ECS Canada Section Spring Meeting 2021

EVENT PROGRAM

Winnipeg, Manitoba

Saturday, May 15th 2021

a division of Harvard Bioscience, Inc.

SCHEDULE

All times indicated in central time

9:30 AM	Conference Opens
9:50 AM	Introductory Comments
10:00 AM	**Keynote** Dr Wolfgang Schuhmann Ruhr-University Bochum
11:00 AM	**Break**
11:15 AM	Dr Maria DeRosa Carleton University
11:45 AM	Dr Philippe Dauphin-Ducharme Université de Sherbrooke
12:15 PM	**Breakout Rooms** with Drs DeRosa and Dauphin-Ducharme
12:30 PM	**Lunch Break/ECS Canada Section Business Meeting**
1:30 PM	Dr Shelley Minteer University of Utah
2:00 PM	Dr Sanela Martic Trent University
2:30 PM	**Breakout Rooms with Drs Minteer and Martic**
2:45 PM	David Herbert University of Manitoba
3:15 PM	Leanne Chen University of Guelph
3:45 PM	**Breakout Rooms with Drs Herbert and Chen**
4:00 PM	Young Investigator Forum

KEYNOTE

Bioelectrochemistry and Electrocatalysis – Distinction without much difference

Wolfgang Schuhmann

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In the framework of the symposiums title “Electrochemistry for a Sustainable and Healthier Future” bioelectrochemical applications in diagnosis as well as sustainable methods for energy conversion are of high importance. Evidently, we can learn from nature how enzymes are catalyzing complex reactions using abundant metals in their active sites in physiological conditions at neutral pH value. In this presentation a journey is made from enzymatic catalysis for hydrogen oxidation, nitrogen fixation and CO2 reduction to inorganic “nanozymes” for the oxygen reduction and CO2-reduction to single entity electrochemistry of individual catalyst particles immobilized on nanoelectrodes.

Acknowledgement. I am grateful to all coworkers and cooperation partners for their input in the research I am allowed to present as well as to a variety of funding agencies including the DFG (German Science Foundation), the BMBF and the ERC.

INVITED SPEAKERS

Aptamers in the central nervous system: Dopamine and Alpha-Synuclein

Erin M. McConnell[1], Katelyn Ventura[2], Joshua Callahan[1], Spencer Boisjoli[1], Matthew R. Holahan[2], ***Maria C. DeRosa[1]***

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Aptamers are single-stranded, synthetic oligonucleotides that fold into 3-dimensional shapes capable of binding non-covalently with high affinity and specificity to a target molecule. The compatibility of short nucleic acids with established platforms, such as electrochemistry or fluorescence systems, serves both to facilitate a better understanding of aptamer-target binding and translate that binding ability into useful sensors. The central nervous system is a particularly challenging domain for aptamer applications due to a number of physical constraints including the blood brain barrier. Nevertheless, given the limited treatment strategies for CNS disorders and the growing burden of neurological and neurodegenerative diseases, developing aptamer systems for diagnostics and treatments continues to be of interest. This presentation will describe two aptamer systems that are relevant to the CNS and are under investigation in our laboratory. In vivo studies on the delivery and impact of the dopamine aptamer will be discussed. In this work, liposomal delivery systems were investigated for the delivery of the dopamine aptamer in a mouse model of cocaine-induced hyperlocomotion. Furthermore, the selection of DNA aptamers that prevent the fibrilization of alpha-synuclein monomer in vitro will also be described. A modification to the traditional SELEX method facilitated the selection of aptamer candidates that interfered with alpha-synuclein aggregation. Electrochemical characterization of target binding will be discussed. Furthermore, aptamers were identified that had a marked effect on the aggregation of alpha-synuclein monomer in vitro and in vivo. Applications for the study of Parkinson's disease will be elaborated.

Molecular Monitoring using Electrochemical Aptamer-based Biosensors

Philippe Dauphin Ducharme

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Achieving real-time, continuous monitoring of a large class of short-lived molecular species directly in the body would represent a significant advancement toward understanding pharmacology and our brain functions. At the moment, only two commercialized platforms can afford real-time and continuous molecular measurements in the body: the glucometer and the pulse oximeter which monitor glucose and oxygen, respectively. Fast-scan cyclic voltammetry represents another alternative toward monitoring neurotransmitters but has mainly focused on monitoring monoamines like dopamine. As a result, these approaches significantly restrict what we can measure continuously in the body and our understanding of the brain machinery.

