QCAM Quebec Centre for Advanced Materials

Newsletter

September 2020

2020 annual symposium –online, 6th November

Petr Fiurasek

Programme

9 - 9:30 am: Opening address by Janice Bailey, Scientific Director of FRQNT; QCAM director Theo van de Ven, McGill, and Bruce Lennox, QCAM member and Dean of Science at McGill.

9:30-10:30 am: Invited speaker, Reiko Oda, IECB Bordeaux, France

10:30-10:45 am: Coffee break sponsored by PRIMA

10:45-11:00 am: Gold sponsor talk, Sébastien Garbarino, PRIMA, Innovation and infrastructure consultant.

11:00 am -12:30 pm: Topical sessions (fundamental)

12:30 - 1:15 pm : Lunch break sponsored by SFR, including a lunch-and-learn webinar (12:45-1:15 pm).

1:15-2:15 pm : Invited speaker, Timothy M. Swager, MIT, Cambridge, USA.

2:15-2:30 pm : Platinum sponsor talk, David Polcari, SFR, Business manager: *Advanced Tools for Materials Characterization.*

2:30-3:30 pm: Topical sessions (applied)

3:30-3:45 pm : Coffee break sponsored by SnowHouse(to be confirmed)

3:45-4:00 pm: Gold sponsor talk, Snowhouse (to be confirmed).

4:00-4:30 pm: Topical sessions (applied), second part

4:30-4:45 pm: Buffer time.

4:45-5:45 pm: Invited speaker, Vincent Chevrier, 3M Minnesota, USA.

5:45-6:00 pm: Awards ceremony: best presentation prizes. Closing remarks.

Call for abstracts

We invite QCAM students to submit an abstract for a 12-minute oral presentation or a 60-second flash talk on their research project. There will be an award ceremony for the best presentations.

Deadline 13th October 2020

Topical sessions

Fundamental: polymer science, self-assembly and nanoscience.

Applied: energy, environmental and biomedical applications.

REGISTRATION:

https://form.jotform.com/202325838698265

FINAL PROGRAMME:

http://cqmf-qcam.ca/symposium?lang=en

STUDENT WORKSHOP, SCIENTIFIC WRITING

24th September 2020

Effective scientific writing, led by Daria Boffito and Gregory Patience (Polytechnique).

Programme: Deliberate practice makes you better, Why, How? Discourse, Style, Metadiscourse.

This workshop will take place online.

More information on the invited speakers and sponsors overleaf →

FEATURE - TACKLING COVID-19 THROUGH FUNCTIONAL MATERIALS (pages 3-6)

Invited speakers

Reiko Oda, IECB Bordeaux, France. Prof Oda's team is interested in understanding the mechanism of formation of molecular assemblies in order to design and build new nanometric molecular assembly systems of amphiphilic molecules, the morphologies and functions of which can be finely tuned. (source: IECB Website).

Vincent Chevrier , Corporate Research Systems Laboratory, 3M, USA. Dr Chevrier is currently working on Materials Informatics at 3M. His talk will focus on nanostructured Si Alloys for Li-ion batteries: how to increase the energy density of Li-ion cells through the use of Si.

Timothy Swager , MIT, USA. Prof. Swager is John D. MacArthur Professor at the Department of Chemistry. His research group develops functional materials and sensors; they also study reaction chemistry for the construction of conjugated systems, electronics, and the materials biology interface (source: Swager group's website).

Sponsors

Platinum

SFR MAGNIFYING NANOSCIENCE

Gold

PRIMA Advanced Materials Moving Forward

molecular VISTA

SnowHouse Solutions

Bronze

1-MATERIAL Organic Nano Electronic

An additional best presentation prizes will be offered by the RSC journal *Chemical Science*

ROYAL SOCIETY OF CHEMISTRY

Prizes and awards: QCAM in the spotlight

Pascale Chevallier: **1st prize, 2020 FRQNT Research Professionals Excellence Awards.** Pascale holds a PhD in polymer chemistry and works at the U.Laval CHU, where she is in charge of an advanced platform for the modification and characterization of surfaces. Her research interests include biomaterials and cardiac, vascular, dental, orthopaedic and, more recently, neurological implants. Member of Prof. Mantovani's group, she also provides invaluable assistance and guidance to QCAM and CERMA researchers looking for specialist expertise and skills in data acquisition and interpretation for the characterisation of the properties materials and their surfaces. Since 2006, more than 150 student researchers from 40 countries have relied on her invaluable help on a daily basis. Involved in 60 international collaborations and in the management of industrial research contracts, Pascale has contributed to develop several medical devices and antibacterial products. Co-author of 136 publications and 3 patents, she has also collaborated on the design and preparation of grant proposals, on the management of industrial collaborative projects and of international academic partnerships and on the training of students, who highly appreciate her interpersonal skills.

