrochemical oxidation of Ag-NPs. The best results were obtained from SPE modified with CNT/Au-NPs/Ag-NPs. We will present their use for the sensing and quantification of HBsAg at levels down-to 40 ng/mL.

Finally, a last example concerning the addition of Ag-NPs in polymer to promote electron transfer between electrode and enzyme will be given [5].

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Palladium Nanoparticles Embedded in Anionic Polyelectrolyte as Low-Metal Content Electrocatalysts for Hydrogen Evolution Reaction

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Hydrogen is a promising clean fuel and an important part of the future energy carrier that can reduce the global energy dependency on fossil fuels and address climate change and environmental issues.¹ Accordingly, electrocatalytic water splitting or hydrogen evolution reaction (HER) is the most economical and effective approach of producing hydrogen. Until now, the most commonly used HER electrocatalysts are still commercially available Pt-based materials owing to their nearly zero overpotential and low Tafel slope.² However, the scarcity and high cost of Pt-based electrocatalysts limit their usage. Therefore, the design and development of cost-effective HER electrocatalysts with high efficiency and stability is an important research area for large-scale hydrogen production.³

In this work, the immobilized poly(lithium 1-[3-(methacryloyloxy)propylsulfonyl]-1-(trifluoromethylsulfonyl)imide), namely Poly(LiMTFSI), is used as a platform for the host-guest of Pd nanoparticles within the polymer matrix providing a synergetic effect to the hybrid structure toward HER. First, the poly(LiMTFSI) is electrochemically generated and immobilized onto the nickel foam electrode by reductive electropolymerization from its respective monomer. Then, the hybrid material is developed through the ion exchange between mobilized Li cations in polymer framework by Pd cations in MeCN/H₂O mixture (40:60 v/v) followed by the electrochemical deposition under self-electrolytic conditions. The use of covalently attached poly(LiMTFSI), provides numerous advantages compared to the conventional drop-casting process using chemically synthesized catalysts. Indeed, the obtained hybrid nanostructure with reduced Pd content (~0.65 μg/cm²), which is 2 orders of magnitude lower than the mass loading by conventional methods. Also, the latter could act as a stabilizer to prevent the generated Pd NPs from aggregation and provides good catalytic stability through covalent bonding with the electrode surface. Moreover, poly(LiMTFSI) could be used as an enhancer to improve the catalyst efficiency due to the negative polymer backbone boosting proton adsorption of the catalyst, which shifts the chemical equilibrium toward the formation of hydrogen gas. Accordingly, the composite exhibits enhanced catalytic performance and stability toward HER with a Tafel slope of 76 mV/dec and a low overpotential of 236 mV at 10 mA/cm².

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Phase Stability and Crystal Orientation of 2D Hybrid Halide Perovskite Films grown by Vapour Transport

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Keywords: Perovskite, Exciton, Absorption

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Low-pressure chemical vapor deposition offers a scalable and low-cost route for the conformal deposition of perovskite materials. Using a multi-step CVD process, we demonstrate the versatility of the technique in the growth of phase stable 3D and 2D lead-halide perovskite films. Using large organic cations, such as phenylethylammonium (PEA), CVD was used to grow PEA_2PbI_4 and its mixed halides with chlorine¹. X-ray diffraction (XRD) and a non-integer dimensionality model of the absorption spectrum provide insights into the orientation of the crystalline planes of PEA_2PbI_4 ¹. Furthermore, detailed XRD analysis of the PEA_2PbI_4 film as a function of film thickness show the appearance of 2D powder diffraction spots, highlighting the different orientational properties of the perovskite planes. Temperature-dependent photoluminescence of PEA_2PbI_4 show a single excitonic peak throughout the temperature range from 20 – 350 K, highlighting its phase stability and lack of defect states¹. These results are further corroborated by temperature-dependent XRD analysis.

