ElectrochemSA

(The Electrochemistry section of the South African Chemical Institute)

Presents

6th International Symposium on Electrochemistry

" Electrochemistry, meeting societal needs"

03 to 06 April 2023

Book of Abstracts

Venue: School of Tourism & Hospitality
University of Johannesburg (UJ), South Africa

UNIVERSITY OF JOHANNESBURG

Welcome Address
Prof Omotayo Arotiba
(ElectrochemSA Chairman)

With deep and sincere gratitude to God, I welcome you to the **6th International Symposium on Electrochemistry.** This symposium is organised by **ElectrochemSA** – the Electrochemistry Division of the South African Chemical Institute. I am glad that we can meet again after covid for this 6th edition after the 5th edition at the University of the Western Cape in Aug 2019.

I believe that electrochemistry has a lot to offer the society. We need to come together and harness our strengths to the betterment of the society. The need for societal impact birthed the theme for this edition - ***"Electrochemistry, Meeting Societal Needs"***. To meet the need of the South African, African and global communities, we must provide a platform for interaction among established electrochemists, upcoming electrochemists and postgraduate students doing electrochemistry research. We need to harmonise diversity, discover new talents and encourage excellence in research. This is what the 6th International Symposium on Electrochemistry is all about.

This edition has brought together almost all the electrochemistry communities in South Africa with a nice international flavour. A keen look at our plenary, keynote, invited oral speakers and other presenters shows our commitment to the vision of this 6th edition. For example, we have equal number of men and women among the plenary and keynote speakers. We chose nine keynote speakers to provide platform of recognition for new generation electrochemists. Furthermore, electrochemistry research groups and postgraduate students across South Africa are well represented.

I am happy to announce that the *Journal of Electroanalytical Chemistry (JEAC)* has granted us a special issue (SI) for this symposium. A special issue with a leading journal like JEAC suggests the quality of our conference. I implore all authors to submit their manuscripts to this SI.

This symposium is also about networking and exploring the most beautiful country in the world – South Africa. We have organised excursion for you to see our wildlife. There are a lot more to see in Johannesburg, you are free to explore and spend your money here after the conference. For sea or ocean lovers, you may need to travel few kilometres farther than Johannesburg.

I am not the only one who worked to put this symposium together. Thus, it is right to acknowledge all co-workers and principal advisers. Please join me to thank the Local Organising Committee (LOC) who shouldered the burden of planning this conference. While I appreciate all those who gave me words of counsel during the planning, I specially thank Prof Emmanuel Iwuoha and Prof Priscilla Baker for their commitment to the success of this edition. I think I am still enjoying their supervision 😊. Very importantly, I say a big thank you to all our sponsors for their financial and materials sacrifice. I gratefully acknowledge the support of our host University – the University of Johannesburg. To all participants, I say thank you for coming all the way to UJ for this conference.

So, let the conference begin!

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Prof Omotayo A Arotiba
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Dr Duduzile Nkosi
(Vice Chair)

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(Vice Chair)

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6th International Symposium on Electrochemistry

"Electrochemistry, meeting societal needs"

03 to 06 April 2023

Programme

Oral Presentations

Monday 3 April 2023

07:30 – 8:45	Registration
8:45 – 9:20	**Opening Ceremony** Welcome address Prof Omotayo Arotiba - the Chairperson ElectrochemSA Introduction of Special Guests Opening Addresses: Dean, Faculty of Science, University of Johannesburg
Chair 1	Prof Emmanuel Iwuoha (UWC)
9:20 -9:25	Introduction of Plenary
9:25-10:10	Plenary 1: **Prof Marc Cretin** (University of Montpellier, France) - *Electro- and photo-electro-materials as catalysts for environmental applications: "From the Material to the Process for Environmental Sciences"*
10:10 -10:30	O1: **Daniel Masekela** (UJ) - *Application of piezo-photocatalyst thin film (FTO/BaTiO3/SnO2) for enhanced catalytic degradation of organic pollutants under visible light and ultrasonic vibration*
10:30-10:50	O2: **Kehinde Jayeola** (UJ) – *Enhanced photoelectrochemical degradation of ciprofloxacin in wastewater over a Bi_2O_2S/ZnO heterojunction photoanode*
10:50 – 11:10	Tea
Chair 2	Prof Omotayo Arotiba (UJ)
11:10-11:40	Keynote 1: **Prof Kwena Desmond Modibane** (University of Limpopo, South Africa) - *Metal organic framework composites: Synthesis and real-life applications of electrochemistry*
11:40 -12:00	O3: **Thapelo Mofokeng** (WITS) - *Electrochemical performance of dual pre-intercalated α-MnO_2 cathode for zinc-ion batteries*
12:00-12:20	O4: **Prof Mesfin Kebede** (UNISA) - *The Impact of Synthesis Route on Electrochemical Performance of LiNi0.6Co0.2Mn0.2O2 Cathode Materials for Lithium-Ion Battery*
12:20-12:40	O5: **Dr Shawn Gouws** (NMU) - *Green Hydrogen Production from PEM Electrolyser: A characterization of Oxidative Evolution Reaction Catalysts*
12:40-13:00	IO6: **Dr Katlego Makgopa** (TUT) - *Nanocomposite materials for high-performance supercapacitor applications*
13:00 -14:00	Lunch and visit to exhibitors
Chair 3	Dr Katlego Makgopa (TUT)

14:00-14:30	Keynote 2: **Prof Philiswa Nomngongo** (UJ) - *Nanomaterial-based electrochemical sensing trace metals: From design to application*
14:30-14:50	O7: **Nyasha Midzi** (UJ) - *Dendrimer supramolecular architecture based electrochemical biosensor for codeine*
14:50-15:10	IO8: **Prof Mangaka Matoetoe** (CPUT) - *Functionalized nanoclay electrochemical sensors for pharmaceuticals*
15:10-15:40	Keynote 3: **Prof Vernon Somerset** (CPUT) - *Electrochemical Sensors for Environmental Applications*
15:40-1600	Tea break
Chair 4	Prof Philiswa Nomngongo (UJ)
16:00-16:20	O9: **Jimodo Jorreta Ogada** (WITS) - *CeO2 Enhances the Activity and Durability of Palladium-based Electrocatalysts for Hydrogen Oxidation in Anion-Exchange-Membrane Fuel Cells*
16:20-16:40	O10: **Mpho Ratsoma** (TUT) - *Application of N-rGO/NH4MnPO4·H2O nanohybrid as battery-type electrode material in hybrid supercapacitors*
16:40-17:00	O11: **Daniel Teffu** (UL) - *High-performance supercabattery based on reduced graphene oxide/metal organic framework nanocomposite decorated with palladium nanoparticles*
17:05-17:40	6 Flash Poster Presentations: P1, P3, P4, P10, P16, P19
17:40-19:00	Drinks and poster session: All Posters

Tuesday 4 April 2023

Chair 5	Prof Priscilla Baker (UWC)
8:10-8:15	Introduction of plenary
8:15-9:00	Plenary 2: **Prof Sabeth Verpoorte** (University of Groningen, Netherlands) - *Reading Out Organ-on-a-Chip Systems*
9:00-9:20	IO12: **Dr Pim De Haan** (University of Groningen, Netherlands) - *Organs-on-chips for drug studies*
9:20 -9:40	IO13: **Prof Usisipho Feleni** (UNISA) - *Nickel Selenide Quantum dot Reactor for Electro-oxidation of Nevirapine in Wastewater*
9:40-10:00	O14**: Lu-Nita Berrange** (UP) - *Porphyrin based porous organic polymers enriched with Fe3O4 nanoparticles as electrosensors for the detection of endocrine disrupting chemicals in water.*
10:00-10:20	O15: **Dr Kefilwe Vanessa Mokwebo** (UWC) - *Electrochemical evaluation and voltammetric determination of nevirapine on a boron-doped diamond electrode*
10:20-10:40	Tea break
Chair 6	Prof Kwena Modibane (UL)
10:40-11:00	O16: **Agnes Mongwe** (WITS) - *High-entropy spinel oxides as bifunctional electrocatalysts for rechargeable zinc-air batteries*
11:00-11:20	O17: **Dr Nithyadharseni Palaniyandy** (IDEAS, UNISA) - *NASICON-type NaSn2(PO4)3 microstructures and nanorods anode for lithium-, and sodium-ion batteries*
11:20-11:40	O18: **Siyabonga Patrick Mbokazi** (UJ) - *Synthesis and Characterization of NiFe2O4 on N, P co-doped carbon nanosheets as an efficient electrocatalyst for oxygen reduction in direct methanol fuel cell*
11:40-12:00	O19: **Colani Fakude** (WITS) - *Palladium nanoparticles supported on high-entropy spinel oxide as a highly efficient electrocatalyst for ethanol oxidation reaction*
12:00-12:20	O20: **Dr Rhiyaad Mohamed** (UCT) - *High Performance Iridium-based Electrocatalysts for Proton Exchange Membrane Water Electrolysis*
12:20-12:50	Keynote 4: **Prof Pierre Henri Aubert** (CY Cergy Paris University, France) - *Vertically aligned carbon nanotubes and conducting polymers: from lab curiosity to scale up*
12:50-13:50	Lunch
Chair 7	Prof Omolola Fayemi (NWU)
13:50 – 14:20	Keynote 5: **Prof Krishna Bisetty** (DUT) - *Role of Theoretical, Experimental and Computational Chemistry in Sensors*
14:20-14:40	O21: **Andisiwe Ngwekazi** (UWC) - *Electrochemical detection of dopamine at cucurbit[7]uril modified transducers.*

14:40-15:00	O22: **Dr Ruchika Chauhan** (Rhodes University) - *Electrochemical characterization of Carbon blacks in different redox probes and their application*
15:00-15:20	O23: **Clementine Louw** (UWC) - *Impedimetric spectroscopy immunosensor for in-vitro detection of Cardiac Troponin I*
15:20-15:40	O24: **Dr Gloria Uwaya** (DUT) - *Electrochemical Sensing Platform Based on Multiwalled Carbon nanotubes and Cobalt Oxide for the Detection of Epicatechin in Food: supported by Insilco Studies*
15:40-16:30	8 Flash Poster Presentation: P21, P25, P27, P31, P32, P33, P37, P40
16:30 –18:00	Drinks and Poster presentations: All Posters
18:00 -	Free evening for networking and collaboration

Wednesday 5 April 2023

Chair 8	Prof Nonhlangabezo Mabuba (UJ)
8:10-8:15	Introduction of plenary
8:15-9:00	Plenary 3: **Prof Jeanet Conradie** (University of the Free State, South Africa) - *The redox chemistry of bidentate ligands and their metal complexes: Electronic influence of substituent groups*
9:00-9:20	O25: **Dr Miranda Ndipingwi** (UWC) - *The Design and Performance of Zinc doped Lithium Manganese Silicate Positive Electrode for Supercapatteries*
9:20 -9:40	O26: **Christopher Nolly** (UWC) - *Supercapacitive Effects of Multi-Walled Carbon Nanotubes-Functionalized Spinel Copper Manganese Oxide.*
9:40-10:00	O27: **Tebogo Mashola** (UJ) - *Electrocatalytic activity of alumina-silicates supported electrocatalysts for oxygen electro-reduction in alkaline media*
10:00-10:20	IO28: **Prof Emmanuel Iwuoha** (UWC) - *Electro-Interferon Gamma Aptasensor TB Test*
10:20-10:40	Tea break
Chair 9	Dr Duduzile Nkosi (UJ)
10:45-11:15	Keynote 6: **Prof Gugu Mhlongo** (CSIR) - *Nano-enabled chemi-resistive sensors and their sensing capabilities: Strategic approaches for enhancement of their sensing performance*
11:15-11:35	O29: **Dr Kaylin Januarie** (UWC) - *Quantum Dots Electrochemical Aptasensor for TB Biomarker Detection*
11:35-12:05	Keynote 7: **Prof Esther Fayemi** (NWU) - *Electrochemical Sensors for Dopamine at Screen-print, Gold and Glassy-carbon Modified Electrodes*
12:05-12:30	ElectrochemSA Division meeting
12:30-13:00	Packed Lunch
13:00-	**Excursions**
19:00	Dinner and Awards