Jacopo Profili, **1st prize at the Acfas 2020 Génie en affaires competition**, for Kalego, an innovative endoscopic probe featuring anti-fogging properties introduced by plasma treatment. Dr Profili carries out research on three multidisciplinary subjects: nanomaterials, environment and plasma; he specialises in advanced alternative plasma processes for the surface treatment of various materials (liquids, polymers, metals and ceramics). Dr Profili first attended Université Pierre et Marie Curie, where he trained in materials science. Then, he focussed on out-of-equilibrium atmospheric pressure plasma processes for the synthesis of nanocomposite thin layers on wood substrates during his twin PhD project (UdeM – Toulouse). After obtaining his PhD, he worked as a research assistant at UdeM. Among his postdoc projects: the design of innovative biofunctional surfaces (with FPInnovations), the synthesis of advanced interfaces for Li-ion batteries (with TOTAL), but also the fundamental study of plasma-liquid interaction for water remediation.

More prizes and awards on page 7

Tackling COVID-19 through functional materials

An overview of QCAM research

At the forefront of the pandemic: the lungs

By Laurianne Gravel-Tatta (graduate student, UdeM)

Pathogens of the coronavirus family target the lungs. For example, the immune response caused by SARS-Cov-2 (severe acute respiratory syndrome coronavirus), the virus causing the disease COVID-19, causes the inflammation of the pulmonary alveoli making normal breathing difficult for severely affected patients as well as for those already suffering from lung problems.

Lung surfactants are the key of the mechanics of breathing. This mixture of phospholipids and proteins covers the air/water interface of the pulmonary alveoli in the form of a monolayer. Their primary role being to reduce surface tension, pulmonary surfactants allow normal expiration while avoiding respiratory collapse.

Phytoglycogen dendrimer

The lungs, with their high surface area of approximately 70 m^2, are a promising pathway for the treatment of respiratory disease such as complications possibly related to COVID-19. SARS-CoV-2 is proposed to destroy type II alveolar cells, which are responsible for the production of lung surfactants. This could thus lead to a decrease in pulmonary surfactants on the surface of the alveoli and could explain the shortness of breath feeling in patients suffering from pneumonia due to COVID-19. The lungs are also the first barrier crossed by all inhaled particles, pulmonary surfactants thus offer the possibility of site-specific physical delivery of chemotherapeutics and antibiotics. Inhalation delivery is expected to be an ideal approach for the treatment of lung cancer and associated pulmonary infection. In this perspective, nanoparticles are ideal vectors for specific delivery of therapeutic molecules. Nanoparticles have a multitude of characteristics which makes them versatile. It is thus possible to choose the chemical composition and to functionalize their surface in order to obtain specific recognition of the affected region. The doses administered can thus be reduced, which in turn reduces the side effects associated with the treatments.

Synthetic nanomaterials based on metals such as gold are commonly used and can affect a normal respiratory cycle. It is therefore essential to study the physical and chemical interaction of nanoparticles with pulmonary surfactants in order to assess their toxicity. Badia's and DeWolf's groups therefore propose the use of a novel phytoglycogen nanoparticle. This nanomaterial is extracted from non-GMO corn, making it safe, natural and eco-friendly. Before determining the efficacy of phytoglycogen nanoparticles to serve as organic nanocarriers for the aerosol delivery of therapeutics, their impact on the biophysical properties and phase structure of lung surfactants must be characterised. Using the Langmuir-Blodgett technique, it is possible to obtain a monolayer at the air/water interface in order to mimic the pulmonary surfactants covering the alveolar sacs. BAM (Brewster Angle Microscopy) images, isotherms (surface pressure vs molecular area) as well as AFM (Atomic Force Microscopy) images allow the analysis of the potential toxicity of phytoglycogen nanoparticles on pulmonary surfactants. As the charge of nanomaterials is an important factor influencing their toxicity, anionic, cationic and neutral nanoparticles are studied to determine the role of electrostatic forces in this type of interaction.