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Synthesis and construction of lead-free hybrid halide perovskite nanocomposites for use in high-performance humidity sensors

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Keywords: Lead-Free Halide Perovskites, Conductive Polymer, Polypyrrole, Overoxidized Polypyrrole, Composites, Humidity Sensors, Fabrication, Electrochemistry, Performance, Mechanism, Optimization.

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This study investigated the effect of combining perovskite materials with conductive polymer materials to develop new humidity sensors with improved stability and sensitivity across different humidity ranges. Humidity sensors have played a crucial role in various sectors, including agriculture, healthcare, and meteorology, by measuring atmospheric water vapor and converting it into an electrical signal. Improvements in these sensors could lead to more accurate and reliable measurements, significantly impacting these sectors.

The primary goal of this research was to identify key parameters in the development of lead-free perovskite-based humidity sensors. The design and functionality of impedance and capacity-based sensors were explored, focusing on stability and measurement sensitivity.

The second objective of this research was to synthesize and characterize perovskite halide-based materials, $\text{Cs}_2\text{BiAgBr}_6$ and Cs_2PdBr_6 , and their composites with Polypyrrole (PPy) or Overoxidized Polypyrrole (OvoxPPy). The synthesis of these particles was carried out by co-precipitation and slow cooling recrystallization, while the PPy and OvoxPPy polymers were prepared by electropolymerization and over-oxidation, respectively. The characterization of the mixtures confirmed the main elements present in each material, with an increase in oxygen content confirming the formation of OvoxPPy.

The third objective of this research was to evaluate the electrochemical properties of these materials electrochemically. The study revealed that perovskite-based particles exhibited interesting electrical conductivities. The addition of conjugated polymers (PPy or OvoxPPy) significantly reduced their electrical resistance and increased the charge transfer kinetics in the material, making them even more conductive. These results suggested a very promising potential for humidity detection applications but also highlighted challenges in terms of stability and reproducibility due to the irreversible nature of the electrochemical reactions involved by these materials.

The final objective was to perform performance tests measuring the sensitivity of these different coatings, at the level of adsorption and desorption, and recovery response times in current of these materials.

The conclusions shed light on how these properties contributed to the overall performance of the sensors.

Electrochemiluminescence biosensing of acute myocardial infarction biomarker in microfluidic devices.

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Keywords: Acute myocardial infarction, Cardiac Troponin I, Biosensors, Impedance Spectroscopy

Immunosensors play a great role in the diagnosis of cardiovascular diseases such as acute myocardial infarction, as they have advantages such as good sensitivity, specificity, fast response time, high affinity, and reproducible measurements, and they can be miniaturized to develop portable point of care testing devices (Kim and Park, 2021). Microfluidic devices have become popular in the field of disease diagnosis due to their sensitivity, reliability, and low-volume sample requirements (Bange, Halsall, and Heineman, 2005). The combination of microfluidic devices with biosensors leads to sensitive, specific, rapid, low-cost, low-sample volume portable point-of-care testing devices that can be used for the detection and monitoring of diseases such as acute myocardial infarction (Nikoleli *et al.*, 2018) (Nesakumar *et al.*, 2019) (Zhang and Zhou, 2022). Electrochemical and electrochemiluminescence techniques can further be used in microfluidic immunosensors to detect disease biomarkers because these techniques are sensitive, specific, fast, and easy to use, as well as offer low detection limits. This work aims to develop a label-free immunosensor for the detection of Cardiac Troponin I and to further integrate it with a microfluidic device towards the development of point-of-care devices.

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Electro-Analytical Assays For The Sensitive And Selective Reporting Of Spermine And Spermidine As Biomarkers For Prostate Cancer.