Thursday 6 April 2023

Chair 10 (8:25 am)	Prof Mangaka Matoetoe (CPUT)
8:30-9:15	Keynote 8: **Prof Frank Marken** (University of Bath, United Kingdom) - *From Microporous Polymer Materials to Ionic Diode Desalination*
9:15-9:35	O31: **Prof Omotayo Arotiba** (UJ) - *Photoelectrocatalytic degradation of diclofenac sodium at a Ag-BiVO4/BiOI anode and Ag-BiOI cathode dual system*
9:35 -9:55	IO32: **Prof Nonhlangabezo Mabuba** (UJ) - *Application of the nanomaterials in freshwater and wastewater quality monitoring and treatment*
9:55-10:15	O33: **Babatope Ojo** (UJ) - *Coupling piezo-polarization effect on Ti/BaZrTiO3 anode with sonoelectro-Fenton oxidation for the removal of aspirin in wastewater.*
10:15-10:45	Keynote 9: **Prof Priscilla Baker** (UWC) - *Electrochemical impedance spectroscopy in the investigation of materials characterization and kinetics*
10:45-11:05	Closing Ceremony
11:05	Tea time and visits to UJ Lab

Poster Presentation (03 and 04 April 2023)

Poster No.	Delegate Name	Title
P1	Funmilola A. Adesanya (NWU)	Electrochemical properties of ZnO/fMWCNTs nanocomposite modified glassy carbon electrode
P2	Sesethu Makaluza (UJ)	Nanomaterial based electrochemical sensors for the detection of nicotine
P3	Dr Dhielnawaaz Abrahams (UWC)	3-Methyl thiophane modified boron-doped diamond (BDD/P3MT) electrodes as efficient phenol detection catalyst for assessing total phenol content in South African tea.
P4	Dr Kanyisa Maqashu (CPUT)	Application of novel Fluorene Clathrate immunosensor for Parvalbumin in Fish
P5	Andrea Siwak (UWC)	Nanostructured immunosensor for low-level detection of waterborne Cryptosporidium
P6	Rezaan Dreyer (UWC)	Developing an electrochemical sensor based on copper modified polymer electrode for the concentration profile of metformin
P7	Onkarabile Pooe (NWU)	Spectroscopy and Cyclic Voltammetry Properties of Speek/CuO Nanocomposite at Screen-Printed Gold Electrodes
P8	Jaymi January (UWC)	Indium Nanoparticulate-Modified Polyanilino-Co-4-Aminobenzoic Acid Amperometric Sensor for the Detection of Lapatinib, a Breast Cancer Drug
P9	Teboho Moeketse (UWC)	Uricase biosensing and optimised electrochemical transduction
P10	Laercia Bila (WITS)	WS2/Nitrogen-Doped Onion-Like Carbon Supported Pt Catalyst for the Electro-oxidation of Ethanol in Direct Ethanol Fuel Cells
P11	Dr C Van Der Horst (CPUT)	Application of a Chitosan-Fe/Ag nanocomposite for the detection of cadmium, zinc and lead ions in water samples
P12	Nelia Sanga (UWC)	Chronocoulometric aptasensing of SARS-CoV-2 nucleocapsid protein detection on quantum dot electrodes.
P13	Marlon Oranzie (UWC)	Electrochemical Aptasensing of B-type Natriuretic Peptide-A Biomarker for Myocardial Infarction
P14	Grace Olorundare (UJ)	An electrochemical immunosensor for Alpha-fetoprotein cancer biomarker based on carbon black/palladium nanoparticles platform
P15	Dimpo Sipuka (UJ)	Comparative study of the photoelectrochemical performance of Cu_2O and $BiVO_4$ towards the degradation of ciprofloxacin in water
P16	Dr Katekani Shingange (UFS)	Enhanced ethanol sensing abilities of fiber-like La1-xCexCoO3(0≤x≤0.2) perovskites based-sensors at low operating temperatures
P17	Dr Duduzile Nkosi (UJ)	A dendrimer - gold nanocomposite based electrochemical aptasensor for the detection of dopamine.
P18	Dr Babatunde Koiki (UJ)	Persulphate assisted photoelectrochemical degradation of non-steroidal anti-inflammatory drug in water on an FTO-AgNPs-Cu2O photoanode
P19	Alenzo Murray (UWC)	Determination of binding constants between heavy metal ions and cucurbit[n]uril complexes
P20	Dr Busisiwe Zwane (UJ)	Electro-Fenton/anodic oxidation treatment of pharmaceutical cocktail of Ciprofloxacin, Sulfamethoxazole and Tetracycline in water
P21	Dr Oluchi Nkwachukwu (UJ)	Characterisation and application of bismuth ferrite - bismuth vanadate p-n heterojunction in the photoelectrocatalytic degradation of ciprofloxacin in water

P22	Tshepo Mohlala (UJ)	Photoelectrocatalytic degradation of emerging pollutants in water on an FTO/BiVO4/NiS Photoanode
P23	Tsholofelo Sebokolodi (UJ)	Application of FTO/BiVO4/ZnIn2S4 heterojunction for the removal of ciprofloxacin
P24	Patience Silinda (UJ)	Photocatalytic degradation of selected highly toxic dyes in water using Ag-TiO2
P25	David Mabena (TUT)	Tin Oxide supported on Electrochemically Exfoliated Graphene for Supercapacitor Application
P26	Ostar Seerane (TUT)	The decoration of SnO2 nanoparticles on N-rGO for supercapacitor applications
P27	Ernst Hechter (WITS)	Magnetic enhancement of high entropy oxide catalysts for ORR and OER
P28	Fitsum Addis Hailu (WITS)	Electrochemical Techniques for Battery Performance Characterization Zinc-air Battery Case
P29	Augustus Lebechi (WITS)	High Entropy Spinel Oxide as a Bifunctional Electrocatalyst for Rechargeable Zinc-Air Battery
P30	Dr Aderemi B Haruna (WITS)	Defect engineered Spinel Li4Ti5O12 anode materials for improved lithium-ion batteries
P31	Tebogo Tsekeli (WITS)	Defect-engineered microwave irradiated manganese rich LiNi0.2Mn0.6Co0.2O2 cathode material for improved lithium-ion batteries
P32	Reinhard Klopper (UP)	The electrochemical reduction of CO2 to value added products
P33	Tankiso Mashabane (UWC)	Electrochemical sensing of nitrogen species in seawater
P34	Refiloe Modise (WITS)	The Synergistic Effects of Ceria Titanate and Carbon as Supports for Platinum Nanoparticles in Acidic Electrolyte
P35	Marius Ngoepe (WITS)	High Entropy Spinel Oxide CeO2@(CoCuFeNiMn)3O4 as bifunctional electrocatalyst for rechargeable zinc-air batteries
P36	Mercy Nduni (WITS)	High-entropy metal oxide supported on onion-like carbon as a catalyst for polysulfide conversion in lithium-sulfur batteries
P37	Masego Ramonyai (WITS)	Hydrolysis effects on the voltammetric analysis of Bi3+ - is complexation the answer?
P38	Thulani Rani (UWC)	Antimicrobial Activity of Green Synthesized Buchu-Capped Iron Nanoparticles Absorbed in Chitosan Hydrogels Against Gram-Negative Escherichia Coli and Salmonella Typhimurium Bacterial Strains
P39	Prof Jeanet Conradie (UFS)	Redox Chemistry of substituted 2,2':6,2"-terpyridines and their Ru(II) complexes.
P40	Tsholofelo Mosalashuping (NWU)	ZnO-Pc Nanocomposite: Synthesis and spectroscopic characterization

Plenary 1

Electro- and photo-electro-materials as catalysts for environmental applications: “From the Material to the Process for Environmental Sciences"

Professer Marc Cretin

Institut Européen des Membrane, Université de Montpellier UMR 5635 UM-CNRS-ENSCM ; CC 047
Place Eugène Bataillon 34095 Montpellier Cedex 5, France

In a developing world, the demands for energy, water on one side and the damage to the integrity of our environment on the other side are constantly increasing. Electrochemistry can be a great tool to solve these problems, with an impact that we can minimize or at least control in our environment, since the main driver of the reaction is the electron that can be produced by sustainable routes.

In electrochemical approaches of energy conversion and production, as well as in drinking water production or wastewater treatment, materials synthesis and interface characterization are important because they are the key components that will greatly affect system performance.

Electro- and photo-electro-chemical processes have numerous advantages for environmental applications including water treatment because of the possibility to design compact and modular reactors with an easy automation. In this perspective, efficient electrode and photo-electrode materials for the production of radicals from water oxidation and electro-Fenton process will be presented.

As a first step, we will be interested in anodic electrode materials with high oxygen overpotential allowing the generation of radicals from water oxidation. In this context, research works on sub-stoichiometric titanium oxides to synthesize porous electrodes will be addressed. In particular, we will show the performance of porous materials integrated in a pilot for the treatment of biorefractory pollutants. In a second part, the modification of carbonaceous materials by 2D structures and Fe-doped carbon nanotubes will be presented for their use in homogeneous and heterogeneous electro-Fenton process, especially at near neutral pH. Finally, in a third and final section, we will give some examples illustrating the potentiality of these materials for the treatment of real effluents (landfill leachates, urines, domestic & industrial wastewaters) using batch reactor and dynamic cross-flow process.

Keywords: Photoelectrochemical & electrochemical advanced oxidation processes, Sub-stoichiometric titanium oxides; Carbon, Graphene, LDH, Fe-doped CNT, Anodic oxidation, electro-Fenton; Reactive electrochemical membranes, Emergent micropollutants, PFAS, Pharmaceutiacal, Antibiotics, Mineralization, Ecotoxicity,

Oral 01

Application of piezo-photocatalyst thin film (FTO/$BaTiO_3$/SnO_2) for enhanced catalytic degradation of organic pollutants under visible light and ultrasonic vibration.

Daniel Masekela[a], N.C Hintsho-Mbita[b] and N Mabuba[a]

[a] Department of Chemical Sciences (formerly known as Applied Chemistry), University of Johannesburg, PO Box 17011, Doornfontein, Johannesburg 2028, South Africa, E-mail: masekeladaniel@gmail.com. [b] Department of Chemistry, University of Limpopo, Sovenga, Polokwane 0727, South Africa

Keywords: Piezo-photocatalyst thin film, Barium titanate, Piezo-photocatalysis, Dyes, Pharmaceuticals

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We report novel biosynthesized SnO_2 loaded on FTO/$BaTiO_3$ thin film for piezo-photocatalytic degradation of methyl orange (MO), methylene blue (MB), ciprofloxacin (CIP) from water. Piezo-photocatalyst thin films were characterised using XRD, FTIR, FE-SEM, TEM, PL and UV-DRS spectroscopy.

The confirmation of the small spherical SnO_2 on the surface of $BaTiO_3$ was confirmed by TEM, EDS and FTIR. Chronoamperometry and electrochemical impedance (EIS) were employed to determine piezo-electrochemical properties of the prepared piezo-photocatalyst thin films. The results showed that $BaTiO_3$ loaded with SnO_2 on its surface exhibited higher piezoelectrochemical current response than pure $BaTiO_3$ (BTO). For example, FTO/$BaTiO_3$@0.2%SnO_2 (best performing thin film) generated about 1.3 mA current under ultrasonic vibration, which is 6 times more than pure FTO/$BaTiO_3$. Furthermore, FTO/$BaTiO_3$@0.2%SnO_2 showed better degradation efficiency of 96, 92 and 64 % for MO, MB and CIP, respectively.

