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SACI
South African Chemical Institute
Change through Chemistry

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ElectrochemSA

(The Electrochemistry Section of the South African Chemical Institute)

Presents

7th International Symposium on Electrochemistry

“ELECTROCHEMICAL SOLUTIONS FOR A SUSTAINABLE FUTURE”

13 to 16 April 2025

Book of Abstracts

Venue: Southern Sun Maharani Hotel, Durban, KwaZulu-Natal

https://www.saci.co.za/ElecrochemSA/7th_home.html

Welcome Address
Prof Krishna Bisetty

(Symposium Chair)

A Warm Welcome to the 7th International Symposium on Electrochemistry !

"Electrochemical Solutions for a Sustainable Future"

Dear Participants,

On behalf of the South African Chemical Institute (SACI), in collaboration with DUT and ElectrochemSA, it is my pleasure to welcome you to the 7th International Symposium on Electrochemistry. Hosted at the stunning Southern Sun Maharani Hotel, a beautiful location that promises to be a fitting backdrop for the symposium.

Electrochemistry is a dynamic and multidisciplinary field that explores the interactions between electrical energy and chemical changes, encompassing a wide range of applications. The meeting will provide a forum for researchers working in the field of electrochemistry and related topics to share and discuss the latest developments in electrochemistry research and create collaboration opportunities. As this is a momentous event on the Electrochem SA-The Electrochemistry Division of the South African Chemical Institute's (SACI) calendar, we look forward to your presence at the 7th International Symposium on Electrochemistry and the contributions you will bring to this event.

The symposium program is enriched with trending topics and features an impressive line-up of invited (plenary and keynote) speakers related to the field of electrochemistry, consisting of more than 11 invited presentations, 29 Oral talks and 14 poster presentations. The thematic discussions will entail Sensors and Biosensors; Electrochemistry for water treatment, energy, environment, food, process industries; Electrocatalysis, Industrial Electrochemistry, Electrochemistry of (nano)materials and computational electrochemistry. We would like to thank you for your participation and support. Beyond the academic exchange, this symposium offers opportunities for networking and exploring KZN, known as South Africa's jewel, that boasts breath taking beauty and vibrant attractions. Take time to enjoy Durban and all its treasures after the conference.

We extend our gratitude to our sponsors for their generous financial support. All exhibitors will have unique opportunities to showcase their products, services and technologies, innovative concepts, new research, products, and technologies to the delegates. Providing exhibitors with ample opportunity to interact and network with delegates and industry representatives. I also wish to acknowledge the support and assistance from the Local Organising Committee (LOC) and the SACI Secretariat, Mrs Laila Smith. A special thanks to Prof Arotiba, the Convenor of ElectrochemSA, for his guidance and support during the planning of this symposium.

Once again, it is a great pleasure to welcome you to Durban and we are confident that you will find the scientific program insightful and the social events delightful.

Wishing you a successful and engaging conference.

Thank you.

Local Organizing Committee


Prof K Bisetty (DUT)
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Dr T Mokhothu (DUT


Dr V Paul (DUT)


Dr P Hloma (DUT)


Dr L Naidoo (DUT)


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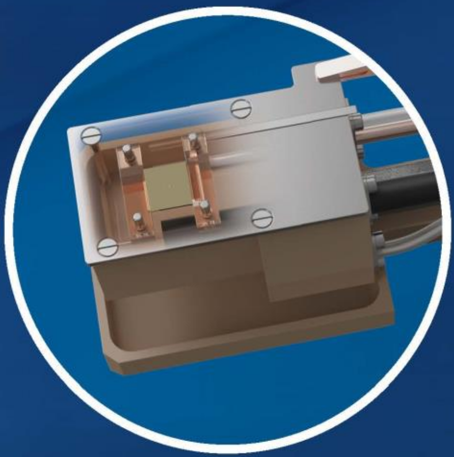


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About us

CHIETA, the Chemical Industries Education and Training Authority, is the statutory body responsible for facilitating education, training and skills development needs.

CHIETA identifies skills gaps and looks at ways to fill these gaps through various training initiatives in partnership with higher education institutes, public entities, skills development providers, and private organisations.

These initiatives are vital to the success and sustainability of nine key industries: fast-moving consumer goods, speciality chemicals, explosives, petroleum, pharmaceuticals, fertilisers, surface coatings, base chemicals, and glass.

CHIETA collects Skills Development Levies from the sector and distributes these funds back to member companies in the form of:
- Mandatory grants paid to members to fund their skills development programmes.
- Discretionary grants for initiatives that respond to the need for priority and pivotal skills.
- Strategic projects aligned to CHIETA's goals and the educational needs of the wider value chain.

CHIETA works in close collaboration with the Quality Council for Trades and Occupations (QCTO) to design and develop occupational qualifications and trades, assessment tools quality assurance, accreditation, monitoring as well as certification of competent learners. This helps to provide well-structured educational opportunities, and ensure that individuals are properly equipped and prepared for successful careers in the chemical and manufacturing industry.

CHIETA is a trusted partner in skills development and training, guided by its well-researched Sector Skills Plan. Through this plan, the Authority is empowered to provide information to the chemicals and manufacturing industry on the sector's training needs.

ENDS

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The Durban University of Technology (DUT) is a globally recognised University based in KwaZulu-Natal, comprising of seven campuses, with five in Durban and two in Pietermaritzburg, with a total of six faculties in Accounting & Informatics, Applied Sciences, Arts & Design, Engineering & the Built Environment, Health Sciences and Management Sciences.

DUT is a member of the International Association of Universities, and is at the forefront of higher education, technological training, research, and innovation. In alignment with DUT's strategy **ENVISION2030**, the University encourages its staff and students to become entrepreneurial and innovative.

At DUT, research and innovation are key to scientific and technological progress. More importantly, innovation is a catalyst in resolving society's deep and pressing socio-economic challenges while also supporting commercialisation. DUT has identified the following key research focus areas for research and innovation.

DUT RESEARCH FOCUS AREAS

- **AFRICAN INDIGENOUS KNOWLEDGE SYSTEMS RESEARCH**
- **CENTRE FOR AFRICAN GOVERNANCE AND DEVELOPMENT (CAGD)**
- **COMPOSITE RESEARCH GROUP (CRG)**
- **COMPUTATIONAL MODELLING AND BIOANALYTICAL CHEMISTRY**
- **ENERGY**
- **ENZYME TECHNOLOGY**
- **FOOD & NUTRITION SECURITY**
- **GENDER JUSTICE AND HUMAN HEALTH DEVELOPMENT (GJHHD)**
- **GLOBAL HEALTH AND SUSTAINABILITY**
- **GREEN ENGINEERING**
- **ICT AND SOCIETY**
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- **IWWT - INSTITUTE FOR WATER AND WASTEWATER TECHNOLOGY**
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- **MATERNAL HEALTH**
- **PLANT BIOTECHNOLOGY**
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7th International Symposium on Electrochemistry

"ELECTROCHEMICAL SOLUTIONS FOR A SUSTAINABLE FUTURE"

13 to 16 April 2025

Programme

O: Oral Presentations

IO: Invited Oral Presentations

Sunday 13 April 2025

Registration: 14:00

Opening Reception: 18:00 - 19:00

Monday 14 April 2025

8:00 – 8:30	Registration
8:30 – 9:00	**Opening Ceremony** **Programme Director: Dr V Paul** 1. Welcome Symposium Chair: Prof K Bisetty 2. Chairperson ElectrochemSA: Prof OE Arotiba
Chair 1	Prof K Bisetty (DUT)
9:00 - 9:05	Introduction of Plenary
9:05 - 9:50	**Plenary 1**: **Prof Emmanuel Iwuoha** (UWC) *Electrochemiluminescent camelid nanobody-immunosensors for disease biomarkers - toward sustainable diagnostic sensing*

9:50 - 10:10	**O1**: **Mr Hopewell Mnyandu** (UKZN) - *Synthesis and Application of an Electrochemical Sensor Based on Molecularly Imprinted Polymer-Carbon Paste Electrode (MIP-CPE) for the Determination of Abacavir Sulphate Drug in Wastewater*
10:10 - 10:30	**O2**: **Mr Guy Prevot** (UWC) - *Silver Nanoparticles for reagent-less aptamer-based biosensor*
10:30 – 11.00	Tea
Chair 2	Dr T Mofokeng (Wits)
11:10 - 11:40	**Keynote 1**: **Prof Philani Mashazi** (RU) *Surface Engineering Towards Capacitive Immunosensor for the Detection of Disease Biomarkers*
11:40 - 12:00	**O3**: **Dr Simphiwe Zwane** (UNISA) - *Detection of Diclofenac and Carbamazepine using Voltammetry and Flow Injection Analysis at Boron-Doped Diamond Thin-Film Electrodes*
12:00 - 12:20	**O4**: **Ms Sesethu Makaluza** (UJ) - *An Electrochemical Sensor for Dopamine on a Graphene-Poly(3,4-ethylenedioxythiophene): Polystyrene Sulphonate Hybrid Ink Nanoplatform*
12:20 - 12:40	**O5**: **Ms Andisiwe Ngwekazi** (UWC) - *Electroanalysis of dopamine in human serum at CB modified electrodes.*
12:40 - 13:00	**IO1**: **Prof Messai Mamo** (UJ) *An in-situ FTIR-LCR meter technique to study the sensing mechanism of a sensor and the relationship between the sensitivity of sensors and their rate of reaction on the surface of the sensing materials*
13:00 - 14:00	Lunch and visit to Exhibition stands
Chair 3	Prof Philani Mashazi (RU)
14:00 - 14:45	**Plenary 2: Prof Kenneth Ozoemena** (Wits) *Multi-functional roles of microwave-assisted synthesis of electrode materials*
14:45 - 15:05	**O6**: **Mr Leonard Sithi** (UWC) - *Construction of polyHIPE-based immunosensor for detection of coronavirus*
15:05 - 15:25	**O7**: **Ms Indiphile Nompetsheni** (UNISA) - *Carbon-based-electrochemical-aptasensor for detection of cryptosporidium in water*
15:25 - 15:45	**O8**: **Dr Nobuhle Ndebele** (UNISA) - *Development of an Electrochemical Sensor for the Rapid Detection of Toxic Heavy Metals in Trace Concentrations*
15:45 - 16:00	Tea break
Chair 4	Dr T Mokhothu (DUT)
16:00 - 16:30	**Keynote 2: Prof Bice Martincigh** (UKZN) *Nanomaterials for electrochemical energy storage*
16:30 - 16:50	**O9**: **Ms Lebohang Morake** (UWC) - *Electrochemical determination of nitrate in model aqueous solutions using MnO2/Poly-L-lysine modified glassy carbon electrodes*
16:50 - 17:10	**O10**: **Mr Collen Nepfumbada** (UNISA) - *Electrochemical Detection of Levofloxacin using Manganese Oxide-Ytterbium Nanoparticles Supported on 2D-hexagonal Boron Nitride*
17:10-17:40	10 x 3 mins Flash Poster Presentations: Chair: Dr P Hloma (DUT)
17:40-19:00	Drinks and poster session: All Posters

Tuesday 15 April 2025

Chair 5	Prof O Arotiba (UJ)
8:10 - 8:15	Introduction of Plenary:
8:15 - 9:00	**Plenary 3**: **Prof Minghua Zhou** (NU) *Novel environmental electrochemistry for water treatment*
9:00 - 9:20	**O11**: **Dr Kelechi Nwambaekwe** (UWC) - *Cu2PdSnS4 Nanomaterial with Enhanced Kesterite Photovoltaic Performance*
9:20 - 9:40	**O12**: **Mr Brine Letsholo** (NWU) - *Squarewave voltammetry detection of heavy metals in water using (Fe3O4/SPEEK) nanocomposite*
9:40 - 10:00	**O13**: **Dr Babatunde Koiki** (UJ) - *Harnessing the (photo) electrochemical properties of BiSI nanorods towards the degradation of norfloxacin in water*
10:00 - 10:20	**O14**: **Mr Daniel Teffu** (UL) - *Exploring the intrinsic properties of a metal-free melamine-COF and Nitrogenated-rGO composite for Advanced Ultracapacitor Applications*
10:20-10:40	Tea Break
Chair 6	Prof T Singh (UKZN)
10:40-11:10	**Keynote 3**: **Prof Katlego Makgopa** (TUT) *Intrinsic properties of N-doped reduced graphene oxide on manganese-based (oxides and phosphates) nanoparticles as electrode materials for supercapacitors*
11:10-11:30	**O15**: **Mrs Kgabo Philipine Makhado** (UWC) - *Electrocatalytic degradation of Antibiotics with Hybrid Graphene Interfaced Cu-Ni Oxides Composites*
11:30-11:50	**O16**: **Dr Mustapha Balarabe Idris** (UNISA) - *Enhanced Electrocatalytic Oxygen Evolution Reaction Performance of Nickel Oxide/Borophene Composite in Alkaline Medium*
11:50-12:10	**O17**: **Ms Mariam Hajee** (UKZN) - *Electrochemical detection of the antiretroviral drug lamivudine using reduced graphene oxide-chitosan nanocomposites*
12:10-12:30	**O18**: **Ms Thethiwe Mthiyane** (DUT) - *Selective electrochemical sensing of sunset yellow in beverages based on synergistic signal amplification of HKUST1 and MWCNTs*
12:30-12:50	**O19**: **Mr Terrence Mothlathlo** (UL) - *Pt- and Ru-decorated metal organic framework as a trifunctional material for water electrolysis and hydrogen fuel cell applications*
12:50-13:40	Lunch
13:40 - 14:00	Final Poster Presentations
Chair 7	Prof U Feleni (UNISA)
14:00 – 14:20	**O20**: **Ms Kehinde Jayeola** (UJ) - *Interfacial Engineering of a Z-Scheme Bi2O2S/NiTiO3 Heterojunction Photoanode for the Degradation of Sulfamethoxazole in Water*
14:20 - 14:40	**O21**: **Prof John Mack** (RU) - *Metal corrole complexes for electrocatalytic hydrogen evolution reactions*

14:40 - 15:00	**O22**: **Mr Tshupo Kgwadibane** (UNISA) - *Raman Imaging of high conductivity Electrochemically Exfoliated Graphene: Fermi Level Shift and the Electrochemically Performance*
15:00 - 15:20	**O23**: **Ms Taylor Fisher** (UJ) - *Comparing Catalytic Applications of Transition Metal MOFs for the Degradation of Norfloxacin (NFX) Antibiotic in Water*
15:20 - 15:40	**O24***:* **Prof OE Arotiba** *(UJ)*-Nuggets for Research Excellence
15:40 - 16:00	Tea Break
16:00 - 16:30	Networking
16:30 - 19:00	Afternoon off
19:00	**GALA DINNER + AWARDS**

