

An aerial photograph of Montreal, Quebec, Canada, showing the city skyline, a large Ferris wheel, and a river. The text is overlaid on the image.

**9<sup>th</sup> ECS Montréal**  
**Student Symposium**

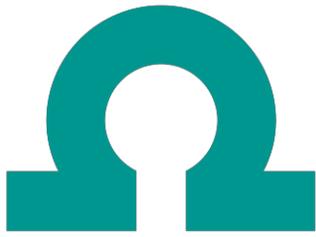
**Program**

Université du Québec à Montréal

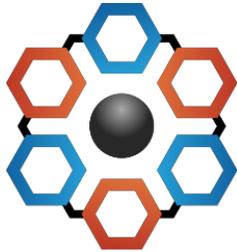
May 10<sup>th</sup> 2019



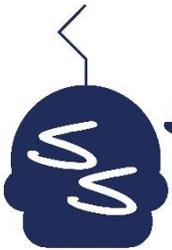
Montreal  
Student Chapter



Metrohm



SFR



SnowHouse  
Solutions



PGSS



BioLogic  
Science Instruments



Gamble  
Technologies



PINE  
research

NanoQAM



McGill  
UNIVERSITY



COMF  
QCAM

UQÀM



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

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**8:00 - 9:00 REGISTRATION**

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**9:00 - 9:10 INTRODUCTORY REMARKS**

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9:10 - 9:30

**Lisa Stephens (McGill University)**

*Image processing techniques in scanning electrochemical microscopy: proof of concept and software development*

9:30 - 9:50

**Danny Chhin (Université du Québec à Montréal)**

*Functionalization of Conducting Polymer Materials Using Bifunctional Copolymers as Dopants*

9:50 - 10:10

**David Polcari (Systems for Research)**

*New Tools for Advanced Surface Characterization*

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**10:10 - 10:30 COFFEE BREAK**

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**10:30 - 11:30**

**Prof. Nikolay Kornienko (Université de Montréal)**

*Dynamic Electrocatalysis in Three Dimensions.*

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**11:30 - 12:15 POSTER – 180 second PRESENTATION**

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**12:15 - 13:30 LUNCH BREAK AND POSTER SESSION**

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**13:30 - 14:30**

**Prof. Gerald S. Frankel (Ohio State University)**

*A New Paradigm for Designing Corrosion Resistant Materials*

14:30 - 14:50

**Olivier Rynne (Université de Montréal)**

*Planning and Analyzing a Design of Experiments for a complex mixture study – Application for composite electrode formulation*

14:50 - 15:10

**Mojgan Hatami (Université du Québec à Montréal)**

*Square Wave Anodic Stripping Voltammetry for Detection of Mn<sup>2+</sup> in Li-ion Battery Environments*

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**15:10 - 15:30 COFFEE BREAK AND POSTER SESSION CONT'D**

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15:30 - 15:50

**Laila Benameur (Quebec Scientific Entrepreneurship)**

15:50 - 16:10

**Abraham Gomez Vidales (McGill University)**

*The influence of addition of iridium-oxide to nickel-molybdenum-oxide electrodes for energy storage applications*

16:10 - 16:30

**Fadwa Ben Amara (Université de Montréal)**

*Potential-Induced Reorganization of Redox-Active Self-Assembled Monolayers in the Presence of Anionic Surfactant*

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**16:30-17:30 POSTER SESSION**

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**17:30 PRIZES AND CONCLUSION**

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## On the ECS Montreal Student Chapter

The mission of the Electrochemical Society (ECS) is to encourage research, discussion, critical assessment, and dissemination of knowledge in the field of electrochemistry. This parent organization allows us to form local student chapters, which receive funding to organize events such as student symposiums. The ECS Montreal student chapter was founded in 2010 by a group of graduate students at Université du Québec à Montréal, and has since then grown to include students from all over Quebec and the greater area (McGill University, Université de Montréal, Université Laval, École Polytechnique de Montréal, Université de Sherbrooke, Institut National de la Recherche Scientifique, University of Ottawa, Clarkson University). Last year, over 100 attendees were involved in our symposium, including both undergraduate and graduate students from chemistry and electrochemical engineering.