Overall, this study showed that piezo-photocatalytic activity of $BaTiO_3$ could be improved through SnO_2 loading. Moreover, we were able to demonstrate $BaTiO_3$/SnO_2 composites may be employed as multifunctional catalyst based on their ability to break down various organic contaminates (dyes and pharmaceutical pollutants) from wastewater.

Oral 2

Enhanced photoelectrochemical degradation of ciprofloxacin in wastewater over Bi_2O_2S/ZnO heterojunction photoanode

Kehinde D. Jayeola[a], Omotayo A. Arotiba[b]

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Keywords: Photoelectrochemical degradation, Semiconductor heterojunction, Bi_2O_2S, ZnO

The quest for controlling water pollution, especially from pharmaceuticals has led to exploring photoelectrochemical (PEC) oxidation technology. In this work, we enhanced the optical and electrochemical properties of zinc oxide (ZnO) by forming a heterojunction with bismuth oxysulphide (Bi_2O_2S). The Bi_2O_2S/ZnO heterojunction photoanode proved to be efficient for the photoelectrochemical degradation of ciprofloxacin (CIP) in wastewater in a two-electrode model. The enhanced performance can be attributed to the presence of a built-in electric field, effective charge separation caused by overcoming the fast rate of recombination of photogenerated electrons and holes, as well as the ability to produce holes with high oxidation potential, lower charge transfer resistance, and high photocurrent density. These were confirmed using various material, optical, and electrochemical characterisation such as XRD, Photoluminescence, FTIR, FESEM, TEM, Electrochemical impedance spectroscopy, Mott Schottky, Linear sweep voltammetry, photocurrent response, and UV-Vis Diffuse reflectance spectroscopy. The Bi_2O_2S/ZnO photoanode removed 96% of CIP after 180 min. LC-MS analysis provided the degradation pathway. The photoanode was stable after 7 treatment cycles (reduction from 96% to 92%). Remarkably, the designed photoelectrochemical reactor was used in the treatment of real wastewater with a marked reduction in the total organic carbon content after 180 min. Therefore, Bi_2O_2S/ ZnO photoanode has potential application in the photoelectrochemical removal of organic pollutants from wastewater.

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1 H. Wu, Z. Hu, R. Liang, O. Nkwachukwu, and O. Arotiba, *Appl. Catal.B: Environ*., 2023, **321**, 122053.

Keynote 1

Metal organic framework composites: Synthesis and real life applications of electrochemistry

Kwena D. Modibane

Nanotechnology Research Lab, Department of Chemistry, School of Physical and Mineral Sciences, University of Limpopo (Turfloop), Polokwane, Sovenga 0727, South Africa

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Abstract: Metal-organic frameworks (MOFs) are known as porous coordination polymers, made of metal clusters and organic linkers through coordination bonds. Their structural diversity and tailorability as well as high specific surface area have made them highly advanced and multipurpose materials with applications such as green hydrogen production, water treatment, water harvesting, gas sensor, carbon dioxide capture, solar cells and battery-type energy storage. However, poor conductivity and low stability limit the capability of these MOFs. To deal with these shortcomings, fusion with the secondary components are is a feasible option. Herein, efforts have been made to summarize recent research activity made at University of Limpopo in the synthesis of MOF composites and their electrochemical applications [1-3]. Reduced graphene oxide/metal organic framework nanocomposite decorated with palladium nanoparticles was studied as an efficient electrode material for energy storage applications using nickel foam as current collector. We reported on a simple in situ chemical oxidative polymerization of aniline in the presence of molybdenum disulphide and metal organic framework to fabricate MoS/MOF/PANI ternary composite as a precious group metal-free electrocatalysts which showed to have a good electrocatalytic grey and green hydrogen production. Considering the cost-effective preparation of metal-organic frameworks from polyethylene terephthalate (PET) waste and their promising potential as adsorbents, this work also reports on the functionalization of PET derived-MIL-101 (Cr) with ethylenediamine (ED) for the removal of palladium ions Pd (II) from aqueous environment and photoelectrochemical hydrogen generation of the resultant composites. On the other hand, titanium dioxide/metal organic framework (TiO_2/MOF) composite was prepared using the sol-gel method and employed as photoanode material for photovoltaic applications, showing the overall power conversion efficiency of 0.722% along with a photocurrent density of 0.46 mA cm^{-2}.

Keywords: Composite, hydrogen production, heavy metal removal, metal organic framework, photovoltaic, supercabattery,

References:

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Oral 3

Electrochemical performance of dual pre-intercalated α-MnO_2 cathode for zinc-ion batteries

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Keywords: Sodium, Potassium, Manganese oxide, Zinc-ion battery.

Due to their affordability, high level of safety, and ability to store large amounts of energy, aqueous zinc-ion batteries have become extremely popular worldwide.[1] Nevertheless, there is still a difficulty in fabricating cathode materials that can deliver excellent performance, while also being simple to produce in large quantities. In this study, we have utilized a hydrothermal approach to produce manganese oxide pre-intercalated with sodium and potassium ions. Dual metal ion pre-intercalation has emerged as a promising strategy to enhance the electrochemical performance of α-MnO_2. X-ray diffraction and transmission electron microscopy analyses confirm the successful synthesis of α-MnO_2. The Na^+/K^+@ α-MnO_2 cathode exhibits a significantly improved specific capacity of 130 mAh/g at a current density of 1 A/g, which is 2.2 times higher than that of the pristine α-MnO_2 cathode. The enhanced electrochemical performance is attributed to the synergistic effect of dual metal ion pre-intercalation, which creates a more open and conductive structure, facilitating the diffusion of hydrogen and zinc ions and improving the overall capacity of the cathode material.

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Oral 4

The Impact of Synthesis Route on Electrochemical Performance of $LiNi_{0.6}Co_{0.2}Mn_{0.2}O_2$ Cathode Materials for Lithium-Ion Battery

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Keywords: Ni-rich cathode, Synthesis method, Electrochemical performance.

The layered Ni-rich transitional metal oxide $LiNi_xCo_yM_{1-x-y}O_2$ (where M= Mn, Al, and x>0.6) is amongst next generation cathode materials, especially most suitable to power electric vehicles (EVs) due to high capacity, high voltage, and low cost and it became as one of the principal candidates for long-range EVs. For instance, the Ni-rich $Li[Ni_{0.8}Co_{0.15}Al_{0.05}]O_2$ and $Li[Ni_{0.6}Co_{0.2}Mn_{0.2}]O_2$ cathodes have already been used for EVs application by Tesla Model 3 and GM Bolt respectively that can deliver a single charge driving range of 380 km which is still short of the recommended minimum range. Ni-rich NCM also has the advantage of flexibility in the composition as the Ni content changes. Generally, the energy density of LIBs mainly influenced by the specific capacity and voltage of the cathode materials since the cathodes serve as the provider of lithium-ions. The electrochemical properties of cathode materials are influenced by the synthesis routes, we have here observed the same for Ni-rich cathode.

In this work, we are presenting the comparison of the sol-gel and combustion synthesis routes on the electrochemical performance of Ni-rich $LiNi_{0.6}Mn_{0.2}Co_{0.2}O_2$ cathode materials. The detail structural, morphological, cyclic voltammetry, and galvanostatic charge/discharge capacity results will be discussed.

Oral 5

Green Hydrogen Production from PEM Electrolyser:

A characterization of Oxidative Evolution Reaction Catalysts

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Keywords: PEM electrolyser, iridium, electrocatalysts, electrochemical characterization

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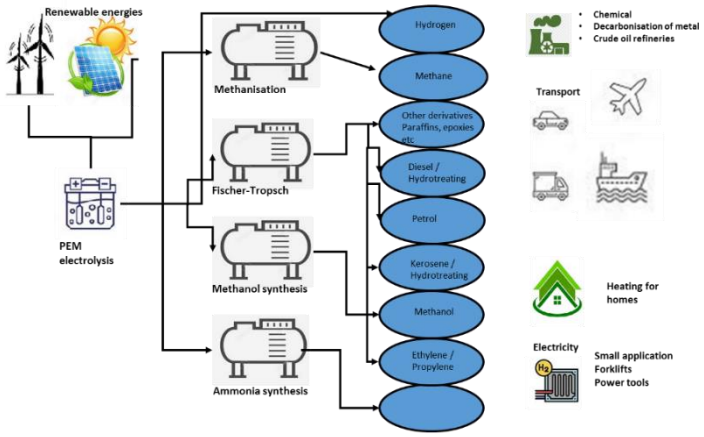
Currently, the main source of hydrogen comes from carbon-based fuels. This both defeats the objectives of green and renewable energy. Where non-renewable carbon-based fuels are used as well as contributing to the CO_2 emission. Therefore, we started investigating PEM electrolyser catalysts to develop new materials in producing green hydrogen. Hydrogen is the most efficient carrier. Green hydrogen is mainly produced from water electrolysis and the utilization of renewable energy sources as power source to split water.

Fig 1 shows a diagram what we envisage regarding the connection of a PEM electrolyser stack with renewable energy to create green hydrogen that can be beneficial in several industrial process to reduce the carbon footprint.



This presentation will cover aspects of the characterization of OER (oxidative evolution reaction) catalysts to reduce the iridium loading and to find alternative elements to ensure good reproducibility and hydrogen production. Material characterization involves XRD, XRF, and electrochemical techniques. Preliminary results shown that the Ir content can be reduce up to 50% that will be a massive cost saver.

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Invited Oral 6

Nanocomposite materials for high-performance supercapacitor applications

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Keywords: Carbon nanomaterials, Energy storage, Supercapacitors

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The design and development of stable electrochemical energy storage (EES) systems (i.e., batteries and supercapacitors) capable of delivering high power and high energy densities has been a hot topic in recent times. Amongst these EES systems, supercapacitors (SCs) have proven high energy storage efficiency, with the promise of meeting the output performance required by advanced technologies (i.e., hybrid/ electric vehicles, smart gadgets, renewable energy resources, etc.). The performance of SC devices is dependent on the physicochemical properties of the electrode materials, thus strategic engineering of these materials is of utmost importance to enhance the performance of the device.[1, 2] Compared to other conventional energy materials, carbon nanomaterials possess unique size-/surface-dependent (e.g., morphological, electrical, optical, and mechanical) properties useful for enhancing the energy storage performance of SC devices. This work focuses on the performance of carbon-based nanomaterials (with a special interest in nitrogen-doped reduced graphene oxide) decorated with metal oxide nanoparticles as electrode materials for SC application.

Some of the excellent energy storage performances for the carbon-based nanocomposite (i.e., N-rGO/Mn_3O_4 nanohybrid) include the enhanced specific capacitance of 345 F g^{-1}, specific energy of 12.0 Wh kg^{-1} (0.1 A g^{-1}), a maximum power density of 22.5 kW kg^{-1} (10.0 A g^{-1}) in a symmetric configuration and an improved energy density of 34.6 Wh kg^{-1} (0.1 A g^{-1}) as well as the maximum power density of 14.01 kW kg^{-1} (10.0 A g^{-1}) in an asymmetric configuration.