Wednesday 16 April 2025

Chair 8	Prof OE Fayemi (NWU)
8:10 - 8:15	Introduction of Plenary
8:15 - 9:00	**Plenary 4: Prof Fabiana Arduini** (UNIROMA) *Paper-based electrochemical (bio)sensors for sustainable analyses*
9:00 - 9:20	**O25**: **Dr Oluchi Nkwachukwu** (UJ) - *A perovskite/spinel structured LaFeO3/Co3O4 heterojunction for photoelectrocatalytic applications in degradation of tetracycline and water splitting*
9:20 - 9:40	**O26**: **Dr Lyndon Naidoo** (DUT) - *Novel insights on the field-flow fractionation characterization of graphene-based materials for electrochemical applications*
9:40 - 10:00	**O27**: **Dr Gwaza Eric Ayom** (UniZulu) - *Electrochemical Applications of Nickel sulphide*
10:00 - 10:20	**IO2**: **Prof Usisipho Feleni** (UNISA) *Electro-oxidation of Ibuprofen and Metoprolol using Manganese Oxide Platform*
10:20 - 10:40	Tea Break
Chair 9	Prof Katlego Makgopa (TUT)
10:45 - 11:05	**IO3: Prof Philippe Banet** (CYU) *Vertically Aligned Carbon Nanotubes (VACNT) doped with Nitrogen and Oxygen for High-Energy Supercapacitors*
11:05 - 11:25	**O28**: **Dr Thapelo Mofokeng** (Wits) - *Sodium-potassium dual pre-intercalated alpha manganese dioxide cathode material for high-performance aqueous zinc-ion batteries*
11:25 - 11:45	**O29**: **Dr Aderemi Bashiru Haruna** (Wits) - *Microwave irradiation engineered surface crystal planes in spinel Li4Ti5O12 anode material for improved performance lithium-ion battery*
11:45 - 12:05	**IO4**: **Prof James Ramontja** (UJ) *Design of Highly Active Silicene Hybrid Sheets for Electrode Applications in Battery-Type Supercapacitors*
12:05 - 12:30	ElectrochemSA Division Meeting
12:45 - 13:00	**Closure**
13:00 - 14:00	**Lunch**

Poster Presentations (13 to 16 April 2025)

Poster No.	Delegate Name	Institution	Title
P1*	Mr Calvin Harilal	DUT	Metal-Organic Framework-Based Immunosensor for Sensitive Lactoferrin Detection
P2*	Mrs Leanne Naidoo	DUT	Anti-corrosive properties of water-borne acrylic composite coatings using electrochemical methods
P3*	Mrs Victoria Adebiyi	DUT	Deep eutectic solvent (DES) as green corrosion inhibitor for protection of mild steel in acidic medium
P4*	Mrs Musawenkosi Nemaura	MSU	Electrocatalytic behaviour of cobalt ferrite decorated graphene oxide nanosheets appended cobalt tetra aminophenoxyphthalocyanine towards nevirapine
P5	Dr Candice Cupido	UWC	Polymeric nanocomposites in drug metabolism sensing
P6*	Mr Benneth Chukwudi Iwuoha	Wits	Electrochemical detection of tramadol using MOF-derived nickel nanoparticles
P7*	Mrs Muriel Mambanda	MSU	Electrochemical detection of caffeine in waste water using plant-based zinc oxide nano particles incorporated in MWCNTs
P8*	Ms Senzekile Majola	DUT	Electrochemical Immunosensor for Insulin Antibody Detection Using Green-Synthesized Gold Nanoparticles Functionalized with Indole-Pyrazole
P9*	Mr Nkgaetsi Marius Ngoepe	Wits	High-entropy spinel oxide nanoparticles for high performance aqueous zinc-ion batteries
P10*	Mr Mpho Ratsoma	TUT	Enhancing the electrochemical efficiency of nitrogen-doped reduced graphene oxide using coal fly ash-derived mesoporous silica nanoparticles for supercapacitor applications
P11	Dr Busisiwe Nokalika Zwane	UJ	Electrochemical sensing of dopamine on a reduced graphene oxide and gold nanoparticles modified electrode
P12*	Ms Tshifhiwa Tshauambea	TUT	Preparation and characterization of metal oxide/metal sulphide composites for degradation of pharmaceuticals from wastewater
P13	Dr Francis Ntumba Muya	UWC	Electrochemical Sensor for Detecting Benzo(a)pyrene in Seawater

*3mins flash presentations

Plenary 1

Electrochemiluminescent camelid nanobody-immunosensors for disease biomarkers - toward sustainable diagnostic sensing

Emmanuel Iwuoha, Onyinyechi Uhuo, Kaylin Januarie, Marlon Oranzie, Jaymi January

Sensor Laboratories (SensorLab), University of the Western Cape, Bellville, Cape Town, South Africa

Email: eiwuoha@uwc.ac.za

Access to disease diagnostic tests is *sine qua non* for the realisation of the universal good health and well-being directives of the Sustainable Development Goal 3 (SDG 3) of the United Nation's 2030 Agenda for Sustainable Development. Highlighted in this presentation are the nanoarchitectonic and electroenergetic properties of functional materials and their application in the development of diagnostic sensor devices. Focus would be on biosensors for critical diseases that are prevalent in Sub-Saharan Africa, such as tuberculosis (TB), cancer and myocardial infarction (MI). Accordingly, amperometric, impedimetric and electrochemiluminescent (ECL) aptasensors and antibody-/camelid nanobody-immunosensors were developed with biocompatible kesterite- and perovskite-amplified nanoplatforms. The presentation will cover our recent work on biosensors for: (i) emerging MI disease biomarkers, such as B-type natriuretic peptide (BNP) and C-reactive protein (CRP); (ii) gelsolin-like actin capping protein (CapG), which is a biomarker implicated in several cancers (e.g. breast cancer, ovarian carcinomas, pancreatic cancer and ocular melanoma); (iii) interferon-gamma (IFN-λ), a latent TB disease biomarker; and (iv) SARS-CoV-2 Spike Protein Receptor-Binding Domain (S1 subunit) (SARS-CoV-2 S1-RBD).

Oral 1

Synthesis and Application of an Electrochemical Sensor Based on Molecularly Imprinted Polymer-Carbon Paste Electrode (MIP-CPE) for the Determination of Abacavir Sulphate Drug in Wastewater

Hopewell Mnyandu[1], Precious Mahlambi[2], Mun'delanji Vestergaard[3]

Department of Chemistry, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg,3209, South Africa

University of Kagoshima

[2]*Email: mahlambip@ukzn.ac.za*

The usage of molecularly imprinted polymer (MIP) based electrochemical sensors is increasing since they possess strong chemical and mechanical stability at extreme pH and temperature. They exhibit operational simplicity, inexpensive preparation, rapid response, low detection limits, high sensitivity, and selectivity for the target analyte. This work focused on the development of an electrochemical sensor based on the molecularly imprinted polymer modified with a carbon paste electrode (MIP-CPE) for the determination of abacavir sulphate in wastewater and river samples. The bulk polymerization method was used to synthesize the MIP with the binding sites prone to abacavir sulphate (template molecule). The resulting MIP polymer molecule had thermal stability of over 500 °C. Graphite powder, paraffin oil, and copper wire (an electrical conductor) were combined with the MIP to form a working electrode. The sensor showed a linear response in a range of 2×10^{-8} to 10×10^{-8} M with R^2 of 0.9682 and a very low limit of detection and quantification of 5.42×10^{-8} M and 1.64×10^{-7} M, respectively. The MIP-CPE sensor was applied for direct determination of abacavir sulphate in spiked deionized water, tap water, river water, WWTP's influent and effluent, with RSD (%) values less than 9.58 and recoveries ranging from 82.2 to 104.9%. The application of MIP/CPE sensor in wastewater samples and their corresponding river samples gave concentrations ranging from 2.40×10^{-7} to 7.19×10^{-6} with RSD less than 17.4% for abacavir sulphate.

O2

Silver Nanoparticles for reagentless aptamer-based biosensor

Guy PREVOT[a,b], Keagan POKPAS[a] ,Mohamed MALLOUKI[b], Philippe BANET[b], Pierre-Henri AUBERT[b],

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[b] *Laboratoire de Physiocochimie des Polymères et Interfaces, CY Cergy Paris Université, 5 Mail Gay Lussac, F-95000 Neuville-sur-Oise*

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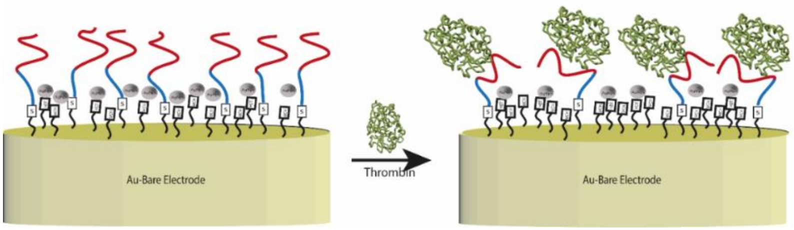
The growing demand for personalized medicine has driven the emergence of biosensors as essential tools for real-time and continuous monitoring of infections and diseases, directly at the patient's point of care. To achieve this, various bio-recognition elements are available for selective interactions, including antibodies, antigens, microorganisms, and aptamers. Of these, aptamers, which are short, generalizable nucleotide sequences exhibit specific and autonomous interactions with their target analytes, making them the subject of extensive research for the development of next-generation biosensors. However, their scalable clinical applications remain limited by challenges in precision, particularly within restrictive medical windows. In this innovative context, metallic nanomaterials, with unique electrochemical, catalytic, optical, and electronic properties, are increasingly integrated in biosensor applications. Silver nanoparticles (AgNPs) facilitate the design of advanced electrochemical probes as an alternative to conventional redox probes which often require additional pre-treatment steps and compromise sensor stability and accuracy. Herein, a novel reagentless thrombin-specific aptasensor, incorporating highly conductive AgNPs stabilized by organothiols, and characterized by Hight transmission electron microscopy (HRTEM) was developed. The AgNPs are immobilized on the sensing platform via thiol linkages prior to the recognition step - either on an antifouling self-assembled monolayer (SAM) surface or directly on the top of aptamer. Conformational changes occurring upon the selective binding between the aptamer and its target enhance modulated electron transfer of the nanoparticles, enabling sensitive, quantitative detection of Thrombin in the nanomolar range without the need for further toxic reagents or extensive pre-treatment steps. The sensor's performance was evaluated through initial characterization by microbalance and electrochemical techniques including cyclic voltammetry and electrochemical impedance spectroscopy demonstrating its potential as an advanced platform for clinical biomarker detection.



Keynote 1

Surface Engineering Towards Capacitive Immunosensor for the Detection of Disease Biomarkers

Philani Mashazi, Daniel Mwanza, Omotayo Adeniyi

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A rapid, low-cost, and accurate point-of-care analytical device for the determination of disease biomarkers is required for the early diagnosis and prognosis of most cancers. An ultrasensitive electrochemical capacitive immunosensor for the label-free detection of anticancer drugs and disease biomarkers (antibodies and antigens) was developed. The immunosensor based on the covalent immobilization of capture proteins (antibodies, or antigens) onto gold or carbon electrode surfaces pre-modified with a thin monolayer of isophthalic acid or phenyl-ethylamine. A methodology based on the steric hindrance of 1,3-substituted aryldiazonium salt was adopted to control the growth and thickness of the sublayer to form a monolayer on the gold and carbon electrode surfaces. The N-terminus capture proteins attached onto an electrode surface via carbodiimide chemistry. The intricate surface treatment methods investigated and discussed with the aim of developing a selective and sensitive sensor for disease biomarkers. The analytical performance of the fabricated electrochemical capacitive sensors was developed.

O3

Detection of Diclofenac and Carbamazepine using Voltammetry and Flow Injection Analysis at Boron-Doped Diamond Thin-Film Electrodes

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The electrochemical detection of two pharmaceuticals, diclofenac (DFC) and carbamazepine (CBZ), was investigated as an oxidation current using boron-doped nanocrystalline diamond (BDD) thin-film electrodes. Both voltammetry and flow injection analysis with amperometric detection (FIA-EC) were used to measure the drugs in standard solutions and a urine simulant. The oxidation potential for DFC was *ca.* 0.7 V vs. Ag/AgCl (3 M KCl) in 0.1 M phosphate buffer (pH 7.2) and was *ca.* 1.2 V for CBZ in 0.1 M perchloric acid. The DFC oxidation reaction was diffusion controlled at the detection potential with evidence of some surface fouling by reaction products. The CBZ oxidation reaction was also controlled by diffusion at the detection potential, but with no surface fouling. FIA-EC analysis of DFC and CBZ revealed a linear dynamic range from at least 0.1 to 100 μM with the actual minimum concentration detectable (S/N=3) being less than the lowest concentration measured. The recovery percentage for DFC in the urine simulant ranged from 94-108% and from 97-100% for CBZ, both assessed using square wave voltammetry. FIA-EC data revealed that the BDD electrodes offer excellent intra and inter-electrode repeatability with an RSD for DFC and CBZ of 4.90% and 3.81%, respectively. The BDD electrode provided good reproducibility and response stability over eight days of continuous use detecting both DFC and CBZ. Overall, BDD electrodes are a viable material for the sensitive, selective, and reproducible electrochemical detection of these two pharmaceuticals.

O4

An Electrochemical Sensor for Dopamine on a Graphene-Poly(3,4-ethylenedioxythiophene): Polystyrene Sulphonate Hybrid Ink Nanoplatform

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Dopamine can be used as a biomarker for diseases such as Alzheimer's, bipolar disorder, schizophrenia, mania, to mention a few, as well as addiction to tobacco [1]. Thus, its measurement can be of biomedical importance [2]. We present an-easy-to-construct, one-step, electrochemical sensor for dopamine based on drop coating of the commercial graphene/poly (3,4-ethylenedioxythiophene): polystyrene sulphonate (Gr-PEDOT: PSS) hybrid ink dispersion on a bare glassy carbon electrode surface. The conductive polymer's structural properties and composition were explored using XRD, Raman, FTIR spectroscopy and electron microscopy. The nanocomposite exhibited a uniform size distribution and functional groups—such as aromatic, thiol, and olefinic bonds—that improved the surface chemistry between the electrolyte/analyte and the electrode. Characterization through electrochemical impedance spectroscopy and voltammetry demonstrated that the Gr-PEDOT: PSS hybrid ink sensor significantly enhances biocompatibility and electron transfer kinetics at the bare electrode surface, and therefore improve electrooxidation of dopamine. All this highlights the advantageous properties of Gr-PEDOT: PSS hybrid ink, chosen for this work, in comparison to other materials. The sensor achieved a detection limit of 0.19 µM within a linear concentration range of 3.13-400 µM dopamine. It also exhibited high selectivity against potential interfering agents like ascorbic acid, caffeine, and urea, with recovery percentages ranging from 105-109% in human serum samples.

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[1] Makaluza, S., Midzi, N., Olorundare, F. O., Sipuka, D. S., Sebokolodi, T. I., Nkosi, D., & Arotiba, O. A. A nitrogen-doped carbon nanosheet/poly (amidoamine) dendrimer-based electrochemical sensor for nicotine in flavored hookah pipe tobacco. Analytical Methods.2024; 16(44): 7518-7526.

[2] Sipuka, D. S., Arotiba, O. A., Sebokolodi, T. I., Tsekeli, T. R., & Nkosi, D. Gold-dendrimer nanocomposite based electrochemical sensor for dopamine. Electroanalysis.2023; 35(3): e202200099.

