Welcome to the

12th Annual Nano Ontario Conference

Oct 11-12, 2022

Hosted by:

WILFRID LAURIER UNIVERSITY

Senate and Board Chamber

Waterloo, Ontario

Land Acknowledgement

Laurier's Waterloo campus is located on the shared traditional territory of the Neutral, Anishnaabe (Anish-nah-bay) and Haudenosaunee (Hoe-den-no-show-nee) peoples. This land is part of the Dish with One Spoon Treaty between the Haudenosaunee and Anishnaabe peoples and symbolizes the agreement to share, protect our resources and not to engage in conflict.

From the Haldimand Proclamation of Oct. 25, 1784, this territory is described as: “six miles deep from each side of the river (Grand River) beginning at Lake Erie and extending in the proportion to the Head of said river, which them and their posterity are to enjoy forever.” The proclamation was signed by the British with their allies, the Six Nations, after the American Revolution. Despite being the largest reserve demographically in Canada, those nations now reside on less than five per cent of this original territory.

To learn more, please visit:

François Lagugné-Labarthet
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Dear NanoOntario Researchers and Guests,

It has been 12 years now that NanoOntario Inc. has been organizing an annual scientific meeting throughout our province highlighting the excellence of Ontario in nanotechnologies and nanosciences. This year is special since we are going back to the real world of more engaging 'in-person' meetings.

For the 2022 Edition, Wilfrid Laurier University is our host and the conference's theme will be on Entrepreneurship and Innovation. Over the past decade, I have been very impressed by all the young talents originating from the universities across Ontario and those who started their companies and developed innovative products based on nanotechnologies and nanoscience discoveries that they translated to successful commercial products.

One of the missions of NanoOntario is not only to support these talents using our network and expertise in nanoscale science, but also to facilitate the access to our characterization and nanofabrication laboratory located in our universities.

Our connection with granting agencies and with our partners can also be critical to move to the next step and to access collaborative grants or participate the business-to-business meetings in key conferences and workshops.

Nano medicine, energy efficiency, material integrity, quality control, wearables, imaging, consumer products, semiconductive economy are current hot themes that are using nanomaterials and nanotechnologies for the development of innovative products with enhanced properties.

I am striving to attend this 12th edition and meet with you,

François Lagugné-Labarthet

LAURIER
Inspiring Lives.

Department of
Chemistry and Biochemistry
WATERLOO | Brantford | Kitchener | Toronto

Professor Hind Al-Abadleh
halabadleh@wlu.ca

Professor Vladimir Kitaev
vkitaev@wlu.ca

As the conference organizers, we are delighted to welcome each and every one of you to the **12-th Annual Nano Ontario Conference and Exhibition** at Wilfrid Laurier University!

It was really exciting to have so many enthusiastic responses to contribute as keynote speakers, panelists and invited speakers for this great event.

Nanoscience is an exciting field that bridges together not only several branches of chemistry but chemistry as a central science with many others fields.

It will be really nice to see and interact with so many of your in person after the last two years, fingers crossed.

Stay safe and get ready to enjoy the Conference and Exhibition!

Yours truly,

Hind Al-Abadleh and Vladimir Kitaev

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75 University Avenue West, Waterloo
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Jonathan Newman
Vice-President: Research

Dear attendees,

On behalf of my colleagues at Wilfrid Laurier University, I am delighted to welcome you to our Waterloo campus for the 12th annual Nano Ontario Conference and Exhibition. In these pandemic times, it is uplifting to see peers gathering once again. The past couple of years have reinforced for me how important these events are to the research process, enabling us to solicit feedback and new perspectives, and to build community through discourse.

The theme of this year's conference, Entrepreneurship and Innovation in Nano-Enabled Technologies, is of particular interest to me, as I am overseeing the development of Laurier's inaugural innovation and entrepreneurship strategy. It is critical for our academic community to foster innovation and commercialization, and I look forward to hearing the ideas you develop and share during your time here at Laurier.

Enjoy the conference.

Sincerely,
Jonathan

Anthony J. Clarke,
Dean, Faculty of Science,
Wilfrid Laurier University

On behalf of the Faculty of Science at Wilfrid Laurier University, I look forward to welcoming you to the 12th Annual Nano Ontario Conference, being held in person for the first time since 2019.

It is wonderful to be able to gather again in person and for us to provide the venue where ideas may be shared and discussed, which hopefully results in future research collaborations. The Faculty of Science has identified research and application of new ideas as a core pillar of our academic mission. Similar to the theme of this years conference of Entrepreneurship and Innovation, the Faculty of Science continues to look towards integrating Entrepreneurship into our curriculum and to be forward thinking in the delivery of academic programming.

My sincerest best wishes for an engaging conference.
Sincerely,
Anthony J. Clarke

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Manuele Santoprete
Director: MS2Discovery Institute

Dear participants,

It is with immense pleasure that, on behalf of the members of the MS2Discovery Interdisciplinary Research Institute, I welcome you to the 12th Annual Nano Ontario Conference and Exhibition. This year the conference will be held at Wilfrid Laurier University, and we are thrilled to host so many scientists and experts, here at Laurier.

Nanoscience and Nanotechnology are rapidly evolving fields or research that are revolutionizing nearly every aspect of our daily lives. There is no doubt that nanoscience has and will continue to lead to many transformational discoveries and industrial applications in many diverse sectors ranging from electronics to medicine, clean air technologies to renewable energy, food safety to smart fabrics, etc. It is for these reasons that at the MS2Discovery Institute we are extremely excited to co-sponsor the event.

The theme for this year conference is Entrepreneurship in Nano-Enabled Technologies and will feature speakers from both academia and industry. I believe this will be a wonderful opportunity to promote collaboration and partnership between participants coming from these two different worlds. This conference will stimulate discussion of recent achievements and new developments in the rapidly evolving area of Nanotechnology.

We are looking forward to your presence here at Laurier and hope you will enjoy the conference and have a pleasant stay in Waterloo.

Sincerely,
Manuele Santoprete

Special Thanks

Sponsors

Faculty of Science, Office of Research Services

Conference Services at Laurier

Susan MacKenzie, Information and Communication Technologies (ICT), Food and Catering Services, Printing Services, Physical Resources, Faculty of Science Admin Office, ICT

Student Volunteers at Laurier

Jason Hsu (Chief Student Volunteers), Yara Khalaf, Uyen Le, Rohini Mohammed, Mirabel Saiar, Avneet Kaur, Gurleen Sidhu, Sanaa Ebrahim, Salika Mehroz, Natalie Fahmi, Zoe Georgiopoulus, Aksaya Ghetheeswaran, Thakaskha Amaranath, Lula Ibrahim, Malavika Pengat, Hosnia Ismailzada, and Brittany Nagy

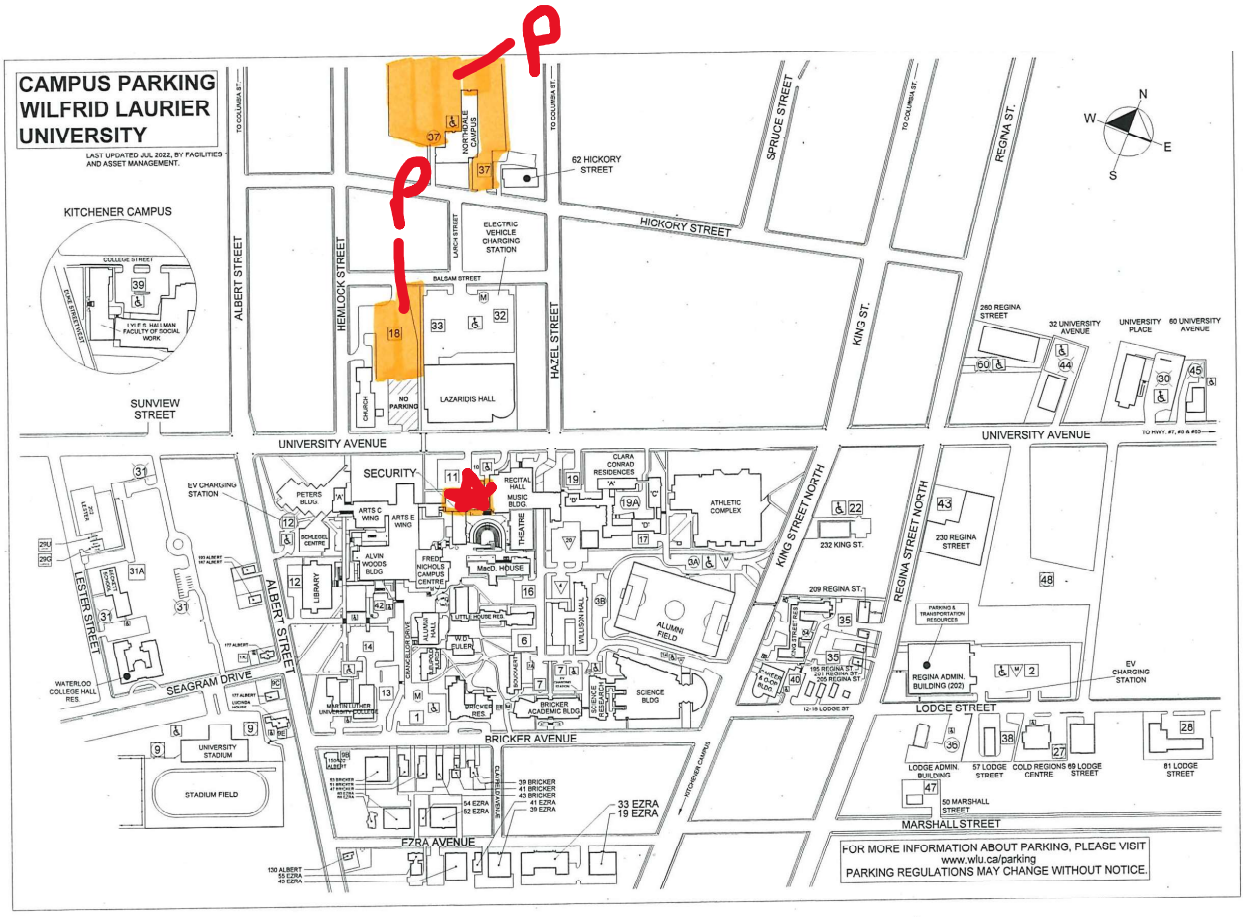
COVID-19 Framework

Laurier has developed a scaled framework to guide safety planning and decision making. At this time, the institution has resumed normal university operations which include the following information:

- Physical distancing is recommended
- Face coverings are required in instructional spaces
- Self-monitoring is recommended
- Vaccination Policy is paused
-

Full details regarding Laurier's COVID-19 response to ensure a health return to campus is located on our web page:

Location Map and Parking



Recommended Hotel

Delta Hotels Waterloo, 110 Erb St W, Waterloo, ON N2L 0C6

Equity, Diversity & Inclusion

(Thanks to Prof. Dr. Stefania Impellizzeri, TMU)

Science and society are stronger when we have a diverse, equitable and inclusive profession. Our goal for this conference is to create an inclusive and respectful environment that facilitates and supports participation from people of all ethnicities, genders, ages, abilities, religions, and sexual orientations. We know that making an explicit commitment to diversity enables excellence, innovation, and transformative action in current and future generations of professionals.

In ensure we achieve the highest standards of EDI, we have:

- Recruited presenters and panelists from diverse populations, backgrounds, and research areas, to increase diversity in thinking and perspective.
- Recruited qualified members of the organizers and judging committees such that the resulting populations are diverse with respect to gender, home institutions, geography, and research expertise.
- Ensure the application of EDI principles in the assignation of awards and honorable mentions.
- We want people to be comfortable being themselves and strive to build a culture where no assumptions or judgments are made on participants. We encourage the use of pronouns for all conference attendees.

Read more of NanoOntario commitment to EDI at:
https://nanoontario.ca/diversity-in- nanoscience/

Hosting Inclusive and Accessible Conferences

(Thanks to Prof. Dr. Stefania Impellizzeri, TMU)

NanoOntario endorses the efforts made in order to ensure an inclusive and accessible conference environment. To anyone either currently organizing a conference or event, or planning to do so, we highly recommend the article by Ana Sofia Barrows, Mahadeo A. Sukhai, and Imogen R. Coe “So, you want to host an inclusive and accessible conference?” FACETS 6, 131-138, available open access at doi.org/10.1139/facets-2020-0017.