The possibilities of treatment are not limited to the lungs. Being the extension of the respiratory tract, the pulmonary alveoli allows gas exchange with the blood. The presence of a thin epithelial barrier and an abundant underlying vasculature allow this exchange between inhaled air and blood. It is therefore also possible to target the desired organ and deliver a drug trough the vast network of blood vessels. The inhalation of medication is not only limited to the treatment of pulmonary diseases, but rather targets the entire human body.

This research project is possible thanks to the QCAM collaborative project grant awarded to Antonella Badia as well as to Christine DeWolf

Materials against COVID-19: a three-dimensional approach

By Matteo Duca (pages 4-6)

"Protect, detect, disinfect": this is materials scientists' threefold response to the challenges posed by the COVID-19 pandemic. Innovative functional materials are indispensable for curbing the spread of SARS-CoV-2. This article will present an overview of NSERC-funded QCAM research projects tackling COVID-19 from three angles.

Protect

From homemade face coverings to medical-grade respirators, masks have turned into the worldwide telltale sign of the ongoing pandemic. The race to secure personal protective equipment (PPE) even sparked an international tug of war while demand largely outstripped supply. The federal government has also rolled out a plan to boost domestic production of PPE in Canada. Research on materials for PPE will not only be instrumental in improving PPE performance: advances in fabrication methods will also allow companies to mass-produce high-quality PPE, as shown by the project led by **Sylvain Cloutier** (see below).

SEM images of mask fabric show a tangle of fibres acting as a net to capture airborne particles through inertial impaction and interception (particles larger than 0.3 μm); diffusion and electrostatic attraction (particles smaller than 0.2 μm). Surgical masks consist of three layers of nonwoven fabric, usually polypropylene, paper or felt; N95 respirators, instead, are composed of four layers and may include an exhalation valve. Melt-blowing is a widely used mass fabrication process, while electrospun fibres have attracted considerable research interest.

The Cloutier group (ÉTS) has taken up the challenge of the mass production of high-performance electrospun cellulose membranes. Sylvain Cloutier's project is a partnership with KWI Kunststoffwerk Industrie Inc: the Cloutier group provides its technical expertise to contribute to the development a large-scale manufacturing process of certified N95 masks. "I was fortunate that I already have a team of experienced students in place, with all of the necessary skills for manufacturing these types of materials" Sylvain Cloutier remarks.

Cloth masks: with a grain of salt

Not all homemade masks are created equal: two papers in ACS Nano[1,2] dissect their filtering performance.

Is kitchen paper soaked in salted water just as good as surgical masks?

Hot topics

A thin graphene layer turns a surgical mask into a superhydrophobic barrier and gets to a scorching 80°C under sunlight. When discarded, just reuse it to desalinise water.

Respirators with a silver spoon: plasmonic effects from Ag nanoparticles fry viruses on a superhydrophobic coating.

But there is much more to PPE than keeping viruses out: antiviral agents incorporated in the PPE outer layer would provide greatly enhanced protection, complementing passive filtering. Researchers have studied a dazzling array of materials with intrinsic or photoinduced antiviral properties, from time-tested antimicrobial silver to graphene. Self-cleaning, superhydrophobic and even self-heating surfaces would be game-changing features of vital importance for health workers in high-risk settings.

Phuong Nguyen-Tri has taken up this challenge. Recently appointed UQTR Research Chair in materials for health and safety at work, he will lead a project in collaboration with QCAM member Gelareh Momen (UQAC) and two industrial partners, NanoBrand and Tekna Plasma Systems Inc. They aim to engineer PPE incorporating antiviral agents based on copper and silver oxides and test this innovative PPE for protection against SARS-CoV-2.