O5

Electroanalysis of dopamine in human serum at CB [7] modified electrodes

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Cucurbiturils are a class of macrocyclic molecules composed of glycoluril monomers liked by methylene bridges[1]. These molecules form a partly enclosed cavity that can host various guest molecules, making them useful in host-guest chemistry. Owing to their exceptionally high affinity for positively charged or cationic molecules, they are frequently used as effective host molecules in the field of solution phase supramolecular recognition[2]. This macrocyclic compound, immobilized at the interface of conducting carbon substrates, was applied in the design of electrochemical sensors for the detection of dopamine. Dopamine (DA) is a prevalent neurotransmitter present in the adrenal glands, and ventral tegmental area, it plays a vital role in motor control, cardiovascular, renal, human metabolism, motivation, cognitive function, and hormonal systems[3]. The typical concentration of DA in the human body is 10–1000 nM[4]. Limited studies have been reported on thin film cucurbituril modified electrochemical sensors for solution-based studies, but cucurbituril based electrochemical sensors have shown great promise for the detection of amphetamine-type stimulants and tryptophan (Try) in solution[5]. In this work we focused on designing CB [7] grafted sensor systems. Initially, L-lysine was electrochemically synthesized, in situ, at the surface of glassy carbon electrodes onto which CB[7] was functionalized through peptide bond formation between the amines from the polymer and the carbonyl groups from CB[7] macrocycle. The cyclic voltammetry (CV), square wave voltammetry (SWV), UV-Vis and FTIR spectroscopy, and scanning electron microscopy (SEM) were used to characterize the sensor structure and its analytical response towards the detection of dopamine in human serum.

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(1) Park, K. M.; Kim, J.; Ko, Y. H.; Ahn, Y.; Murray, J.; Li, M.; Shrinidhi, A.; Kim, K. Dye-Cucurbit[n]Uril Complexes as Sensor Elements for Reliable Pattern Recognition of Biogenic Polyamines. *Bull. Chem. Soc. Jpn.* **2018**, *91* (1), 95–99. https://doi.org/10.1246/bcsj.20170302.

(2) Yang, M. X.; Tang, Q.; Yang, M.; Wang, Q.; Tao, Z.; Xiao, X.; Huang, Y. PH-Stimulus Response Dye-Cucurbituril Sensor for Amino Acids in Aqueous Solution. *Spectrochim. Acta - Part A Mol. Biomol. Spectrosc.* **2020**, *230*, 118076. https://doi.org/10.1016/j.saa.2020.118076.

(3) Juárez Olguín, H.; Calderón Guzmán, D.; Hernández García, E.; Barragán Mejía, G. The Role of Dopamine and Its Dysfunction as a Consequence of Oxidative Stress. *Oxid. Med. Cell. Longev.* **2016**, *2016*. https://doi.org/10.1155/2016/9730467.

(4) Sun, F.; Zeng, J.; Jing, M.; Zhou, J.; Feng, J.; Owen, S. F.; Luo, Y.; Li, F.; Wang, H.; Yamaguchi, T.; Yong, Z.; Gao, Y.; Peng, W.; Wang, L.; Zhang, S.; Du, J.; Lin, D.; Xu, M.; Kreitzer, A. C.; Cui, G.; Li, Y. A Genetically Encoded Fluorescent Sensor Enables Rapid and Specific Detection of Dopamine in Flies, Fish, and Mice. *Cell* **2018**, *174* (2), 481-496.e19. https://doi.org/10.1016/j.cell.2018.06.042.

(5) Gardini, F.; Özogul, Y.; Suzzi, G.; Tabanelli, G.; Özogul, F. Technological Factors Affecting Biogenic Amine Content in Foods: A Review. *Front. Microbiol.* **2016**, *7* (AUG), 1–18. https://doi.org/10.3389/fmicb.2016.01218.

Invited Oral 1

An *in-situ* FTIR-LCR meter technique to study the sensing mechanism of a sensor and the relationship between the sensitivity of sensors and their rate of reaction on the surface of the sensing materials

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Understanding the sensing mechanism is one of the key steps in fabricating sensors to detect gas in an atmosphere or a confined space. There are different types of sensing mechanisms, to mention a few: electrostatic, polarisation, swelling of the sensing materials, and charge transfer. Charge transfer, which leads to deep oxidation (total decomposition), is a common sensing mechanism for semiconductor metal oxide sensing materials. Our study effectively combines *in situ* FTIR with an LCR meter to analyse nanomaterials' deep oxidation-based (total decomposition) sensing mechanism for detecting volatile organic compounds (VOCs). This study used nanomaterials as sensing materials to detect organic compounds. The results have shown that all the sensing mechanisms followed deep oxidation of organic compounds to produce CO_2, H_2O, and other molecules. By monitoring the CO_2 IR band intensity, we established a direct correlation between surface reaction rate and sensor sensitivity, reinforcing the role of oxidation in VOC detection.

Malepe et. al. *Results in Physics*, 2023, 52, 106864

Olifant et. al. *Nano Express*, 2021, 2, 020010

Plenary 2

Multi-functional roles of microwave-assisted synthesis of electrode materials

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Over the years, our research group has focussed on the use of microwave-assisted synthesis electrode materials for lithium-ion batteries, and electrocatalysts for fuel cells and sensors. Recently, we have expanded our focus to explore "beyond lithium-ion" battery technologies, with particular emphasis on rechargeable zinc-air batteries (ReZABs). ReZABs offer significant promise for renewable energy storage due to their safety, environmental friendliness, and higher theoretical energy density compared to conventional lithium-ion batteries. While zinc-air batteries are typically non-rechargeable, one of the major obstacles to developing a viable rechargeable version is the sluggish kinetics of oxygen reactions at the air-cathode. This challenge underscores the need for efficient cathode catalysts to enhance both the oxygen reduction (ORR) and oxygen evolution (OER) reactions.

In this seminar, I will present our recent work on developing innovative bifunctional air-cathode catalysts, such as high-entropy spinel oxides (HESOx), for ReZABs, which show promise to rival lithium-ion battery pack. The presentation will last about 40 minutes, with ample time for Q&A session.

O6

Construction of polyHIPE-based immunosensor for detection of coronavirus

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In recent years, there has been growing interest in global biosecurity threats, including the spread of emerging infectious diseases (EIDs) and bioterrorism. The international community is highly concerned with monitoring and controlling the spread of EIDs. A proper detection system is a crucial step in preventing or reducing the spread of a virus outbreak before its economic, human, and environmental impacts become catastrophic [1]. As much as traditional methods for detecting infectious diseases have been useful, their long detection times [2] and use of sophisticated equipment [3] render them inefficient for such analysis, and hence there is a growing demand for new technology that is easy to use, fast, specific, sensitive, and cost-effective. Recently, there has been a surge in research focused on developing biosensors for detecting pathogenic microorganisms and toxins [4]. Immunosensor development requires a range of materials because of their outstanding properties, but porous polymers provide additional advantages in the construction of these devices. One of such porous polymers is polyHIPEs, whose key features, including a large surface area and well-defined porosity, make them ideal for sensor development. Nevertheless, there are few studies in the literature that focus on the use of polyHIPEs as materials for sensor development. In this work, we demonstrate the synthesis and modification of polystyrene-based polyHIPE films on an ITO substrate. Additionally, we present the development of an immunosensor that utilizes the modified polyHIPE electrode and coronavirus antibodies, specifically PtXTM Alpaca Anti-Spike S1 (Sb23), to detect the coronavirus antigen PtXTM Spike Protein S1 (His) Ultra.

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[1] B. Pejcic, R. De Marco, G. Parkinson, The role of biosensors in the detection of emerging infectious diseases, Analyst. 131 (2006) 1079–1090. https://doi.org/10.1039/b603402k.

[2] Q. Liu, X. Jin, J. Cheng, H. Zhou, Y. Zhang, Y. Dai, Advances in the application of molecular diagnostic techniques for the detection of infectious disease pathogens (Review), Mol. Med. Rep. 27 (2023) 1–14. https://doi.org/10.3892/mmr.2023.12991.

[3] I.A. Quintela, T. Vasse, C.S. Lin, V.C.H. Wu, Advances, applications, and limitations of portable and rapid detection technologies for routinely encountered foodborne pathogens, Front. Microbiol. 13 (2022). https://doi.org/10.3389/fmicb.2022.1054782.

[4] E. Janik-Karpinska, M. Ceremuga, M. Niemcewicz, M. Podogrocki, M. Stela, N. Cichon, M. Bijak, Immunosensors—the future of pathogen real-time detection, Sensors. 22 (2022) 1–20. https://doi.org/10.3390/s22249757.

O7

Carbon-based electrochemical aptasensor for the detection of *Cryptosporidium* in water

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Recently, water contamination has emerged as one of the critical global conundrums. *Cryptosporidium* is among the numerous parasites that deteriorate water quality, potentially leading to outbreaks of waterborne diseases. Concerns over environmental pollution and its impact on public health have spurred research in the development of sustainable environmental technologies. This study focuses on the development carbon-based-aptasensor for early detection of *Cryptosporidium* in water bodies, addressing both pollution and scarcity concerns. Precipitation method was used to synthesize the composite. Structural and morphological characteristics of the as-synthesized composite were investigated using various techniques including X-ray diffraction (XRD), high-resolution transmission electron microscopy (HR-TEM), and Fourier transform Infrared spectroscopy (FTIR) and Raman spectroscopy. Cyclic voltammetry (CV) and electrochemical impendence spectroscopy (EIS) were used to study the electrochemical activities of the modified electrodes. The synthesized nanocomposite was used as a transducing material for immobilizing the aptamer. The performance of the developed aptasensor was evaluated using square wave voltammetry and cyclic voltammetry. The aptasensor achived a good a low limit of detection of 0.874 µM with a linear range of 1- 11 µM and a sensitivity of 1.38×10^{-10} µM which is exceptionaly high for trace of analytes.

O8

Development of an Electrochemical Sensor for the Rapid Detection of Toxic Heavy Metals in Trace Concentrations

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Heavy metal ions, even in trace concentrations, are a major pollutant with adverse health effects on human life and the ecosystem at large. The detection of toxic heavy metals such as lead (Pb^{2+}) and cadmium(Cd^{2+}), to name a few, remains a challenge. Established detection techniques involve complex working procedures and require skilled personnel to operate the equipment. They are relatively expensive and time-consuming. This research explores the development of an electrochemical sensor for the simultaneous detection of Pb^{2+} and Cd^{2+}. Electrochemical sensors offer a promising alternative to the widely used detection techniques with accurate real-time results, higher sensitivities, and lower detection limits (LoD).

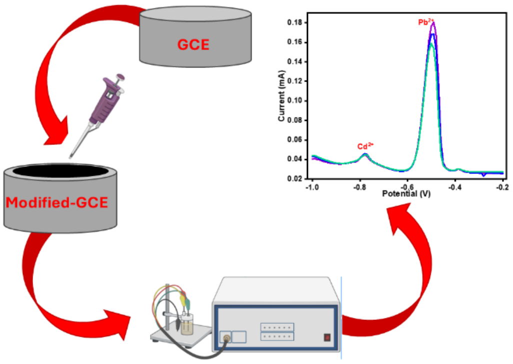

Figure 1. Modification of the glassy carbon electrode and simultaneous detection of Pb^{2+} and Cd^{2+} using DPV.

In this study, carbon-based nanomaterials were synthesised and utilised as electrocatalysts to detect Pb^{2+} and Cd^{2+}. These materials chosen for their large specific surface area, low cost and high conductivity were characterised using various techniques such as XRD, XPS, SEM, TEM and EDS to determine the structural and chemical properties of the materials. Upon electrode modification, the electrochemical properties of the electrocatalysts were studied primarily using cyclic voltammetry (CV) and electrochemical impedance microscopy (EIS). Electrochemical techniques such as differential pulse voltammetry (DPV), EIS, anodic stripping voltammetry (ASV), and chronoamperometry were employed in the detection of lead and cadmium (Fig 1). Obtaining relativity low detection limits (LoDs) and high sensitivity values comparable to those cited in literature and within the WHO limits for Pb^{2+} and Cd^{2+}.

Keynote 2

Nanomaterials for electrochemical energy storage

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The decline in fossil fuel reserves, coupled with their adverse effects on the environment and human health, has given impetus to the search for clean, sustainable, and renewable energy sources. These renewable energy resources need effective energy storage technologies. Electrical energy storage systems include batteries, compressed air, flywheels, pumped hydro-energy, conventional capacitors, and electrochemical capacitors (ECs). ECs bridge the gap between batteries and conventional capacitors as emerging energy storage and power supply devices due to environmental compatibility, lower costs, potentially higher energy and power densities, low-temperature dependencies, and better cyclabilities than conventional capacitors. The energy storage capabilities of ECs are largely dependent on both the electrolyte and electrode materials. Several materials, such as conducting polymers, redox-based metal oxides, and carbon-based materials, have been reported as suitable EC electrode materials. Of these, carbon-based materials offer attractive advantages that include lower cost, higher stability and conductivity, and better rate capability and reversibility than conventional redox-based metals/materials. However, these carbonaceous materials often achieve lower specific capacitance and energy densities than intrinsic pseudocapacitive materials. One means of improving the capacitance is to develop porous nano-sized or nanostructured electrode materials. Carbon nanotubes and reduced graphene oxide, which exhibit high electrical conductivity, show potential in this sphere. They can be further improved by doping, the formation of composites, and the inclusion of conducting polymers. This presentation will provide some examples from our laboratories where carbon nanotubes and reduced graphene oxide were tailored for enhanced performance in ECs.

O9

Electrochemical determination of nitrate in model aqueous solutions using MnO_2/Poly-L-lysine modified glassy carbon electrodes

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The pursuit of economic growth and development has led to significant environmental challenges, with nitrate pollution posing serious risks to water quality and public health. Contamination of water bodies with excessive concentrations of nitrate, driven by anthropogenic activities such as inadequate wastewater treatment, agricultural runoff and industrial discharge can alter the chemical composition of water leading to issues like eutrophication, which directly affect the functioning of water systems and the biodiversity they support [1]. Additionally, polluted water can pose risks such as methemoglobinemia (also called blue baby syndrome) [2]. Therefore, the first step of response to addressing the issue of water pollution is to monitor pollutants effectively to ensure that water quality standards are maintained and to inform pollution mitigation strategies. Conventional nitrate detection techniques-such as colorimetry, spectrophotometry, ion chromatography, Raman spectroscopy, chemiluminescence- offer high accuracy but are typically labour-intensive, expensive, and require sophisticated instrumentation and expert operators, thus limiting their application for rapid, in-situ monitoring. These limitations have driven interest in developing simpler, nanomaterial-enabled electrochemical sensors[3].

In this study, we propose an electrochemical sensor based on glassy carbon electrode (GCE) modified with manganese dioxide (MnO_2) nanoparticles and poly-L-lysine (PLL) to fabricate two configurations: GCE/PLL and GCE/PLL/MnO_2. Preliminary investigations indicate that PLL not only serve as a highly conductive support-with an experimental diffusion coefficient of $4{,}42 \times 10^2 cm^2/s$-but also provides an extensive surface area for the deposition of nanoscale MnO_2 particlesClick or tap here to enter text.. The synergistic contact between MnO_2 and PLL is expected to enhance the overall electrical conductivity, while MnO_2 contributes high surface area and redox mediation properties, as demonstrated in nitrite detection studies reporting linear ranges from 0.01 to 1520 µM and limits of detection in the nanomolar range. Therefore, the expectation is that MnO_2 will electro-reduce nitrate to determine its concentration in solution. The modified electrode will then be characterized by cyclic and square wave voltammetry to elucidate electron transfer kinetics, establish the linear range, determine the limit of detection and assess selectivity.