The ECS Montreal Student Chapter is hosting its 9<sup>th</sup> annual student symposium this year, giving students the opportunity to present their work in a stimulating and friendly environment.



### Chapter officers

President: **Jeremy Dawkins** (McGill University)  
Vice-President: **Siba Moussa** (McGill University)  
Secretary: **Islam Asselah** (UQAM)  
VP Communications: **Taylor Hope** (UQAM)  
Treasurer: **Laurence Savignac** (UQAM)  
Faculty Advisor: **Steen Schougaard** (UQAM)

# **Keynote Presentation Abstracts**

## Dynamic Electrocatalysis in Three Dimensions

**Prof. Nikolay Kornienko**

Department of Chemistry Université de Montréal

[nikolay.kornienko@umontreal.ca](mailto:nikolay.kornienko@umontreal.ca) or <https://sites.google.com/site/catalysisandenergy/>

From nature's enzymes to synthetic metal-organic frameworks (MOFs), three-dimensional catalysts possess key inherent attributes that enable them to function in a manner not feasible in non-porous materials. For example, enzyme catalytic pockets feature not only binding sites, but also amino acid residues that stabilize high-energy intermediates through hydrogen bonding or electrostatics. Local hydrophobicity modulates reorganization energies and an adaptable structure responds to stimuli. Porous amorphous catalysts similarly feature structural rearrangement to yield a catalytically active state upon the application of a voltage, though they lack a well-defined hierarchical structure.

The chemical tunability and three-dimensional structure of MOFs has drawn great interest in designing functional materials with predetermined, precisely controlled pore dimensions and chemistry. In the context of electrochemistry, MOFs have been used as supercapacitors, battery electrodes, and catalysts for fuel cells and fuel forming reactions. MOFs here are especially advantageous as their inherent porosity and high density of catalytically active sites is beneficial for electrocatalysis.

In this talk, I discuss how my PhD training in heterogeneous electrocatalysis and postdoctoral experience in biological systems has sculpted my independent research program at the University of Montreal which aims to combine the best of both worlds in electrocatalyst design. I will demonstrate how MOF-based materials are applied as electrocatalysts for the conversion of CO<sub>2</sub> to useful fuels and chemicals. In addition, I detail how *in-situ* spectroscopy on these MOFs elucidates their dynamics throughout the course of reaction and the mechanism of their catalytic cycle.

## A New Paradigm for Designing Corrosion Resistant Materials

**Prof. Gerald S. Frankel**

Department of Chemistry Ohio State University

[frankel.10@osu.edu](mailto:frankel.10@osu.edu) or <https://fcc.engineering.osu.edu/>

Corrosion, the environmental degradation of materials, is a complex process that depends on details of the material and the environment. Metals, glasses and ceramics all undergo corrosion processes, and predicting the degradation of all three of these material classes is important for the design of a mined geologic nuclear waste repository that should prevent the release of dangerous radionuclides for a performance period of  $>10^5$  y. Decades of study of corrosion processes have led to considerable fundamental understanding of various effects of the environment and material structure and composition. However, the design process of new materials for corrosion resistance has been largely trial and error. This talk will present an Integrated Computational Materials Engineering (ICME) approach to the design of corrosion-resistant metal alloys, glasses and ceramics as part of a DoE Energy Frontier Research Center (EFRC). Some results from the glass and ceramics thrusts will be reviewed, and then efforts to design corrosion resistant high entropy alloys will be presented. Finally, a new unifying framework for the stabilization of corrosion pits in metals will be described, including a new model for critical pitting temperature and potential.

# **Oral Presentations Abstracts**

## Potential-Induced Reorganization of Redox-Active Self-Assembled Monolayers in the Presence of Anionic Surfactants

Fadwa Ben Amara<sup>1</sup>, Kaiyang Tu<sup>2</sup>, Yanqi Feng<sup>1</sup>, Ian Burgess<sup>2</sup> and Antonella Badia\*<sup>1</sup>