Researchers have also tried to upgrade existing surgical masks and face coverings. This shortcut to enhanced PPE would also go a long way towards alleviating the shortage of this critical equipment. **Marta Cerruti** (McGill) teams up with Blachford Ltd. to develop antiviral coatings that can easily be applied to fabric, forming a stable protective layer. Ideally, this spray-on formulation would allow anyone to boost the protective performance of their scarves and cloth masks.

Meanwhile in Portugal...

A reusable cloth mask with certified antiviral activity. Lasting up to 50 washing cycles, "it features different protection layers and a water-repellent treatment".

(Quiz: Can you guess the antiviral material? Hint: "It's not a heavy metal. It's a biodegradable chemical")

In the future, the design of PPE should ensure their reusability after proper disinfection and take into account their end-of-life fate, since the environmental footprint of dis-

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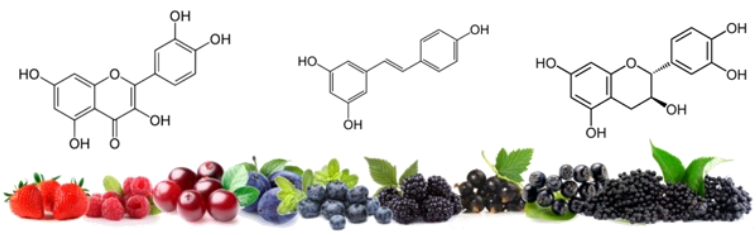
carded PPE is looming large—think about our pavements littered with blue surgical masks.

There is yet another way of preventing SARS-CoV-2 infection, one explored by two projects involving QCAM researchers as co-PI. **Roger Gaudreault** (UdeM) and **Theo van de Ven** (McGill) will contribute to a multidisciplinary study of polyphenols in collaboration with industrial partner Fruitomed Inc.



Molecular structures of three polyphenolic compounds (courtesy of Fruitomed Inc.)

Dr Gaudreault gives us a flavour of this project: "polyphenols are bioactive molecules naturally present in fruits and vegetables, and more particularly in abundance in dark berries. Our team will evaluate the power of polyphenols to inhibit interactions between SARS-CoV-2 proteins and receptors on the surface of cells in humans, as well as to attenuate the process of viral replication". The researchers will try and unravel the formation of polyphenol-protein complexes by using a combination of theory and experiments.

Detect

Materials science holds the key to the development of sensitive yet affordable diagnostic tools. Improved testing devices for COVID-19 will enable health authorities to implement the aggressive testing approach advocated by WHO. Currently, laboratory testing is carried out by quantitative reverse transcription polymerase chain reaction (qRT-PCR). Though reliable, this technique does not provide real-time results and it cannot always be deployed as point-of-care test. While the biomarker of qRT-PCR is viral RNA, other diagnostic devices will instead detect antibodies or viral antigens. The race for the development of groundbreaking diagnostics is on.

Federico Rosei (INRS) will adopt a twofold approach. On the one hand, he joins forces with Maxwellian Inc, a company specialising in optical fibre sensors and photonic-plasmonic resonators. Their aim is to devise a commercially viable plasmonic optical sensor. The project will build on the extensive expertise in nanomaterials for optoelectronic applications developed by the Rosei group. This know-how is also at the heart of a second collaboration, this time with Solstar Pharma, a company focussing on R&D of therapeutic agents. This partnership aims to develop an affordable, miniaturised device for the detection of COVID-19 and related antibodies. In contrast to other immunoassays, the proposed approach relies on photoelectrochemical biosensing exploiting the interaction between tailored core/multi-shelled quantum dot and the molecular recognition element layer.

Electrochemists have also joined the fray, hoping to replicate the success story of handheld glucose meters. **Mohamed Siaj** (UQAM) partners with Azure Biosystems to develop a novel, low-cost diagnostic platform exploiting COVID-19 aptamers.

Do viruses have their own barcode? To answer this question, **Jesse Greener** (Laval) intends to combine patent-pending microfluidic assaying accessory provided by Bruker Ltd. and infrared spectroscopy. He aims to achieve high-throughput early detection of SARS-CoV-2 in clinical fluids without sample processing. Prof. Greener, who names the technique "live viral spectroscopy", explains: "Infrared spectroscopy is a well-known analytical chemistry technique which can be applied to proteins, nucleic acids, lipids and other bio-macromolecules. Since viruses, such as the SARS-CoV-2, are composed of these basic building blocks, they will generate a unique spectral fingerprint that can be exploited for diagnostics applications. As such, IR spectroscopy has already been proven for viral detection in unpurified liquid blood samples and even live infected cells." Reliable detection in as-is samples would be a considerable asset: with this aim, other researchers are also investigating approaches based on surface-enhanced Raman spectroscopy.