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(1) Adimalla, N.; Qian, H. Groundwater Chemistry, Distribution and Potential Health Risk Appraisal of Nitrate Enriched Groundwater: A Case Study from the Semi-Urban Region of South India. Ecotoxicol Environ Saf 2021, 207, 111277. https://doi.org/10.1016/j.ecoenv.2020.111277.

(2) COMLY, H. H. CYANOSIS IN INFANTS CAUSED BY NITRATES IN WELL WATER. J Am Med Assoc 1945, 129 (2), 112–116. https://doi.org/10.1001/jama.1945.02860360014004.

(3) Amali, R. K. A.; Lim, H. N.; Ibrahim, I.; Huang, N. M.; Zainal, Z.; Ahmad, S. A. A. Significance of Nanomaterials in Electrochemical Sensors for Nitrate Detection: A Review. Trends in Environmental Analytical Chemistry 2021, 31, e00135. https://doi.org/10.1016/j.teac.2021.e00135.

O10

Electrochemical Detection of Levofloxacin using Manganese Oxide-Ytterbium Nanoparticles Supported on 2D-hexagonal Boron Nitride

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Levofloxacin (LEV), a promising fluoroquinolone antibacterial agent extensively used as a potent antidote for acute respiratory tract infections. However, its pervasive use may cause substantial risks for human health and the environment. For this reason, it is important to develop accurate and highly sensitive detection methods for monitoring the concentration levels of LEV in water. Herein, this study focuses on the hydrothermal synthesis of a novel manganese oxide doped ytterbium ($YbMn_2O_3$) nanoparticles supported on hexagonal boron nitride (h-BN) nanocomposite. The structural and morphological arrangement of the prepared materials was characterized using FTIR, XRD, XPS, HR-SEM, and HR-TEM. The SEM revealed- the formation of spherical $YbMn_2O_3$@hBN structure, whilst the existence of Mn–O and B–N functional group were confirmed by FTIR. Owing to its unique electronic and catalytic properties, $YbMn_2O_3$ synergistically interacts with the h-BN. This synergy enhances conductivity, promoting efficient electron transfer during electrochemical processes. Under optimised conditions, the sensor demonstrated remarkable low detection limit (LOD =0.026 µM) and excellent sensitivity (1.7948 $\mu A \mu M^{-1}$ cm^{-2}) with a wide linear range (0.05–112 µM). Furthermore, the proposed sensor displays excellent selectivity, reproducibility, and stability towards the LEV detection. The $YbMn_2O_3$@hBN/GCE sensor was also employed to determine the LEV in real water sample and commercial LEV tablet, displaying 108% and 99% recovery.

Plenary 3

Novel environmental electrochemistry for water treatment

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Environmental electrochemistry is increasingly important in water treatment for its process efficiency and eco-friendliness. In this work, we report our attempts on novel materials and processes for treatment of emerging contaminants. We synthesized an efficient single-atom Co-N/C catalyst for electrocatalytic dehalogenation, which provided more active sites and a faster charge transfer rate. The defluorination and dechlorination efficiencies were 67.6 and 95.6%, respectively, with extremely low Co leaching (6 μg L^{-1}) and low energy consumption (22.7 kWh kg^{-1}). H* and direct electron transfer were the primary causes of dehalogenation [1]. To enhance H* production, the phosphorus-doped cobalt nitrogen carbon catalyst (Co-NP/C) was prepared for electrocatalytic dechlorination, which had high catalytic activity in a wide pH range (3-11). The introduction of phosphorus was found enhanced the electron density of cobalt and regulated the electron transfer.

We further developed the heterogeneous electro-Fenton process based on dual-functional cathodes. The catalyst composed of nitrogen-doped carbon nanotubes encapsulating zero-valent iron (Fe@N-C) was synthesized, which demonstrated superior degradation of sulfamethazine (SMT) under mildly alkaline conditions. The primary reactive species generated by Fe@N-C were H* and singlet oxygen ($^1O_2$), with hydroxyl radicals (·OH) playing a supportive role [2]. Additionally, the catalyst with boron and nitrogen co-doped carbon nanotubes encapsulating zero-valent iron (Fe@BN-C) was fabricated, which significantly increased the selectivity for H_2O_2 to 94%, and H_2O_2 was directionally converted to $^1O_2$ via surface ·OH. Theoretical calculations confirmed the confinement effect of Fe^0 overcame the rate-limiting step for H_2O_2 formation, achieving high efficiency and selectivity for $^1O_2$ transformation[3].

Traditional free radicals-dominated electrochemical advanced oxidation processes (EAOPs) and sulfate radical-based advanced oxidation processes (SR-AOPs) are limited by pH dependence and weak reusability, respectively. To address these shortcomings, electro-enhanced activation of peroxymonosulfate (PMS) was proposed. Firstly, a novel perovskite-Ti_4O_7 composite anode activating PMS (E-PTi-PMS) system achieved an ultra-efficient removal rate (k = 0.467 min^{-1}) of carbamazepine (CBZ). The electric field expedited the decomposition and utilization of PMS, promoting the generation of radicals and expanding the formation pathway of $^1O_2$. This system presented superiorities over wide pH (3-10) and less dosage of PMS (1 mM), expanding the pH adaptability and reducing the cost of EAOPs [4].

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[1] Song, G., et al., Environ. Sci. Technol. 2023, 57: 14482-14492.

[2] Su, P., et al., Appl. Catal. B: Environ. 2022, 313:121457.

[3] Su, P., et al., Chem. Eng. J. 2023, 452:139693.

[4] Jin, J., et al., Water Res., 2023, 232: 119682.

O11

Cu_2PdSnS_4 Nanomaterial with Enhanced Kesterite Photovoltaic Performance

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This study presents an innovative approach to improve the performance of photovoltaic (PV) devices using Cu_2PdSnS_4 (CPTS) nanoparticles as an absorber layer material. Although kesterite materials have been recognized for their potential in PV applications, their device performance is often limited by high antisite defect and secondary phase formation, leading to a high open circuit voltage deficit ($V_{oc,def}$)[1–4]. To overcome these limitations, we demonstrate the fabrication of a PV cell composed of CPTS nanoparticles as an absorber layer (for purposes of comparison we synthesized pristine Cu_2ZnSnS_4, CZTS and applied it as an absorber layer in PV cells), which exhibits a remarkable improvement in the open circuit voltage (V_{oc}) of 900 mV, twice that of the CZTS-based PV cell. Furthermore, the CPTS-based devices showed substantially improved PV cell parameters, including fill factor (FF) of 83.4% and power conversion efficiency (PCE) of 1.01%, compared to pristine CZTS devices[5]. Optical studies revealed enhanced redshift absorption of CPTS nanoparticles, while electrochemical studies demonstrated improved current production, high electron mobility, and low charge resistance, highlighting the electrochemical and optical advantages of CPTS as an absorber material. Our study demonstrates that CPTS nanoparticles hold great potential for enhancing the bulk properties of kesterite nanomaterials, enabling superior PV performance in a sustainable manner.

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[1] K. C. Nwambaekwe, V. John-Denk, S. F. Douman, P. Mathumba, S. T. Yussuf, O. V. Uhuo, P. I. Ekwere and E. I. Iwuoha, *J. Mater. Res. Technol.*, 2021, **12**, 1252–1287.

[2] K. C. Nwambaekwe, V. P. Batir, L. Dermenji, N. D. Curmei, E. Arushanov and E. I. Iwuoha, *Mater. Chem. Phys.*, 2023, **301**, 127594.

[3] K. C. Nwambaekwe, M. Masikini, P. Mathumba, M. E. Ramoroka, S. Duoman, V. S. John-Denk and E. I. Iwuoha, *Nanomaterials*, 2021, **11**, 794.

[4] S. T. Yussuf, M. E. Ramoroka, S. B. Mdluli, K. C. Nwambaekwe, P. I. Ekwere, O. V. Uhuo, C. O. Ikpo and E. I. Iwuoha, *J. Alloys Compd.*, , DOI:10.1016/j.jallcom.2022.168211.

[5] K. C. Nwambaekwe, M. E. Ramoroka and E. I. Iwuoha, *J. Sci. Adv. Mater. Devices*, 2023, **8**, 100553.

O12

Squarewave voltammetry detection of heavy metals in water using (Fe_3O_4/SPEEK) nanocomposite

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Water is essential to life on earth. Rapid population growth and industrial expansion pose risks to safe drinking water, exposing it to contaminants like heavy metals, which can cause pollution even at low levels. The purpose of the research is to fabricate an electrochemical sensor using iron oxide/sulphonated polyether ether ketone (Fe_3O_4/SPEEK) nanocomposite on a platinum screen-printed electrode (SPPtE) for detection and quantification of arsenic in water. The Fe_3O_4 nanoparticles, SPEEK polymer, and Fe_3O_4/SPEEK nanocomposite were successfully synthesized by coprecipitation and solvent casting method. Various characterization techniques such as Fourier transform infrared (FTIR), Xray diffraction, and Ultraviolet visible light (UV-VIS) were carried out the structural properties of the nanomaterials and their surface morphology was characterized by scanning electron microscopy (SEM). The electrochemical performance of the modified electrodes was studied using cyclic voltammetry (CV) in $K_3[Fe(CN)_6]$ redox probe. High electron transport was observed at the nanocomposite modified electrode (SPPtCE-Fe_3O_4/SPEEK) compared to the bare SPPtE with good stability under 15 repetitive scans. Electro-oxidation of arsenic prepared in PBS pH 7 was also carried out at (SPPtCE-Fe_3O_4/SPEEK) via CV at a scan rate of 25 mVs^{-1}. Square-wave results showed that the developed sensor displayed excellent electro-catalytic activity towards arsenic over a linear concentration range from 1.62-9.70 pM with correlation coefficients (R^2) of 0.99, the limit of detection (LOD) of 10.2723 pM and the limit of quantification (LOQ) of 31 pM, respectively.

O13

Harnessing the (photo) electrochemical properties of BiSI nanorods towards the degradation of norfloxacin in water

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The increasing demand for cheap and sustainable technology for the production of reactive oxidants for water treatment continues to draw researchers' attention. Photoelectrochemical (PEC) technology remains a promising approach because of the synergistic effects arising from both photocatalytic and electrochemical techniques [1]. In this work, bismuth sulphur iodide (BiSI) nanorods were prepared and characterised with XRD, FESEM, TEM, and UV-DRS [2]. Also, its photoelectrochemical properties were studied using linear sweep voltammetry, cyclic voltammetry, electrochemical impedance spectroscopy, and Mott-Schottky measurements. Furthermore, the impressive properties of BiSI nanorods were harnessed towards generating reactive oxidants for the degradation of norfloxacin in water. When BiSI photocatalyst was applied for the degradation of norfloxacin, the photocatalytic (PC), electrochemical (EC), and photoelectrochemical (PEC) techniques achieved 30.8, 65.4, and 88.5% degradation respectively. Also, the versatility of BiSI nanorods in a PEC system achieved a 94.6% reduction of 4-nitrophenol within 180 min as well as a 100% degradation of orange II dye within 60 min. Scavenger studies revealed that reactive oxidants such as holes, hydroxyl radicals, and superoxides participated in the degradation process. The electrode was found to be stable and can be applied for the degradation of other pharmaceutical pollutants in a PEC degradation system.

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1. M. Medina-Casas, V. Pérez-Herranz, J. Giner-Sanz, S. Mestre, M. García-Gabaldón, Statistical comparison of the photoelectrochemical degradation of an antibiotic pollutant using two Sb-doped SnO2 ceramic anodes coated with photoactive $CdFe_2O_4$ and $ZnFe_2O_4$ layers, Separation and Purification Technology, (2024) 130954

2. J. Liu, J. Wu, N. Wang, F. Tian, J. Li, Surface reconstruction of BiSI nanorods for superb photocatalytic Cr (VI) reduction under near-infrared light irradiation, Chem. Eng. J., 435 (2022) 135152.

O14

Exploring the intrinsic properties of a metal-free melamine-COF and Nitrogenated-rGO composite for Advanced Ultracapacitor Applications

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The newly studied crystalline porous polymer, covalent organic frameworks (COFs) has attracted more attention due to its precious properties including porous nature and high surface area. A composite based on melamine-based COF and nitrogenized Reduced Graphene Oxide (mCOF/NrGO) was synthesized through a simple impregnation method at room temperature and used as a positive electrode in asymmetric supercapacitors (ASC). The COF contains mesopores and can prevent restacking of the NrGO allowing sufficient ion transfer. The prepared composite was characterized by Fourier transform infrared spectroscopy (FTIR), Thermogravimetric analysis (TGA), X-ray diffraction (XRD) and scanning electron microscopy (SEM). The electrochemical evaluation of the composite was performed using a three-electrode system on nickel foam (NF) in a 3M KOH electrolyte. The maximum specific capacity of mCOF was obtained to be 97.8 C/g respectively at a current density of 2.0 A/g. However, after the incorporation of NrGO to the mCOF the specific capacity raised sharply to 387 C/g at the same current density of 2.0 A/g. The full-cell application of the composite was performed using AC as an anode and the synthesized electrode material as a cathode. The AC//mCOF/NrGO cell has shown a power density of 1013 W/kg and an energy density of 6.5 Wh/kg respectively. Generally, this work demonstrates a metal-free 3D COF material as an important template for realizing high-performance supercapacitors. Further work such as the introduction of conducting polymers to the hybrid composite can be done to improve the electrochemical performance of the materials.

Keynote 3

Intrinsic properties of N-doped reduced graphene oxide on manganese-based (oxides and phosphates) nanoparticles as electrode materials for supercapacitors

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Electrochemical energy storage (EES) devices have emerged as key components to support renewable energy sources required to mitigate the detrimental impacts brought by the use of fossil fuels as well as the advanced energy demand arising from rapid technological growth.[1,2] Supercapacitors (SCs) have stood out amongst EES devices due to their ability to deliver robust power outputs. The latest advancements in SC electrode materials have underscored the importance of engineered nanostructures, cyclic stability, and extended lifespan, which are key factors in enhancing device reliability.[3] Heteroatom-rich materials have emerged as promising electrode materials for developing high-performance electrochemical energy storage devices.[4] This work focuses on the performance of carbon-based nanomaterials (with a special interest in nitrogen-doped reduced graphene oxide, N-rGO) decorated with metal oxide and phosphate-based nanoparticles as electrode materials for SC application.

Hence, this work focuses on the integration of the non-Faradaic charge storage mechanism of N-rGO with the Faradaic charge storage of either Mn_3O_4 or $NH_4MnPO_4 \cdot H_2O$ as a vital approach toward the construction of supercapacitors with improved energy and power outputs.[3,4] Some of the prepared nanocomposites, such as N, P-rich ammonium manganese phosphate hydrate ($NH_4MnPO_4 \cdot H_2O$, *Mn-AMP*) decorated on N-rGO, displayed battery-type behaviour with excellent performance for supercapattery application. The asymmetric electrochemical cell configuration of the N-rGO/*Mn-AMP* nanocomposite demonstrated great cycling stability through gradual capacity attenuation for 10 000 cycles, as evidenced by the retention of 74% of the initial capacity and coulombic efficiency of 98.8% after the 10 000th cycles.

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1. T. Patra, J. Panda and T. R. Sahoo, *Mater. Today Proc.*, 2019, 41, 247–250.