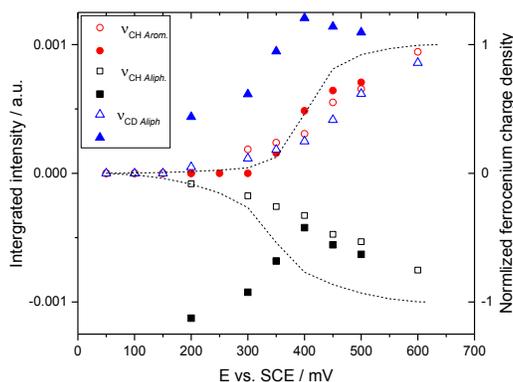
<sup>1</sup>Département de chimie, Université de Montréal

<sup>2</sup> Department of Chemistry, University of Saskatchewan

[antonella.badia@umontreal.ca](mailto:antonella.badia@umontreal.ca)

An odd-even effect has been observed in the apparent redox potential of self-assembled monolayers (SAMs) of ferrocenylalkanethiolates ( $\text{Fc}(\text{CH}_2)_n\text{S}$ ) chemisorbed to gold in the presence of inorganic electrolytes[1]. Recently, we noticed that this effect is reversed with the use of anionic surfactants. This project aims to uncover the origin of this inversion by investigating the reorganization of the SAMs during potential sweeps between the reduced and oxidized states when dodecyl sulfate versus perchlorate are used as the electrolyte anion. The technique used for this purpose is *in-situ* attenuated total reflection - Surface-enhanced infrared absorption spectroscopy (ATR-SEIRAS), that have been previously used to document the redox-induced structural changes occurring in ferrocene-terminated SAMs[2].

Preliminary results show an irreversible reorientation of the alkyl chains, as well as an increase in surfactant adsorption with the number of cycles.



**Fig. 1.** Normalized ferrocenium charge density (dashed line) and integrated intensities of  $V_{\text{CH Arom}}$ ,  $V_{\text{CH Aliph}}$  and  $V_{\text{CD Aliph}}$  during anodic (open symbols) and cathodic (full symbols) potential scans. The electrolyte is deuterated sodium dodecyl sulfate.

### References

1. Feng, Y., et al., *Odd-Even Effects in Electroactive Self-Assembled Monolayers Investigated by Electrochemical Surface Plasmon Resonance and Impedance Spectroscopy*. The Journal of Physical Chemistry C, 2017. **121**(44): p. 24626-24640.
2. Rudnev, A.V., et al., *Ferrocene-terminated alkanethiol self-assembled monolayers: An electrochemical and in situ surface-enhanced infra-red absorption spectroscopy study*. Electrochimica Acta, 2013. **107**: p. 33-44.

## Functionalization of Conducting Polymer Materials Using Bifunctional Copolymers as Dopants.

**Danny Chhin**, Laura Padilla-Sampson, Jason Malenfant, Vincent Rigaud, Ali Nazemi,\* Steen B. Schougaard\*

<sup>a</sup> *NanoQAM and Department of Chemistry, Université du Québec à Montréal, 2101 Jeanne-Mance, Montreal, Quebec (Canada)*

We propose a simple yet very versatile method to functionalize conducting polymers by the use of a bifunctional copolymer that can act as a redox-active dopant. As a model system, a copolymer comprised of 4-vinylcatechol and styrenesulfonic acid moieties were used as both the electrolyte and the dopant for PEDOT electropolymerization. The composite polymer shows promising improvement in capacity compared to PEDOT:PSS (52 mAh g<sup>-1</sup> vs 18 mAh g<sup>-1</sup>) which originates from the Catechol faradic reaction. These results indicate that both the redox and ionic moieties are active, proving the working concept of the bifunctional copolymer as a redox-active dopant. The effectiveness of bifunctional copolymer was further investigated through an increase in the ratio of 4-vinylcatechol. The presence of non-ionic moieties actively interferes with the copolymer doping ability by preventing PEDOT from adopting a planar conformation favorable to bipolaron conduction. The bifunctional dopant effect on PEDOT structure and properties is clearly expressed through UV-Vis and film morphology, giving us insight into the doping process.