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Keynote 2

Nanomaterial-based electrochemical sensing trace metals: From design to application

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Keywords: Toxic trace metals; Humans and ecological health effects; Nanomaterials; Analytical performance, Electrochemical sensing

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Heavy metal contamination is one of the common environmental problems that threatens world's sustainability at risk. Analysis of trace levels of toxic metals reveals that that these metals can cause various hazards in humans and ecological health issues. As a result, considerably effort has been invested into developing methodologies for the detection of heavy metals, thus solving their environmental and health effects. Among these methodologies, nanomaterial-based electrochemical sensor has been used to achieve rapid and high-sensitivity for analysis of trace concentrations of of heavy metals in different environmental matrices. Various studies have proved that the incorporation of nanomaterials improves and significantly enhances the multi-elemental detection ability, sensitivity, and selectivity. Several nanomaterials have great attention in analytical chemistry owing to their advantages, such as ease of synthesis, large specific surface area, low cost, and high stability. Up to this far, the developed nanomaterial-based electrochemical sensors have shown a significant increase in sensitivity and detection limits. Therefore, heavy metal detection systems based on nanomaterials gives new entries to existing electrochemical sensors or are leading to the development of new detection devices that could be attraction interest for applications in food and biological fields.

Oral 7

Dendrimer supramolecular architecture based electrochemical biosensor for codeine

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Keywords: electrochemical biosensor; dendrimer; codeine; supramolecular

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The abuse of prescription drugs that contain codeine has increased over the years, not only in South Africa but on a global scale.[1] The detection of codeine and other related compounds in biological fluids such as blood and urine as well as in wastewater remains a challenge as the prevalent techniques require large sample volumes, trained personnel to operate them while it takes time to obtain results due to lengthy sample preparation.[2] This research used an aptamer immobilised on a dendrimer and graphene quantum dots (GQD) modified carbon electrode as a biosensor for the detection of codeine. The aptamer was electrodeposited on the carbon electrode followed by drop coating with GQD. The modified electrode and the biosensor were characterised using cyclic voltammetry and electrochemical impedance spectroscopy (EIS). The nanocomposite improved the electrochemical performance of the electrode in the presence of a redox probe, improving the detection limit and the stability of the biosensor.[3]

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Invited Oral 8

Functionalized nanoclay electrochemical sensors for pharmaceuticals

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Keywords: sensors, nevirapine efavirenz, zidovudine nanoclay bimetallic

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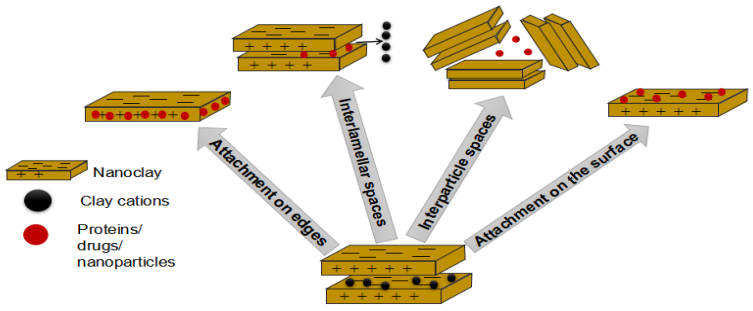
Antiretroviral drugs (ARVs) monitoring is vital in ensuring good quality products, adherence by patients as well as environmental protection. Therefore a simple fast accessible technique is a necessity. Hence, use of nanoclay which is ever-available, high surface area, stable, resistant to extreme temperature with excellent intercalation properties and environmentally friendly. Nanoclays' are phyllosilicates made up of SiO_4 tetrahedra polymeric layers attached to (Mg,Fe,Al)O,OH)6 octahedra thin sheets. Functionalisation improves the clays poor conductivity. In situ nanoclay functionalization with Silver, zinc oxide and silver-gold bimetallic nanomaterials forming nanoclay composites its reported as well it's the composites characterized. The bimetallic, oxide and metal nanoclay composites sensors were fabricate for Efavirenz, nevirapine and zidovudine respectively. The sensor's fabrications were optimized for human serum albumin (HSA) attachment on the composite of interested, drop coated on GCE, supporting electrolyte and HAS drying time.

Differential pulse voltammetry and cyclic voltammetry were used to assess the fabricated sensors potential in analysis of the pharmaceuticals, after method optimisation for pulse amplitude, starting potential and stirring. All sensors depicted linear calibration graphs with limits of detection of 0.31µM, 0.30 µM, and 0.39µM for Efavirenz, nevirapine and zidovudine respectively. The sensors were validated using recovery in biological samples, stability, interferences and repeatability studies. All sensors applicability was tested using commercial tables or capsules.



Keynote 3

Electrochemical Sensors for Environmental Applications

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Keywords: Electrochemical sensor; electrodes; environment; detection; sensitivity.

Environmental samples pose new challenges to the analytical chemist (and analytical laboratories) because typical concentration levels are two orders of magnitude lower than those in most geological samples in the low range of ng/g. Environmental monitoring is becoming increasingly alarming to protect the public and the environment from toxic contaminants and pathogens released into air, soil, and water from toxic chemical wastes, spills, manufacturing waste and even underground storage tanks [1].

A major part of analytical research in detection improvement is devoted to the development of new and robust methodologies. For example, new analytical tools are required for economical and real-time monitoring of environmental pollutants, and for prevention of toxic materials in the environment. Progress in the field of analytical chemistry is aimed at bringing the analytical data close to the production operations. Such advances offer improved analytical methods with reduced environmental impact. A real-time field detection system is highly desirable for continuous environmental monitoring to overcome the limitations such as sample collection and transport to a central laboratory, problems associated with commonly used methods for environmental pollutants [1].

In recent years, the development of chemical and biological sensors is currently one of the most active areas of analytical research towards on-site detection. The electrochemical sensor is one of the most popular sensors presently available and has been applied in many important fields, such as clinical, industrial, environmental, and agricultural analyses. Electrochemical sensors offer the advantage of low detection limit, fast response, easy manufacturing, small size and low price, allowing direct, real-time and fast measurement of many environmental pollutants [2].

The paper will discuss the type of electrochemical sensors that were constructed in the Environmental Chemistry Research Group, Chemistry, CPUT. The focus will be on the advances made towards nanomaterials, sensor platforms, simultaneous detection, sensitivity, selectivity, and limit of detection. These findings will further be compared to research done in other laboratories.

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Oral 9

CeO_2 Enhances the Activity and Durability of Palladium-based Electrocatalysts for Hydrogen Oxidation in Anion-Exchange-Membrane Fuel Cells

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Keywords: Palladium-based nanocatalysts, ceria, hydrogen oxidation reaction, anion-exchange-membrane fuel cell.

Fuel cells are well-known clean energy conversion devices that effectively transform the chemical energy contained in a fuel such as H_2 into electrical energy without emitting harmful substances or greenhouse gases.[1]

The transportation industry has recently commercialized the proton exchange membrane fuel cell (PEMFC), which is the most popular low-temperature technology.[2] The anion-exchange-membrane fuel cell (AEMFC) is a more recent technology and is gaining popularity because of its potential benefits, which include a wider range of less expensive and more durable oxygen reduction catalyst options.[3,4] The electro-oxidation of hydrogen is vital for the development of the anion-exchange-membrane fuel cell (AEMFC).

This study reports the synthesis and electrocatalytic properties of different alternatives of palladium-based nanocatalysts supported on carbon black (CB), onion-like carbon (OLC), and CeO2 - Pd/CB, Pd/OLC, Pd-CeO_2/CB, and Pd-CeO_2/OLC – towards hydrogen oxidation.

The addition of CeO_2 significantly improved the HOR performance when compared to the carbon-only support, with Pd-CeO_2/OLC showing promises as a high-performing and durable anode catalyst for the AEMFC.

The results of this study are published in the ACS Catalysis Journal. [5]

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Oral 10

Application of N-rGO/$NH_4MnPO_4 \cdot H_2O$ nanohybrid as battery-type electrode material in hybrid supercapacitors

Ratsoma, M.S.,[a]* Raju, K.,[b] Modibane, K.D.[c] & Makgopa, K.,[a]

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Keywords: Hybrid Supercapacitors, Nanohybrid, Supercapattery, Battery-type.

Renewable energy has emerged as a key solution to mitigating the negative effects brought on by the use of fossil fuels and to meeting the rising global demand for energy.[1] Supercapacitors, as one of the promising electrochemical energy storage systems, have stood out amongst energy storage devices due to their ability to deliver robust power outputs while being able to still retain their stability and efficiency after long charge-discharge cycles.[2] The performance of supercapacitors is dependent on the physicochemical properties of the electrode materials. Hence, a robust design and optimization of the properties of electrode materials is necessary to enhance the energy storage performance of supercapacitors. Combining the high stability, high surface area, and excellent electronic conductivity of the heteroatom-doped carbon material with the excellent electronic and ionic conductivity of the ammonium metal phosphate (AMP) results in a synergy of the properties.[3,4] This study reports on the synthesis and characterisation of the N-rGO/Mn-AMP nanohybrid for application in high-performance hybrid supercapacitors. The N-rGO/Mn-AMP nanohybrid demonstrated a high specific capacity of 101.2 C g^{-1} compared to 87.3 and 59.8 C g^{-1} obtained from the Mn-AMP and N-rGO, respectively. A hybrid supercapacitor of the nanohybrid and activated carbon demonstrated a specific capacity of 51.6 C g^{-1}, an energy density of 14.3 Wh kg^{-1}, a power density of 10 kW kg^{-1}, and ~92% capacity retention after 2000 cycles at 1.0 A g^{-1}.

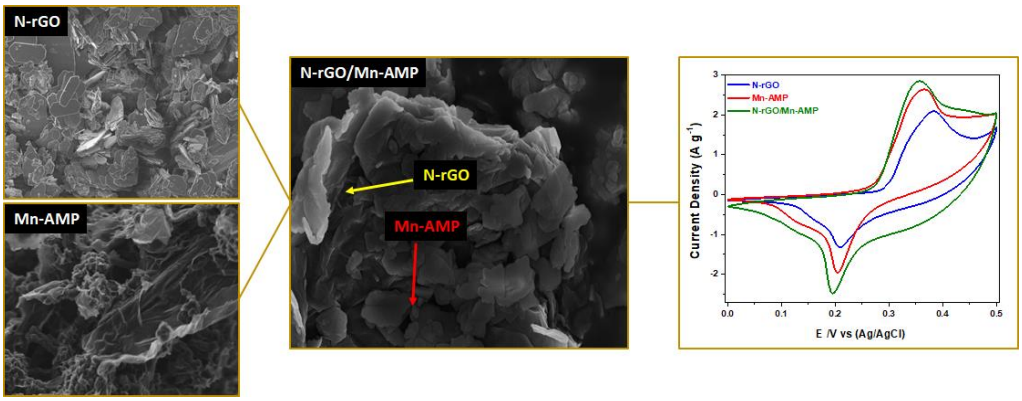

Figure 1: SEM and CV analysis of N-rGO, Mn-AMP, and N-rGO/Mn-AMP nanohybrid.

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Oral 11

High-performance supercabattery based on reduced graphene oxide/metal organic framework nanocomposite decorated with palladium nanoparticles

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Reduced graphene oxide/metal organic framework nanocomposite decorated with palladium nanoparticles (Pd-rGO/MOF) was studied as an efficient electrode material for energy storage applications using nickel foam (NF) as a current collector and aqueous 3.0 M KOH as electrolyte. Pd-rGO/MOF nanocomposite showed a morphology in which a thin layer of rGO coating existed over MOF with unique bright spots indicating the presence of Pd nanoparticles. The synthesised materials were analysed by cyclic voltammetry (CV), electrochemical impedance spectrometry (EIS), and galvanostatic charge-discharge (GCD) for application in supercabattery. The Pd-rGO/MOF nanocomposite displayed improved electron transfer kinetics and superior battery-type performance with a large specific capacity of 712.0 C g^{-1} at 2.0 A g^{-1} in a three-electrode system. Furthermore, Pd-rGO/MOF nanocomposite exhibited high electrochemical performance when applied as a positive electrode and activated carbon (AC) as a negative electrode in an asymmetric, two-electrode system, configuration. The AC//Pd-rGO/MOF displayed an excellent maximum energy density of 26.0 Wh kg^{-1} (at 0.6 A g^{-1}), power density of 1600 W kg^{-1} (at 2.0 A g^{-1}), and good charge-discharge stability after 3500 cycles. This highlights the impact of Pd nanoparticles on the rGO/MOF nanocomposite for energy storage applications in supercabattery.