Conference Code of Conduct

(Thanks to Prof. Dr. Stefania Impellizzeri, TMU)

The 12th Annual Nano Ontario Conference & Exhibition is committed to providing a safe, productive, and welcoming environment for all participants. The conference provides an excellent opportunity for members and meeting attendees to connect, learn and expand and grow their careers. At all times, meeting attendees, volunteers and staff should act in accordance with the present Code of Conduct, dedicating themselves to the highest standards of personal honour and professional integrity, and accepting and defending the primacy of public well-being.

We all play a role in fostering a positive environment of trust, respect, open communication, and ethical behaviour. As such, we urge all our participants to:

- Being respectful of all individuals involved in the meeting including attendees, volunteers, management, and coordinators.
- Being respectful of rules and policies of the meeting.
- Making every effort to be professional, considerate, and collaborative.
- Being conscious of critiquing ideas, not individuals.
- Being respectful of each other in conversation, during oral and poster presentations, and during group and social events.
- Accepting that disruptive, harassing, or other inappropriate statements or behaviour toward an individual is unacceptable.
- Not engaging in unacceptable behaviour*

**Examples of unacceptable behavior:*

- Disruption or obstruction of any meeting activity or social events.
- Physical or verbal harassment, including sexual harassment, bullying, discrimination in any form, or abuse of any attendee.
- Intimidation, threats, or coercion.
- Conduct or knowingly creating a condition that threatens or endangers any person.
- Conduct that is, or is reasonably seen to be, humiliating or demeaning to another person.

- Aiding or encouraging others to act in a manner prohibited under these guidelines.
- Verbal comments based on gender, sexual orientation, disability, physical appearance and dress, body size, socioeconomic status, education background, marital status, and personal characteristics protected under the Charter of Rights and Freedoms (race, religion, national origin).
- Inappropriate use of nudity and/or sexual images in public spaces or in presentations.
- Threatening, stalking, and harassing of any attendee at the event or meeting, including speakers, volunteers, staff, service providers, and guests; unwelcome sexual advances; requests for sexual favours; harassment intended and communicated in a joking manner.

In addition, participants are asked to adhere to the following rules:

- The recording or transmissions of any education sessions, presentations, demos, videos, or content in any format is strictly prohibited.
- Disruption of presentations during sessions, in the exhibit hall, or at other events organized throughout the virtual meeting. All participants must comply with the instructions of the moderator.
- Any direct selling of products/services offered by speakers, industry partners, or consultants in any public area of the virtual platform is prohibited. Many of the engagement conversations are based around knowledge and expertise and are not categorized as a direct sales pitch.
- Selling must be conducted during mutually agreed upon private video, audio or text conversations.
- Participants should not copy or take screenshots of Q&A or any chat room activity that takes place in the virtual space.

We reserve the right to take any action deemed necessary and appropriate, including immediate removal from the meeting without warning or refund, in response to any incident of unacceptable behavior.

If you believe someone is violating the code of conduct, please contact any of the conference organizers or volunteers. All reports will be kept confidential.

Social Media Policy

(Thanks to Prof. Dr. Stefania Impellizzeri, TMU)

You are NOT permitted to post about others' data and specific materials without expressed consent from the author.

You are encouraged to post general comments about the conference or publicly available information (e.g., title of the talk or abstract materials)

Tag @NanoOntario

Schedule

For the latest version of the schedule, please visit:

Abstracts of Nano Ontario 2022

Table of Contents: **Page**

Invited Speakers:

Cynthia Goh, University of Toronto

Nanomaterials: from fundamental science to applications and impact **7**

Muhammad N. Yousaf, York University

Rewiring Cell Surfaces with Click Chemistry for Applications in Tissue Engineering **8**

François Lagugné-Labarthet, Western University

NanoOntario Inc.: Past, Present and Future **9**

Ghassan E. Jabbour, University of Ottawa

Reactive Printing and Coating for Self-Assembly of Nanoparticles and Quantum Dots **10**

Maryam Ebrahimi, Lakehead University,

Formation of 1D and 2D carbon-based nanomaterials on surfaces **11**

Arya Ghadimi, Nyssa IP

Intellectual Property: A Bridge Between Invention and Commercialization **12**

Nano Ontario Award Winners 2022:

Danielle McRae, University of Waterloo,

The effect of melatonin on the structure and properties of model lipid membranes and its protection against amyloid damage by AFM, LSPR and BLM **13**

Anna Klinkova, University of Waterloo,

Catalyst design and reaction mechanisms in sustainable electrochemistry **15**

Leyla Soleymani, McMaster University,

Electrochemical biosensors for infectious disease diagnostics **17**

Xueliang (Andy) Sun, Western University, *Challenges and Opportunities of All Solid-State Batteries: From Interface Design to New Solid-State Electrolytes* **18**

Poster Presentations: **Page**

P1 Acoustic modulation of quantum optical emitters

***Hala Sakhnini*[1]**, *Dan Dalacu*[2], *James Stotz*[1]

[1]*Queen's University,* [2]*National Research Council of Canada* **20**

P2 Emerging 2D Materials for Nanoscale Transistors: A Computational Perspective

Mayuri Sritharan *and Youngki Yoon*

Waterloo Institute for Nanotechnology, University of Waterloo **21**

P3 One-dimensional Defects on Si(111)-√3× √3-Ag: A DFT Study of the Step Edge and Antiphase Boundary Sites

Hanieh Farkhondeh, *Tong Leung*

WATLab, University of Waterloo **23**

P4 Novel Single Nanocluster Device Fabricated by Ultra-high Performance Ion Beam Lithography

Xiaoyi (Frank) Guan, Lei Zhang, Hanieh Farkhondeh, Joseph P. Thomas, Nina Heinig, Tong Leung

WATLab, University of Waterloo **24**

P5 Er Implanted TeO_2-Coated Si_3N_4 Waveguide Amplifier

Yuxuan (Michael) Gao, *Batoul Hashemi, Bruno Segat Frare, Feng Guo, Jonathan Bradley, Peter Mascher, and Andrew P. Knights*

Department of Engineering Physics, McMaster University **25**

P6 Synthesis of Novel Single-Crystalline HfO_2 Nanostructures and Their Magnetic Properties

Mahdi Beedel [1], *Md Anisur Rahman* [2], *Hanieh Farkhondeh* [1], *Joseph Palathinkal Thomas* [1], *Lei Zhang* [1], *Nina F. Heinig* [1], *Xiaoyi Guan* [1], *and Kam Tong Leung* [1]

[1]*WATLab, University of Waterloo* **26**

P7 Construction of a spin-based self-assembled nanostructured layer on Au (111)/Mica surface

Milad Chagami Amlashi[1,#], Karolis Norvaiša[2], Dmitry Akhmetzyanov[4], Mathias Senge[2,3], Maryam Ebrahimi[1,]*

[1]Lakehead University, [2]University of Dublin, [3]Technical University of Munich; [4]University of Waterloo

27

P8 Measurement of thickness dependent anisotropic thermal conductivities in highly anisotropic semiconductors

***Shany Mary Oommen[1]**, Simone Pisana[1,2]*

[1]Department of Physics &Astronomy, [2] Electrical Engineering & Computer Science, York Univ.

28

P9 3D Printing Integration of Fiber to Chip Coupling and Packaging

***Dylan Genuth-Okon**, Yu Jiang, Andrew P. Knights*

[1]Engineering Physics, McMaster University

29

P10 Surface chemistry of CuO nanoparticles with intermediates identified in CO_2 electrochemical reduction (CO_2ER) using in-situ ATR-FTIR spectroscopy

***Jason Hsu[1]**, Yaser Abu-Lebdeh[2], Mohamed Houache[2], Hind Al-Abadleh[1]*

[1]Wilfrid Laurier University, [2]National Research Council of Canada

30

P11 Open-Air Fabrication of Oxide-Based Cantilever Gas Sensors

***Masoud Akbari[1,2,3]**, Kissan Mistry[3], Viet Huong Nguyen[4], Skandar Basrour[2], Kevin Musselman[3], David Muñoz-Roja[1]*

[1,2] Univ. Grenoble Alpes, CNRS, France, [3] University of Waterloo, [4] Phenikaa University, Vietnam

31

P12 Nonenzymatic Saliva-Range Glucose Sensing Using Electrodeposited Cuprous Oxide Nanocubes on a Graphene Strip

***Wenyu Gao[1]**, Xiaojing Zhou[2], Nina F. Heinig[1], Joseph P. Thomas[1], Lei Zhang[1] and Kam Tong Leung[1]*

[1]WATLab, University of Waterloo, Waterloo, [2]University of Newcastle, Australia

32

P13 Preparation of κ-carrageenan/graphene oxide/cellulose nanocrystal eco-friendly composite hydrogel beads and their efficient adsorption for heavy metals

Yalda Majooni, Nariman Yousefi*

Chemical Engineering, Toronto Metropolitan University **34**

P14 Experimental protocol of dithiothreitol assay to quantify the oxidative potential of atmospheric particulate matter

Le Thi Le Uyen, *Yara Khalaf, Hind A. Al-Abadleh*

Chemistry and Biochemistry, Wilfrid Laurier University **35**

P15 A Case Study on Quantifying Nanoparticle Toxicity: Using Dithiothreitol Assay to Study the Oxidative Potential of Atmospheric Particles in Kitchener, ON

Yara Khalaf*, Uyen Le, and Hind A. Al-Abadleh*

Chemistry and Biochemistry, Wilfrid Laurier University **36**

P16 Integrated Microfluidic and Electrochemical Nano-biosensor: Towards Solutions for Point of Care Diagnosis of Cervical Cancer

Fatemeh Keyvani*[1], Nandini Debnath[1], Mahmoud Ayman Saleh[1,2], Mahla Poudineh[1]*

[1] Electrical and Computer Engineering, University of Waterloo **38**

P17 Sensing and characterization of Extracellular Vesicles via Surface-enhanced Raman spectroscopy for Ovarian cancer diagnosis

Lorena Veliz*, Tyler Cooper, François Lagugné-Labarthet*

Department of *Chemistry, Western University* **40**

P18 Plasmonic Sensors Based on 3-D Arrays of Gold-Plated Silver Nanoparticles

*Jacob Speers, Vladimir Kitaev**

Chemistry and Biochemistry, Wilfrid Laurier University **41**

P19 Assessing the Properties of Nanoclusters for Photodynamic Therapy

Kristen Harrington *and Kevin Stamplecoskie*

Department of Chemistry, Queen's University

42

P20 Size Effects of Gold Nanoparticles on Binding to L-Cysteine

Seyedeh Marzieh Kalantarian[1]*, Narges Hajighasemi[1], Heng Yong Nie[2], and Yolanda S. Hedberg[1,2]*

[1]Department of Chemistry, University of Western; [2]Surface Science Western

43

P21 Gold Nanoparticles Synthesized Using Various Reducing Agents and the Effect of Aging for DNA Sensing

Yuzhe Ding[1]*, Po-Jung Jimmy Huang[1], Mohamad Zandieh[1], Jinghan Wang[1] and Juewen Liu[1]*

[1]Department of Chemistry, Waterloo Institute for Nanotechnology

44

P22 Using cationic liposomes to deliver in vitro transcribed long dsRNA to RTG-2 and RTgill-W1 cells for IFN induction

Shayne Oberhoffner[1]*, Dominique Daniels[1], Aizah Ijaz[2], Stephanie DeWitte-Orr[1,2]*

[1] Biology, Wilfrid Laurier University; [2] Health Sciences, Wilfrid Laurier University

45

P23 Single-Molecule Atomic Force Microscopy Force Spectroscopy of Phytoglycogen Nanoparticles Modified by High-Shear Screw Extrusion

Benjamin Baylis[1]*, John R. Dutcher[1], Laura Roman[2], Mario M. Martinez[2,]*

[1]University of Guelph, [2]Aarhus University

46

P24 Heightening innate immune responses in ovarian cancer cells with double-stranded RNA-phytoglycogen nanoparticles in vitro

Jadaa, N.[1]*; Lewis, A.[1]; Tran, A.[1], Feng, T.[2]; Moore, E.[2]; de Jong, J.D.[2]; DeWitte-Orr, S.J.[1,3]; Poynter, S.J.[1]*

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47

P25 Hydration Properties of Charge Modified Phytoglycogen Nanoparticles

Carley Miki, *Michael Grossutti, John R. Dutcher*

Physics Department, University of Guelph **48**

P26 Exploring the antiviral effects of a novel phytoglycogen-based nanoparticle and polyinosinic/polycytidylic acid in human lung cells.