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Keywords: Prostate cancer, Metal Organic Framework, Polyamine, Aptamer, Sensor

Prostate cancer is a major public health issue, being the second leading cause of death in men [1, 2]. Despite the excellent prognosis when detected at an early or localized stage, many cases are diagnosed at later stages with less effective treatment options [3, 4]. Routine screening using prostate-specific antigen (PSA) blood tests and digital rectal exams have limitations in distinguishing indolent from aggressive disease, leading to unnecessary clinical follow-ups and interventions [5, 6]. Recent studies have shown that polyamines like spermidine and spermine are elevated in prostate tumor tissues compared to benign counterparts, indicating their potential as sensitive and specific prostate cancer biomarkers [7, 8]. However, their potential has not been fully realized due to the lack of suitable assays for monitoring polyamine levels non-invasively. To address this challenge, a research study aims to develop a conductive metal-organic frameworks (CMOFs) based aptasensor with high sensitivity for polyamine detection. The sensor's performance will be evaluated for early detection and screening of prostate cancer through polyamine biomarkers. The study will design a CMOF composition and structure with suitable metal centers and organic ligands that can strongly and selectively interact with polyamines through intermolecular forces like electrostatic interactions or hydrogen bonding [9, 10]. Aptamers will be incorporated for high affinity and specificity, allowing sensitive detection even at low concentrations [11, 12].

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Electrochemical Sensing Platform based on poly-lysine modified electrode(s) for the detection of Antidepressant Drugs.

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Keywords: Depression, Fluoxetine, GCE Electrode, Poly-L-Lysine, Therapeutic Drug Monitoring, Mental Health

Could the next major worldwide disaster be a mental health pandemic? The burden of mental disorders has been on an exponential increase globally, thus consequently affecting society, the economy, the environment, and healthcare systems. The widespread use of antidepressants has raised environmental concerns within scientific communities. Antidepressants are discharged into the environment through human metabolism, excretion, disposal, and wastewater discharge from hospitals, households, and pharmaceutical manufacturers¹. Due to their long-term use, antidepressants are generated in larger quantities than other drugs. Their widespread use and presence in urban wastewater have had significant behavioural and physiological effects on aquatic species, making them a class of "pseudo-persistent" contaminants of emerging concern². The next global pandemic could be a socio-economic ecological problem, and there is a need for holistic physiological Mental Health Monitoring. Sensitive and Selective analytical protocols to improve Therapeutic drug monitoring (TDM), clinical toxicity, and environmental impact assessment are crucial for drug discovery, development, and administration.

This study aims to develop an electrochemical method for detecting fluoxetine (FLX), a commonly used antidepressant. The sensor electrodes were developed to determine the FLX in an aqueous medium using an unmodified commercial glassy carbon electrode (GCE) and Poly-L-lysine modified (GCE/PLL). The electrochemical behaviour and detection of FLX at the GCE unmodified transducer and GCE/PLL were studied using cyclic voltammetry (CV), square-wave voltammetry (SWV) chronoamperometry (CA) and electrochemical impedance spectroscopy (EIS). The best performance of GCE/PLL related to the lowest limit of detection (0.53 µg/L) and the best sensitivity (204.14 ± 4.69 µA/µM) was obtained using square wave voltammetry at a scan rate of 30mV/s in a concentration range of 0 – 50 µM (versus Ag/AgCl). This innovative method holds promise for significantly improving the accuracy and sensitivity of drug detection, paving the way for more effective therapeutic drug monitoring and environmental impact assessment. The accuracy of the applied method will be proved by comparing the detection results with the conventional UV-VIS spectrophotometric method.

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Electrochemically Reduced Graphene Oxide Multi-Pencil-Graphite-in situ Plated Bismuth-Mercury-film-Electrode Array for the Determination of Gallium and Indium by Anodic Stripping Voltammetry

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Keywords: Multi- Electrochemically reduced graphene oxide- Bismuth Mercury Film- pencil-graphite electrode array., gallium, indium, anodic stripping voltammetry.