Keywords: Nanocomposite, metal-organic framework, palladium nanoparticles, reduced-graphene oxide, supercabattery,

Plenary 2

Reading Out Organ-on-a-Chip Systems

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Microfluidics is in many ways a mature technology when it comes to culturing cells and tissue for physiological studies of healthy and diseased organ models *in vitro*. The idea that a researcher can manipulate the cellular microenvironment more effectively in small microchannels than larger containers has been well established in the organ-on-a-chip concept. The fluid handling control that is inherent to microfluidics has also been exploited to develop dynamic experiments in which conditions are changed precisely over time. Researchers are now learning how to manage flow in such a way that medium can be continuously delivered to built-in sensors and/or external analysis systems, enabling quantitative monitoring of physiological processes. In this presentation, I will talk about some recent work we have done together with various partners in which we exploit microfluidics to achieve new analytical approaches to more comprehensively understand the behaviour of precision-cut liver slices and endothelial cell culture *in vitro*.

Invited Oral 12

Organs-on-chips for drug studies

Pim de Haan[a] and Elisabeth Verpoorte[a]

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Keywords: Organ-on-a-chip, Analytical chemistry, Drug research.

Organs-on-chips (OOC) are miniaturized models of human organs, based on microfluidic channels to culture the different cell types in separate compartments. The microchannels can be used to supply cell media and growth factors to the cells, as well as to expose the cells in the OOC to medicinal drugs or toxicants. This work describes the conceptualization, design, operation, and read-out of such OOC systems, with a focus on their use in drug development. We highlight examples from a gut-on-a-chip, a miniaturized model of the human gastrointestinal tract, which incorporates both the digestive processes and the subsequent absorption of compounds through the gut wall. This system was used to monitor the drug biovailability – the fraction of the administered dose that reaches the central circulation. In that system, read-out was done with several different analytical-chemical techniques, including spectrometry and chromatography, and we show potential applications of various in-line electrochemical techniques for detection in the future.

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Invited Oral 13

Nickel Selenide Quantum dot Reactor for Electro-oxidation of Nevirapine in Wastewater

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Keywords: Electrochemical sensor, 3-mercaptopropionic acid, nevirapine, nickel selenide quantum dots, wastewater

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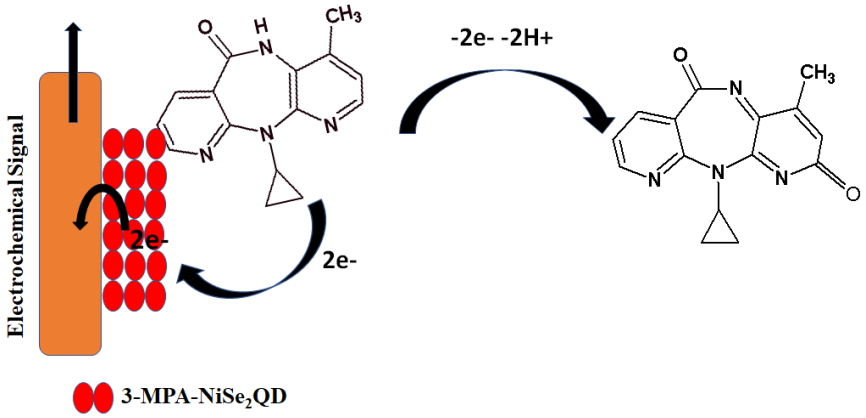
An electrochemical sensor-based on nickel selenide quantum dot, capped with 3-mercaptopropionic acid (3-MPA), was embedded on an L-cysteine modified gold electrode for nevirapine (NVP) detection. The 3-MPA-$NiSe_2$QD material was fully characterised using FTIR, SEM, Raman, HR-TEM, XRD, SAXS, PL and UV-Vis. Differential pulse voltammetry was used to study the electrochemical responses of 3-MPA-$NiSe_2$QD/L-cyst/Au electrochemical sensor to NVP, with a characteristic oxidation peak at 0.76 V. The electrochemical sensor obtained a low limit of detection (LOD) value of 0.0133 pM (0.0035 ng/L), limit of quantification (LOQ) of 0.0442 pM (0.0118 ng/L) and sensitivity of 6.15 µA/pM with a linear range of 0.25 – 0.63 pM, respectively. Thus, the reproducibility, stability, and repetitive usability shown by the proposed sensor made it suitable for the determination of nevirapine in real wastewater samples.



Scheme 1: Plausible mechanism for the electrooxidation of NVP on a modified gold electrode.

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Oral 14

Porphyrin based porous organic polymers enriched with Fe_3O_4 nanoparticles as electrosensors for the detection of endocrine disrupting chemicals in water.

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Keywords: Endocrine disrupting chemicals, Porphyrin organic polymer

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Endocrine disrupting chemicals (EDC) are abundant in nature and have been found in undesirable concentrations in water sources, increasing the possibility of entering the food chain. These chemicals mimic hormones in the body and interfere with regular reproductive function and development of living organisms. In this study solvothermally synthesized Fe_3O_4 nanoparticles were added to synthesized metallated porphyrin-based porous organic polymers (Fe_3O_4@MPPOP) to act as catalysts for the electrocatalytic detection of o-phenylphenol and butylparaben. These EDC compounds are widely used in personal hygiene products and found in food sources. The morphological, structural and electrochemical characteristics of the composites were characterized using transmission electron microscopy, X-ray diffraction, Fourier transform infrared spectroscopy and electrochemical techniques. The Fe_3O_4@MPPOP/GCE sensor was applied in real samples such as apple peels, sunscreen and river water. Thus Fe_3O_4@MPPOP nanocomposites could emerge as promising materials for the detection of endocrine disrupting chemicals in water.

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Oral 15

ELECTROCHEMICAL EVALUATION AND VOLTAMMETRIC DETERMINATION OF NEVIRAPINE ON A BORON-DOPED DIAMOND ELECTRODE

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Keywords: Boron-doped diamond electrode, voltammetry, nevirapine, wastewater water, pharmaceutical formulation.

Conventional mainstream electrochemical sensors usually employ commercial electrodes such as glassy carbon (GC), gold (Au), carbon paste and screen-printed carbon as electrodes material. The difference in the physicochemical properties of these electrodes results in them having different electrocatalytic properties[1]. For instance, AuE is highly conductive and redox-active with redox peaks between 0.5 to 1.0 V, while GCE is inert. To enhance the electrochemical performance of these electrodes and the sensors, different materials and composites such as nanomaterials and polymers are used to modify the electrode either by electrodeposition, drop-coating or chemical cross-linking[2, 3]. However, such sensors suffer from stability, repeatability, fouling, and low background-to-signal ratio. As another electrode material that has gained interest in the last decade, boron-doped diamond (BDD) electrodes have shown excellent and unique electrochemical properties for sensing inorganic and organic compounds compared to their counterparts[4]. To test the electrochemical performance of the described BDD, nevirapine (NVP), was used as a model organic compound. Differential pulse voltammetry (DPV) was used to evaluate the analytical performance of the proposed electrode, where a limit of detection (LOD) and limit of quantification (LOQ) of 0.0099 µg.mL^{-1} and 0.034 µg.mL^{-1}, respectively, were obtained in the linear dynamic range of 0.05 – 5 µg.mL^{-1} (R^2 = 0.996). The reported analytical method was sensitive, selective, and repeatable, hence its practical ability was tested in wastewater, drinking water and pharmaceutical formulation. The recovery percentages ranging from 96% to 105.3%. have proven satisfactory for the proposed electroanalytical method.

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Oral 16

High-entropy spinel oxides as bifunctional electrocatalysts for rechargeable zinc-air batteries.

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Keywords: Electrocatalysts, Oxygen Reduction Reaction (ORR), Oxygen Evolution Reaction (OER), Rechargeable Zinc-Air Batteries (RZAB), High-entropy spinel oxide ($HESO_x$).

Sluggish kinetics caused by chemically inert O_2 molecules during oxygen reduction/ oxygen evolution reactions in rechargeable zinc-air batteries pose a barrier in electrocatalysis for energy storage[1]. In heterogeneous catalysis, oxygen chemistry relies on rare and precious metal electrocatalysts hence reducing the consumption of these elements while improving the catalytic activity is crucial. In this work, highly efficient bifunctional high-entropy spinel oxide ($HESO_x$) electrocatalysts were synthesized by a one-step powder forming Pechini method and explored towards efficient ORR and OER. It is rationally designed such that $(MnFeCoNiCu)_3O_4$ nanoparticles make up the catalysts to introduce the high-entropy effect which offers favourable electrochemical activity in alkaline media, especially when coupled with carbon. Specifically, our etched $(MnFeCoNiCu)_3O_4$/C exhibits high catalytic performance which is comparable to that of Pt/C and IrO_2 for ORR and OER respectively. The bifunctionality index (ΔE) of 0.71 V for ORR and OER was obtained for the etched material which is relatively low compared to that of Pt/C and IrO_2 (0.78 V) reported in literature[2]. Moreover, the etched $HESO_x$ electrocatalyst is highly stable during continuous working conditions and exhibits a good power density of 151.9 mW cm^{-2} in rechargeable zinc-air batteries.

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Oral 17

NASICON-type $NaSn_2(PO_4)_3$ microstructures and nanorods anode for lithium-, and sodium-ion batteries

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a

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Keywords: NASICON, $NaSn_2(PO_4)_3$, Anode, Microspheres, Nanorods

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NASICON type materials are playing an important role because of its high-ionic conductivity and stable structure in lithium-ion and Sodium-ion batteries. Herein, we developed microspheres and nanorods of $NaSn_2(PO_4)_3$ (NSP) via a modified Pechini method and investigated them as anode materials for Lithium/Sodium storage applications. The NSP is made up of isolated $[SnO_6]$ octahedral and $[PO_4]$ tetrahedral units that are interconnected by corners to form the framework anion $[Sn_2(PO_4)_3]$1, 2. It was discovered that NSP microparticles and nanorods have a high crystallinity. The electrochemistry results showed that NSP nanorod has greater capacity, cyclic stability, and rate capability than microspheres for sodium-ion batteries over 200 cycles. The enhanced capacity of the NSP_{nr} could be due to the nanorods long interlayer spacing, and the material's crystalline nature resulted in accelerated kinetics of Na-ions and improved electrochemistry performances. NSP microspheres, as opposed to NSP nanorods, display greater specific capacity and exceptional cycling stability in lithium-ion batteries. This study amply displays the various structures that can be synthesized and how electrochemistry affects those structures.

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Oral 18

Synthesis and Characterization of $NiFe_2O_4$ on N, P co-doped carbon nanosheets as an efficient electrocatalyst for oxygen reduction in direct methanol fuel cell

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Keywords: Spinel oxide composite, Electrocatalytic activity, Fuel cells

Climate change and pollution emissions from fossil fuels have always posed a serious threat to the environment hence intense efforts have been made worldwide to develop green and sustainable technology for energy conversion and storage. To date, Platinum-based catalysts are still the best oxygen reduction reaction cathode materials used in commercial fuel cells, however, their scarcity and high cost is still a hindrance to fuel cell technology. To mitigate the cost of fuel cells, considerable efforts have been made to develop non-noble metal catalysts that include Ni, and Fe transition metals but their catalytic activity is still low to meet practical application. The preparation of nickel ferrite nanoparticles immersed on nitrogen and phosphorus dual doped carbon nanosheets was fabricated by an in-situ foaming technology where an emulsifier material was explored as the source of carbon material. In the synthesis procedure, a self-sacrificing template known as graphitic carbon nitride was used while the emulsifier material acts as the surfactant. Incorporating nickel ferrite onto the surface of the emulsifier and graphitic carbon nitride sandwich-mixture expands and carbonizes the carbon nanosheets with the decomposition of the graphitic carbon nitride at 1000^{o}C. The as synthesized nickel ferrite composite was characterized by XRD, RAMAN, FTIR, TEM, SEM, BET and XPS and its superior catalytic activity towards oxygen reduction was tested using CV, Hydrodynamic LSV, and Chronoamperometry. The superior electrochemical performance of this electrocatalyst demonstrate that the co-doped carbon nanosheets with nickel ferrite nanoparticles can be used as an efficient and cost-effective material towards oxygen reduction reaction.