## Planning and Analyzing a Design of Experiments for a complex mixture study – Application for composite electrode formulation

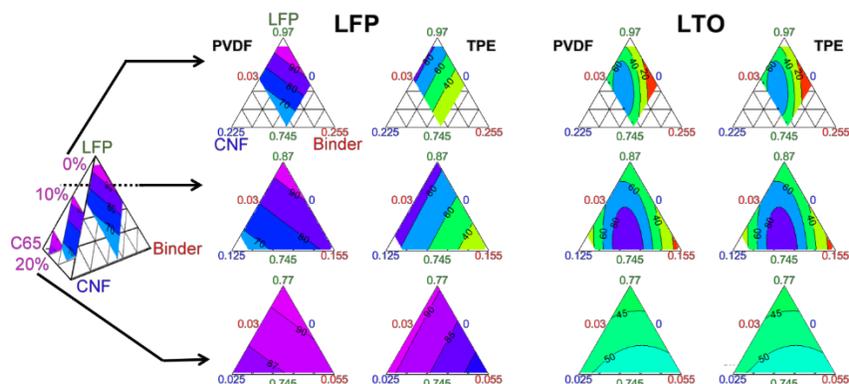
**Olivier Rynne**,<sup>a</sup> Matthieu Dubarry,<sup>b</sup> Corentin Molson,<sup>c</sup> David Lepage,<sup>a</sup> David Aymé-Perrot,<sup>d</sup> Arnaud Prébé,<sup>e</sup> Dominic Rochefort,<sup>a</sup> Mickaël Dollé<sup>a</sup>

<sup>a</sup> Université de Montréal, <sup>b</sup>University of Hawaii, Hawaii Natural Energy Institute, <sup>c</sup>Pierre and Marie Curie University, <sup>d</sup>Total, <sup>e</sup>Hutchinson SA  
[olivier.rynne@umontreal.ca](mailto:olivier.rynne@umontreal.ca), [mickael.dolle@umontreal.ca](mailto:mickael.dolle@umontreal.ca)

The research in the field of Li-ion batteries is stronger than ever, with a common aim of increasing the energy and power density. More and more studies pinpoint the limitation of power-related performance for Li-ion batteries to the microstructure of each electrode. This random arrangement of the active material and carbon filling particles bound by the binder is typically characterized through physical values such as tortuosity, porosity and MacMullin Number.

To investigate the relationship between microstructure and performance in details, we used a Design of Experiments to evaluate close to seventy different formulations with LiFePO<sub>4</sub> and Li<sub>4</sub>Ti<sub>5</sub>O<sub>12</sub> as the active materials (AM), carbon black (CB) and carbon nanofibers (CNF) as the conductive fillers, and two different binders: polyvinylidene fluoride and a thermoplastic elastomer. By keeping the loading and porosity constant throughout the study, all formulations are homogeneously dispersed in a regular tetrahedron of coordinates (AM, CB, CNF, Binder). First, the microstructure was characterized in order to extract data related to the tortuosity, porosity and electrical conductivity. Then, galvanostatic measurements, in charge and discharge, from C/25 to 30C allowed to gather information such as the low- and high-rate capacity, energy and power and the Peukert constant for intermediate rates. The statistical analysis of all these results showed some clear correlations between the formulation and the microstructure and performance of the cells. Thus, it was made possible to draw the optimal formulation to get the best compromise depending on the application requirements (energy, rate or power). Finally, trends between the physical properties and performance were deciphered. This could be used to fine-tune the best possible electrode.

This presentation will detail the methodology of Design of Experiments applied to Li-ion battery electrodes' formulation and give some key results.



## Square Wave Anodic Stripping Voltammetry for Detection of $Mn^{2+}$ in Li-ion Battery Environments

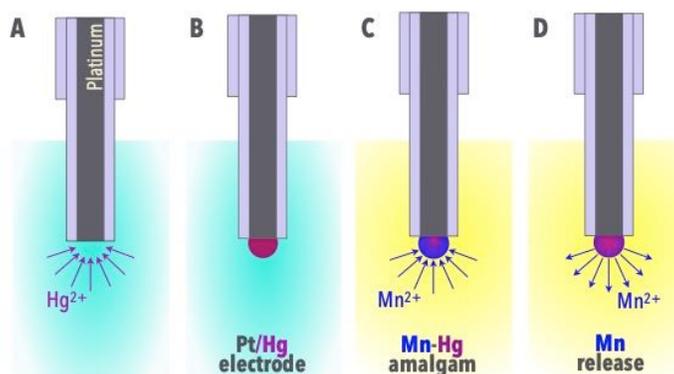
**Moigan Hatami**,<sup>a</sup> David Polcari,<sup>a</sup> Md Sazzad Hossain,<sup>a</sup> Mohammadreza Z. Ghavidel,<sup>a,b</sup> Ion C. Halalay,<sup>c</sup> Janine Mauzeroll,<sup>b</sup> Steen B. Schougaard<sup>a,\*</sup>