2. X. Zhou, T. Meng, F. Yi, D. Shu, Z. Li, Q. Zeng, A. Gao and Z. Zhu, *Electrochim. Acta*, 2021, 370, 137739.

3. K. Raju, H. Han, D. B. Velusamy, Q. Jiang, H. Yang, F. P. Nkosi, N. Palaniyandy, K. Makgopa, Z. Bo and K. I. Ozoemena, *ACS Energy Lett.*, 2020, 5, 23–30.

4. K. Makgopa, M. S. Ratsoma, K. Raju, L. F. Mabena and K. D. Modibane, *ACS Omega*, 2021, 6, 31421–31434.

O15

Electrocatalytic degradation of Antibiotics with Hybrid Graphene Interfaced Cu-Ni Oxides Composites

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Recently, antibiotics in the water environment have caused serious risk to human health due to their difficult biodegradability and environmental accumulation [1]. It has been reported that advanced oxidation processes (AOPs) can efficiently break down antibiotics in wastewater by producing reactive oxygen species with potent oxidation capabilities, like hydroxyl radicals. AOPs that show promise include electrocatalysis (EC) [2]. The study focuses on the electrocatalytic degradation of antibiotics (tetracycline (TC)), with enhanced synthesized hybrid graphene interfaced Cu-Ni oxides composites (rGO, NiO/rGO, CuO/rGO, CuO-NiO, CuO-NiO/rGO, and CuO-NiO/rGO-gC_3N_4. The structural advancement of composites was studied by using UV–vis, FTIR, SEM, EDX, CV, and EIS techniques. The CuO-NiO/rGO sample obtained the lowest band gap energy compared to all other rGO-integrated composites, which shows the pleasing optical properties consisting of 2.25 eV band gap energy. The EIS showed the higher-frequency arc in the Nyquist plots of all rGO composites. The CuO-NiO/rGO-g gC_3N_4 composites showed the highest diffusion coefficient at their surface, thus a high electron transfer rate and stability. This was determined to give the properties for the efficient electrocatalytic activity of TC antibiotic model wastewater contaminants. The quaternary composite CuO-NiO/rGO-gC_3N_4 obtained the highest electrocatalytic degradation activity of 73.13% within 60 minutes of reaction, as compared with other nanocomposites showing very low peaks of TC after degradation, indicating high performance for both treatment processes. Moreover, the presence of rGO and gC_3N_4 in predominant CuO-NiO allows efficient e^-/h^+ separation and transfer by the creation of a heterojunction interface. An inexpensive CuO-NiO/rGO-gC_3N_4 nanoparticle was a promising catalyst for degradation of TC to useful products in aqueous or non-aqueous medium.

Ethiraj, A.S., Uttam, P., Varunkumar, K., Chong, K.F. and Ali, G.A., 2020. Photocatalytic performance of a novel semiconductor nanocatalyst: Copper doped nickel oxide for phenol degradation. Materials Chemistry and Physics, 242, p.122520.

Q. Guo, Y. Zhang, J. Qiu, G. Dong, Engineering the electronic structure and optical properties of g-C3N4 by non-metal ion doping, J. Mater. Chem. C. 4 (2016) 6839–6847.

O16

Enhanced Electrocatalytic Oxygen Evolution Reaction Performance of Nickel Oxide/Borophene Composite in Alkaline Medium

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The development of noble metal-free electrocatalysts for anodic water splitting in an alkaline medium is highly desirable yet challenging. In this study, a facile approach is adopted for the preparation of NiO/borophene composite with excellent oxygen evolution reaction (OER) activity. Owing to the synergistic effect of borophene nanosheets, all NiO/borophene (NiO-B-$_X$) composites exhibit superior OER activity in terms of current density, overpotential and Tafel slope as compared to pristine NiO. The enhanced OER activity of NiO-B-$_X$ electrocatalysts is attributed to a synergistic influence of p-type B doping, which introduces positive charge carriers onto the NiO thereby facilitating rapid charge transport in OER. Furthermore, the ability of the borophene nanosheet to provide an enlarged surface area could have mitigated the aggregation of NiO nanoparticles thereby exposing more electrochemically active sites and thus increasing the OER activity. Among all the NiO-B-$_X$ electrocatalysts, NiO-B-$_{10}$ exhibits the lowest potential at 10 mA cm^{-2} of 1.376 V and Tafel slope of 58.02 mV dec^{-1} and demonstrates stable current density over 8 hours.

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1. T. W. Chen, P. Kalimuthu, P. Veerakumar, K. C. Lin, S. M. Chen, R. Ramachandran, V. Mariyappan and S. Chitra, *Molecules*, 2022, **27**.
2. W.-F. Chen, J. T. Muckerman and E. J. C. c. Fujita, 2013, **49**, 8896-8909.
3. M. B. Idris, T. Subramaniam, D. J. D. Sappani and R. Materials, 2022, **129**, 109359.
4. M. B. Idris and S. Devaraj, *Journal of Energy Storage*, 2019, **26**, 101032.
5. H. Araújo, B. Šljukić, S. Gago and D. M. J. F. i. E. R. Santos, 2024, **12**, 1373522.

O17

Electrochemical detection of the antiretroviral drug lamivudine using reduced graphene oxide-chitosan nanocomposites

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The high prevalence of HIV/AIDs in South Africa has resulted in the use of antiretroviral drugs (ARVDs) such as lamivudine [1]. This has given rise to the wide occurrence of this drug in water bodies. Various analytical techniques, such as HPLC and GC, have been widely used for the detection and quantification of drugs; however, these techniques are costly and time-consuming. Therefore, an alternative rapid, accurate, simple, and in-situ measurement technique, such as electrochemical sensing, is needed to detect and quantify ARVDs in the environment. In this work, reduced graphene oxide-chitosan (rGO-CS) nanocomposites synthesised by a simple reflux method were used to modify a glassy carbon electrode (GCE) for the detection of lamivudine in aqueous systems. The nanocomposites were characterised by SEM, TEM, UV-vis, XRD, Raman spectroscopy, CV, and EIS to investigate their physiochemical and electrochemical properties. The 2:1 rGO-CS nanocomposite exhibited the best electrochemical properties and, hence, was used as a potential electrode modifier by drop casting it on a GCE and tested for the detection of lamivudine in wastewater. It was found that lamivudine undergoes an electrochemical reduction process at an optimum pH of 2 in a modified Britton-Robinson buffer as the supporting electrolyte. The process was determined to be irreversible and dominated by diffusion mass transport with the presence of some adsorption mass transport. Two protons and two electrons were involved in the electrochemical process. The limit of detection and quantitation for the 2:1 rGO-CS/GCE were determined to be 0.09295 μM and 0.3098 μM, respectively, with percentage recoveries of 87 – 92%. The concentration of lamivudine in an influent wastewater sample was determined to be 0.1312 μM. Hence, rGO-CS could be used as a potential sensing material for the detection of pharmaceuticals in the environment.

O18

Selective electrochemical sensing of sunset yellow in beverages based on synergistic signal amplification of HKUST1 and MWCNTs

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In this study, a highly selective electro-oxidation method for sunset yellow (SY) detection in real food samples is presented on the basis of the integration of HKUST1 with multiwalled carbon nanotubes (MWCNTs) doped on a glassy carbon electrode (GCE). Cyclic voltammetry (CV) measurements of the HKUST-1-MWCNT-composite electrode revealed enhanced sensitivity for SY, with a distinct redox peak potential of approximately 0.6 V, which was attributed to the highly active surface of the electrode. This response was notably more pronounced than those of tartrazine (TZ), allura red (AR) and amaranth (AM). Electrochemical impedance spectroscopy (EIS) analysis revealed a low charge transfer resistance (R_{ct}) for the GCE-HKUST-1-MWCNT electrode, indicating that the integration of HKUST-1 and MWCNTs significantly enhanced the electrical conductivity. In addition, Monte Carlo simulations revealed that a single copper paddlewheel (the secondary building unit of HKUST-1) greatly enhanced the dispersion of the MWCNTs within the matrix. Notably, revealing that the preferred adsorption site of SY was within the inner surface of the MWCNTs, leading to signal amplification. Overall, the sensor achieved limits of detection (LODs) and limits of quantification (LOQs) of 1.03 µM and 3.44 µM, respectively, within a defined linear dynamic range. Furthermore, the sensor demonstrated strong practical applicability in real sample analysis, with an excellent recovery rate ranging from 83.11–114%. This sensing technique shows great promise for the selective monitoring and detection of synthetic colourants in the food sector.

O19

Pt- and Ru-decorated metal organic framework as a trifunctional material for water electrolysis and hydrogen fuel cell applications

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The development of efficient hydrogen fuel cell (HFC) and water splitting electrocatalysts is critical for advancing clean energy technology. This study explores the synthesis of Pt- and Ru- incorporated on copper zeolitic imidazolate framework (CuZIF) using electroless plating method. Comprehensive characterization through Fourier transform infrared spectroscopy (FTIR), thermalgravimetric analysis (TGA), x-ray diffraction spectroscopy (XRD) and scanning electron microscopy (SEM) confirmed the successful synthesis of pristine CuZIF and metallic incorporated Pt@CuZIF and Ru@CuZIF. Electrochemical measurements were conducted in 0.1 M KOH to evaluate the catalytic activity of the prepared materials in water electrolysis for hydrogen evolution reactions (HER) and oxygen evolution reaction (OER), and in HFC for production of electricity. Pt@CuZIF confirmed the enhanced catalytic activity for HER and OER showing Tafel slopes of 118 and 118.5 mV/dec, suggesting Volmer-Heyrovsky mechanism, with the lower overpotentials of 345 and 474 mV, respectively. EIS results revealed that HER and OER significantly benefited Pt@CuZIF electrocatalyst, evidenced by its low charge transfer resistance and high capacitance value. Electrochemical fuel cell tests showed that the Pt@CuZIF have excellent performance and longevity which revealed the lower discharge voltage of 0.13 V, energy density of 68.42 Wh/kg and power density of 205.26 W/kg.

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[1] Shen, M., Huang, W., Chen, M., Song, B., Zeng, G. and Zhang, Y., 2020. (Micro) plastic crisis: un-ignorable contribution to global greenhouse gas emissions and climate change. *Journal of Cleaner Production*, *254*, p.120138.

[2] Makhafola, M.D., Balogun, S.A. and Modibane, K.D., 2024. A Comprehensive Review of Bimetallic Nanoparticle–Graphene Oxide and Bimetallic Nanoparticle–Metal–Organic Framework Nanocomposites as Photo-, Electro-, and Photoelectrocatalysts for Hydrogen Evolution Reaction. *Energies*, *17*(7), p.1646.

[3] Guoa, Y., 2007. Supplementary Material (ESI) for Journal of Materials Chemistry A.

[4] Kumar, A., Sadanandhan, A.M. and Jain, S.L., 2019. Silver doped reduced graphene oxide as a promising plasmonic photocatalyst for oxidative coupling of benzylamines under visible light irradiation. *New Journal of Chemistry*, *43*(23), pp.9116-9122.

[5] Monama, G.R., Ramoroka, M.E., Ramohlola, K.E., Seleka, M.W., Iwuoha, E.I. and Modibane, K.D., 2024. Terbium-and samarium-doped Li2ZrO3 perovskite materials as efficient and stable electrocatalysts for alkaline hydrogen evolution reactions. *Environmental Science and Pollution Research*, *31*(42), pp.54920-54937.

O20

Interfacial Engineering of a Z-Scheme $Bi_2O_2S/NiTiO_3$ Heterojunction Photoanode for the Degradation of Sulfamethoxazole in Water

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Towards the development of semiconductor interface with enhanced spatial separation of carriers under visible light irradiation for photoelectrochemical (PEC) oxidation process, we explored the fabrication of a $Bi_2O_2S/NiTiO_3$ heterojunction photoanode for the removal of sulfamethoxazole in water. The $Bi_2O_2S/NiTiO_3$ photoanode was synthesised via an in situ hydrothermal process, and it exhibits better light absorption and charge separation as well as a reduced rate of recombination of photoexcited charge species. compared to pristine Bi_2O_2S and $NiTiO_3$. The improved photoelectrocatalytic performance can be attributed to the synergistic interaction between Bi_2O_2S and $NiTiO_3$ and the existence of an S─O bond at the heterojunction interface, thus resulting in a Z-scheme heterojunction formation. Various characterisation methods such as XPS, UV-DRS, electrochemical impedance spectroscopy, photoluminescence, FESEM, TEM, and photocurrent response measurements were explored to explain the optical and electrochemical properties of the semiconductor heterojunction. The PEC degradation process was optimised, demonstrating the degradation efficiency removal of 80% of 5 mg/L sulfamethoxazole in water, with a TOC removal of 45.5%. The Z-scheme heterojunction formation mechanism is proposed to explain the enhanced photoelectrocatalytic activity of the photoanode. This work generally contributes to the development of efficient and sustainable photoanodes for environmental remediation.

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[1] K.D. Jayeola, D.S. Sipuka, T.I. Sebokolodi, J.O. Babalola, M. Zhou, F. Marken, O.A. Arotiba, Interfacial Engineering of a Z-Scheme $Bi_2O_2S/NiTiO_3$ Heterojunction Photoanode for the Degradation of Sulfamethoxazole in Water, ACS Applied Materials & Interfaces 17(1) (2025) 1385-1398. https://doi.org/10.1021/acsami.4c20102.

O21

Metal Corrole complexes for electrocatalytic hydrogen evolution reactions

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Since 2016, the Institute of Nanotechnology Innovation at Rhodes University has collaborated with Profs Xu Liang and Weihua Zhu at Jiangsu University on research related to the rational structural modification of A3 and A2B type meso-substituted triarylcorroles for electrocatalysis. Corroles are porphyrin analogues with a single methylene bridge from the porphyrin framework removed to form a direct pyrrole-pyrrole bond. [1,2] A heteroaromatic 18 π-electron system is maintained on the inner ligand perimeter, resulting in a core coordination pocket comprised of three NH protons and one imino nitrogen. Hence, a trianionic corrole ligand can be formed that is capable of stabilizing central metal ions in unusually high oxidation states enhancing the suitability of corrole complexes for electrocatalysis. The main focus of our research has been on hydrogen evolution reactions on glassy carbon and gold electrode surfaces and the use of molecular modelling to identify key trends in the structure property relationships. [3-9]

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[1] R. Orłowski, D. Gryko and D. T. Gryko, Chem. Rev., 2017, 117, 3102.

[2] J. Mack, Chem. Rev., 2017, 117, 3444.

[3] Y. Niu, M. Li, W. Zhu, J. Mack, G. Fomo, T. Nyokong and X. Liang, Dyes Pigments, 2017, 142, 416.

[4] M. Li, Y. Niu, W. Zhu, J. Mack, G. Fomo, T. Nyokong and X. Liang, Dyes Pigments, 2017, 137, 523.

[5] B. Fu, Y. Niu, X. Yu, X. Fang, J. Mack, S. Dingiswayo, T. Nyokong, X. Liang and H. Xu, Dyes Pigments, 2021, 195, 109699.

[6] X. Liang, Z.-Y. Pan, W. Guo, J. Mack, R. Soy, T. Nyokong, Q.-C. Zhang and W. Zhu, J. Phys. Chem. C, 2022, 126, 21476.

[7] W. Zhu, L. Li, Y. Wang, J. Mack, S. Dingiswayo, T. Nyokong and X. Liang, Dyes Pigments, 2022, 199, 110046.