Oral 19

Palladium nanoparticles supported on high-entropy spinel oxide as a highly efficient electrocatalyst for ethanol oxidation reaction

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Keywords: High entropy spinel oxide, electrocatalyst, mass activity, electro-oxidation, fuel cells

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High-entropy nanoparticles have become a rapidly growing area of research in recent years. Because of their multi-elemental compositions and unique high-entropy mixing states (i.e., solid-solution) that can lead to tunable activity and enhanced stability, these nanoparticles have received notable attention for catalyst design and exploration. Herein, we introduce a carbon-supported high entropy spinel oxide, Pd@HESO/C as an efficient electrocatalyst for ethanol electrooxidation, an anodic reaction in direct alkaline fuel cells (DAFCs). Upon characterization using x-ray photoelectron microscopy, high-resolution transmission electron microscopy, and scanning electron microscopy, the electrocatalyst demonstrated remarkable properties for ethanol oxidation reaction. The electrocatalyst obtained mass activity ($j_{mass)}$, onset potential (E_{onset}), charge transfer resistance of 3001 $mAcm^{-1}{}_{Pd}$, -0.68 mV (*vs* Ag/AgCl), and 151±2.25 Ω, respectively, outperforming the commercial Pt/C and Pd/C electrocatalysts. Moreover, Pd@HESO/C demonstrated better CO tolerance and excellent electrocatalytic stability as it retained more than 90% mass activity after 500 cycles. This electrocatalyst lends itself as a promising cost-effective high-performing electrocatalyst for DAFCs.

Oral 20

High Performance Iridium-based Electrocatalysts for Proton Exchange Membrane Water Electrolysis

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Keywords: Electrocatalysis, Oxygen Evolution Reaction, Water Electrolysis.

Proton exchange membrane water electrolysis (PEMWE) offers a promising route for the production of green hydrogen from renewable energy sources and could be the master key to unlocking a future sustainable energy system. One of the main barriers delaying the wide-spread adoption of PEMWE technologies is the slow kinetics of the oxygen evolution reaction (OER) occurring at the anode and the need for high-cost, low-abundance precious metal-based electrocatalysts. Iridium-based oxides are still considered the only feasible option for practical applications due to their high activity and considerable corrosion stability under the harsh electrochemical reaction conditions. To improve the overall efficiency of PEMWEs, electrocatalyst development must concomitantly address performance metrics in terms of activity, durability and material cost.

In this paper, I will present an overview of the electrocatalyst research and development activities for PEMWE applications at HySA Catalysis, one of three Department of Science and Innovation funded national flagship programme Hydrogen South Africa Centres of Competence. The paper will focus on novel synthesis strategies geared towards the preparation of highly crystalline, rutile-type iridium oxide nanoparticles with high OER performance. Firstly, a novel wet-chemistry synthesis method that avoids the use of reducing agents and eliminates the need for high temperature thermal oxidative treatment will be presented.[1] Secondly, a novel dry-chemistry based metal-organic chemical deposition process as a simple, one-step preparation method for iridium-based nanoparticles supported on various doped tin oxides will be discussed.[2-4] Furthermore, challenges associated with the use of metal oxide supported electrocatalyst materials under PEM electrolyser operating conditions will be discussed.

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Keynote 4

Vertically aligned carbon nanotubes and conducting polymers: from lab curiosity to scale up

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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.[1,2,3] 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, in the field of electrochemical storage, VACNT still show limitations on both gravimetric and volumetric energy (5 Wh/kg and 1 mWh/cm^3). To improve electrodes capacitances, it is necessary to apply post-treatments to the VACNTs: (*i*) first, we have developed an easy method based on electrodeposition of electronic conducting polymer (ECP) in order to combine VACNT with ECP.[4,5] (*ii*) We have also explored the VACNT doping with N and O heteroatoms by two paths: direct growth of doped VACNT and post synthesis treatment. In this presentation, these two routes will be described and some result on electrode/supercapacitors performances will be presented. The second part of the presentation will be devoted to scale-up synthesis; especially I will focus on the *roll-to-roll* electrosynthesis of conducting polymers on VACNTs electrodes and their application to pseudo-supercapacitors.

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Keynote 5

Role of Theoretical, Experimental and Computational Chemistry in Sensors

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Keywords: Sensors, Nanomaterials, Experimental, Computational Machine Learning

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The integration of nanomaterials could lead to new miniaturized biosensors with high sensitivity and ultrafast response. This technology has already evolved to a highly advanced level, but a combined strategy could be highly beneficial and bring forth fresh perspectives in the era of artificial intelligence.

Thus, the goal of this talk is to introduce new methodologies that can be used in an integrated fashion in the design of electrochemical nano bio/chemical sensors. In this context, the synergies between the experimental and computational approaches in addressing the design and mechanism of electrochemical sensors for applications in the food, health and environmental sectors will be demonstrated. Further, the role of machine learning in improving electrochemical analyses will be introduced.

Oral 21

Electrochemical detection of dopamine at cucurbit[7]uril modified transducers.

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Keywords: Cucurbituril, electrochemical sensor, dopamine.

Cucurbiturils are a class of macrocyclic compounds with highly polar carbonyl portals and a hydrophobic cavity[1]. Owing to their exceptionally high affinity for positively charged or cationic compounds, they are frequently used as effective host molecules in the field of supramolecular recognition [2]. This macrocyclic compound was applied in the design of electrochemical sensors for the detection of biogenic amines. Biogenic amines (BAs) are organic bases, which can be present in foods and can cause several adverse reaction in the consumers[3]. They are generally produced by microbial decarboxylation of amino acids in food products. The most significant BAs occurring in foods are histamine, serotonin and dopamine[4]. Limited studies have been reported on thin film cucurbituril modified electrochemical sensors for solution based studies[5]. The cucurbituril based electrochemical sensors were used for the detection of Amphetamine-type stimulants and Tryptophan (Try) in solution[6]. In this work we focused on designing sensors by immobilizing CB[7] at the surface of glassy carbon electrode following a drop coating and chemical grafting method. The sensors were characterized by CV,SWV,UV-Vis, AFM, FTIR and SEM to confirm the immobilization of CB [7] and its analytical response. The sensors were applied for the detection of dopamine in aqueous medium.

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Oral 22

Electrochemical characterization of Carbon blacks in different redox probes and their application

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Keywords: carbon blacks, cyclic voltammetry, inner sphere redox probe, outer-sphere redox probe.

Abstract

Carbon Black is a material rich in carbon nanostructures with numerous beneficial properties when applied in electroanalysis; specifically, when used as a modifier of electrochemical sensor surfaces. Typically, the application of carbon black enhances the surface area and conductivity and supports other molecules, such as catalysts. Differing grades of carbon black exist – with varying properties such as average nanoparticle size and structure, dispersibility in different solvents, electrical conductivity, etc. – which in turn impacts their ability to act as modifiers for electrochemical sensors. No single study has yet comparatively characterised a large range of different grades of carbon black for their application in electrochemical sensors.

Here, we explore several commonly studied carbon black grades (N220, N234, N326, N330, N339, N375, N550, N660 and Lamp Black), alongside newer grades of carbon black (Printex-200, Printex G, Printex XE-2B, and Printex Zeta). Carbon black materials were initially characterised by Raman Spectroscopy. Coated onto glassy carbon electrodes, their influence on cyclic voltammetry and electrochemical impedance spectroscopy was measured using three different redox probes: ferro/ferricyanide (anionic), ferrocene methanol (neutral) and hexaammineruthenium (cationic). Based on these results, selected grades of carbon black – either applied to screen-printed electrodes alone, or subsequently modified using the redox mediator 1,10-phenanthroline-5,6-dione – were then used to lower the overpotential associated with anodic detection of NADH in tris-HCl buffer. The study provides a detailed analysis of the utility of different grades of carbon black for application in electrochemical sensors.

Oral 23

Impedimetric spectroscopy immunosensor for in-vitro detection of Cardiac Troponin I

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

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The World Health Organization reports that cardiovascular diseases (CVD) are the leading causes of death globally and estimated that more than 23.6 million deaths will be due to CVD in 2030 (1) (2) . In South Africa cardiovascular diseases account for 1 in 6 deaths (17.3%) according to the Heart and Stroke foundation stats published in 2016. The foundation further reports that cardiovascular disease is the lead cause of death in South Africa after HIV/AIDS and that 225 people die every day due heart disease. Early detection of cardiovascular diseases such as acute myocardial infarction (AMI) is important as it can assist the patient and also assist in cutting cost and time for prognosis of the disease (3) (4). Detection of biomarker levels in plasma is currently one of the best ways for prognosis and diagnosis of acute myocardial infarction (5). In this work a label-free biosensor was developed for detection of an AMI biomarker, Cardiac Troponin I, by electrochemical impedance spectroscopy. Carbon quantum dots (CQD) were synthesized, characterized, and used to modify the surface of the electrode. The sensor was fabricated by assembling CQD, EDC/NHS, antibody, and bovine serum albumin onto the surface of the screen-printed carbon electrode. The sensor showed a linear response for cardiac troponin in the concentration range of 0.001 ng/mL to 0.018 ng/mL.

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Oral 24

Electrochemical Sensing Platform Based on Multiwalled Carbon Nanotubes and Cobalt Oxide for the Detection of Epicatechin in Food supported by *In Silico* Methods

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Keywords: Electrochemical sensor, Co_3O_4 NPs, Multiwalled carbon nanotubes, Epicatechin, DFT, Monte Carlo simulation

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Epicatechin (EC) is widely used in the formulation of pharmaceuticals and chocolate containing food matrices owing to its cardiovascular benefits, anti-cancer effects, antioxidant, antiviral and anti-inflammatory properties [1–3]. Although, chromatographic methods are the most used technique for EC detection in raw and processed foods, there is also an interest in exploring the potency of a cost-effective nano material-based sensor with real time analysis for the detection of EC.

This study reports the design of an electrochemical sensor for the detection of epicatechin (EC) in food samples (dark chocolate and apple) using cobalt oxide nanoparticles (Co_3O_4) synthesized from Carica papaya peel extract, combined with multiwalled carbon nanotubes (GCE/MWCNTs/Co_3O_4) doped onto glassy carbon electrode. The structural, morphological, and electrochemical properties of the electrode materials were examined using Fourier transform infrared spectroscopy (FT-IR), field emission scanning electron microscopy (FE-SEM), cyclic voltammetry (CV), and electrochemical impedance spectroscopy (EIS).