<sup>a</sup> NanoQAM and Dep. of Chemistry, Université du Québec à Montréal, Montréal, Québec H3C 3P8, Canada

<sup>b</sup> Laboratory for Electrochemical Reactive Imaging and Detection for Biological Systems, Department of Chemistry, McGill University, 801 Sherbrooke Street West, Montreal, Quebec H3A 0B8, Canada

<sup>c</sup> General Motors Global R&D, Warren, MI 48092-2031, USA

Li-ion batteries (LIB) are one of the most impressive industrial success stories of the last few decades. After an extensive research effort, Li-ion batteries have found widespread use in commercial products. A newer generation of LIB was developed containing manganese, namely manganese oxide batteries (LMO or *spinel*- $Li_xMn_2O_4$ ) and lithium nickel manganese cobalt oxide batteries (NMC). These batteries provide a wide range of advantages, However, batteries containing *spinel*- $LiMn_2O_4$  spinel experience severe capacity fading on charge–discharge cycling and hindered battery performance. In order to solve this problem, it is first necessary to detect  $Mn^{2+}$  ion in the solution of the electrolyte.



To this end, an electrochemical probe was fabricated using electrochemical deposition of a Hg capped onto a 25  $\mu m$  Pt disk microelectrode. The Pt/Hg microelectrode was fully characterized by optical microscopy, cyclic voltammetry, scanning electrochemical microscopy. Using square wave voltammetry to overcome reproducibility issues with classical linear sweep anodic stripping voltammetry,  $Mn^{2+}$  was quantified in non-aqueous solution with a limit of detection of 14  $\mu M$ . Finally, using this detection scheme, the trapping ability of aza-15-crown-5 ether and iminodiacetic acid dilithium was investigated. The results indicate that both compounds effectively trap  $Mn^{2+}$  in non-aqueous solution.

### References:

- 1) Danis, *et al.* Anal.Chem. 2015, 87, 2565-2569.
- 2) Danis, *et al.* Electrochimica Acta. 2015, 162,169-175.
- 3) Etacheri, *et al.* Energy & Environment Science, 2011, 4, 3243-3262.

## The influence of addition of iridium-oxide to nickel-molybdenum-oxide electrodes for energy storage applications

**Abraham Gomez Vidales**, and Sasha Omanovic

<sup>1</sup>[Department of Chemical Engineering, McGill University, Montreal, Quebec]

[abraham.gomezvidales@mail.mcgill.ca](mailto:abraham.gomezvidales@mail.mcgill.ca); [sasha.omanovic@mcgill.ca](mailto:sasha.omanovic@mcgill.ca)