[8] Z. Qu, Y. Wang, M. Li, W. Zhu, J. Mack, N. Molupe, T. Nyokong and X. Liang, Inorg. Chem., 2023, 62, 4786.

[9] Y. Pan, X. Zhang, X. Zhang, W. Zhu, J. Mack, T. Nyokong, X. Liang, submitted for publication in the Journal of Electroanalytical Chemistry in 2025.

O22

Raman Imaging of High Conductivity Electrochemically Exfoliated Graphene: Fermi Level Shift and the Electrochemical Performance

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The electrochemical exfoliation process was performed using a two-step intercalation/exfoliation method(1). The intercalation was conducted at a constant current density of 20 mA/cm^2 for 800 seconds in 100 mL of an electrolyte that consisted of a mixture of concentrated sulfuric acid (98 wt% H_2SO_4) and phosphoric acid (85 wt% H_3PO_4)(1). The electrolyte mixture was prepared using different volume ratios of concentrated sulfuric to concentrated phosphoric acid: 100:0 (sample 1), 95:5 (sample 2), 90:10 (sample 3), and 80:20 (sample 4). After the intercalation process, the exfoliation of the intercalated graphite was carried out in a 0.1 M ammonium sulfate electrolyte at a constant cell potential of 10 V. The resulting suspension was then filtered, washed, and centrifuged to separate the EEG from unexfoliated graphite particles. Following centrifugation, the suspension was filtered and freeze-dried to obtain the final EEG product. Additionally, the EEG product was re-dispersed in deionized water and vacuum-filtered using a 0.45 µm cellulose membrane to produce a freestanding EEG film with an average thickness of approximately 20.5 µm. These films were extensively characterized using Raman spectroscopy and imaging techniques. The shift in the Fermi level of EEG was examined using Raman imaging. The Raman signatures of EEG were correlated with the electronic band structure near the Dirac point of graphene, revealing an upshift in the Fermi level of graphene(2). This indicated that EEG is n-type doped. Furthermore, the shift in the Fermi level was linked to the high conductivity of EEG and low potential barriers between the EEG-based electrode surface and the highest occupied molecular orbital (HOMO) of the electrolyte, which would contribute to high-performance electrochemical processes.

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1. Momodu D, Madito MJ, Singh A, Sharif F, Karan K, Trifkovic M, et al. Mixed-acid intercalation for synthesis of a high conductivity electrochemically exfoliated graphene. Carbon N Y. 2021 Jan;171:130–41.

2. Madito MJ. Correlation of the Graphene Fermi-Level Shift and the Enhanced Electrochemical Performance of Graphene-Manganese Phosphate for Hybrid Supercapacitors: Raman Spectroscopy Analysis. ACS Appl Mater Interfaces. 2021 Aug 11;13(31):37014–26.

O23

Comparing Catalytic Applications of Transition Metal MOFs for the Degradation of Norfloxacin (NFX) Antibiotic in Water

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Widespread use of antibiotic drugs such as norfloxacin (NFX) to treat common human infections is increasing the pharmaceutical pollution of global wastewater and surface water sources. As antibiotic pollution poses the risk of adverse ecological effects while also fueling antibiotic resistance, there is a need to optimize water treatment processes that remove antibiotics through sustainable, low-cost methods. Catalytic processes such as piezocatalysis and photocatalysis have emerged as a recently studied class of treatment technologies that convert mechanical or solar energy to effectively degrade organic pollutants in the presence of catalytic materials. The combination of such processes can also improve pollutant degradation kinetics while playing on the synergistic effect of light and power. To optimize these treatment technologies requires studying catalyst materials that are effective at low doses, such as metal organic framework (MOF) nanomaterials. MOFs exhibit high porosity and surface area complimented with catalytic properties that can be tuned to improve the degradation of a wide range of pharmaceuticals. This study focuses on the development of MOFs combined with Bismuth Ferrite (BFO) to create a stable material that can be applied for catalytic processes. Whereas BFO is a semiconductor material capable of NFX degradation, the removal of NFX can be accelerated when combined with Fe- and Cu- MOFs that provide increased active sites and prevent recombination rates that inhibit the oxidation process of pollutants. The analysis of MOF/BFO catalysts for piezocatalysis, photocatalysis, and piezo-photocatalysis were performed to explore the efficacy of MOF catalyst processes for NFX removal. While ongoing research is being performed to conclude the best effective process and catalyst properties that can be employed for NFX removal, this work highlights the potential of employing MOF material catalysts for pollutant abatement and provides valuable insights into optimizing advanced oxidation treatment processes.

Plenary 4

Paper-based electrochemical (bio)sensors for sustainable analyses

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As reported in my review entitled “Electrochemical paper-based devices: When the simple replacement of the support to print ecodesigned electrodes radically improves the features of the electrochemical devices” published in Current Opinion in Electrochemistry SI: Emerging Opinions (2022) [F. Arduini. *Curr. Opin. Electrochem*. 2022, 101090]: “*Paper-based electrochemical (bio)sensors have emerged as highly attractive analytical devices for their superior sustainable features, such as avoiding the use of polyester as support and the reduction of waste, being incinerated after use. However, paper-based electrochemical (bio)sensors have recently demonstrated further advantages, including the simple combination with vertical microfluidics and their use as a reservoir to deliver smart electrochemical (bio)sensors able to i) contain the reagents, ii) preconcentrate the target analyte, and iii) synthesize the nanomaterials inside the paper network. Furthermore, these devices have demonstrated their ability to overcome the limitations of the other printed electrochemical sensors in the measurement of entirely liquid samples by detecting the target analyte in the aerosol phase or solid sample, without the additional sampling system. These achievements highlight their valuable and varied advantages in the sensing sector*”. In this plenary lecture, I will report on the roadmap research activity carried out in the last 8 years related to the development of nanomodified paper-based electrochemical devices for delivering smart lab-on-a-chip-on-paper as well as sustainable tools for overcoming the limitation of polyester-ceramic-based printed (bio)sensors.

O25

A perovskite/spinel structured $LaFeO_3/Co_3O_4$ heterojunction for photoelectrocatalytic applications in degradation of tetracycline and water splitting

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Towards a dual-functioning photoelectrocatalyst for environmental remediation and green energy solutions, FTO-supported $LaFeO_3/Co_3O_4$ heterojunction photoanodes of different ratios were synthesized using sol-gel method for the photoelectrocatalytic (PEC) degradation of tetracycline in real wastewater and in overall water splitting [1]. Structures and morphologies were investigated with XRD, XPS, FESEM, HRTEM. Photoluminescence and optical analysis showed that all the materials were visible light active and the heterojunction exhibited higher photocurrent density than $LaFeO_3$ and Co_3O_4 through direct Z scheme heterojunction formation. $LaFeO_3$ 30%/Co_3O_4 70% heterojunction demonstrated hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) [2]. It also showed improved TOF and OER with low onset potential and a photocurrent density above 10 mA/cm^2 in 1 M KOH at a lower over-potential. The heterojunction recorded a low Tafel slope of 102 mV dec^{-1} indicating a faster reaction rate than the pristine semiconductors. The heterojunction exhibited a PEC degradation of 79% in 10 ppm tetracycline [3]. Real wastewater sample treatment showed a total organic carbon removal of 60% and LCMS analysis informed the fragmentation patterns. The heterojunction showed improved stability (from chronopotentiometry and LSV data after 30 cycles) and h^+ and $^\circ OH$ are the major species in the PEC degradation of tetracycline in real wastewater sample.

D. Kim, D.K. Lee, S.M. Kim, W. Park, U. Sim, Photoelectrochemical water splitting reaction system based on metal-organic halide perovskites, Materials 13(1) (2020) 210-210.

A. Raveendran, M. Chandran, R. Dhanusuraman, A comprehensive review on the electrochemical parameters and recent material development of electrochemical water splitting electrocatalysts, RSC Adv 13(6) (2023) 3843-3876. https://doi.org/10.1039/d2ra07642j.

A.C. Faleye, A.A. Adegoke, K. Ramluckan, J. Fick, F. Bux, T.A. Stenstrom, Concentration and reduction of antibiotic residues in selected wastewater treatment plants and receiving waterbodies in Durban, South Africa, Sci Total Environ 678 (2019) 10-20. https://doi.org/10.1016/j.scitotenv.2019.04.410

O26

Novel insights on the field-flow fractionation characterization of graphene-based materials for electrochemical applications

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The flow-method physicochemical characterization of graphene-based materials (GBMs) is essential for the engineering of sensors. In this work, an asymmetrical flow field-flow fractionation (AF4) method was developed for the characterization of size and size distribution of graphene oxide (GO) and reduced graphene oxide (RGO), respectively. Notably, stable particle size distributions (PSDs) and sizes in the nano-range were exhibited for both materials, with complementary dynamic light scattering (DLS) measurements undertaken. Additionally, interfacial conductivity analyses between the GBMs and applied separation solvent performed by electrochemical impedance spectroscopy (EIS), revealed differing electroactive behaviours of each GBM. Finally, subsequent zeta potential experiments for GO and RGO demonstrated good colloidal stabilities, as supported by the successful fractionation of the GBMs by AF4. These findings contribute toward the standardized separations-based characterization of GBMs as widely applied nanomaterials in electrochemical applications.

O27

Electrocatalytic Applications of Nickel Sulfides/Phosphides Towards Water Splitting

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Interest in cost-effective and easily available materials employable as catalysts in water splitting is growing. This is because of the current quest to move from a fossil fuel-based economy to a greener sustainable one which is weighed down by the use of the expensive noble metal catalysts. Single-source precursors are a straightforward route to the formation of these desired nanomaterials. We employed single-source molecular complexes such as $[Ni\{S_2P(OR)(4\text{-}C_6H_4OMe)\}_2]$ [Me = Methyl; R = H, C_3H_7], $[Ni\{S_2P(OR)(4\text{-}C_6H_4OEt\}_2]$ [Et = Ethyl; R = $(C_6H_5)_2CH$], $[Co\{S_2P(OC_4H_9)(4\text{-}CH_3OC_6H_4)\}_3]$ and $[Fe\{S_2P(OH)(4\text{-}CH_3OC_6H_4)\}_3]$ to prepare different compositions of nickel sulfides and phosphides through the solventless and the colloidal route. The obtained sulfides/phosphides were examined as electrocatalysts in hydrogen/oxygen evolution reactions in alkaline media. These materials showed good results in lowering the constraining overpotential associated with water splitting. For instance, the Fe-Ni_2P electrode needed only 68 mV with a Tafel slope of 110 mVdec^{-1} to attain the benchmark current density of 10 mA cm^{-2} for hydrogen evolution reaction. Transition metal-based electrocatalysts like sulfides and phosphides of nickel are therefore showing promise in replacing the noble metal-based catalysts.

IO2

Electro-oxidation of Ibuprofen and Metoprolol using Manganese Oxide Platform

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Pharmaceutical compounds, such as ibuprofen and metoprolol, are of increasing concern due to their persistence in the environment and potential adverse effects on human health. In this work, we developed an electrochemical sensor system for the determination of ibuprofen and metoprolol based on a modified manganese oxide nanoparticle (MnO_2NPs) on a screen-printed carbon electrode (SPCE). The characterization of MnO_2NPs modifier was investigated via Fourier transform infrared (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman spectroscopy techniques, UV/vis spectroscopy, and small-angle X-ray scattering spectroscopy. The electrochemical behavior of the MnO_2NPs was studied using differential pulse voltammetry (DPV) and cyclic voltammetry (CV) techniques. The optimum experimental conditions were investigated by examining the effects of scan rates, pH on the CV responses, and electrolytes on the DPV response. The MnO_2NPs modified electrode demonstrated enhanced catalytic activity in the electro-oxidation of both ibuprofen and metoprolol. The oxidation peaks of ibuprofen and metoprolol were observed at +1.14 V and +1.46 V, respectively, for the MnO_2NPs/SPCE sensor. The sensor's limit of detection was 3.81 pM and 4.6 pM respectively and its linear response was from 0.97–5.82 pM. Furthermore, interference and stability studies were conducted to evaluate the performance of the MnO_2NPs/SPCE sensor under optimum conditions, which resulted in a good performance. The proposed sensor was successfully used for the determination of ibuprofen and metoprolol in the application of real water samples.

IO3

Vertically Aligned Carbon Nanotubes (VACNT) doped with Nitrogen and Oxygen for High-Energy Supercapacitors

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Owing to their surface area, anisotropy and good electrical conductivity, Vertically Aligned Carbon Nanotubes carpets (VACNT) are promising materials for ultracapacitor electrodes exhibiting high specific power. To obtain low cost, highly conducting and light electrodes, we have developed a single-step process to synthesize VACNT on aluminum current collectors which is compatible with industrial requirements: the Aerosol Assisted Catalytic Chemical Vapor Deposition [1], [2]. This method provides long, dense and clean VACNT with height between ten and hundred µm and densities between 80 and 200 mg/cm^3. Nevertheless, VACNT show some limitations on both gravimetric and volumetric energy (5 Wh/kg and 1 mWh/cm^3). To improve electrodes capacitances we have developed an easy method based on electrodeposition of electronic conducting polymer (ECP) in order to combine VACNT with ECP [3-5]. We are also looking to VACNT doping with heteroatoms such as N and O by two paths: direct growth of doped VACNT and post synthesis treatment. We will present first results on controlled direct growth of VACNT containing nitrogen on Si substrates and on VACNT/Al doped with N and O prepared by post VACNT synthesis vapor phase treatment. We will focus on the control of their characteristics (length, diameter, density, doping rate) and their electrochemical performances as ultracapacitors electrodes. The N@VACNT from direct growth are few walled "bamboo" shaped nanotubes with a nitrogen weight content of 4.5%. The doped VACNT/Al from post-synthesis treatment have an oxygen atomic content up to 16.2% and nitrogen atomic content up to 6.6%. The electrode capacitance was increased up to 102 F/g and the specific energy to 13.7 Wh/kg.

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[1] M. Pinault et al, Nano Lett., 2005.

[2] M. Delmas et al, Nanotechnology, 2012.

[3] S. Lagoutte et al, Electrochimica Acta, 2014.

[4] T. Vignal et al, Electrochimica Acta, 2020.

O28

Sodium-potassium dual pre-intercalated alpha manganese dioxide cathode material for high-performance aqueous zinc-ion batteries

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Manganese dioxide is a promising cathode material for aqueous zinc-ion batteries (AZIBs) due to its high theoretical capacity, high operating voltage, abundance and low cost.[1] However, the dissolution of MnO_2 and the disproportionation of Mn^{3+} result in irreversible reactions and significant structural degradation during prolonged charge/discharge cycles, which limits their commercial viability. In addition, there are still some challenges in fabricating cathode materials that can deliver excellent performance, while also being simple and less costly to produce in large quantities. In this study, we have utilized a two-step synthetic method: Couette-Taylor flow reactor and hydrothermal method to produce alpha manganese oxide pre-intercalated with sodium and potassium ions. The pre-intercalation of Na^+ and K^+ stabilizes the tunnel structure and has the effect of electrostatic shielding to facilitate the (de)intercalation of Zn^{2+}.[2] X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and transmission electron microscopy (TEM-ESD) coupled with energy dispersive spectroscopy analyses confirm the successful synthesis of $Na^+/K^+@\alpha\text{-}MnO_2$. The $Na^+/K^+@\alpha\text{-}MnO_2$ cathode showed a specific capacity of 310 mAh g^{-1} when subjected to a current density of 0.1 Ag^{-1}. This capacity exceeds that of the same cathode material synthesised through a conventional method (253 mAh g^{-1}) under the same current density conditions. The enhanced electrochemical performance is attributed to the flower-like morphology and the synergistic effect of dual metal ion pre-intercalation, which created open active sites and conductive structures, facilitating the diffusion of hydrogen and zinc ions and improving the overall capacity of the cathode material.