In response, we are developing electrochemical aptamer-based (E-AB) sensors, a modular and convenient mean of monitoring molecules continuously in complex matrices and in the body. These sensors are comprised of a redox-reporter-modified and electrode-bound aptamer "probe" that upon target-binding alters the kinetics with which electrons exchange to/from the redox reporter producing an easily measured change in current when the sensor is interrogated using square-wave voltammetry. Although highly sensitive, unfortunately, this technique can only produce voltammograms every 10s of seconds, significantly limiting our temporal resolution in measuring short-lived molecular targets.

In response, we have developed electrochemical phase interrogation [1]. This technique uses repetitive short alternating potential pulses of specific frequencies that are sensitive to changes in electron transfer properties incurred by a surface-attached redox reporter. Such interrogation approach allows for selective monitoring of binding-induced changes in electron transfer affording unprecedented sub-second-resolved molecular measurements (i.e., 1 point every ~300 ms) in this class of sensors. I will show that electrochemical phase interrogation can enable for such measurements when E-AB sensors are deployed for long periods directly in undiluted complex matrices or in the body. Electrochemical phase interrogation likewise provides mechanistic information on the signaling mechanism and overall stability of this class of sensors in such environments. We envision that these advancements will further help E-AB sensors translate as new analytical tools for personalized medicine to improve our understanding of neuropharmacology and drug metabolism.

[1] Downs, A. M., Gerson, J., Ploense, K. L., Plaxco, K. W., Dauphin-Ducharme, P. Anal. Chem. 2020 92, 14063-14068.

Enzymatic Bioelectrocatalysis for Green Electrosynthesis

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In the last 5 years, there have been extensive studies and new materials designed for interfacing biocatalysts with electrode surfaces. This talk will discuss electroanalytical techniques for studying biocatalysis, including both mediated bioelectrocatalysis and direct bioelectrocatalysis. The talk will discuss electrode materials innovation for interfacing complex proteins with electrode surfaces as well as using them for sustainable electrosynthesis of ammonia as well as other value-added products (i.e. chiral amines, chiral amino acids, polymers, etc.). This talk will discuss strategies for cofactor regeneration. Finally, this talk will discuss the use of synthetic biology for microbial bioelectrosynthesis of ammonia and other value-added products.

Bioelectrochemistry of a neuronal protein tau

Sanela Martic

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Tau is a neuronal protein and one of the biomarkers of neurodegenerative diseases, such as Alzheimer's disease. Tau protein undergoes post-translational modifications, aggregation, and is a viable drug target. In addition, this protein is a vital biomarker in biological fluids towards early detection of neurodegenerative diseases. We reported on using electrochemical impedance spectroscopy and cyclic voltammetry for detection of protein-protein interactions (1), protein-ligand interactions (2), enzymatic catalysis and enzyme inhibition (3) while focusing on tau protein and its biochemistry. For example, tau-tau, tau-ferritin, tau-transferrin protein interactions were monitored, and protein kinase-catalyzed phosphorylation of tau protein was detected. The phosphorylation inhibitors, such as antibodies, were screened for their efficacies. Bioelectrochemical methodologies were used to gain insight into various facets of protein biochemistry, and represent promising tools in neuroscience research.

References

1. A) Carlin, N., Martic-Milne, S. (2018). Anti-tau antibodies based electrochemical sensor for detection of tau protein. J. Electrochem. Soc.165: G3018-G3025. B) Jahshan, A., Esteves, J.O.V., Martic-Milne, S. (2016). Evaluation of ferritin and transferrin binding to tau protein. J. Inorg. Biochem. 162: 127-134. C) Esteves, J.O.V., Trzeciakiewicz, H., Loeffler, D.A., Martic, S. (2015). Effects of tau domain-specific antibodies and intravenous immunoglobulin on tau aggregation and aggregate degradation. Biochemistry. 54: 15-18.
2. Trzeciakiewicz, H., Esteves, J.O.V., Carlin, N., Martic, S. (2015). Electrochemistry of heparin binding to tau protein on Au surfaces. Electrochim. Acta. 162: 24-30,
3. Esteves, J.O.V., Martic-Milne, S. (2016). Electrochemical detection of anti-tau antibodies binding to tau protein and inhibition of GSK-3-β-catalyzed phosphorylation. Anal. Biochem. 496: 55-62