***Kristof Jenik*[1]**, *Tamiru Alkie[1], Megan Dutcher[2], Emily Moore[2], Jondavid Dejong[2] Stephanie J DeWitte-Orr[1]*

[1] Biology, Wilfrid Laurier University, [2]Glysantis Inc, Guelph **49**

P27 Encapsulation of long dsRNA in liposomes and SARS-CoV2 virus like particles for the stimulation of antiviral RNA interference in human cells

***Dominique Daniels*[1]**, *Shayne Oberhoffner[1], Stephanie DeWitte-Orr[1,2]*

[1] Biology, Wilfrid Laurier University; [2] Health Science, Wilfrid Laurier University **50**

P28 Enhanced delivery of long double-stranded RNA to ovarian cancer cells using cationic polystyrene latex nanocarriers

***Natalie L. Aldor*[1]**, *Shira Y. Miller[1], Vladimir Kitaev[2], Sarah J. Poynter[1]*

[1] Health Sciences, Wilfrid Laurier University, [2]Chemistry, Wilfrid Laurier University **52**

P29 Removal of Pharmaceuticals from Water Using Graphene-Containing Beads

Samson Abioye, Nariman Yousefi

Department of Chemical Engineering, Toronto Metropolitan University **53**

P30 Design and Fabrication of Color-generating Nitride based Thin-Film Optical Filters for Photovoltaic Applications

Paramita Bhattacharyya[1], Brahim Ahammou[1,2], Fahmida Azmi[1], Rafael Kleiman[1], and Peter Mascher[1]

[1] Engineering Physics, McMaster University, [2] Univ Rennes, France **55**

P31 Optimization of Electromagnet Geometries for Transcranial Magnetic Stimulation of Visual and Motor Cortices

***Olga Andriyevska*[1]**, *Coral Hillel[1], Jennifer Steeves[1], Christopher Barrett[1,2], Ozzy Mermut[1], Simone Pisana[1]*

[1]York University; [2]McGill University **56**

Nanomaterials: from fundamental science to applications and impact

M. Cynthia Goh

Department of Chemistry, Department of Materials Science and Engineering, Department of Chemical Engineering and Applied Science, Institute of Medical Science, University of Toronto and Institute of Management and Innovation, University of Toronto at Mississauga

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Why are we fascinated with the nanoscale? In this talk I will answer that question from the perspective of my lab, in terms of the challenges as well as opportunities that are offered. I will discuss perspectives on the commercialization of scientific knowledge and why it is important in our impact on society, particularly with regards to the global community. I will talk about the companies we have started, and how the interplay between science and commercialization can be beneficial to all: the academic scientist, the student, the public. I will present a model on how I see an innovation ecosystem is built, and the results of the 'experiment' in a unit that I had founded called the Impact Centre. I will then discuss a new model on 'community based innovation' as illustrated with our work on a lighting project.

Rewiring Cell Surfaces with click chemistry for applications in cell biology and tissue engineering.

Muhammad N Yousaf[1]

[1]*York University, Department of Chemistry and Biology, Toronto, ON, Canada*

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1. An integrated method that combines bio orthogonal chemistry, liposome fusion and cell surface engineering will be introduced and applied to cell biology and biotechnology.
2. A new rapid and traceless click chemistry reaction that reacts with primary amines will be introduced and applications explored from bioconjugation to tissue engineering. Commercial aspects of the click chemistry reaction will also be discussed.

NanoOntario Inc.: Past, Present and Future.

François Lagugné-Labarthet

Western University, Chemistry Department, 1151 Richmond Street, London, On, N6A 5B7.

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Since 2008 NanoOntario Incorporated is representing the interests of academic, government, industrial and finance community in the development of nanotechnologies. The members of NanoOntario, coming from academia and private sectors, work together on a volunteering basis to raise the profile, increase the research capacity, build the investment, and drive economic returns from nanotechnology in the province of Ontario and across Canada.

Nanoscale investments have brought our province to be one of the top leaders in the field of nanotechnology and of its applications in many fields ranging from Surface science, Micro and nanofabrication to NanoMedicine or imaging technology.

In this presentation, through a few examples of activities conducted by NanoOntario Inc., such as our annual conference, workshops, participation to international missions, pitch awards, we will review how our activities of NanoOntario can help to the development of new technologies that will benefit people and highlight our province as a leader in nanosciences.

NanoOntario is open to new members who wish to participate to its expansion and further attract attention at the Provincial, National and International levels. Professional diversity of our members is key to the success, bringing new expertises and new ideas. Equity, diversity and inclusivity are also values that are defended by NanoOntario since 2017 with the creation of a series of Awards at different career stages for our most talented Nanoscale researchers engaged in research and development at a University or a company in Ontario and who self-identify as members of the five equity-seeking groups.

We will continue these actions, develop new ones and be always welcoming for new members who wish to be more engaged to further expand our role provincially and nationally.

Reactive Printing and Coating for Self-Assembly of Nanoparticles and Quantum Dots

Ghassan E. Jabbour
University of Ottawa

In recent years, there has been a surge of interest in metallic nanoparticles (MNPs) and functional semiconducting quantum dot (QD) materials due to their adaptable optical and electronic properties, which make them well-suited for use in fields such as sustainable energy harvesting and conversion devices, antiviral materials, and printed electronics. MNPs, QDs, and thin films of these entities have been fabricated using a wide range of methods including mechanical milling, sputtering, and high-resolution lithography. However, these methods have their limitations due to factors including sample size, cost, and processing time. Current solution-based approaches offer a less complicated and cheaper technique that can be adapted, and in some cases practiced, for mass manufacturing. However, there is significant concern about the environmental impact of the solvents employed in industrial-scale manufacture of MNPs and QDs. Our recently developed reactive printing approach has attracted attention for its potential in MNPs synthesis due to its adaptability, scalability, reduced solvent quantities used, and low cost. The process's amenability to roll-to-roll (R2R) production facilitates its translation from lab-scale synthesis to large-scale manufacturing systems. Our lab has made significant strides in this area, and we'll discuss those developments, including the manufacturing of gold and silver nanoparticles on stiff and flexible substrates such as cloth and face mask. Antiviral MNPs were assembled in situ on rigid surfaces and on commercial face masks consisting of nonwoven and woven textiles, allowing for 99.99% disinfection of a surrogate virus to SARS-CoV-2. Finally, if time permits, we will provide some examples of QDs created using this method.

Formation of 1D and 2D carbon-based nanomaterials on surfaces

***Maryam Ebrahimi*[1]**

[1]*Assistant Professor and Tier 2 Canada Research Chair, Lakehead University, Department of Chemistry, Department of Physics (Adjunct), Thunder Bay, Ontario, Canada*

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On-surface reactions offer a platform to design molecular-based low-dimensional nanomaterials whose chemical and electronic properties can be tailored by their chemical structure. The molecules' functional groups and the reactivity of the substrates control the molecule-molecule and molecule-substrate interactions, which steer the design of the obtained molecular structures. We present various surface reactions for creating 1D and 2D polymers, metal-organic networks, and organometallic structures on Au(111), Ag(111) and Cu(111). To identify their topography and chemical nature, we employ scanning tunnelling microscopy and non-contact atomic force microscopy, and other surface characterization techniques, such as X-ray photoelectron spectroscopy, complemented with density functional theory calculations.

The chemical and thermal stability and structural design of these molecular-based low-dimensional nanomaterials make them promising candidates for various applications. These materials are tailored to exhibit unique electronic properties, charge mobility and/or electron spin-based structure, suitable for carbon-based nanoelectronics, spintronics, and quantum technology applications. [1-10]

Maryam Ebrahimi acknowledges that part of this research was undertaken, thanks to the funding from the Canada Research Chairs Program and NSERC Discovery Grant.

References:

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Intellectual Property: A Bridge Between Invention and Commercialization

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There are opportunities and dangers awaiting an invention that attempts to leave the lab on its journey towards commercialization. Opportunities may be offered by investors and collaborators, while dangers can be posed by copycats and competitors. Intellectual property protection can provide a bridge allowing an invention to navigate these dangers on its path towards the opportunities for commercialization. This presentation will introduce the basic types of Intellectual Property (IP), and their application to a nanotechnology-based invention. The presentation will also provide practical steps for recognizing and protecting IP rights, particularly in an academic or institutional setting.

The effect of melatonin on the structure and properties of model lipid membranes and its protection against amyloid damage by AFM, LSPR and BLM

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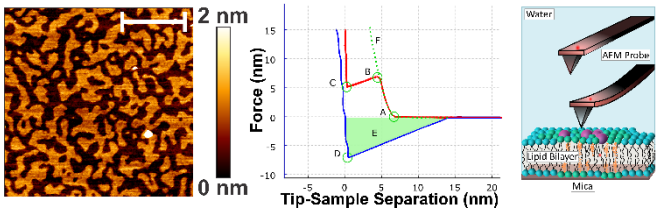
Alzheimer's disease (AD) is a neurodegenerative disease, characterized by dementia and memory loss, currently without cure or preventative measure. AD is associated with amyloid toxicity, which is a result of the non-specific interaction of amyloid-β oligomers with the neuronal membrane. Our previous studies have shown that age- and AD-related changes in the composition and structure of these membranes could modify its interaction with amyloid-β and trigger membrane damage [1]. Melatonin, a neuroactive small-molecule, is known to be protective against amyloid-β toxicity in cellular and animal studies; however, the molecular mechanisms of its action have not yet been fully elucidated. Melatonin is known to partition into the lipid membrane [2,3] and thus may change the structure of membrane nanodomains and their physical properties; these changes may further affect amyloid-membrane interactions, and perhaps reduce amyloid-induced damage.



In this study, we model neuronal membranes with supported lipid bilayers. Using atomic force microscopy (AFM) and atomic force spectroscopy, we characterized the topographical structure (nanodomains) and nanomechanical properties of these lipid bilayers (see figure), and investigated the changes in these bilayers following the introduction of melatonin. With localized surface plasmon resonance (LSPR) spectroscopy, we studied how melatonin affects amyloid-β accumulation on the supported model membranes [4]. Complementary to these techniques, Black Lipid Membrane (BLM) was used to assess the damaging effect of amyloid in model membranes. We discovered that melatonin incorporates into the membrane and reduces amyloid-membrane binding and membrane damage. These findings contribute to a better understanding of the molecular mechanisms of AD and aid to the development of novel strategies for its cure and prevention.

We acknowledge the NSERC operating grant and CFI and ORF Infrastructure grants to ZL; NSERC PDF scholarship to DMM, Ontario Graduate Scholarship (OGS) to MR, and WIN Fellowships to MR and NM.

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Catalyst design and reaction mechanisms in sustainable electrochemistry

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The precise control of nanostructure and surface atomic arrangement can be used to tune the electrocatalytic properties of materials and improve their performance. However, the long-term structural stability of electrocatalysts with complex nanoscale morphology, a necessary requirement for industrial implementation, often remains elusive. Recently, we elucidated electrochemical and electrical driving forces behind structural transformations in geometrically complex nanoscale electrocatalysts used in carbon dioxide electroreduction and other cathodic processes of intense interest [1,2,3]. The resulting comprehensive experimental and theoretical framework elucidating the chemical and physical mechanisms in nanoscale catalyst reconstructions under applied bias has immense importance for understanding and solving structural stability problems in electrocatalysts for the water- and CO_2-reduction electrolyzers.

Another challenge with water and CO_2 electrolyzers is that electroreduction of CO_2 or hydrogen production via water electrolysis typically relies on water oxidation to oxygen gas as a secondary process, which is associated with high energy requirements. We show that when oxygen evolution is replaced with urea electrooxidation to environmentally-friendly nitrogen gas, the theoretical cell voltage of the electrolyzer can be significantly lowered [4]. Furthermore, this approach simultaneously enables efficient treatment of urea-laden wastewaters. The caveat is overoxidation of urea to NO_x^- usually dominates over its oxidation to N_2 on most commonly used $Ni(OH)_2$ anodes. We also found that NO_x^- formation is accompanied by the near-stoichiometric formation of cyanate (NCO^-). Based on our experimental and computational findings, we show that the formation of NO_x^- and N_2 follows two distinct vacancy-dependent pathways. We also demonstrated that the reaction selectivity can be steered towards N_2 formation by altering the composition of the catalyst, e.g., doping the catalyst with copper ($Ni_{0.8}Cu_{0.2}(OH)_2$) increases the faradaic efficiency of N_2 from 30% to 55% [5].