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1. N. Palaniyandy, M.A Kebede, K Raju, K.I Ozoemena, L Le Roux, M.K Mathe, RJayaprakasam, Materials Chemistry and Physics, 2019, 230, 258–266.

2. J Zeng, Z. Zhang, Y. Chen, X. Chen, H. He, J. Wang, Journal of Electroanalytical Chemistry 934 (2023) 117306.

O29

Microwave irradiation engineered surface crystal planes in spinel $Li_4Ti_5O_{12}$ anode material for improved performance lithium-ion battery

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The low theoretical specific capacity and rapid capacity degradation especially at long cycling have been the key challenges to the practical application of lithium titanate ($Li_4Ti_5O_{12}$) as anode material for stable high-energy and high-power densities lithium-ion batteries (LIBs)$^{1-4}$. This study reports a novel strategy of the synergy of surface crystal plane engineering by microwave irradiation and non-stoichiometry defects to synthesize a high specific capacity, high-rate and long-term cycle life $Li_4Ti_5O_{12}$-CeF_3-TiO_2 (LTO-CeF_3-m) anode material for LIB. The innovative anode material shows outstanding specific capacity, rate capability and long-term cycle stability. It is of interest to note that the LTO-CeF_3-m anode material has specific capacities of 191.1 mAh g^{-1} at 175 mA g^{-1} (1 C) which is greater than theoretical specific capacity of LTO (175 mAh g^{-1}). Furthermore, LTO-CeF_3-m has specific capacities of 168.3 and 119.9 mAh g^{-1} at 875 (5 C) and 1750 mA g^{-1} (10 C) respectively. In addition, it shows a specific capacity of 166.5 mAh g^{-1} after 1000 cycles at 5 C, and capacity retention of 98.9 %. These notable electrochemical performances of LTO-CeF3-m are attributed to the synergy of surface crystal plane engineering by microwave irradiation and non-stoichiometry defects that transformed the surface crystal plane (111) of LTO to (220) and (311) in LTO-CeF_3-m. The LTO-CeF3-m material has grain boundaries and high surface area which significantly improved mass transport. Therefore, the unique structure of LTO-CeF_3-m anode material is key development to safe and durable high-energy and high-power lithium-ion batteries and potential applications in large scale energy storage.

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1. Y.-J. Bai, C. Gong, N. Lun and Y.-X. Qi, Yttrium-modified $Li_4Ti_5O_{12}$ as an effective anode material for lithium-ion batteries with outstanding long-term cyclability and rate capabilities, *J Mater Chem A*, 2013, **1**, 89–96.

2. M. Akhtar, T. Majumder, J.-K. Chang and S. B. Majumder, High-Performance and Safe Hybrid Li-Ion Batteries Based on $Li_4Ti_5O_{12}$–TiO_2 (A)–TiO_2 (R)@C Anode and $Na_3V_2O_2(PO_4)_2F$–$Na_3V_2(PO_4)_3$@C Cathode, *ACS Sustain. Chem. Eng.*, 2022, **10**, 1390–1397.

3. C. Ho, C. V. Li, K. Chan, H. Yung and Y. Tay, Interfacing TiO_2 (B) Nanofibers with $Li_4Ti_5O_{12}$ Towards Highly Reversible and Durable TiO_2-based Anode for Li−Ion Batteries, *Energy Technol.*, 2019, **7**, 107–112.

4. X. Bai, T. Li and Y.-J. Bai, Capacity degradation of $Li_4Ti_5O_{12}$ during long-term cycling in terms of composition and structure, *Dalton Trans.*, 2020, **49**, 10003–10010.

5. A. B. Haruna, D. H. Barrett, C. B. Rodella, R. M. Erasmus, A. M. Venter, Z. N. Sentsho, K. I. Ozoemena. Microwave irradiation suppresses the Jahn-Teller distortion in Spinel $LiMn_2O_4$ cathode material for lithium-ion batteries. *Electrochimica Acta 426 (2022) 140786*

IO4

Design of Highly Active Silicene Hybrid Sheets for Electrode Applications in Battery-Type Supercapacitors

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In this study, silicene nanosheets (SNs) were synthesized using molten salt chemical exfoliation. Polythiophene (PTh) and SNs/PTh nanocomposites were prepared through an in-situ chemical oxidative polymerization method. Raman spectroscopy confirmed the formation of SNs, PTh, and various SNs/PTh nanocomposites at different ratios. X-ray diffraction (XRD) analysis verified the presence of crystalline SNs, the amorphous nature of PTh, and the combination of crystalline SNs with amorphous PTh in the nanocomposites. Field-emission scanning electron microscopy (FESEM) revealed the morphology of silicene sheets and the distribution of PTh granular globes and fakes in the SNs/PTh nanocomposites. Transmission electron microscopy (TEM) showed transparent and reduced-stacking SNs, as well as aggregated PTh fakes and evenly distributed PTh fakes over the SNs surface in the nanocomposites. Electrochemical tests indicated that SNs/PTh nanocomposites exhibited higher specific capacitance, energy density, and stable cycling performance compared to individual SNs and PTh. Cyclic voltammetry (CV) measurements showed that the best performing supercapacitor electrode, SNs/PTh-67 nanocomposite displayed a specific capacitance of 276.25 F/g at a scan rate of 5 mV/s and delivered an energy density of 13.8 Wh/kg. The SNs/PTh-67 nanocomposite also exhibited excellent cycling stability with a capacitance retention of 85.9% after 2000 consecutive charge–discharge cycles at a current density of 4 A/g. This study demonstrates the potential of SNs/ PTh-67 nanocomposite as a stable and high-performance electrode material for supercapacitors.

POSTER 1

Metal-Organic Framework-Based Electrochemical Immunosensor for Sensitive Lactoferrin Detection

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The goal of this presentation is to introduce a very sensitive electrochemical immunosensor for measuring lactoferrin, a vital protein that plays many different roles in biological systems. The sensor's improved performance is supported by computational studies since it makes use of the unique properties of the copper-based Metal-Organic Framework MOF-199. The glassy carbon electrode (GCE) on which the electrochemical immunosensor was built was modified using a composite of MOF-199 and multi-walled carbon nanotubes (MWCNTs).

The analytical properties of the sensor yielded a 0.1 μg/mL limit of detection (LOD) and a 0.3 μg/mL limit of quantification (LOQ). For extremely specific lactoferrin detection, the sensor included anti-lactoferrin antibodies. Computational studies were used to understand the molecular interactions between the MOF-199 composite, the anti-lactoferrin antibodies, and the target analyte including the mechanisms driving the sensor's performance.

The resultant electrochemical immunosensor has outstanding lactoferrin detection sensitivity and specificity, making it a valuable tool for a variety of uses in biotechnology, healthcare, and food safety.

P2

Anti-corrosive properties of water-borne acrylic composite coatings using electrochemical methods

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This study investigates the anti-corrosive properties of water-borne acrylic (WBA) composite coatings modified with various nanomaterials for the protection of mild steel in aggressive saline environments.

Anti- corrosive nanomaterials such as zinc phosphate ($Zn_3(PO_4)_2$), graphene oxide (GO), and polyvinylpyrrolidone (PVP) were incorporated into the WBA matrix. The composites were characterized by Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and field emission scanning electron microscopy (FESEM). Corrosion resistance was evaluated using potentiodynamic polarization (PDP) and electrochemical impedance spectroscopy (EIS) in a 5% NaCl solution, complemented by salt spray and QUV® accelerated weathering tests simulating harsh environmental conditions to assess the longevity and performance of the anticorrosive materials.

Results indicate that the WBA-$Zn_3(PO_4)_2$, emerged as the most effective anti-corrosive coating, offering superior corrosion resistance, minimal blistering, and excellent adhesion due to its strong passivation and barrier properties. While, WBA-GO and WBA-$Zn_3(PO_4)_2$/PVP displayed reasonable protective properties but were slightly less effective than $Zn_3(PO_4)_2$ alone. The weakest performers were WBA-PVP, WBA-GO/PVP, and WBA-PANI, which struggled with limited resistance and adhesion issues.

These findings suggest that optimally formulated water-borne acrylic nanocomposites are eco-friendly alternatives with low VOC content and can offer a sustainable solution for corrosion protection in harsh environments.

P3

Deep eutectic solvent (DES) as green corrosion inhibitor for protection of mild steel in acidic medium

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Metal-Organic Frameworks (MOFs) are a type of crystalline porous materials that has a wide range of uses in drug delivery, gas storage and catalysis. Deep Eutectic Solvents (DES) are a novel class of green solvents which has special qualities such biodegradability, low volatility, and adjustable polarity. Combining these two materials together has exciting prospects for the creation of cutting-edge functional materials.

This study entails the green synthesis of metal-organic frameworks using deep eutectic solvents and post-synthetic modification of MOFs properties by introducing functional groups with DESs to give the DES-MOF composite. This will be followed by the characterization of the synthesized materials using advanced analytical techniques such as X-ray diffraction, scanning electron microscopy, and spectroscopic methods. The ability of the composite to provide effective corrosion prevention for metal surfaces will be assessed by studying the mechanism of corrosion inhibition and the evaluation of its performance under various environmental conditions. Computational techniques such as density functional theory and molecular dynamics simulations would be utilized to gain insights into the molecular-level interactions and the performance of the DES-MOF composite.

This topic will not only contribute to advancing the understanding of corrosion inhibition mechanisms but also holds implications for the development of environmentally friendly and efficient inhibitors.

P4

Electrocatalytic behaviour of cobalt ferrite decorated graphene oxide nanosheets appended cobalt tetra aminophenoxyphthalocyanine towards nevirapine

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The detection of Nevirapine through cobalt ferrite nanoparticles decorated graphene oxide nanosheets appended cobalt tetra aminophenoxyphthalocyanine modified electrodes is reported. The electrochemical oxidation behaviour of NVP was studied using Cyclic voltammetry (CV), Linear sweep voltammetry, differential pulse voltammetry and Chronoamperometry (Fig 1 A, B, C and D). The limit of detection and limit of quantification of Nevirapine were found to be 2.1 × 10-2 M and 2.9 × 10-3 M respectively. The catalytic rate constant was found to be 3.35x 101 M-1 S-1 for Nevirapine and the Tafel slope being 42mVdecade-1. Gibbs energy (ΔG0) for the composite was at -20.500KJmol-1 and β of 3.921 ×103M-1. CoTAPhPcNPs-CoFe2O4-GONS showed good sensitivity and stability towards the detection of Nevirapine. The developed sensing platform shows excellent stability and sensitivity to make it suitable for the determination of NVP in the complex system.

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1. Atia TA, Altimari P, Moscardini E, Pettiti I, Toro L, Pagnanelli F. Synthesis and Characterization of Copper Ferrite Magnetic Nanoparticles by Hydrothermal Route. Chem Eng Trans. 2016;47:151-6

2. Shumba M, Nyokong T. Development of nanocomposites of phosphorus-nitrogen co-doped graphene oxide nanosheets and nanosized cobalt phthalocyanines for electrocatalysis. Electrochim Acta. 2016;213:529–39. Available from:http://dx.doi.org/10.1016/j.electacta.2016.07.079

3. Shumba M, Nyokong T. Electrocatalytic application for gold nanoparticles decorated sulfur-nitrogen co-doped graphene oxide nanosheets and nanosized cobalt tetra aminophenoxy phthalocyanine conjugates. Electrochim Acta. 2017;236:212

P5

Polymeric nanocomposites in drug metabolism sensing

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Conducting polymer nanocomposites have found applications in various electrochemical sensors due to their optimal performance in enhancing surface area, conductivity, flexibility, versatility and sensitivity [1]. Common nanocomposites in this category consist of metallic nanoparticles incorporated into polymeric structures of polyaniline, polythiophene, PEDOT and many others. The incorporation of nanomaterials within the polymer matrix seeks to combine the favourable characteristics of the individual components into a single electrocatalytic platform for detection of various analytes. These can range from biological materials such as DNA, proteins and viruses to metals, contaminants and drugs. One drug of interest in this study is a second line drug associated with the treatment of Tuberculosis, namely clofazimine. Tuberculosis (TB) is still highly prevalent in South Africa despite treatment being available for many years due to inadequate healthcare and high rates of poverty [2]. Another reason for its high prevalence is the development of drug resistant strains of TB which are resistant to conventional treatment and therefore require the disease to be treated with second line drugs such as clofazimine. Monitoring the levels of these drugs in human plasma or urine will allow us to determine how fast of slow the patient metabolises and adjust the dosage of drugs accordingly, thereby reducing adverse drug reactions and improving quality of life. In this work a polythionine-carbon dot nanocomposite material was used for the detection of clofazimine. Drug metabolism sensors are therefore a very versatile tool and can be applied to various other drugs for monitoring purposes. Another sensor of interest would therefore be a nickel nanoparticle decorated PEDOT:PSS nanocomposite for the detection of metformin. This drug is typically associated with the treatment of diabetes but has also found application in reducing the cytokine storm in COVID-19 treatment. Both sensors were found to be successful in monitoring the presence of these drugs in complex media in the presence of interferents.

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[1] A. Fakier-Lesch, R. F. Ngece-Ajayi, N. Mohamed, and C. Cupido, “Electrochemical Determination of Clofazimine Using A Carbon Dot Polythionine Nanocomposite-Modified Screen-Printed Electrode,” *Electroanalysis*, vol. 37, no. 1, Jan. 2025, doi: 10.1002/elan.202400278.

[2] C. Franke, R. F. Ajayi, O. Uhuo, K. Januarie, and E. Iwuoha, “Metallodendrimer-sensitised Cytochrome P450 3A4 Electrochemical Biosensor for TB Drugs,” *Electroanalysis*, vol. 32, no. 12, pp. 3075–3085, Dec. 2020, doi: 10.1002/elan.202060384.

P6

Electrochemical detection of tramadol using MOF-derived nickel nanoparticles

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Tramadol, a synthetic analogue of codeine, belonging to the family of opioid drugs, is indicated for rapid onset analgesia in the peri-operative period, trauma or emergency unit, as well as in the intensive care and ward settings. Its use, if not properly regulated can lead to seizure, hypertension, psychiatric symptoms like hallucinations, panic attacks, which are life threatening.[1] In this study, the use of glassy carbon electrode (GCE) modified with nickel nanoparticles (NiNPs) in the electrochemical detection of tramadol was investigated. Metal organic framework (MOF) was synthesised via microwave-assisted hydrothermal technique. The as-synthesized MOF was used as a template for the synthesis of nickel nanoparticles (NiNPs) via calcination method.[2] The nanocatalyst was characterized using XRD, SEM, EDX, HRTEM and XPS. Cyclic voltammetry (CV) and differential pulse voltammetry (DPV) were used for the electrochemical sensing, which reveals that the GCE modified with the nanoparticles (GCE-NiNPs) favours faster electron transport and electrocatalysis toward tramadol when compared with the bare GCE. The current evolutions from the scan rate studies show that the reaction is completely irreversible with a linear Randles-Sevcik plot showing a slope of 0.609, indicating mixed diffusion- and adsorption-controlled process. Further analysis showed Tafel Slope ($b = 0.198$ V) indicating good kinetics and charge transfer coefficient ($\alpha = 0.701$) indicating that the activation free energy curve for this reaction is asymmetrical. The GCE-NiNPs for tramadol detection, showed sensitivity of 18.881 uA/mM with limits of detection (LoD) and quantification (LoQ) of 0.031 mM and 0.010 mM, respectively. Furthermore, sodium dodecyl sulphate (SDS) was used to enhance the sensitivity of the snensor. The GCE-NiNPs+SDS for tramadol, showed sensitivity of 99.431 uA/mM with LoD and LoQ of 0.0034 mM and 0.011 mM, respectively. Thus, an improvement in the sensitivity, LoD and LoQ were observed after the addition of SDS.