Finally, **Sylvain Cloutier** (ÉTS, see also page 4) and his industrial partner Varitron Technologies Inc. will work together on the design of autonomous flexible hybrid electronic devices for patient-monitoring.

Test test test

Nature Biotechnology *gives a round-up of cutting-edge diagnostic tests currently in development.*

Disinfect

Even materials scientists may suffer from *fomesphobia,* a condition unrelated to the fear of missing out. Rather, we

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could say that it is yet another hallmark of the COVID-19 pandemic, along with face coverings, hand sanitiser and Zoom meetings. Medical research has identified several diseases that spread through contaminated objects, or *fomes* / *fomites* (the term, meaning "tinder", dates back to the 16th century, first introduced by Italian scholar Girolamo Fracastoro). qRT-PCR assays can detect SARS-CoV-2 RNA on various surfaces after exposure to the virus; however, researchers have not pinpointed the extent to which fomites contribute to the spread of SARS-CoV-2 (the WHO considers it a "likely mode of transmission"). Apart from the fear of fomes, ensuring proper disinfection of high-touch surfaces is an everyday life-or-death challenge in hospitals and healthcare facilities – even more so now that we are faced with the rise of multidrug-resistant bacteria.

Materials science can provide effective solutions, from superhydrophobic surfaces repelling contaminated droplets to photoactive coatings zapping microbes in a flash. Take for instance **Federico Rosei**'s collaborative project with industrial partners Bioastra Technologies. Their aim is to deal microbes a double blow: the antiviral activity of metal-oxide photocatalytic nanoparticles will complement antimicrobial charged polymers in the Bioastra's proprietary sol-gel formulation. The final product will be a fast-setting, spray-on composite ensuring lasting protection.

We also know that soap wins hands down against SARS-CoV-2. Surfactants, in fact, blast the protective lipid shell enveloping the coronavirus. This provides the inspiration for the project bringing together a regular and an industrial QCAM member: **Gaétan Laroche** (U. Laval), specialising in surface engineering, will collaborate with **AVMOR Ltd**, a leading company in safe cleaning solutions. They aim to functionalise polymer or metal surfaces with covalently bound amphiphilic surfactant molecules, thus achieving a permanent protection against viral contamination.

Véronic Landry, another QCAM member at Laval, will instead look at a challenging material: wood. Despite its highly valued aesthetic appeal and its environmental qualities, wood remains an outsider when it comes to the interior design of public and commercial buildings. This is because routine care and excessive wear of wooden surfaces limit a more widespread use of this material. The Landry group and industrial partners CANLAK and EMCO-INORTECH will develop high-performance, industrially viable antiviral coatings intended for "high touch" wooden surfaces in commercial and public buildings (hospitals, shops, schools, etc.).

From wood to leaves: let us discover **Gelareh Momen**'s self-cleaning surfaces. The UQAC professor will mimic the superhydrophobic properties of lotus leaves to design a multifunctional coating with antiviral and antibacterial activity. She and her collaborators, Nanophyll, will specifically target the SARS-CoV-2, hoping to destroy as much as 99% of the viruses on the surfaces treated with this innovative spray-on coating. The Momen group will also build on the expertise acquired last year, when these researchers developed an antiseptic coating for aluminium.

Red-carding the virus

An Italian sports equipment manufacturer supplies antiviral jerseys to a top-flight soccer team. They feature a superhydrophobic treatment and ZnO nanoparticles.

In the next months, QCAM researchers will contribute to developing innovative strategies to protect, detect, disinfect. Three crucial aspects in the effort to curb the pandemic, three challenges that our researchers are well positioned to address. Now more than ever before, materials do matter.

Further readings

C. Weiss et al., Toward Nanotechnology-Enabled Approaches against the COVID-19 Pandemic. *ACS Nano* **14**, 6383-6406 (2020).