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Electrochemical biosensors for infectious disease diagnostics

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Biosensors have shown great promise for use in point-of-care diagnostics and continuous health monitoring. There is a great need for biosensors that are easy to use and do not rely on reagent addition, sample processing, and washes that are difficult to use by non-technical users. Here, I will discuss strategies focused on the integration of functional nucleic acids with electrochemical readout for reagent-less. This talk will focus on the engineering of redox DNA-barcoded DNAzymes and aptamers that translate the capture of infectious disease targets into the release of a redox barcode. These barcoded functional nucleic acids are immobilized onto electrode surfaces for biorecognition. The barcodes released from these surfaces are autonomously diffused and analyzed on electrochemical chips for bioanalysis. Our barcoded functional nucleic acids have been demonstrated for the detection of both bacteria (Escherichia coli) and viruses (Porcine epidemic diarrhea virus (PEDv)). These assays have been evaluated for use in unprocessed clinical samples (human urine and porcine saliva) and have demonstrated clinically-acceptable performance. We will also discuss the integration of these assays with miniaturized readers and actuators that are created using commercial printed circuit board technologies.

Challenges and Opportunities of All Solid-State Batteries:

From Interface Design to New Solid-State Electrolytes

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All-state-state lithium batteries (ASSLBs) have gained worldwide attention because of the high ionic conductivity of SEs, intrinsic safety and increased energy density. In ASSLBs, solid-state electrolyte is a key component and interface is a big challenge. In this talk, I will talk about two types of solid-state electrolytes including sulfide-based electrolyte (focusing on interface) and halide-based electrolytes (focusing on synthesis and increase of ionic conductivity).

In the first part of this talk, I will demonstrate to apply atomic layer deposition/molecular layer deposition (ALD/MLD) for interface design between sulfide-based electrolyte and cathode material. Compared with polymer-based and oxide-based electrolytes, sulfide-based electrolyte generally exhibits the highest ionic conductivity (10^{-3} ~ 10^{-2} S/cm) and favorable mechanical property. However, the serious interfacial challenge, bad air stability, narrow electrochemical windows of sulfide-based electrolyte significantly impede development of sulfide-based ASSLBs **[1]**. Generally, an artificial, uniform and ultrathin interfacial layer is critical to address these challenges. ALD) and MLD are unique coating techniques that can realize excellent coverage and conformal deposition with precisely controllable at the nanoscale level due to its self-limiting nature, which are ideal for addressing the challenges of interface in SSLBs [2-4].

In the second part of this talk, I will talk about halide-based electrolyte for ASSLBs. Compared with sulfide-based electrolyte, both experimental and theoretical results recently demonstrate that halide-based electrolytes have more advantages including high RT ionic conductivity (>10^{-3} S cm^{-1}, theoretically possible 10^{-2} S cm^{-1}), wide electrochemically stable window (possible up to 6 V), high air-stability, good stability toward oxide cathode materials, and even salable water synthesis strategy **[5-10]**.

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P1

Acoustic modulation of quantum optical emitters

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The ability to modulate and store quantum information is a critical aspect of future secured quantum communications. The development of quantum networks relies on designing devices capable of coupling to quantum systems without disturbing their sought-after quantum properties while operating at high frequencies. One notable method of modulating quantum information is the use of acoustoelectric devices. Acoustoelectric devices can generate significant strain and displacement fields to modulate semiconductor nanostructures containing quantum emitters. Such acoustic excitations can be electrically excited by applying a radio frequency electromagnetic field to transducers across a piezoelectric material.

Surface acoustic waves (SAWs) can be generated via interdigitated transducers deposited and patterned onto the piezoelectric surface, and have been shown to modulate single photons from electronic traps in quantum wires [1]. In this work, we are instead targeting a quantum dot within a free standing nanowire [2]. Bulk acoustic waves (BAWs) can be generated by bulk acoustic wave resonators consisting of a piezoelectric layer sandwiched between two metal electrodes. The frequency of the BAW device is dictated by the thickness of the piezoelectric film layer and can reach into the gigahertz. These transducers can be designed to create acoustic excitations that can strongly couple to the vibrational modes of the semiconductor nanowire. This mode coupling can be targeted to ensure that the strain within the nanowire is optimized at the position of a quantum dot to enable a dynamic modulation of its bandgap.

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P2

Emerging 2D Materials for Nanoscale Transistors: A Computational Perspective

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Two-dimensional (2D) materials, with their atomistic thinness and exceptional electronic properties, have generated great interest as candidates for active materials in ultrascaled field-effect transistors (FETs) in the sub-10 nm regime. While many 2D materials such as molybdenum disulfide [1] and black phosphorous [2] have been widely investigated for various applications, integration of these materials into CMOS technology is not entirely feasible as most of these materials suffer from the lack of a compatible oxide layer. We thus consider an emerging family of 2D transition metal dichalcogenides (TMD) materials (MX_2 where M = hafnium/zirconium and X = selenium/sulfur) that form natively compatible high-κ oxides [3]. We investigate such novel nanomaterials and their potential in 2D material-based FET technology through numerical simulations. We implement a state-of-the-art multi-phase simulation process whereby the material level properties (Fig. 1) are simulated through density functional theory (DFT) and electronic transport properties are simulated through the non-equilibrium Green's function (NEGF) method. Using our rigorous quantum transport simulator, we explore and engineer novel nanoelectronics for various applications including low-power, high-performance, and ultrascaled electronics. We predict and optimize the performance of these devices thereby providing key insights and design strategies into the use of these emerging materials towards realizing 2D material-based FET technology.

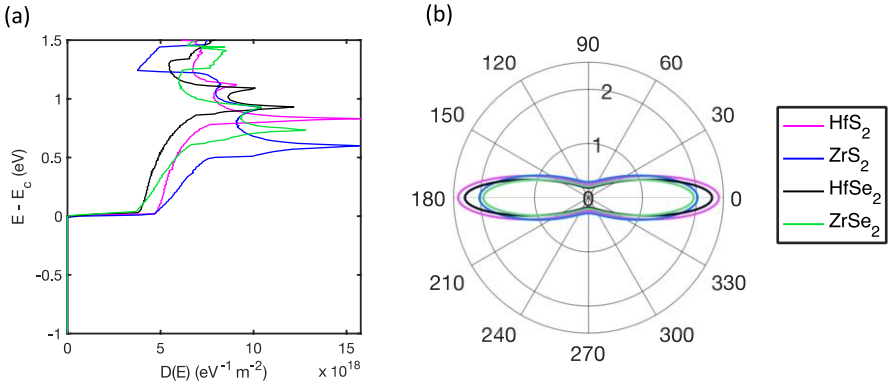

Fig. 1. Simulated (a) density of states and (b) electron effective masses of the 2D semiconductors.

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P3

One-dimensional Defects on Si(111)-√3× √3-Ag: A DFT Study of the Step Edge and Antiphase Boundary Sites

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The Si(111)-√3×√3-Ag surface structure and properties have been the subject of extensive research in the past few decades. The anomalies found in its electronic structure measured at both room temperature and low temperature and in its high conductivity due to the presence of the surface metallic states have made the √3×√3-Ag surface a benchmark surface for exploring novel phenomena in supported single-atom-thick, two-dimensional material systems. Among all studies on the various properties, those focusing surface defects are rather limited. As the step edges and antiphase boundaries are found to be the more abundant defect features on the Si(111)-√3×√3-Ag surface, detailed understanding of their structural configurations and associated properties is essential to further unravelling the overall electronic properties of this intriguing surface. Large-scale first-principle calculations based on the density functional theory (DFT) are used to investigate the equilibrium geometries of the step edges and antiphase boundaries on the Si(111)-√3× √3-Ag surface. One-dimensional chains of Ag trimers are found to be stabilizing the step edges and antiphase boundaries, with all the Si dangling bonds passivated by Ag atoms at the step edge and antiphase boundary sites. The calculated total density of states suggests the reinforcement of the surface states within the band gap arising from step-edge structures. The contribution of hybrid states with the Ag-Si moieties in the valence and conduction bands are also demonstrated by their calculated partial density of states. As these defect sites have also been found to be the most favorable adsorption sites for bio-organic molecules such as cysteine, they are expected to play a crucial role in designing applications in catalysis and chemical sensing.

This work was supported by the Natural Sciences and Engineering Research Council of Canada.

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P4

Novel Single Nanocluster Device Fabricated by Ultra-high Performance Ion Beam Lithography

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Nanoclusters belong to a special material regime between single atom/molecule and their bulk, where the energy levels remain as discrete individual states before merging into bands.[1] Nanoclusters also exhibit distinct phase and chemical states from their bulk, which promotes novel phenomena and applications. HZO ($Hf_{0.5}Zr_{0.5}O_2$) nano materials attract a lot of recent interests since their orthorhombic phase shows strong ferroelectricity. [2,3] Here, we use a novel magnetron-sputterer-based gas-phase aggregation nanocluster source with *in-situ* quadrupole mass filter to synthesis defect-rich size-selected $Zr_xHf_{1-x}O_2$ nanoclusters, where x can be tuned continuously from 0 to 1. These unique nanoclusters are drop-casted into a sub-10 nm nanogap fabricated by an ultra-high performance ion beam lithography system. The novel liquid metal alloy ion source (containing four different ions: Si^+, Si^{++}, Au^+ and Au^{++}) combining with a laser interferometer stage has enabled us to perform high precision patterning and milling in the nanoscale over a large area.[4] The single nanocluster device made by the orthorhombic $Zr_xHf_{1-x}O_2$ nanoclusters could become a strong candidate of future non-volatile memory devices.

This work is supported by NSERC.

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P5 Er Implanted TeO_2-Coated Si_3N_4 Waveguide Amplifier

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Optical amplifiers are crucial for compensating the attenuation of the light signal in the optical communication networks. The invention of the Erbium-doped fiber amplifier (EDFA) has extended the optical network by regenerating the optical signal covering the telecommunication C-band (1525 - 1564 nm) with low noise. Intensive research efforts have been applied to miniaturize the EDFA into on-chip amplifiers for optical interconnects, which are known as erbium-doped waveguide amplifiers (EDWAs), aiming to offer robust performance with low-cost and high integration.

In this work, we propose an Er-implanted tellurium-oxide-coated silicon nitride waveguide amplifier (shown in Figure 1). The amplifier design integrates the high gain in Er-implanted tellurite glass as well as the ultra-low loss silicon nitride waveguide with low-cost fabrication. We show that the waveguide platform demonstrates low background propagation losses of 0.25 dB/cm extracted from the Q factor of a ring resonator device. We measure 7 dB signal enhancement at 1558 nm in a 10 cm long spiral waveguide for 42 mW of launched 1470 nm pump power. These results demonstrate a promising approach for the monolithic integration of compact EDWAs and silicon-based photonic integrated circuits.

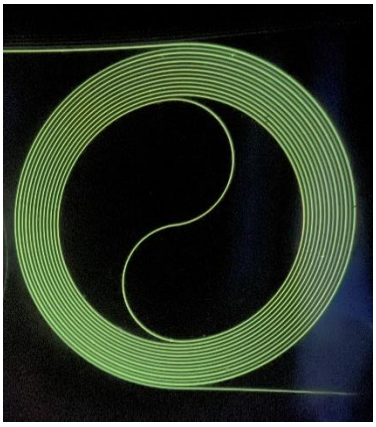

Figure 1. Glowing silicon nitride spiral waveguide amplifier under 1470 nm pumping. The green emission is from the second-order up conversion of Er ions.

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P6 Synthesis of Novel Single-Crystalline HfO_2 Nanostructures and Their Magnetic Properties

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Over the last two decades, hafnium dioxide (HfO_2), has received special attention due to its many technologically interesting properties, including large dielectric constant (κ≈25), wide bandgap (~5.7 eV), high refractive index (2.9), high laser-induced damage threshold, and superb thermal and chemical stability. [1–3] Owing to its excellent CMOS-technology compatibility, the observation of room temperature ferromagnetism in HfO_2 [4] particularly promises the easy integration of CMOS technology with spintronics. Similar to other semiconductors and wide band gap oxides [5,6], the single-crystalline HfO_2 one-dimensional (1D) nanostructures are expected to exhibit novel properties superior to their HfO_2 thin film counterparts. To date, the synthesis of single-crystalline HfO_2 1D nanostructures has, however, been unattainable because of the extremely low vapor pressures and high melting points of Hf (2233 ℃) and HfO_2 (2800 ℃), and also of the suppression of vapor-liquid-solid (VLS) growth during the growth process. In this work, we present the synthesis of various single-crystalline HfO_2 nanostructures, including single-crystalline HfO_2 nanowires for the first time, by using a catalyst-assisted pulsed laser deposition technique. We also compare the magnetic properties of the HfO_2 nanowires with the nano square pyramids and explain the role of surface oxygen vacancies in creating a room temperature ferromagnetic property in HfO_2 nanowires.