The designed sensor (GCE/MWCNTs/Co_3O_4) demonstrated excellent electron transport properties as well as excellent electrocatalytic activity towards EC, with a low R_{ct} value of 4.74 kΩ than that of the bare electrode. A detection limit of 0.12 µM and a sensitivity of 0.0837 µA/µM were obtained using square wave voltammetry (SWV) for EC concentrations between 47.6 - 310.3 µM. The designed sensor demonstrated good repeatability, stability, reproducibility, selectivity, and excellent recoveries (90-108%) with relative standard deviations ranging from 0.46 to -2.52 for the detection of EC in food samples. Further, the EC's energy band gap (- 5.15 eV) and absolute hardness (- 2.57 eV) calculated at the density functional theory (DFT) level, indicate its strong chemical reactivity. Finally, the computed Monte Carlo adsorption energy confirms the strong electrostatic interaction between the surface of the GCE/MWCNTs and the Co_3O_4 NPs. It is expected that the results presented in this study will pave the way for research involving the detection of antioxidants in food and in pharmacology.

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Plenary 3

The redox chemistry of bidentate ligands and their metal complexes: Electronic influence of substituent groups.

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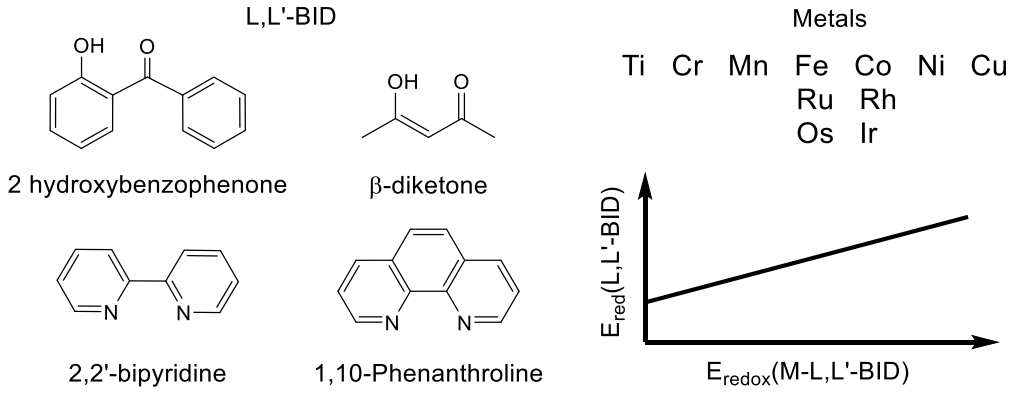
Keywords: bidentate ligands, metals, reduction, oxidation, DFT, relationships.

The majority of bidentate ligands (L,L'-BID with donor atoms L and L') exhibit irreversible electrochemical reduction. When bonded to a metal, the resulting metal-L,L'-BID chelates are typically stable and display reversible metal-based redox behavior. These metal-L,L'-BID compounds have a range of applications, including use as catalysts, in biology, and as redox mediators in dye-sensitized solar cells. Understanding the redox behavior of these compounds is critical for all these applications.

The redox behavior of various L,L'-BID ligands and metal-L,L'-BID compounds, as determined through cyclic voltammetry, will be presented [1-7]. The electronic influence of the different substituent groups on the L,L'-BID ligands, on the redox behavior of both the L,L'-BID ligands and the metal-L,L'-BID compounds, will be analyzed. This contribution highlights some relationships between the properties of the ligands (pK_a, reduction potential, Lever electronic parameter, DFT calculated descriptors), the properties of the ligands' substituents (Gordy scale group electronegativities, Hammett meta-substituent constants), and the metal-based redox potential of metal-L,L'-BID compounds. Theoretical results obtained through density functional theory are used to complement the observed redox behavior.



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Oral 25

The Design and Performance of Zinc doped Lithium Manganese Silicate Positive Electrode for Supercapatteries

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Keywords: Nanomaterials, Li_2MnSiO_4, Zn doping, Li-ion battery, Supercapacitor

Rechargeable batteries and supercapacitors owing to their high energy and power densities are considered as promising energy storage devices for stable electricity supply from intermittent renewable energy sources in electric, hybrid electric vehicles and the power grid [1]. To meet the demands of next-generation applications, researchers worldwide are working to improve considerably, the storage capabilities and cycle life of these energy storage devices and even better, develop new and high-performing electrode materials and devices with exceptional capabilities. The design of hybrid energy storage devices known as supercapatteries, is an effective approach to boost the energy and power capabilities of these systems. Lithium manganese silicate (Li_2MnSiO_4) has been identified as a possible cathode material which can theoretically achieve the energy requirements of advanced Li-ion batteries due to its high theoretical capacity, excellent thermal stability, and environmental-friendliness. However, Li_2MnSiO_4 electrode material possesses some inherent drawbacks, such as poor electronic conductivity and structural instability which restricts its wide-ranging applications [2-3]. In this work, a solvothermal approach was developed for the improvement of the local environment and charge transfer kinetics of Li_2MnSiO_4 by Zn-doping. X-ray diffraction confirmed the crystalline phases of the nanomaterials. Skewed as well as bell-shaped particle size distributions of the nanocrystals were illustrated by small angle X-ray scattering studies. Electrochemical studies revealed superior performance of 4% Zn-doped Li_2MnSiO_4 electrode material with a specific capacity of 80.46 C g^{-1} at 20 mV s^{-1}. Supercapattery cells fabricated with activated carbon and $Li_2Mn_{1-x}Zn_xSiO_4$ as the negative and positive electrodes, respectively delivered good capacitance retention and coulombic efficiencies over 3000 cycles.

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Oral 26

Supercapacitive Effects of Multi-Walled Carbon Nanotubes-Functionalized Spinel Copper Manganese Oxide.

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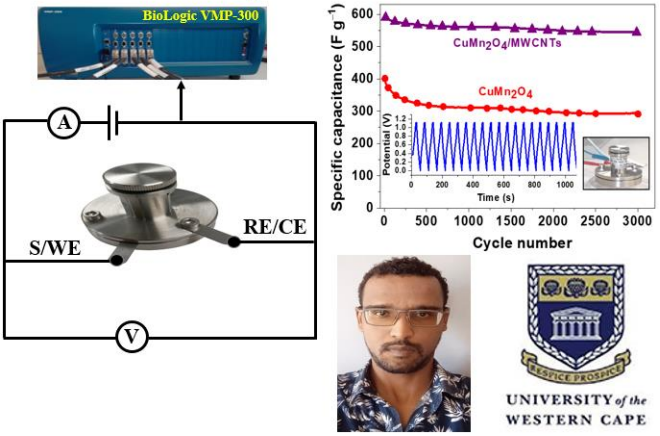
Keywords: Nanocomposite Electrode, Spinel Metal Oxide, Specific Capacitance.

The rapid increase in energy demand and consumption of fossil fuel resources has evoked the need for developing renewable energy generation systems such as photovoltaic cells, wind and hydroelectric turbines. However, due to the intermittent nature of solar and wind energy, including the expensive construction cost of hydroelectric power stations, high performance energy storage technologies are in great demand. In this regard, supercapacitors have attracted significant interest in the area of electrochemical energy storage due to their unique advantages such as high specific power, extended life cycle and fast charge/discharge rate capabilities [1]. However, their major limitation is low specific energy, hence motivating researchers to develop electrode materials capable of generating enhanced energy storage capacities. In this study, spinel copper manganese oxide nanoparticles integrated with acid-functionalized multi-walled carbon nanotubes ($CuMn_2O_4$/MWCNTs) were synthesized in the development of supercapacitor electrodes. The $CuMn_2O_4$/MWCNTs nanocomposite preparation process involved initial synthesis of the $CuMn_2O_4$ precursor material, via hydrothermal method, followed by a reflux growth method for the nanocomposite. Electrochemical analysis of $CuMn_2O_4$/MWCNTs were performed in a two-electrode asymmetric cell and delivered a maximum specific capacitance, specific energy and specific power of 2246 F g^{-1}, 64 Wh kg^{-1} and 15000 W kg^{-1}, respectively, at 0.5 A g^{-1} specific current. Electrochemical stability studies conducted over 7000 cycles illustrated the $CuMn_2O_4$/MWCNTs asymmetric supercapacitor exhibiting a capacitance retention of 78% at 1 A g^{-1} specific current.

Graphical Abstract



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Oral 27

Electrocatalytic activity of alumina-silicates supported electrocatalysts for oxygen electro-reduction in alkaline media.

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Keywords: Electrocatalysis, Oxygen-electroreduction, Zeolites, Pore-structure

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The fast-developing industrial production and economics lead to the high demand of energy. With the depletion of fossil fuel reserves and climate change caused by greenhouse gases from fossil fuel combustion for energy production, there is a great need for alternative energy resources [1]. Alkaline fuel cells are electrochemical devices that convert chemical energy to electrical energy through the electro-oxidation of fuels at the anode and the electro-reduction of oxygen at the cathode. Zeolites materials are used in this study due to their interesting properties, which are of outmost importance in catalysis. The incorporation of exogenous metal nanoparticles into the zeolites framework results in an increase in the acidity of the zeolites and the generation of metal sites, which enhances the performance of the catalyst due to the synergy between metal nanoparticles and the acid sites inside the zeolites [2, 3, 4]. The ZSM-5 zeolite was successfully synthesized by hydrothermal synthesis method, followed by the incorporation of metal nanoparticles through post-impregnation method. The metal-loaded zeolites catalysts showed improved catalysis, with the bimetallic ones performing better than the tri-metallic catalysts. Although the zeolites-based catalysts showed great electrochemical stability compared to the carbon-based electrocatalyst, their catalytic activity still needs improvement.

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Invited Oral 28

Electro-Interferon Gamma Aptasensor TB Test

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An electrochemical interferon gamma (IFN-λ) aptasensor technology for sensitive and selective diagnosis of tuberculosis (TB) is being presented. The sensor was developed with chitosan/copper-indium-zinc-sulfide nanocomposite sensing platform, in combination with methylene-blue labeled interferon gamma (IFN-λ)-specific aptamer hairpin. IFN-λ TB detection is quantified by changes in electrochemical signal in the presence or absence of target. Specifically, it is based on the use of chitosan/copper-indium-zinc-sulfide (χtCIZS) nanocomposite as sensing platform and signal amplifier in monitoring changes in the electrochemical signals resulting from the biorecognition of the high-affinity binding aptamer molecules to IFN-λ target protein. The detection of the conformational changes in the aptamer-hairpin structure upon target binding was studied by chronocoulometry. The sensor was shown to be very sensitive to IFN-λ, with a linear range and a limit of detection in the pg/mL range. The aptasensor exhibited excellent response stability for up to 30 successive chronocoulometric scans.

Keynote 6

Nano-enabled chemi-resistive sensors and their sensing capabilities: Strategic approaches for enhancement of their sensing performance

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Keywords: 6th International Symposium on Electrochemistry, Abstract, Conference.

The development of semiconductor metal oxide (SMO) based chemi-resistive sensors have a rich history of about 50 years amongst other types of gas sensors hence they find major applications in various sectors including detection of food adulteration, environmental pollution, human diseases, flammable gases etc. In spite of all current advances in the field of sensing, the use of SMOs as active sensing materials has met limited success due to their high-power consumption, poor sensitivity and lack of gas selectivity thereby rendering them inappropriate for application as reliable, robust, and accurate chemical/gas sensors. For this reason, development of novel active sensing materials to achieve superior sensing capabilities deserves more efforts. Herein, novel approaches to produce nano-enabled SMO chemi-resistive sensors based on ZnO, In_2O_3, FeO_2O_4 as active sensing materials have been developed. Different strategies to improve their gas sensing performance such as addition metal cation additives as catalysts or dopants and heterostructures have been explored to address environmental, agricultural and food issues. Numerous characterization techniques have been employed to acquire detailed information pertaining to their structural, morphological, surface defects and textural properties.