S. Talebian, G. G. Wallace, A. Schroeder, F. Stellacci, J. Conde, Nanotechnology-based disinfectants and sensors for SARS-CoV-2. *Nature Nanotechnology* **15**, 618-621 (2020).

W. C. K. Poon et al., Soft matter science and the COVID-19 pandemic. *Soft Matter*, (2020).

L. Gravel-Tatta, At the forefront of the pandemic: the lungs

https://statnano.com/nanotechnology-in-battle-against-coronavirus

QCAM: tackling COVID-19 through materials

This year, 4 of the 16 QCAM collaborative project grants (2020-2022) fund proposals focussing on diagnostic methods or materials for PPE.

QCAM members have received 14 NSERC Alliance-COVID-19 grants (12 of which as main applicants) out of a total of 63 awarded to Quebec-based groups.

Data at the time of going to press. Source: NSERC website

Bulletin board

A close-knit team weaves innovative fabrics Our members Nadi Braidy (carbon and ceramic nanomaterials) , Armand Soldera (modelling of materials), Jérôme Claverie (synthesis) and Denis Rodrigue (polymer moulding and choice of solvents) have set up a «micro research network» . They aim to develop a polymer with auxetic properties and to functionalise it with nanoparticles. This project is supported by a 1.5 M$ contribution agreement granted as part of the programme *IDEaS - Innovation for Defence Excellence and Security (IDEaS*) of the Department of National Defence.

Flat out towards 2D lattices thanks to research by the Rosei and Perepichka groups. Discover how to make mesoscale ordered domains with π-conjugated polymers in their *Nature Materials* (cover) article.

Side-chain groups unravel the mystery of surprising reversible shape changes. The Zhao group presents a novel liquid crystalline elastomer featuring a tug of war between side groups and the main chain. Follow the thread to their *Angewandte Chemie* communication.

Slipping a singlet under your skin thanks to an innovative nanocapsule for theranostic applications. Fiorenzo Vetrone's and Federico Rosei's groups at INRS manage to encapsulate upconverting nanoparticles and a photosensitiser in a single carrier. Near-IR radiation unleashes singlet oxygen, killing cancer cells *in vitro*.

Chemical Science, and as heard on *ICI Première*.

La preuve par l'image

A QCAM student and a researcher have reached the final of the ACFAS photo contest "La prevue par l'image". They are **Williams Marcel Caceres Ferreira** *(PhD student, photo no. 15) and* **Jacopo Profili** *(researcher, photo no. 16) both at U. Laval. Well done!*

New members

- *Prof.* *Davide Brambilla* (UdeM)
- *Prof.* *Philippe Dauphin Ducharme* (associate, UdeS).

Update

- Prof. Phuong Nguyen-Tri is now a *regular member*

QCAM in the spotlight!

Corinne Hoesli will contribute to an ambitious research project on cell-based cancer vaccines. The consortium also includes two industrial partners, Saint-Gobain Life Sciences and Kanyr Pharma Inc and it will receive a $924,000 grant from NSERC, MEDTEQ and Mitacs; **Nathalie Tufenkji** wins the 2020 Award for the Support of Women in the Engineering Profession of Engineers Canada. "By committing to developing equitable, diverse and inclusive learning and working environments, we will ensure the continued world-class excellence of our engineering community in Canada", says Nathalie Tufenkji. She has also received a Killam Fellowship for her project on the impacts of plastic pollution in northern climates; **Bruce Lennox** is awarded the Chemical Institute of Canada Montreal Medal for his outstanding contribution to the profession of chemistry or chemical engineering in Canada; **Fiorenzo Vetrone** carries off the CSC Keith Ladler Award, recognising outstanding early-career contributions to physical chemistry, for research carried out in Canada, by a scientist residing in Canada; **Federico Rosei** has been elected Distinguished Lecturer of the Photonics Society of the Institute of Electrical and Electronics Engineers (IEEE), the only Canadian among the six academics receiving this prestigious accolade; **Abderraouf Boucherif** receives the *Prix Tremplin en Sciences Naturelles et Génie* 2020 awarded by Université de Sherbrooke. «His cutting-edge research activities show considerable potential for significant findings in the field of micronanotechnology and energy». Congratulations!