This work was supported by the Natural Sciences and Engineering Research Council of Canada.

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P7

Construction of a spin-based self-assembled nanostructured layer on Au (111)/Mica surface

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Controlled formation of low-dimensional nanomaterials with ordered electron spin sites offers a platform for the fabrication of spin-based quantum materials [1-2]. Herein, we present the formation of one-dimensional (1D) self-assembled structure of a *de novo* biradical porphyrin molecule on Au (111)/mica. The molecule consists of two equivalent wing-like stable organic radical sites, with *cis* and *trans* configurations. The chemical structure and the adsorbed geometry of the *cis* configuration prevent the interaction of the radical or electron spin sites to the surface. Both *cis* and *trans* enantiomers were drop-casted to Au (111)/mica under ambient conditions. X-ray Photoelectron Spectroscopy confirmed the adsorption of the molecules on the surface through the binding energies and chemical shifts attributed to the elemental composition of the molecules. Scanning Tunneling Microscopy images at the solid-liquid interface illustrate the formation of ordered 1D molecular structures on the surface. Electron Spin Resonance Spectroscopy technique revealed the open-shell nature of the resultant monolayer on the surface. This study offers an approach based in surface and nanoscience for the construction and characterization of spin-based molecular structures.

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P8 Measurement of thickness dependent anisotropic thermal conductivities in highly anisotropic semiconductors

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Semiconductors with highly anisotropic thermal conductivity are a substrate in device designs with highly efficient heat dissipation. In this study, we measured the anisotropic thermal conductivities as a function of thickness in various highly anisotropic semiconductors using time domain thermoreflectance technique. Our results show that in graphite, as the thickness of the flake reduces both in-plane and out-of-plane thermal conductivities deviates significantly from the bulk value due to the presence of phonons with large mean free path; On the other hand, due to the presence of phonons with shorter mean free path, MoS_2 flakes with thicknesses similar to graphite showed thermal conductivities comparable to its bulk value. When the thickness of the flake is reduced and is comparable with the mean free path of the phonons, heat transport is not diffusive anymore and becomes quasi-ballistic. Understanding the thermal anisotropy in two-dimensional materials as a function of their thickness has relevant applications in various fields such as microelectronics, thermoelectric applications, etc. [1].

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P9 3D Printing Integration of Fiber to Chip Coupling and Packaging

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Printing capabilities of inexpensive consumer 3D printers and freely available design and slicing tools have advanced to the point where they can produce complex and functional structures for a multitude of applications. One such application is silicon photonics. A large hurdle in silicon photonics is packaging, connecting the optical components (coupling) of such chips to the outside world via fibers. Coupling fibers to a chip is an intricate process in which a misalignment of a micrometer can cause a sharp increase in loss. A common way to stick fibers to a chip after coupling is to use UV epoxy, but this process has the unforeseen consequence of uncoupling the fiber as the epoxy cures and shifts the tip of such fiber. An industrial approach is to use multi-million dollar equipment to keep these fibers coupled to the chip, and polymer interfaces [1], widely inaccessible to research labs and start-ups. Other approaches exist, including photonic wire bonds [2], microspheres [3], micromirrors [4], and fiber ferrules [5], but all these require specialized equipment or unconventional fabrication of the integrated chips themselves. The approach being investigated uses UV epoxy, but ensures stability of the fiber by using a rigid v-groove structure at the tip, being held by common pick-and-place tools and 3D printed components. Optical coupling of one or two sides of a chip can be performed, fiber arrays can be used, and electric contacts can also be implemented via wirebonding to a printed circuit board (PCB). This alternative is extremely accessible, only requiring 3D printing, an XYZ stage, a vacuum tweezer, a v-groove fiber, and UV epoxy. Successful first results of the coupling, pre and post-epoxy curing will be demonstrated, painting an optimistic picture for the future of accessible silicon photonic packaging.

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P10 Surface chemistry of CuO nanoparticles with intermediates identified in CO_2 electrochemical reduction (CO_2ER) using in-situ ATR-FTIR spectroscopy

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Global climate change caused by increasing levels of CO_2 from human activities affects the ecosystem and civilization as we know it. Therefore, processes to decrease atmospheric CO_2 levels are of high interest. One process of CO_2 removal is electrochemical reduction (CO_2ER) using metal and metal oxide catalysts. By using metals such as copper (Cu) and silver (Ag) as catalysts for CO_2ER, CO_2 can be reduced to other useful hydrocarbons. Bicarbonate and formate are the most observed intermediates of CO_2ER. However, the current limitations of CO_2ER stems from the low selectivity of different metal catalysts to certain products due to the abundant number of hydrocarbon products. The goal of this research is to understand the fundamental mechanism of surface interactions between bicarbonate and formate with CuO and CuO/Ag nanoparticles. The specific objectives include using ATR-FTIR to quantify how each species binds to CuO and CuO/Ag surfaces in the dark and under irradiation. We aim to determine the structure of surface complexes, and adsorption/desorption thermodynamics and kinetics. This research will bring insights on the performance of CuO and CuO/Ag as catalysts and their viability in CO_2ER and could be used to optimize materials and conditions for large-scale application of CO_2ER.

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P11 Open-Air Fabrication of Oxide-Based Cantilever Gas Sensors

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Gas sensors have a vast variety of applications such as toxic gas detection, air quality monitoring, and early disease detection. Among the different gas sensing platforms, cantilever-based sensors have attracted considerable interest in recent years thanks to their ultra-sensitivity and high-speed response. The gas sensing mechanism in a dynamic cantilever sensor is based on its resonance frequency shift upon adsorption of a gas molecule on the sensor.[1] Metal oxides such as ZnO, SnO2, etc. are commonly used as the sensing material to sense a variety of gases such as ethanol, acetone, hydrogen, methane, etc. [2][3]

The aim of the research is to fabricate high-sensitivity/selectivity dynamic cantilever gas sensors by developing freestanding oxide-based cantilevers. Reducing the size of the cantilever and the number of layers on the cantilever allows for larger sensitivities.[4] The oxide layer is deposited using Atmospheric Pressure-Spatial Atomic Layer Deposition (AP-SALD), with tuned composition and properties for targeted sensing applications. This deposition technique is capable of producing high-quality metal oxide thin films with precise thickness control, up to 2 orders of magnitude faster than ALD and of occurring in open atmospheric conditions.[5] Accordingly, first we study deposition of oxides by AP-SALD and characterize the properties of the films. Next, a gas sensing bench setup is developed to investigate sensing response of the oxides using silicon cantilevers as transducer. Eventually, the oxide-based freestanding cantilevers are fabricated and their frequency response to several analytes are measured.

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P12

Nonenzymatic Saliva-Range Glucose Sensing Using Electrodeposited Cuprous Oxide Nanocubes on a Graphene Strip

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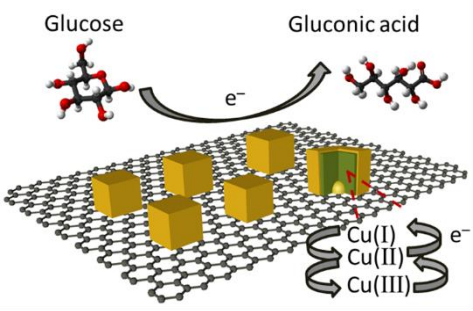
Cuprous oxide (Cu_2O) nanomaterials provide a versatile platform for building nonenzymatic glucose sensors. In particular, Cu_2O nanocubes with controllable sizes and distributions can be deposited electrochemically on a conductive graphene strip as a soft substrate under different conditions, including overpotential, temperature, copper-ion electrolyte concentration, and deposition time. Graphene provides a promising substrate for sensing because of its high

conductivity, high specific surface area, and unique thermal and mechanical properties. A more negative overpotential is found to produce smaller nanocubes with a large number density, while the deposition temperature could affect the morphology of nanocubes. The size of the nanocubes increases with increasing copper-ion concentration and deposition time. Using an optimal condition of -1.0 V vs Ag/AgCl, 1 mM [Cu^{2+}], and 100 s deposition time at room temperature, we obtain a near-homogeneous monolayer of Cu_2O-shell Cu-core nanocubes, ~50 nm in size, on a graphene strip substrate.

The Cu_2O nanocubes/graphene system is used as a high-performance sensor with a wide detection range of 0.002 $-$ 17.1 mM and a high sensitivity appropriate for saliva-range glucose sensing. It has also been used to test glucose in the real saliva sample with 95% accuracy. This nonenzymatic glucose sensor is considerably better in performance than other nonenzymatic sensors, including those based on bare graphene, and graphene sputter-coated with a Cu film, and conventional enzymatic sensors such as glucose oxidase immobilized on graphene (with and without Nafion). In addition to being an excellent catalyst, Cu_2O nanocubes have a large specific surface area and a large amount of active sites.

These nanomaterial properties, along with the use of a high conductivity substrate like graphene, make the Cu_2O nanocubes/graphene sensor among the best saliva-range glucose sensors reported to date.[1]



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P13 Preparation of κ-carrageenan/graphene oxide/cellulose nanocrystal eco-friendly composite hydrogel beads & their efficient adsorption for heavy metals

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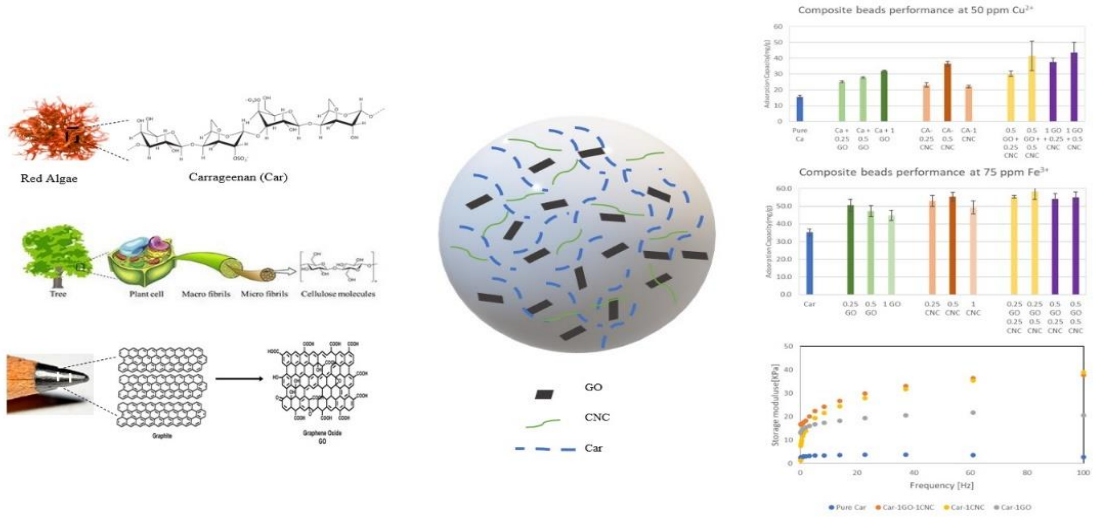
Polysaccharide-based polymers (also known as biopolymers) are a green and sustainable class of water contaminant adsorbents that have been widely studied in past years. Some of these green polymers are able to form hydrogel beads in presence of cationic ions. Biopolymeric-based beads are not only sustainable adsorbents, but they also have a great potential to be packed in a column and used in a flow-through system on large scale. Despite all the advantages, they usually suffer from low mechanical stability and low adsorption capacity. To enhance their performance and durability, encapsulation of nanomaterials in the polymeric matrix has been proposed[1]. In this study, we encapsulate graphene oxide (GO) and cellulose nanocrystal (CNC) into κ-carrageenan-based beads. We have investigated the performance of binary composite beads (Car-GO, Car-CNC) as well as ternary composite beads (Car-GO-CNC) in heavy metal removal by Cu^{2+} and Fe^{3+}, as standard models of divalent and trivalent cations, respectively. Our results show that the addition of GO and CNC contributes significantly to Cu^{2+} adsorption and enhances the beads' environmental performance by up to 130% for Car-CNC, 101% for Car-GO, and 185% for Car-GO-CNC. Moreover, the addition of nanomaterials not only improves the adsorption of Fe^{3+} to up to 70% but also significantly increases the adsorption rate. After 1 hour of contact with adsorbent, pure Car beads remove only 18% of Fe^{3+}, whereas ternary beads remove 65%. The dynamic rheology test shows that the addition of both nanomaterials, especially CNC, can improve the mechanical strength of the beads by more than 400%. To investigate the composition, morphology, and stability of the hybrid beads, we further characterized composite beads by FTIR, TGA, etc.