Direct Electrochemical Hydrogenation of C=N and C=O Bonds in Acidic Solution

David Herbert

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The direct electrochemical hydrogenation of unsaturated organic compounds is an appealing route to increasing the sustainability of this important reaction by replacing petroleum-derived H_2 gas with renewable Bronsted acids and introducing mechanisms for using non-fossil fuel sources of electrical energy. As part of our broader program studying benzannulated N-heterocycles, we identified conditions for the direct, electrochemical hydrogenation of C=N and C=O using carbon working electrodes, with excellent selectivity. This talk will report these findings in the context of CO_2-to-fuel reactions and the production of value-added organic compounds.

First-Principles Simulations of Ni-based Materials for Electrochemical Ammonia Oxidation

Leanne Chen

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Coupling renewably generated electricity with waste chemicals to generate value-added products has potentially transformative benefits for society by curbing chemical emissions and mitigating climate change. One such waste chemical is excess ammonia from agricultural livestock production, which depletes nitrogen from the soil and has harmful health effects on human and aquatic life. Ammonia can be partially converted electrochemically to nitrate, and this mixture of ammonium nitrate can then be re-introduced into the nitrogen cycle as fertilizer. In contrast to the reverse process nitrogen reduction, the mechanism of ammonia oxidation and in particular the formation of NO_x species is comparatively less explored. In this talk, I will describe our recent efforts to map the reaction mechanism of electrochemical ammonia oxidation to dinitrogen, nitrite, and nitrate on oxidized Ni surfaces and discuss possible ways to direct selectivity toward oxygenated products using periodic density functional theory.

YOUNG INVESTIGATOR FORUM

Session I

Start time	Speaker	Title
4:00 pm	Brandon Lemelin-Donnelly *Université Laval*	*A road map to studying direct interspecies electron transfer (DIET) in microfluidic bioelectrochemical systems*
4:15 pm	Jonathan Spada *McGill University*	*Nickel and Molybdenum Based Thin Films Deposited on Multi-Walled Carbon Nanotubes as Electrocatalysts for Hydrogen Evolution Reaction*
4:30 pm	Tanner George *Saint Mary's University*	*A Multidisciplinary Approach to Understanding the Structure and Electrochemistry of Precursors Behind the Direct Electrodeposition of MoS_2 – A Critical Analysis of a Literature Preparation*
4:45 pm	At Nguyen *University of Manitoba*	*Design battery electrode matrices from conducting polymer composites*
5:00 pm	Mariam Odetallah *University of Manitoba*	*Measuring the effect of different parameters on the electrochemical conductivity for composite electrodes*

Session II

Start time	Speaker	Title
4:00 pm	Tianxiao Ma *University of British Columbia*	*On the investigation of the influence of local packing density and underlying surface crystallography on the stability of thiolated DNA SAMs*
4:15 pm	Vikram Singh *University of Manitoba*	*Electrochemical Characterization and Detection of Antibiotic Compounds at the Modified Working Electrode*
4:30 pm	Linlin Liu *Université Laval*	*Towards studies on electroactive bacterial biofilms using spectroelectrochemistry*
4:45 pm	Nastaran Khodaparastasgarabad *Université Laval*	*Microfluidic bioelectrochemical flow cell with wall tube electrode configurationfor studies of biocatalysis*
5:00 pm	Lingling Gong *Université Laval*	*Computer simulations of acetate concentration profile near electroactive biofilms under two different microflow modes.*

Session III

Start time	Speaker	Title
4:00 pm	Mike McKague *University of Waterloo*	*Helmholtz EDL Theory Applied to Pore Network Modelling of Electro-Driven Water Desalination*
4:15 pm	Stephanie Gao *Trent University*	*Electrochemical oxidation of phenolic analogues towards C-C bond formation*
4:30 pm	Tyra Lewis *Trent University*	*Differential Reactivity of Quercetin with Molecular Oxygen and Electrochemically Generated Superoxide Anion Radical*
4:45 pm	Ruby Aslam *Aligarh Muslim University*	*Inhibitory influence of L-Valine methyl ester saccharinate on the dissolution rate of mild steel in 5% HCl solution*