Nanoparticle inclusion and other approaches have been investigated to improve the sensitivity of sensors for metal analysis. Microelectrode arrays are commonly employed to improve the active surface areas of electrodes resulting in improved detection sensitivity. This study introduces a novel multi-pencil-graphite electrode array (M-PGE-A) as a disposable array to increase the active surface area of the PGEs. The M-PGE-As are modified with reduced graphene oxide sheets and an in situ-plated bismuth-mercury-film (Multi-ERGO-BiHgFi-PGEA) for further improvement in active surface area, and electron-transfer kinetics of graphene and accumulative properties of the bimetallic metal film. This setup enables highly sensitive simultaneous determination of gallium (Ga) and indium (In) concentrations in water samples using square wave anodic stripping voltammetry (SWASV). A 1 mg mL⁻¹ graphene oxide (GO) solution was sonicated and deposited onto the multi-pencil graphite electrode array (M-PGE-A) through cyclic voltammetry reduction. The Multi-ERGO-BiHgFi-PGE array exhibited enhanced Ga and In oxidation, peaks compared to single pencil graphite electrodes. The unique electrode array showed improved detection sensitivity up to 8 PGEs without the common limitations of diffusion suffered by microelectrode arrays. Optimization of deposition potential, deposition time, and pH resulted in well-defined and reproducible peaks, achieving detection limits of 1.929 nmol L⁻¹ for Ga and 0.9917 nmol L⁻¹ for In. This innovative electrode array demonstrated practical utility in quantifying Ga and In in tap water samples, showcasing its potential for environmental analysis.

Highly organized cucurbituril functionalized redox active thin films for site-directed sensing of histamine.

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Keywords: Cucurbituril, electrochemical sensor, histamine.

Cucurbiturils are a class of macrocyclic compounds with highly polar carbonyl portals and a hydrophobic cavity¹. Owing to their exceptionally high affinity for positively charged or cationic compounds, they are frequently used as effective host molecules in the field of supramolecular recognition². This macrocyclic compound was applied in the design of electrochemical sensors for the detection of biogenic amines. Biogenic amines (BAs) are organic bases, which can be present in foods and can cause several adverse reactions in the consumers. They are generally produced by microbial decarboxylation of amino acids in food products. The most significant BAs obtained in food is histamine⁴. Limited studies have been reported on thin film cucurbituril modified electrochemical sensors for solution based studies⁵. The cucurbituril based electrochemical sensors were used for the detection of Amphetamine-type stimulants and Tryptophan (Try) in solution⁶. In this work we focused on designing sensors by immobilizing CB[7] at the surface of glassy carbon electrode following a drop coating and chemical grafting method for the determination of histamine. Histamine-rich foods may cause food intolerance in sensitive individuals. Thus, the analysis of histamine levels is of importance for human health and food safety.

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Uricase Biosensing and Optimised Electrochemical Transduction for the prototyping of biomedical devices on flexible substrates

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Keywords: Uric acid, graphene oxide, copper Schiff base, biomedical devices, printed flexible electronics.

Abstract

The human body secretes an infinite number of organic compounds which are indicators of a person's health status. The currently evolved research fields are directed towards the development of smart devices which are capable of sensing and monitoring applications of biochemical markers. The current work focuses on Uric acid (UA; 2,4,6-trihydroxy purine), as one of antioxidants in the human physiology. The abnormal levels of UA in biological systems cause diseases such as gout, hypothyroidism, hyperuricemia, primary hypertension, coronary heart disease, etc. Hence, there is a need for the design and construction of biosensors that can facilitate the easy detection of UA in biofluids.

In this work, we have reported glassy carbon electrodes (GCEs) and screen-printed carbon electrodes (SPCEs) modified with reduced graphene oxide nano-sheets (rGO), and copper Schiff base complex (Cu-BPND) for easy uric acid detection and quantification in synthetic urine samples. These platforms were characterised by cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and square wave voltammetry (SWV) for their electrochemical properties. The uricase enzyme was further immobilised onto the modified transducers using drop casting and a chemical grafting method. The key parameters such as reagent concentration, film thickness and time suspected to affect response signals were optimised.

This work also encompasses the printed electronics which are aimed at prototyping of the independent biomedical devices for diagnosis of UA which is a marker of several diseases for which gout being the well-known UA disease.

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