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P14 Experimental protocol of dithiothreitol assay to quantify the oxidative potential of atmospheric particulate matter

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There are numerous causes for certain health diseases from exposure to air pollutants on a global scale. The health impacts of air pollution originate from the toxicity of particulate matter (PM) upon inhalation. Some organic compounds and transition metals in PM generate reactive oxygen species (ROS) that are the most damaging biologically. The Dithiothreitol ($C_4H_{10}O_2S_2$, DTT) assay is one of the prevalent acellular assays used to predict the oxidative potential of atmospheric PM. It is very important to optimize the experimental procedure of the DTT assay to correlate the measured oxidative potential with various chemical components in PM such as quinones, polycyclic aromatic hydrocarbons, humic-like substances, iron and copper. The objective of our work is to investigate the health impacts of field-collected aerosols by using the DTT assay to quantify their acellular chemical toxicity. The DTT assay is conducted in the dark due to the light sensitivity of DTT under conditions that simulate biological conditions (37°C, pH 7.4). We hypothesize that the synergistic effect of organic matter and transition metals amplifies the oxidative potential of PM. Preliminary results were completed on the quantification of DTT consumption of standard chemical compounds that include1,4 naphthoquinone (NQN), 1,2-NQN, phenol, 2-aminophenol, 4-aminophenol, 9,10-phenanthrenequinone (PQN), Cu (II) and Fe (III). Our project is significant because it paves the way to inform measures aimed at preventing environmental health risks due to aerosol exposure.

P15 A Case Study on Quantifying Nanoparticle Toxicity: Using Dithiothreitol Assay to Study the Oxidative Potential of Atmospheric Particles in Kitchener, ON

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Fine particulate matter ($PM_{2.5}$) in the atmosphere is of high priority for air quality management efforts to address human adverse health effects.[1] Several studies show the association between increased ambient $PM_{2.5}$ and morbidity or mortality.[2] This association is explained by the oxidants produced by $PM_{2.5}$ through multiphase chemistry.[3] However, the impact of $PM_{2.5}$ on health differs by region because it depends on the atmospheric particles' chemical composition, which varies by source type.[4] Waterloo Region is the third fastest developing region in Canada, and this development comes with the cost of increased emissions and air pollution. Hence, there is a need to provide scientific data to monitor and identify local areas of poor air quality. In my poster, I will describe recent experimental results that quantify the ability of the atmospheric particles to produce reactive oxygen species (ROS) under conditions that stimulate oxidative stress in the human body. These experiments use an acellular Dithiothreitol (DTT) assay to study specific redox-active species that are common in $PM_{2.5}$, including 9,10-Phenanthrenequinone (PQN), 1,4-Naphthoquinone (1,4NQ), 1,2-Naphthoquinone (1,2NQ), and Copper. The DTT assay is a known technique to determine DTT consumption rate, which is proportional to the oxidative potential (OP) of the chemicals under study. The DTT molecule has a two-thiol group that gets oxidized when exposed to ROS, and this catalytic redox reaction happens in the presence of quinones and transition metals in $PM_{2.5}$.[4-6] We hypothesize that $PM_{2.5}$ particles collected from specific sites in Kitchener, ON have measurable oxidative potentials that could induce inflammation in lung cells due to its chemical composition. Our project will fill the knowledge gap on the toxicity of fine PM and inform the community about the air around them.

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P16 Integrated Microfluidic and Electrochemical Nano-biosensor: Towards Solutions for Point of Care Diagnosis of Cervical Cancer

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Cervical cancer (CC) is a global problem, standing as the fourth most common cancer among women worldwide [1]. The CC burden is substantially higher in low- and middle-income countries (LMIC), with nine in ten CC-associated deaths occurring in LMIC [2]. CC, if detected early, is highly treatable. CC screening and treatment at early stages costs less than $500 USD and has 90% survivability, whereas treating the invasive CC costs about $5,000 USD with only 15% survivability [3,4]. Limited access to complex laboratory equipment and professionals for sample processing and analysis in LMIC contributes to the higher CC burden in these regions. Therefore, low-cost and easy-to-use assays for CC detection in point-of-care settings are critical to early diagnosis and timely treatment.

Here we present an integrated microfluidic electrochemical assay for CC diagnosis, named IMEAC, that can detect CC circulating deoxyribonucleic acid (DNA)- CC diagnosis and prognosis biomarkers- in isolated plasma samples [5–7]. Our IMEAC combines two main modules to achieve this: a novel passive plasma separator (PPS) microfluidic device that isolates plasma without a need for applying an external force, and a graphene oxide (GO) based-electrochemical biosensor that employs single-stranded nucleic acid probes for specific CC circulating DNA recognition. The PPS device uses capillary force along with sedimentation to isolate approximately 22 µL of plasma from 160 µL of whole blood

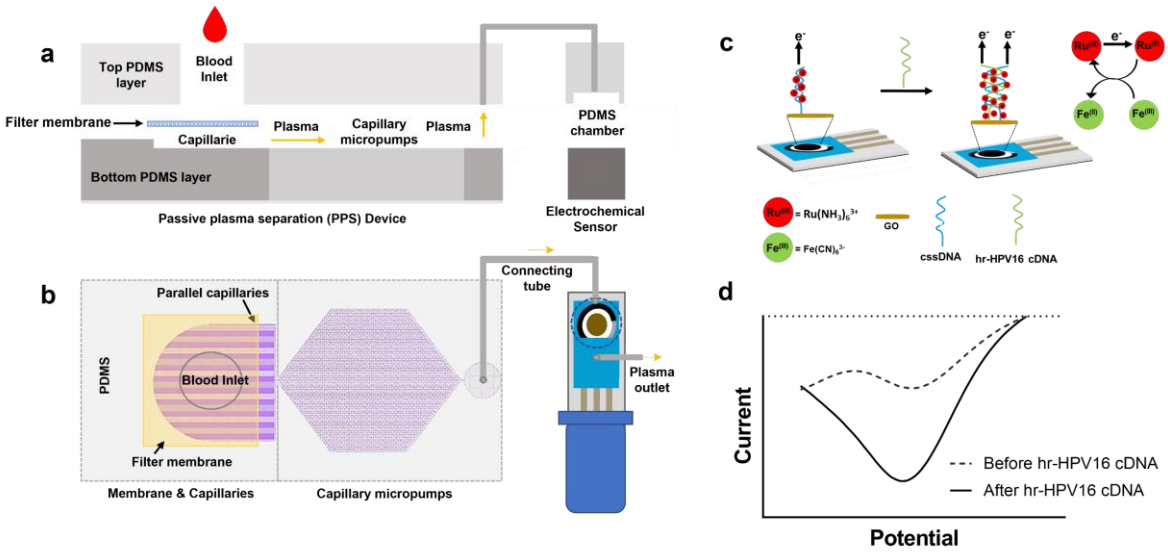

Figure 1, Overview and working mechanisms of IMEAC. Side view **(a)** and top view **(b)** of the IMEAC device that integrates two main modules: PPS for plasma isolation and an electrochemical biosensor. **(c)** Working principle of the electrochemical sensor for hr-HPV16 cDNA detection. **(d)** a sample graph extracted from IMEAC showing the presence of hr-HPV cDNA in the extracted plasma sample.

without any dilution in 10 minutes. The electrochemical detection is achieved via GO-modified electrodes immobilized with probe molecules that detect circulating DNA targets. The primary advantage of our IMEAC device is that it avoids the use of the conventional "gold standard" centrifugation method which requires access to external equipment and materials. Thus, our IMEAC device can be used as a complete assay that generates plasma from whole blood for the detection of CC biomarkers in the point-of-care testing setting.

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P17 Sensing and characterization of Extracellular Vesicles via Surface-enhanced Raman spectroscopy for Ovarian cancer diagnosis

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The detection and characterization of Extracellular Vesicles (EVs) have attracted the research community's interest due to their critical function in intercellular communication [1-3]. However, the development of new methodologies for the analysis of EVs is hindered by their small size and the complex matrix in which they are usually found. For this reason, the use of novel techniques based on nanomaterials combined with different purification and spectroscopic detection methods has appeared as suitable and sensitive alternatives. The fabrication of nanohole arrays using electron beam lithography allows the possibility to trap the EVs and, at the same time, obtain a spectroscopic signature of the content of the EVs through surface-enhanced Raman spectroscopy (SERS) enabling the identification and sorting of different EVs.

Nevertheless, summarizing the data and correlating the fingerprints of many different Raman spectra is an extremely challenging task. In this regard, the application of machine learning, owing to its outstanding achievements in processing and classifying information for diagnosis purposes, allows the analysis of a wide variety of data in short periods of time. In the present work, the fabrication of new SERS substrates based on nanohole arrays with different shapes for the identification of an epithelial human immortalized cell (hIOSE) and three cell lines derived from Ovarian cancer fluids (EOC06, EOC18 and EOC29) will be described. Analysis of the EVs unique fingerprint and their characterization by SERS will also be presented. Finally, the application of different machine learning algorithms such as PCA, logistic regression (LR), Support vector machine (SVM), Naïve Bayes (NB), Random Forest (RF), and CN2 ruler for the differentiation of the cell lines will be discussed.

Keywords: Extracellular vesicles, Surface-enhanced Raman spectroscopy, Nanohole arrays, plasmonic, nanomaterials, Machine Learning.

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P18 Plasmonic Sensors Based on 3-D Arrays of Gold-Plated Silver Nanoparticles

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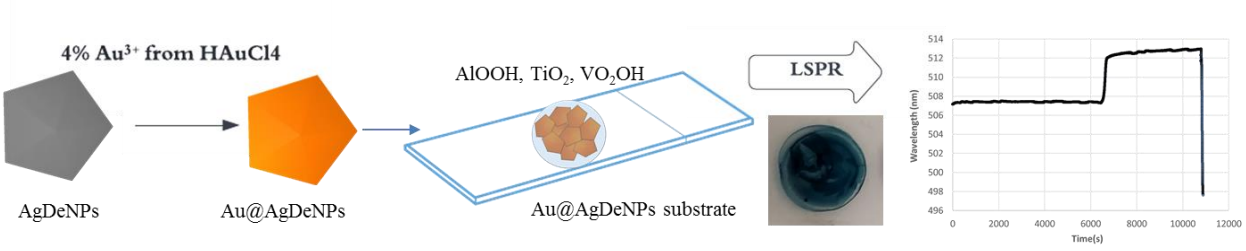
Plasmonic metal nanoparticles (PLNPs) offer several unique advantages due to their nanoscale properties.[1] The primary feature of PLNPs is their localized surface plasmon resonance (LSPR) that enables a range of applications including drug release[2] and plasmonic sensing.[3] Silver nanoparticles (AgNPs) feature superior optical properties when compared to other metals, yet chemical stability of silver is limited, necessitating coating or alloying. Gold plating provides the best combination of properties with sufficiently improved stability and acceptably dampened LSPR resonance due to gold *d-sp* transitions. In this work, we employed previously developed decahedral silver nanoparticles (AgDeNPs)[4] with sharp LSPR peaks (Q > 15) due to 5-fold degenerated primary resonance in D_{5h} symmetry and optimized size- and shape-selection. Gold plating of AgDeNPs at 3-5 at% Au/Ag was found to be optimal to impart stability of the resulting Au@AgDeNPs, gauged by the resistance to high concentrations of chloride and 3 wt% hydrogen peroxide.

The main challenge in the formation of plasmonic arrays as the LSPR substrate on the surface is to reliably physically separate PLNPs, either avoiding or controlling the overlap of their LSPRs. Distancing PLNPs in 2-D arrays can be suitable for larger particles (ca. >100 nm), while for Au@AgDeNPs with the largest dimension ranging from 40 to 70 nm, formation of 3-D arrays is a better strategy. To produce 3-D arrays with the controlled Au@AgDeNPs separation, a process forming a matrix of gel-forming metal oxide nanoparticles were developed using inert AlOOH, photocatalytically active titania, and redox-active VO_2OH. Formation and optical properties of the resulting plasmonic arrays and prototype SPR testing will be presented and discussed.



Schematics of the plasmonic sensing: main preparation steps and schematic LSPR response.