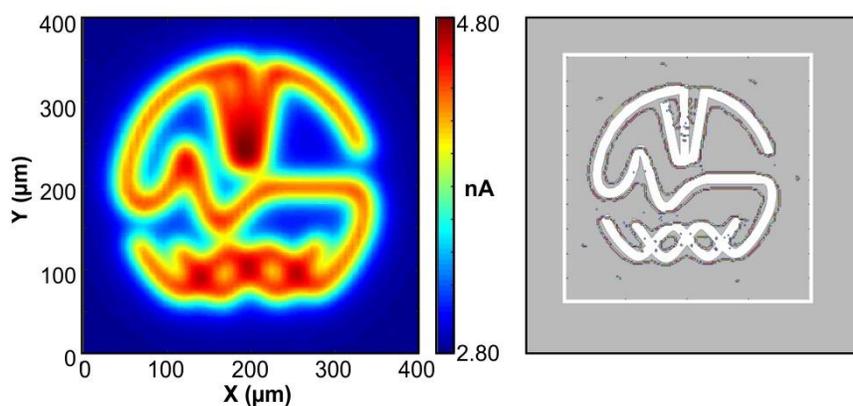
Ni<sub>0.6-x</sub>Mo<sub>0.4-x</sub>Ir<sub>x</sub>-oxide coatings were fabricated with the purpose of investigating the influence of Ir content on their charge storage/delivery capability when used as an electrode for electrochemical supercapacitor and a cathode for hydrogen evolution reaction. Experimental work in alkaline medium confirmed that the amount of Ir in the Ni-Mo-oxide significantly influences the material's charge storage capacity. The highest overall capacitance ( $108 \pm 2 \text{ mF cm}^{-2}$  at  $1 \text{ mA cm}^{-2}$ ) was obtained for the composition containing 40 mol.% of Ir (Ni<sub>0.36</sub>Mo<sub>0.24</sub>Ir<sub>0.4</sub>-oxide). This sample was found to retain ca. 86% of its initial capacitance after 2500 charging/discharging cycles, at  $1 \text{ mA cm}^{-2}$ . In addition, it was found that as the Ir-oxide content increased, the electrocatalytic activity towards hydrogen evolution also increased. This was attributed to the following two effects: the increase in the number of Ir surface sites and to the possible modification of the electronic structure of the material. Long-term electrolysis experiments confirmed high deactivation resistance of the Ni-Mo-Ir-oxide cathodes. It was also demonstrated that it is possible to *in-situ* reactivate the electrodes, making them potentially good cathode candidates for water electrolysis in the acidic medium.

## Image processing techniques in scanning electrochemical microscopy: proof of concept and software development

**Lisa Stephens**<sup>a</sup>, and Janine Mauzeroll<sup>a</sup>

<sup>a</sup>[Department of Chemistry, McGill University, Montreal, Quebec]

Advances in electrochemical instrumentation have made a variety of electrochemical imaging methods under the umbrella of scanning probe microscopy (SECM, SICM, SVET, SECCM, etc.) more accessible than ever before. Quantitative analysis of these images is typically focused on relating the current measured at a single point at to the rate of a process of interest; while useful, this procedure doesn't use much of the information contained in the image. In this presentation, the benefits of applying image processing algorithms to electrochemical images will be discussed. Both simulated and experimental SECM images will be used to demonstrate how methods such as edge detection and binary masking can enhance quantitative analysis of these systems, without requiring any change to the experimental setup. Integration of these procedures into user friendly, open source software will also be discussed.



# Posters titles

**Tao Liu** (UQAM) – *CH<sub>3</sub>NH<sub>3</sub>PbX<sub>3</sub> Perovskite Solar Absorber*

**Yongneng Wu** (Clarkson) – *Poly(ionic liquid) Derived Graphitic Nanoporous Carbon Membrane Enables Superior Supercapacitive Energy Storage*

**Nicolo Rossetti** (Polytechnique) – *Electrochemically Stable and Adherent Conductive Polymers Coatings for High Quality Muscle Signal Recording*

**Mengyang Fan** (INRS) – *SELECTIVE ELECTROREDUCTION OF CO<sub>2</sub> TO FORMATE ON 3D [100] LEAD DENDRITES*

**Yaroslav Filipov** (Clarkson) – *Realization of logic XNOR gate on enzyme-based reaction with optical detection and XNOR gate based electrochemical proteins release system*

**Abraham S. Finny** (Clarkson) – *A 3D Printing Platform for Development of Bioink Based Wearable Sensors*

**Madeline Masi** (Clarkson) – *Electrocatalytically Triggered DNA Release from a pH Switchable Modified Electrode*

**Madhura Bellare** (Clarkson) – *Electrochemical release of His-tagged proteins by destruction of NTA-Cu(II)-protein complex*

**Fariborz Chitsazzadeh** (UQAM) –

**Aswin P. Pitchiya** (Clarkson) – *Ionic Liquid Imbibed Dual-Conducting Graphene-Polyacetylene Nanocomposite Membranes.*

**Romarc Beugré** (UQAM) – *Local electrochemistry of nickel (oxy)hydroxide electrocatalysts prepared using bipolar electrodeposition*