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1. Lesley J. Scott and Caroline M. Perry. Drugs, 60 (1) (2000): 139-176

2. Lesego Gaolatlhe, Rasmita Barik, Sekhar C. Ray, Kenneth I. Ozoemena. Journal of Electroanalytical Chemistry, 872 (2020) 113863

P7

Electrochemical detection of caffeine in wastewater using plant-based zinc oxide nano particles incorporated in MWCNTs

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A simple novel electrochemical sensing platform was developed based on nano zinc oxide derived from plant material. The nanomaterial was deposited on multiwalled carbon nanotubes modified glassy carbon electrode and characterized by cyclic voltammetry and electrochemical impedance in a redox probe (Fig 1A, B). The electrode surface area after modification was 0.15 cm2, which was twice large that of a bare glassy carbon electrode. The new fabricated sensor was applied for determination of caffeine (Fig 1C). The limit of detection (LOD) was 3.52×10^(-8) M for caffeine. The electrode showed good reproducibility, sensitivity and stability for detection of caffeine. A good recovery level obtained for real samples suggests practical utility of the ZnO/MWCNT/GCE as an effective sensor for simultaneous determination of caffeine.

S. Chitravathi and N. Munichandraiah, J. Electroanal. Chem. 764, 93 (2016). doi:10.1016/j. jelechem.2016.01.021.

J.J. Gowda, G.G. Gunjiganvi, N.B. Sunagar, M.N. Bhat and S.T. Nandibewoor, SC Adv. 5, 49045 (2015). doi:10.1039/C5RA05802C.

M. Moyo, R.F. Lehutso and O.J. Okonkwo, Sens. Actuat. B 209, 898 (2015). doi:10.1016/j. snb.2014.12.059.L. Jiang, Y. Ding, F. Jiang, L. Li and F. Mo, Anal. Chim. Acta 833, 22(2014). doi:10.1016/j. aca.2014.05.010

P8

Electrochemical Immunosensor for Insulin Antibody Detection Using Green-Synthesized Gold Nanoparticles Functionalized with Indole-Pyrazole

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Insulin antibodies have shown to be a strong predictor of diabetes development in genetically susceptible individuals and the development of type 1 diabetes is closely linked to antibodies against beta cells (islet cells) such as insulin [1]. Developing a cost-effective, sensitive, and selective insulin detection system is vital for diabetes management. Current methods offer high sensitivity and reliability but are costly, time-consuming, require extensive sample preparation, and may emit hazardous radiation. Electrochemical assays offer high sensitivity, selectivity, rapid response, automation, reliability, and cost-effectiveness, addressing the limitations of conventional methods. Electrochemical immunosensors, leveraging biosensor technology, are particularly effective for detecting antigen-antibody interactions and have become powerful tools for rapid and sensitive biomarker detection [2]. In this study, an electrochemical immunosensor was developed for the detection of insulin antibodies. The sensor was constructed using a platinum electrode modified with gold nanoparticles synthesized through a green approach using lemon peel extract. To enhance the electrochemical properties, the nanoparticles were further functionalized with an indole-pyrazole derivative. The fabrication steps of each component in the electrode modification were studied using cyclic voltammetry and electrochemical impedance spectroscopy. Square wave voltammetry was employed to assess the sensor's ability to detect insulin antibodies across a range of concentrations. The immunosensor exhibited a limit of detection and sensitivity of 0.99 ng/mL and 1.42 A/ng/mL, respectively. The immunosensor also demonstrated excellent reproducibility and achieved high recovery rates for insulin antibodies in synthetic human serum, with recoveries ranging from 99.70 % to 111 %.

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[1] Farrokhnia M, Amoabediny G, Ebrahimi M et al. (2022) Ultrasensitive early detection of insulin antibody employing novel electrochemical nano-biosensor based on controllable electro-fabrication process Talanta, 238(122947): 1-12. https://doi.org/10.1016/j.talanta.2021.122947

[2] Li S, Al-Misned F A, El-Serehy H A et al. (2021) Green synthesis of gold nanoparticles using aqueous extract of Mentha Longifolia leaf and investigation of its anti-human breast carcinoma properties in the in vitro condition Arabian Journal of Chemistry, 14(2): 102931. https://doi.org/10.1016/j.arabjc.2020.102931

P9

High-entropy spinel oxide nanoparticles for high performance aqueous zinc-ion batteries

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High-entropy spinel oxides (HESOx) have shown capabilities of becoming one of the promising materials in electrochemical energy storage application such as rechargeable batteries due to their excellent mechanical, chemical, and physical properties [1, 2]. In this work, (CoCuFeNiMn)3O4 powders were synthesized using a Laminar-flow reactor and calcined at different temperatures (500, 750 and 900 oC). X-ray diffraction (XRD) confirmed the formation of spinel oxide structure, scanning electron microscopy (SEM) confirmed different particle sizes and X-ray photoelectron spectroscopy (XPS) showed that all metals are present with different oxidation states. Furthermore, electrochemical properties of high-entropy spinel oxides were studied as cathode material for zinc ion batteries. The (CoCuFeNiMn)3O4 electrode material calcined at 500 oC showed enhanced electrochemical performance with 203.6 mAh.g-1 at current density of 0.3 Ag-1 and it shows a good cycling stability of 75.6% retention at 1 Ag-1 after 500 cycles. This suggest that small particle sizes of the (CoCuFeNiMn)3O4 can be regarded as a prospective candidate for an electrode material in the field of zinc-ion batteries applications.

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1. Jia, H., Li, Y., Ali, U., Liu, B., Jin, Z., Li, L., Chen, Y., Zhang, L., Wang, T. and Wang, C., 2024. High-entropy doping strategy towards reinforced Mn-O bond for durable aqueous zinc ion batteries. Nano Energy, 122, pp.109348.

2. Guan, X., Fan, X., Zhu, E., Zhang, J., Yang, L., Yin, P., Guan, X. and Wang, G., 2024. Controlled establishment of advanced local high-entropy NiCoMnFe-based layered double hydroxide for zinc batteries and low-temperature supercapacitors. Journal of Colloid and Interface Science, 658, pp.952-965.

P10

Enhancing the electrochemical efficiency of nitrogen-doped reduced graphene oxide using coal fly ash-derived mesoporous silica nanoparticles for supercapacitor applications

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In recent years, renewable energy (RE) has become a cornerstone in the global pursuit of a green and sustainable energy sector, as it consists of naturally replenishable and environmentally friendly resources such as solar, wind, and hydropower (Gielen et al., 2019). The implementation of solar and wind power in electric grids is hindered by their natural intermittency. This raises concerns regarding energy quality due to possible instability in the power grid, rendering energy storage support essential for a reliable energy supply (Nadeem et al., 2019). Supercapacitors (SCs) are a promising storage option for RE because of their rapid charge/discharge rates, long cycling efficiency, and eco-friendliness. The performance of SCs largely depends on the active material in electrodes. Therefore, careful design and tuning of the active material's composition, particle size, surface area, pore size, and morphology are required to enhance SC performance to meet the energy demands of next generation technologies (Makgopa, Ratsoma and Modibane, 2022). In a bid to promote the integration of RE into the energy mix and to limit the environmental impact of generating electricity from coal, this study investigates the effect of coal fly-ash derived silica (SiO2) nanoparticles on the electrochemical efficiency of nitrogen-doped reduced graphene oxide (N-rGO) for development of high-performance supercapacitors.

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1. Gielen, D., Boshell, F., Saygin, D., Bazilian, M.D., Wagner, N., & Gorini, R. 2019. The role of renewable energy in the global energy transformation. Energy Strategy Reviews, 24: 38-50.

2. Nadeem, F., Hussain, S.M.S., Tiwari, P.K., Goswami, A.K. & Ustun, T.S. 2019. Comparative Review of Energy Storage Systems, Their Roles, and Impacts on Future Power Systems. IEEE Access, 7: 4555-4585

3. Makgopa, K., Ratsoma, M.S. & Modibane, K.D. 2022. Intrinsic properties of metal–organic frameworks (MOFs) in supercapacitor applications. Current Opinion in Electrochemistry, 36: 101112

P11

Electrochemical sensing of dopamine on a reduced graphene oxide and gold nanoparticles modified electrode

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Electrochemical sensing of dopamine using reduced graphene oxide (rGO) and gold nanoparticles (AuNPs) modified electrodes offers a promising approach for sensitive and selective detection of this critical neurotransmitter. This study explores the synergistic properties of rGO and AuNPs, which enhance electron transfer and electrochemical activity, enabling efficient dopamine detection. The integration of these nanomaterials improves conductivity, biocompatibility, and stability, making the sensor suitable for real-world applications. Reduced graphene oxide- gold nanoparticle electrochemical sensor was fabricated by drop coating reduced graphene oxide followed by electrodeposition of gold nanoparticles on a glassy carbon electrode (GCE), for the detection of dopamine. The reduced graphene oxide (rGO) were characterised by Fourier transform infrared spectroscopy (FTIR), Raman, Brunauer- Emmett-Teller (BET) and X-Ray diffraction (XRD). Field emission scanning electron microscopy (FESEM) and transmission electron microscopy (TEM) were used to study the morphological and structural properties of the nanomaterials. Cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS) and square wave voltammetry (SWV) were used for the electrochemical characterisation of the electrodes in each step of the construction of the electrochemical sensor. Compared to the bare GCE, the modified electrode showed an enhanced electrocatalytic effect. Square wave voltammetry was used for the quantitative determination of epinephrine.

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[1] C.T. Fakude, O.A. Arotiba, F. Arduini, N. Mabuba, Electroanalysis 32, (2020)

[2] D. Majer, M. Finšgar, Biosensors 11, (2021)

[3] K. Sen, S. Ali, D. Singh, K. Singh, N. Gupta, FlatChem 30, (2021)

P12

Preparation and characterization of metal oxide/metal sulphide composites for degradation of pharmaceuticals from wastewater

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Wastewater used to be viewed as one of the leading causes of environmental pollution; however, with the shift towards the circular economy, it is now one of the sources of valuable resources (i.e. clean water, renewable energy, useful chemicals, and nutrients) (Ghimire, Sarpong et al. 2021). An adequate supply of different resources is essential in meeting the demands of the continuous population growth around the world. Metal oxide-based nanoparticles (i.e. TiO2, ZnO, etc.) have been identified as one of the most versatile photocatalysts because of their functional properties and versatility toward different applications (Lettieri, Pavone et al. 2021). Amongst various metal oxides, TiO2 gained much interest in photocatalysis due to its cost-effectiveness and non-toxicity. However, studies showed that TiO2 successfully treats wastewater with low amounts of contaminants due to its limited flux of UV photons (Thambiliyagodage 2022). Therefore, incorporating other semiconductors with narrow bandgaps onto the surface of TiO2 makes it sensitive to visible light (Thambiliyagodage 2022). Due to their strong photocatalytic activity, transition metal dichalcogenides have been extensively investigated as potential photocatalysts. Tungsten disulphide (WS_2) is one such transition metal dichalcogenide that has garnered significant attention, primarily due to its tunable electronic bandgap, which ranges from 1.4 to 2.0 eV when reduced from bulk material to the nanoscale (Cho, Chang-Jian et al. 2018). Its narrow bandgap, combined with its chemical stability, makes WS_2 a promising candidate for the development of visible-light-active photocatalytic systems (Cho, Chang-Jian et al. 2018). This study investigates the application of TiO_2/WS_2 composites for the degradation of pharmaceutical pollutants in wastewater using various methods, including visible-light-driven photodegradation and electrochemical degradation. The TiO_2/WS_2 composite was synthesized via a one-pot hydrothermal method and subjected to thermal treatment at 200°C for 24 hours. Material characterization was performed using FTIR, BET, SEM, TGA, and XRD, while the electrochemical properties of the synthesized materials were also analyzed.

P13

Electrochemical Sensor for Detecting Benzo(a)pyrene in Seawater

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Benzo(a)pyrene (BaP), a persistent and highly carcinogenic polycyclic aromatic hydrocarbon (PAH), poses a significant threat to marine ecosystems and public health due to its bioaccumulative nature and long-term toxicity [1-2]. Conventional methods for BaP detection in seawater often require complex sample preparation, costly instrumentation, and time-consuming procedures [3]. In this study, we present the development of a highly sensitive and selective electrochemical sensor for the rapid detection of BaP in seawater samples. The sensor is based on a modified electrode platform incorporating polysulfone hydrogel and nanostructured materials that enhance electron transfer kinetics and surface affinity for BaP molecules [4].

Electrochemical characterization using cyclic voltammetry (CV) and square wave voltammetry (SWV) demonstrated excellent analytical performance with a low detection limit, wide linear range, and high reproducibility. The sensor showed strong selectivity toward BaP even in the presence of other PAHs and marine matrix interferences. Real seawater samples collected from coastal regions were successfully analyzed, confirming the sensor's robustness in complex environments.

This work offers a promising point-of-care solution for environmental monitoring, enabling rapid, in-situ detection of BaP and contributing to efforts aimed at preserving marine health and ensuring water safety. Future work will focus on integrating the sensor into portable devices for real-time monitoring applications in remote or resource-limited settings.

1. Zhao, Y., Chen, Z., Li, Q., et al. (2022). A novel electrochemical immunosensor for benzo(a)pyrene detection in seawater using MWCNT-chitosan composites. *Frontiers in Chemistry*, **10**, 950854. https://doi.org/10.3389/fchem.2022.950854.
2. Fu, W., Yang, H., He, X., et al. (2018). Capacitive sensors based on MIPs and antibodies for BaP detection. *Talanta*, **185**, 226–234. https://doi.org/10.1016/j.talanta.2018.03.05
3. Mouffouk, F., Pauli, M., & Dzyadevych, S. (2013). Electrochemical DNA sensors for BaP detection. In *Electrochemical Sensors, Biosensors and their Biomedical Applications* (pp. 439–455). Springer. https://doi.org/10.1007/978-94-007-1324-6_55
4. Wang, J., Liu, G., & Jan, M. R. (2012). Ultrasensitive detection of polycyclic aromatic hydrocarbons using nanostructured electrochemical platforms. *Electrochimica Acta*, **76**, 1–7.
5. Wang, H., Yang, Z., Wang, X., et al. (2011). Dual signal amplification strategy for sensitive detection of BaP using MB@SiO_2-HRP-PAMAM immunosensors. *Biosensors and Bioelectronics*, **30**(1), 1–6. https://doi.org/10.1016/j.bios.2011.09.018

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