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P19 Assessing the Properties of Nanoclusters for Photodynamic Therapy

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Every year more than 200,000 Canadians are diagnosed with cancer. Despite many advances in cancer research, there is still need for improved cancer treatment options. This project involves the synthesis and characterization of metal nanoclusters, which have been proposed as photodynamic therapy (PDT) agents, a type of cancer therapy. As clusters are being explored for their use in PDT, it important to identify clusters that are both stable in physiological conditions and able to produce reactive oxygen species, the active compounds in PDT. Here, we use absorbance and emission spectroscopy to monitor the stability of clusters in conditions that mimic physiological conditions. We also quantify the production of reactive oxygen species from different clusters to determine if they will be effective PDT agents. Overall, cluster stability and reactive oxygen species production varies with cluster structure and ligand. This work provides useful information in selecting nanoclusters that will be suitable for PDT.

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P20 Size Effects Of Gold Nanoparticles On Binding To L-Cysteine

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Abstract

Radiotherapy (RT) is one of the major therapeutic strategies in cancer treatment. It conveys a high intensity of ionizing radiations (X-ray) accurately through the tumor cells, which leads to the death of the tumor tissues. However, there is always a potential damage for the surrounded healthy tissues during RT. Increasing the efficiency of RT could happen by using radiosensitizeng agents that can adsorb the photons and focus their effect on the cancerous cells and improve the therapeutic index. Gold nanoparticle (AuNP) is one of those agents which is inert, biocompatible with a high chemical stability. Among all the amino acids that are abundant biomolecules in the body environment, L-Cysteine (Cyst) as a thiol containing amino acid, binds strongly to AuNPs [1]. According to previous studies by the Hedberg group [2]by means of time-of-flight secondary ion mass spectrometry (TOF-SIMS), the interaction between 5 nm AuNPs and Cyst yields a product called gold-cysteine-thiolate complex which is relatively stable. However, further investigations are needed on the bond between AuNPs and Cyst. In this work, the interaction between Cyst and different sizes of AuNPs were also investigated using TOF-SIMS. All the tests were run with fresh Al foils used as the substrate on which the same mass of different sizes of AuNPs and Cyst solution were dropped on the surface. The intensities of recorded peaks at TOF-SIMS based on the peak area were collected and normalized towards the total intensity and different ratios were calculated to account for differences in NP distribution in the image.

Acknowledgement:

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P21 Gold Nanoparticles Synthesized Using Various Reducing Agents and the Effect of Aging for DNA Sensing

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Citrate-capped gold nanoparticles (AuNPs) are one of the most commonly used reagents in colloidal science and biosensors. In this work, we first compared AuNPs prepared using four different reducing agents: citrate, glucose, ascorbate and 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid (HEPES). At the same absorbance at the surface plasmon peak of 520 to 530 nm, citrate-AuNPs and glucose-AuNPs adsorbed more DNA and had higher affinity to the adsorbed DNA. In addition, citrate-AuNPs had better sensitivity than glucose-AuNPs for label-free DNA detection. Then, using citrate-AuNPs, the effect of aging was studied by incubation of the samples at room temperature and 4℃ for up to 6 months. During aging, the colloidal stability of the citrate-AuNPs gradually decreased. In addition, the DNA adsorption efficiency and the DNA sensing sensitivity also dropped around 4-fold after 6 months. The aging behaved similarly at both temperatures. Heating at boiling temperature of the aged citrate-AuNPs could not rejuvenate the sensing performance. This study shows that while citrate-AuNPs are better than the other three, its surface property is changing gradually and this can influence its colloidal properties and sensing performance.

Acknowledgements

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P22 Using cationic liposomes to deliver in vitro transcribed long dsRNA to RTG-2 and RTgill-W1 cells for IFN induction

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Long double-stranded RNA (dsRNA) is a potent immunostimulant of host cells that protects against viral infection by upregulating the type I interferon (IFN)-based innate immune response. The intensity of the IFN response is dependent on effective dsRNA delivery. This research investigates the use of commercial cationic liposomes (composed of L-α-phosphatidylcholine, stearylamine, and cholesterol) as an efficient delivery mechanism to enhance IFN-stimulated gene (ISG) upregulation and the subsequent antiviral state. Liposome delivery systems in rainbow trout have not been extensively studied, so their use as carriers and adjuvants are both novel and attractive avenues of study.

DsRNA were loaded into liposomes (dsRNA-liposomes), as determined by gel shift assay and immunoblots. Due to the relative novelty of dsRNA-liposomes to rainbow trout immunological studies, half of the dsRNA-liposomes were further extruded (E-dsRNA-liposomes) to homogenize the liposome solution and compared against unextruded (U-dsRNA-liposomes). Dynamic light scattering and entrapment efficiency assays are being performed to analyze size distribution of the liposome preparations and dsRNA entrapment efficiency.

Cationic liposomes can be toxic in high concentrations, so cell viability assays were performed with E/U-dsRNA-liposomes to determine sub-lethal doses for immunostimulatory evaluation in Rainbow Trout (*Oncorhynchus mykiss)* gonad (RTG-2) and gill (RTgill-W1) cells. Non-toxic E-dsRNA-liposomes concentrations are being used to investigate the upregulation of *IFN1* and key ISGs *mx1* and *vig3.* Early data suggests that dsRNA-liposome complexes upregulate ISGs at comparable levels to naked dsRNA while requiring a fraction of the dose. At 6 hours after treatment, ISG upregulation has been detected. This research suggests liposomes are useful carriers for long dsRNA in fish and facilitate a more potent immune response to dsRNA alone, providing a novel avenue for broad spectrum antiviral therapeutics in fish.

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P23 Single-Molecule Atomic Force Microscopy Force Spectroscopy of Phytoglycogen Nanoparticles Modified by High-Shear Screw Extrusion

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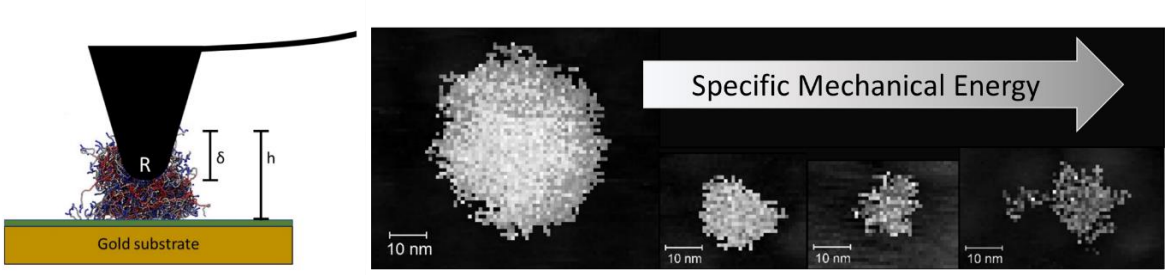
Phytoglycogen is a naturally occurring nanoparticle that is produced in sweet corn. It is composed of highly branched glucose chains that form a compact spherical particle with a dendrimer-like architecture. Phytoglycogen's composition and structure leads to highly ordered hydration water [1] and its size and mechanical stiffness greatly depend on its hydration state [2]. These properties combined with phytoglycogen's non-toxicity, stability in water, and ability to be combined with bioactive molecules make it an attractive nano-platform technology with applications in personal care, nutrition, and biomedicine. High-shear screw extrusion is a high-throughput method that applies a shear force to fragment the particles without the use of harsh chemicals. We have subjected phytoglycogen nanoparticles to high-shear screw extrusion at three different intensities or Specific Mechanical Energies (SMEs) [3]. The resulting size-reduced phytoglycogen nanoparticles were measured using Atomic Force Microscopy (AFM) Force Spectroscopy to evaluate their size, structure and mechanical stiffness in comparison to native phytoglycogen nanoparticles. AFM Force Spectroscopy acquires a large number of force-distance curves to provide high-resolution maps of the outer structure, internal structure, and mechanical modulus of single nanoparticles [2]. Extrusion at the lowest SME (122 Wh/kg) resulted in smaller, less hairy particles with a larger Young's modulus indicating the preferential removal of the softer outer region of the phytoglycogen nanoparticles. Extrusion at a moderate (278 Wh/kg) and high (488 Wh/kg) SME resulted in a subsequent decrease in the Young's modulus and increase in the particle hairiness with no further significant reduction in the particle size. These results show the effectiveness of high-shear screw extrusion to produce tunable size-reduced phytoglycogen nanoparticles and provides insights into this novel sustainable nano-platform technology.



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P24 Heightening innate immune responses in ovarian cancer cells with double-stranded RNA-phytoglycogen nanoparticles in vitro

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Ovarian cancer is the fifth most common cause of cancer-related deaths in Canada; despite this, there has been little improvement in survival rates over the last five decades. Innate immune stimulants can act as chemotherapeutic agents and have the potential to turn cold tumours hot and recruit the immune system to clear the tumour cells. Double-stranded (ds) RNA, including the synthetic polyinosinic cytidylic acid (poly I:C), has shown promise as a cancer therapeutic. The ovarian cancer cell lines in this study were previously tested for their ability to produce an immune response to poly I:C; SKOV-3 is a dsRNA-resistant cell line and OVCAR-3 is dsRNA-sensitive. Here we demonstrate that the addition of a modified nanophytoglycogen carrier can turn the dsRNA-resistant SKOV-3 into a sensitive cell line, and enhance the response in the dsRNA-sensitive OVCAR-3. The poly I:C-nanoparticles (pICNPs) have two therapeutic modes of action. First, the pICNPs showed cytotoxicity and caused significant cell death in OVCAR-3 compared to control cells and poly I:C alone, measured using two cell viability dyes alamarBlue and CFDA-AM. At concentrations where poly I:C alone was causing no cell death, the pICNPs induced nearly complete cell death. Second, the pICNPs compared to poly I:C-alone induced a significantly more robust type I interferon response in both cell lines, measured through qRTPCR for the innate immune genes CXCL10, interferon-beta, and ISG15, and an ELISA for the CXCL10. Nanoparticles carrying innate immunes stimulants, such as dsRNA, represent a robust and multifunctional therapy that may show efficacy against a range of ovarian tumour cells and increase the efficacy of existing treatments.

P25 Hydration Properties of Charge Modified Phytoglycogen Nanoparticles

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Phytoglycogen (PG) is a natural and sustainable biopolymer produced in the kernels of sweet corn as compact, highly branched nanoparticles. Its unique dendritic architecture and physical properties make PG ideal for a wide range of applications. To tailor the physical and chemical properties of the particles for specific functions, chemical modification can be used. Modifications of particular interest include the attachment of anionic and cationic chemical groups, where the addition of a charge provides a means of further tuning the physical properties of PG nanoparticles.

We investigate the effects of charge modification on the hydration properties of PG nanoparticles by covalently attaching either anionic (carboxymethylation; CM-PG) and cationic (glycidyltrimethylammonium chloride; GTAC-PG) groups. We used ellipsometry and attenuated total reflection infrared (ATR-IR) spectroscopy to probe changes in swelling properties and network water structuring at relative humidity values ranging from <4% to >90%. We observed dramatic differences between the results for native and charge modified PG, as well as between anionic and cationic modifications. These studies highlight how charge modification of PG nanoparticles can be used to achieve new materials with different physical properties for enhanced applications.

P26 Exploring the antiviral effects of a novel phytoglycogen-based nanoparticle and polyinosinic/polycytidylic acid in human lung cells.

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Recently, there has been interest in the use of nanoparticles as as delivery agents for antiviral immune stimulants. Polyinosinic: polycytidylic acid (poly I:C) is a double-stranded RNA molecule that acts as an immunostimulant. Since most viruses produce dsRNA during their replicative cycle, the host cell mounts a potent immune response upon exposure. The current project focused on using a novel phytoglycogen nanoparticle (NP) as a carrier for poly I:C, to test whether it enhanced poly I:C's immuno-stimulatory effects and protected cells from infection. The impacts of poly I:C + NP and free poly I:C on the cell were characterized *in vitro* in human embryonic lung (HEL 299) cells. The protective effects of poly I:C + NP and free poly I:C against virus infection were measured using an antiviral assay. HEL 299 cells were pretreated with poly I:C + NP as well as free poly I:C then infected with vesicular stomatitis virus expressing green fluorescent protein (VSVgfp). Significantly more protection was measured in poly I:C + NP treated cells compared with poly I:C alone. HEL 299 cells stimulated with poly I:C + NP also expressed higher levels of immune defense agents; interferon-beta (IFN-beta), C-X-C motif chemokine ligand 10 (CXCL10) and interferon-stimulated gene 15 (ISG15) compared to free poly I:C alone at 6h, 24h, 48h and 168h. Thus, the use of poly I:C + NP should be further examined as it serves as a promising antiviral agent.