Oral 29

Quantum Dots Electrochemical Aptasensor for TB Biomarker Detection

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Keywords: Aptasensor, biomarker, interferon-gamma, quantum dots, tuberculosis

Mycobacterium tuberculosis, a dangerous infectious illness, is what causes tuberculosis (TB), which affects people's lungs and respiratory systems [1]. It is the greatest cause of infection-related death worldwide, exceeding the human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), and as such poses a significant global burden [2]. An essential inflammatory cytokine that aids in the body's immunological response to combat viruses and bacteria is interferon-gamma (IFN-γ). As a result, it can be utilized as a biomarker for the diagnosis of TB [3]. T-helper and cytotoxic T-cells produce interferon-gamma, which possesses antiviral, antiproliferative, differentiation-inducing, and immunoregulatory functions [4,5]. Antibody-based approaches have been the standard way for detecting interferon-gamma over the years. These diagnostic techniques, like ELISA, have a high sensitivity for interferon-gamma, but are time-consuming and labour-intensive [6]. Therefore, it is crucial to create a substitute technique for interferon-gamma detection. Herein, we propose a straightforward and sensitive quantum dot electrochemical aptasensor for interferon-gamma detection. The aptasensor is based on novel L-cysteine functionalized tin telluride selenide (L-cysteine-SnTeSe) quantum dots and interferon-gamma aptamer. The step-by-step fabrication of the aptasensor and the response to interferon-gamma detection was evaluated by electrochemical impedance spectroscopy (EIS). The proposed electrochemical aptasensor obtained a detection limit of 0.151 pg/mL and a linear range of 10 – 55 pg/mL. The aptasensor demonstrated good selectivity to interferon-gamma in the presence of interference-causing substances and displayed good stability. When tested in real sample, the aptasensor obtained a good recovery range of 98 – 105%, indicating its ability for use in infectious disease monitoring.

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Keynote 7

Electrochemical Sensors for Dopamine at Screen-print, Gold and Glassy-carbon Modified Electrodes

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Keywords: 6th International Symposium on Electrochemistry, Abstract, Conference.

Dopamine (3, 4-dihydroxy phenethylamine) an organic chemical of the catecholamine neurotransmitters is the most researched because of its major role in the human body such as in hormonal, renal, central, cardiovascular systems, and human metabolism. Metal oxides nanoparticles and selected conducting polymers SPEEK and PANI were coated on different electrodes for the electrochemical detection of dopamine (DA).

At SPCE- Fe_3O_4/SPEEK electrodes, the limit of detection for dopamine DA concentration using square wave voltammetry yielded 7.1 μM which competes well with other electrodes reported in the literature and a sensitivity value of 0.005 μA/μM. The sensor was selective, sensitive, and successfully applied in the analysis of DA in the real sample with good resultant recovery percentage.

The drop casting method was used for the fabrication of gold modified electrode of sulfonated polyether ether ketone/zinc oxide (SPEEK/ZnO) nanocomposite for the electrochemical oxidation of dopamine. The result obtained at Au/SPEEK/ZnO modified electrodes was compared with those obtained at the bare Au and Au/SPEEK nanocomposite modified electrodes. The ZnO nanoparticles increased the electroactivity of SPEEK towards dopamine oxidation. Satisfactory stability result was recorded for the Au/SPEEK/ZnO modified electrode when stored at room temperature for several days.

The electrochemical response of dopamine on a glassy-carbon-modified electrode was determined using differential pulse voltammetry (DPV) at physiological pH 7.0. The dynamic range for the dopamine determination was from 2.0×10^{-5} to 2.4×10^{-6} M with detection limits 0.153×10^{-7}, 0.166×10^{-7}, and 0.176×10^{-7} M for GCE/PANI-NiO, GCE/PANI-ZnO, and GCE/PANI-Fe_3O_4 sensors, respectively. The LOD value reveals that the best electrode is GCE/PANI-NiO. The common interfering species such as ascorbic acid and serotonin do not interfere over this range of concentrations which shows the selectivity of the proposed sensors. The prepared electrode exhibited satisfactory stability when stored at ambient conditions.

Keynote 8

From Microporous Polymer Materials to Ionic Diode Desalination

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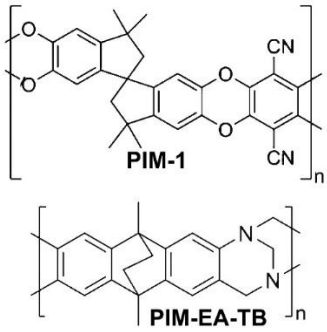
Keywords: Micropores; Polymers; Ionic Diode; Voltammetry; Electroosmosis; Desalination.

Polymers of intrinsic microporosity (or PIMs) are highly processable and readily applied to electrode or as membranes. Two prototypical PIMs are PIM-1 [1] and PIM-EA-TB [2] (see Figure). Both possess rigid molecular backbones and pack into porous solid films with high surface area and with typically 1 nm pore size [3]



PIMs have found their way into electrochemical applications in energy devices [3] and in sensors [4], but also provide fertile ground for fundamental study on ion transport and electroosmotic water transport. The intrinsic microporosity leads to binding and transport with size selectivity and chemical selectivity. Recent studies suggest that PIM-EA-TB allows electroosmotic drag coefficients of several thousand water molecules per mobile anion depending on the state of protonation [5]

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Oral 31

Photoelectrocatalytic degradation of diclofenac sodium at a Ag-$BiVO_4$/BiOI anode and Ag-BiOI cathode dual system

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Keywords: Photoelectrocatalytic degradation; p-n heterojunction; water treatment; bismuth vanadate anode; bismuth oxyiodide cathode

The challenges of water treatment, owing to high pollution load and the presence of recalcitrant pollutants necessitate the development of complementary/alternative methods. Photoelectrocatalysis (PEC), an electrochemical approach to advanced oxidation process, has shown promising results in the degradation of organic pollutants in water [1-3]. Current research in PEC is geared towards improving performance, cost and application in real wastewater conditions. We report the photoelectrocatalytic removal of diclofenac sodium from water using a reactor consisting of Ag-$BiVO_4$/BiOI anode and Ag-BiOI cathode [4]. The electrodes were prepared through electrodeposition on FTO glass and modified with Ag nanoparticles through photodeposition. The structural and morphological studies were carried out using XRD, SEM, and EDS which confirmed the successful preparation of the materials. The optical properties as observed with UV-DRS revealed that the electrodes were visible light active and the incorporation of metallic Ag particles on the surface increased the absorption in the visible light region. The p-n heterojunction photoanode decreased the spontaneous recombination of photoexcited electron-hole pairs. The results from PEC degradation experiments revealed that replacing platinum sheet with Ag-BiOI as counter electrode resulted in higher (92%) and faster removal of diclofenac sodium as evident in the values of apparent rate constants. The prepared electrodes showed good stability and impressive reusability. Thus, we designed a lower cost and more efficient dual photoelectrode system by replacing Pt cathode with a cheaper Ag-BiOI photocathode.

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Invited Oral 32
Application of the nanomaterials in freshwater and wastewater quality monitoring and treatment

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Keywords: (bio)sensors; (bio)adsorbents; sonoelectrochemical oxidation, piezophotacatalysis, disinfection, heavy metals.

It is essential to ensure that the quality of fresh water and wastewater is monitored and treated for mitigating inorganic, organic pollutants as well as disinfection to prevent them from harming humans. This research is set on the premise of developing newer, efficient, and sustainable fresh water and wastewater quality monitoring and treatment methods to complement the existing systems. For water quality monitoring of heavy metals such selenium(III) and cadmium (II), electrochemical (bio)sensors modified with nanomaterials such as nitrogen-doped graphene (NG), carbon nanofibers, carbon black and gold nanoparticles were applied. They had low detection limits from 0.092- to 1.44 ppb for selenium(III) and cadmium (II).

For water treatment, above 90% of cadmium(II) was successfully removed by adsorption using the carbon nanodots coated of PES. In addition, a degradation efficiency of 86.16% (in simulated wastewater), total organic carbon (TOC) removal efficiency of 63.16% (in simulated wastewater) and 41.47% (in actual wastewater) were obtained upon applying FTO/$BaZr_{(0.1)}Ti_{(0.9)}O_3$ electrode for sonoelectrochemical (SEC) oxidation of sulfamethoxazole. Finally, under both ultrasonic vibration and UV light exposure (piezocatalysis), FTO/BTO/AgNPs degraded about 72 % and 98 % of CIP and MB from wastewater, respectively using piezoelectric thin-films. SnO_2 loaded fluorine-doped tin oxide/barium titanate (FTO/BTO) thin film for piezo-photocatalytic degradation of methyl orange (MO), methylene blue (MB) and ciprofloxacin (CIP), as well as for the removal of gram-negative *E. coli* and gram-positive *S. aureus* bacteria from water.

Therefore, water quality monitoring and treatment is essential in developing analytical protocols through the application of nanomaterials to enhance the existing wastewater treatment methods.

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Oral 33
Coupling piezo-polarization effect on Ti/$BaZrTiO_3$ anode with sonoelectro-Fenton oxidation for the removal of aspirin in wastewater.

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Keywords: Barium titanate; sonolysis; sonoelectrochemical degradation; scavenger study; ciprofloxacin.

We hereby present the sonoelectro-Fenton oxidation (SEF) of aspirin in wastewater on Ti/BZT anode and carbon felt cathode. Piezo-polarization effect possessing $BaZrTiO_3$ (BZT) was synthesized and its structural, morphological properties and crystal orientation were examined using XRD, HRTEM, FESEM, EDS and SAED. The synthesized $BaZrTiO_3$ was immobilized on titanium sheet (Ti) to obtain Ti/BZT anode. The anode was electrochemically characterized using electrochemical impedance spectroscopy while chronoamperometry technique was applied to find out the extent of activation of the piezo-polarization effect of the Ti/BZT anode in the presence of ultrasound irradiation. Applying the prepared anode for SEF oxidation for the removal of aspirin in water, an impressive degradation efficiency of 96.36% was obtained at optimum operating conditions of 60 W ultrasound power and 10 $mAcm^{-1}$ applied current density for 120 min. Simultaneous oxidation at the surfaces of both piezo-polarizable Ti/BZT anode and carbon felt cathode also contributed to this performance. In addition, the presence of ultrasound irradiation in the reactor contributed immensely to the performance of the electrodes and the technique by continuously cleaning the electrode surfaces and improving the rate of electro-regeneration of Fenton reagent (Fe^{2+}) on the cathode. The synergy developed during SEF technique, which stems from the in situ oxidative action occurring at the surfaces of both electrodes positions SEF oxidation technique as a reliable method for the treatment of organics polluted water.

Keynote 9
Electrochemical impedance spectroscopy in the investigation of materials characterization and kinetics

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Electrochemical sensors are sensitive and selective analytical tools, that have been established unequivocally for the evaluation and monitoring of analyte species in the environment, in food, in water and the health industry. Her trending research focuses on the integration of these sensors with microelectromechanical support towards the development of current tools for real time, real world deployment. The primary focus of the SARChI chair in Analytical Systems and Processes for Priority and Emerging Contaminants (ASPPEC) is the integrated application of analytical tools and technology to develop early warning systems for trace-level detection and quantification of critical contaminants. These systems are primarily electrochemically driven, but draw on a wide range of supporting analytical techniques and energy sources for feasible outcomes.

The application of frequency modulated electrochemical techniques, notably electrochemical impedance spectroscopy (EIS) to the design and evaluation of electrochemical smart materials. The frequency modulations remains a very effective way to separate Faradaic processes from non homogeneic surface phenomena. EIS technology has been applied to the characterisation of organic and inorganic materials according to their equilibrium electrical properties. These materials include polymeric hydrogels, novel polymer composites that have been applied in the design of immunosensors, biosensors and chemical sensors and many more. In this work we will highlight the application of EIS to the characterisation of semiconductive polymers as an encapsulating matrix for perovskite materials as opposed to the application of EIS for the elucidation of electrochemical mechanisms involved in catalytic and impeding electrochemical transduction.