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P27 Encapsulation of long dsRNA in liposomes and SARS-CoV2 virus like particles for the stimulation of antiviral RNA interference in human cells

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Long (>30bp) double stranded RNA (LdsRNA) is created during the replication cycle of all viruses and its presence in cells triggers antiviral immune responses in the host including the antiviral RNA interference (RNAi) response to LdsRNA (dsRNAi), which is a newly discovered antiviral response in vertebrates [1], [2]. *In vitro* delivery of LdsRNA to *homo sapien*s (human) cells can stimulate the antiviral dsRNAi response [2], however we hypothesize that *in vivo* treatments will require a carrier molecule to deliver the LdsRNA to target cells and avoid LdsRNA degradation. This study seeks to assess virus like particles (VLPs) and liposomes as carriers for the delivery of LdsRNA to human cells for the stimulation of the dsRNAi response against human coronavirus 229E (HCoV-229E). We have encapsulated HCoV-229E LdsRNA in SARS-CoV2 VLPs (Abnova) via a disassembly and reassembly method [3]. A GFP expression plasmid was also encapsulated in the VLPs and delivered to HepG2 cells (human hepatoblastoma) [4], [5]. In addition to VLPs, HCoV-229E LdsRNA was also encapsulated in liposomes and has been delivered to Hel-299 cells (human embryonic lung) [6]. CFDA and Alamar Blue assays have been performed to determine a non-toxic dose. Furthermore, we have shown total encapsulation of the LdsRNA in liposomes through LdsRNA immunoblots. We will next determine whether treatment with LdsRNA-VLPs and LdsRNA-liposomes can provide antiviral protection against HCoV-229E through median tissue culture infectious dose ($TCID_{50}$) assays. This is the first study to explore the delivery of LdsRNA encapsulated in liposomes for the stimulation of the antiviral dsRNAi response in vertebrates. While VLPs have been used to deliver LdsRNA to invertebrates [7], this is the first study to use VLPs to deliver LdsRNA to vertebrate cells. If effective, this strategy could be expanded to deliver LdsRNA sequences to target other vertebrate viruses.

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P28 Enhanced delivery of long double-stranded RNA to ovarian cancer cells using cationic polystyrene latex nanocarriers

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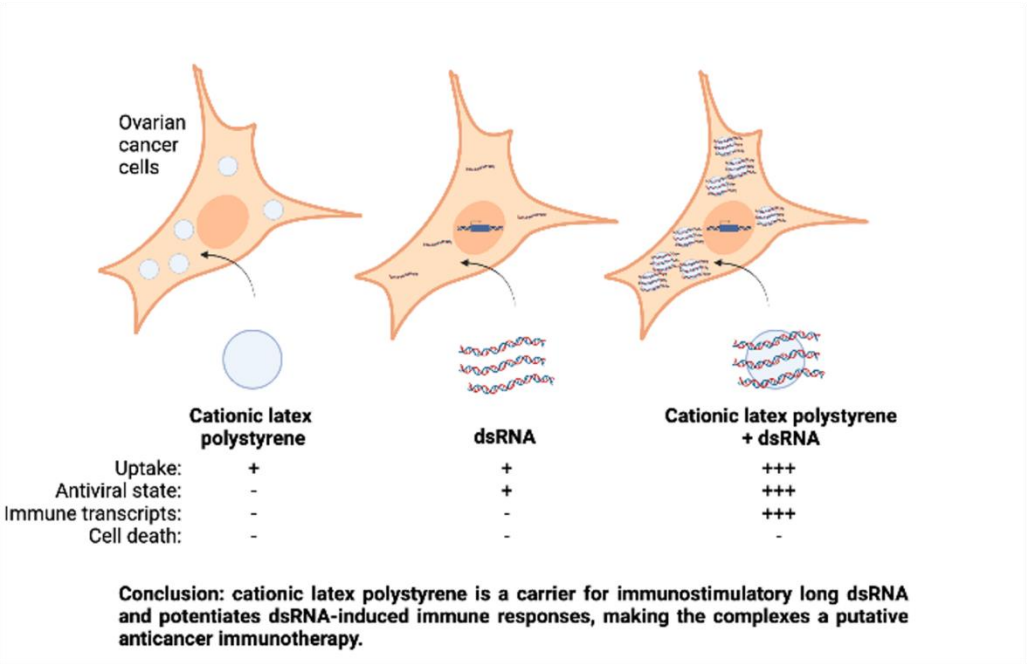
Long double-stranded (ds)RNA, a potent stimulator of type I interferon and the innate immune response. In the present study, we demonstrated for the first time the efficacy of cationic polystyrene latex nanoparticles (clNPs) as a dsRNA carrier, improving cellular delivery and robustly potentiating the immunostimulatory capacity of dsRNA in the ovarian cancer cell line SKOV3. The clNPs complexed with an *in vitro* transcribed dsRNA molecule, were bound by SKOV3 cells and had increased cellular association compared to uncomplexed clNPs. clNPs complexed with dsRNA induced a more robust innate immune response compared to dsRNA alone. Transcript expression of two interferon-stimulated genes, were increased 47- and 108-fold over dsRNA and induced a significant antiviral state against vesicular-stomatitis virus, resulting in a 3.3-fold improvement on the efficacy of dsRNA. These data highlight the potential of polystyrene latex nanoparticles as dsRNA carriers for anticancer immunotherapies, improving the uptake and efficacy of the nucleic acid.



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P29 Removal of Pharmaceuticals from Water Using Graphene-Containing Beads

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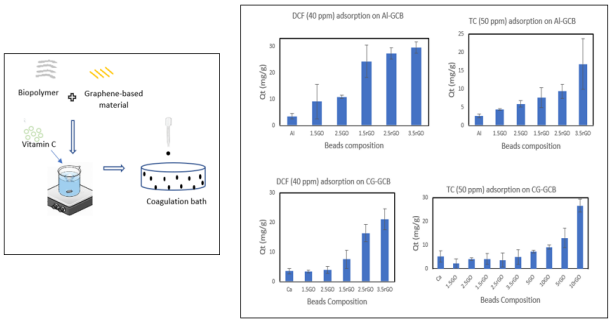
Contaminants of emerging concern (CECs), with the potential of causing long-term health effects, have not received much attention in water and wastewater treatment. CECs such as polychlorinated biphenyls (PCBs), per- and polyfluoroalkyl substances (PFAS), bisphenol A, pharmaceuticals, and personal care products, can bioaccumulate in human body causing harms ranging from endocrine disruption to antibiotic resistance[1], [2]. They are also capable of changing sexual behavior in aquatic animals[3].

This study aims to remove pharmaceuticals from water using adsorption process. The removal process is enabled by graphene-based two-dimensional (2D) nanomaterial which is developed into three-dimensional macrostructures (3DM). 2D nanomaterials present the advantage of a large surface-area-to-volume ratio in water treatment. In this work, to facilitate pharmaceutical removal from aqueous solution, graphene oxide (GO) is synthesized using the modified Hummer's method [4], and the GO is later reduced to reduced graphene oxide (rGO). The reduction process follows a green, facile approach using ascorbic acid (vitamin C)[4]. The 3DM is synthesized by encapsulating graphene-based nanomaterials (GO and rGO) in alginate (Al) and carrageenan (CG) biopolymers. The subsequent 3D graphene-containing beads (GCB) are formed through ionic gelation and covalently crosslinking biopolymer with GO/rGO.

GCB adsorbents were systematically investigated for the removal of diclofenac (DCF) and tetracycline (TC) from water. Compared to pure 'Al' biopolymer beads, 3.5rGO (GCBs with only 3.5% rGO) improved the adsorption capacity by 535% and 747% for TC and DCF removal, respectively. The improved and superior performance of rGO-containing beads is attributed to the hydrophobic properties of the rGO beads, and the enhanced π- π interactions between the aromatic rings of the contaminants and the π- π domains of the rGO-containing adsorbents.

Keywords: Biopolymer, Graphene-containing beads (GCBs), Pharmaceuticals, Water and Wastewater.



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P30 Design and Fabrication of Color-generating Nitride based Thin-Film Optical Filters for Photovoltaic Applications

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The use of electric vehicles (EVs) can reduce greenhouse gas emissions, air pollution, dependency on fossil fuels, and their adverse health effects on humans. But we can only utilize the full environmental benefits of EVs when they are charged with renewable energy sources with zero or low carbon emissions. As a solution, Mobarak et al. [1] suggested integrating low-cost, flexible, and thin-film copper indium gallium selenide (CIGS) solar cells directly onto all the upward-facing body parts of electric vehicles. However, this integration of solar cells comes with an aesthetic drawback. Previously, colorful photovoltaics (PVs) have been designed with one-dimensional (1D) photonic crystals or various 1D and 2D metallic nanostructures for aesthetic building-integrated photovoltaics (BIPVs) [2,3]. But the functionality of our application differs from that of BIPV as we need maximum absorption of the solar spectrum to obtain maximum conversion efficiency. Minus filters or notch filters are special optical filters that reject a selected wavelength band and transmit shorter and longer wavelengths. They are widely used in various scientific and technological applications such as, laser-based fluorescence instrumentation, and Raman spectroscopy [4]. Thus, we propose replacing the anti-reflective coating (ARC) present in standard solar cells with a notch filter (a narrow high-reflection region in the visible range along with high transmission for the rest of the solar spectrum) to give a distinct color rendering to solar-charged EVs.

Notch filters can be designed using a rugate filter structure consisting of continuously modulated refractive indices [5] or using a repetitive two-material stack of alternating high (H) and low (L) refractive index materials with precise thickness, also known as the standard two-material technology (S2MT) [6], [7]. We proceeded with the S2MT design. We used OptiLayer [8] to simulate our designs, and the random optimization technique was used along with the gradual evolution method to obtain the optimized structures. We performed our simulations with a multilayer structure of alternating high and low refractive indices of 2.09 [9] and 1.45 [10], respectively, on top of a silicon substrate (refractive index of 4.08) at a reference wavelength (λ_0) of $400\ nm$. Our selected design has 11 layers with around 67% reflection from $345\ nm$ to $473\ nm$. There is less than 10% reflection in the high transmission region of $300\ nm$ to $345\ nm$ and $473\ nm$ to $1200\ nm$ with a HMFW of $78\ nm$.

For fabricating this design, materials are needed that are transparent to the portion of the solar spectrum targeted by the solar cells' active material and that have refractive indices close to our simulation. Thus, we chose the combination of silicon nitride and silicon oxynitride as our high and low refractive index materials, respectively [9]–[13]. Electron cyclotron resonance plasma-enhanced chemical vapor deposition (ECR-PECVD) was used to deposit the multilayer structure on silicon wafers. A $SiH_4/N_2/O_2/Ar$ precursor mixture was used to obtain the silicon nitride and oxynitride layers. The stoichiometry and the required refractive index for each layer were adjusted by tuning the gas flow rate in the reactor chamber. To characterize the refractive index and thickness for each layer, variable angle spectroscopic ellipsometry (VASE) was used. A detailed comparison of our simulation and fabrication results will be presented.

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P31 Optimization of Electromagnet Geometries for Transcranial Magnetic Stimulation of Visual and Motor Cortices

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In neurocognitive research, transcranial magnetic stimulation (TMS) has shown notable clinical promise for treatments of various neurological disorders, such as Major Depressive Disorder [1] and stroke-induced reduction of brain function [2, 3]. TMS is a non-invasive magnetically induced neuromodulation technique based on cortical excitation/inhibition. To further study the poorly understood physiological mechanisms underlying TMS, a York University interdisciplinary collaboration will implement a new device combining near infrared spectroscopy (NIRS) and TMS. NIRS methods allow for the measurement of hemodynamics associated with alterations in blood flow following the application of TMS, which is a new and noninvasive biophotonic sensory approach to studying TMS. TMS will be further evolved with novel designs of TMS coils and pulsing protocols. A human brain has complex nonhomogeneously anisotropic electromagnetic properties and a variety of brain regions that would yield various therapeutic responses to TMS. Therefore, the study of TMS demands a large range of magnetic field focality depths, concentrations, and orientations. Currently, the two main TMS coil geometries used are simple pancake and figure-8 coils. New coil geometries (such as eccentric, slanted, etc.) promise to provide more complex desired magnetic field configurations. COMSOL Multiphysics Software is used to model induced electric fields in a brain for each of the coil shapes, optimizing geometric and electric parameters. After modeling, prototypes will be produced at York University, and tested in a laboratory setting using the TMS-NIRS methodology.

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