# WIN WORKSHOP

## Recent Trends in Encapsulation

**MARCH 25, 2024**

**8:30 AM**

**QNC 1501**

# Program

WATERLOO INSTITUTE FOR nanotechnology

NSERC CRSNG

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

University of Strathclyde Glasgow

# Agenda

## 25 March EST

| Start | End | Event | Location |
|---|---|---|---|
| 8:30 AM | 8:35 AM | **Territorial Acknowledgement & Welcoming Remarks**<br>**Bernard Duncker,** *Associate Vice President, Research and International, University of Waterloo* | **QNC 1501** |
| 8:35 AM | 8:40 AM | **Opening Remarks**<br>**Sushanta Mitra,** *WIN Executive Director* | |
| 8:40 AM | 10:00 AM | **Session 1: Technical Presentations** | **QNC 1501** |
| 8:40 AM | 9:00 AM | **Jan van Hest** (Institute for Complex Molecular Systems, TU/e, Netherlands) | |
| 9:00 AM | 9:20 AM | **Clare Hoskins** (Pure and Applied Chem, University of Strathclyde, UK) | |
| 9:20 AM | 9:40 AM | **Sirshendu Misra** (MME, WIN) | |
| 9:40 AM | 10:00 AM | **Utsab Banerjee** (MME, WIN) | |
| 10:00 AM | 10:15 AM | **Morning Break** | |
| 10:15 AM | 11:55 AM | **Session 2: Technical Presentations** | |
| 10:15 AM | 10:35 AM | **Monica Oliveira** (Mech and Aero Engg, University of Strathclyde, UK) | |
| 10:35 AM | 10:55 AM | **Veronika Magdanz** (SYDE, WIN) | |
| 10:55 AM | 11:15 AM | **Paolo Capobianchi** (Mech and Aero Engg, University of Strathclyde, UK) | |
| 11:15 AM | 11:35 AM | **Hany Aziz** (E&CE, WIN) | |
| 11:35 AM | 11:55 AM | **Juewen Liu** (Chem, WIN) | |
| 11:55 AM | 12:00 PM | **Closing Remarks**<br>**Sushanta Mitra,** *WIN Executive Director* | |
| 12:00 PM | 1:00 PM | **Networking Lunch** | **QNC 1st Floor Atrium** |

# PRESENTERS


## Jan van Hest

Professor

Chemical Engineering and Chemistry

Eindhoven University of Technology

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Jan van Hest obtained his PhD in macro-organic chemistry with professor Bert Meijer from Eindhoven University of Technology (TU/e) in 1996. He then worked as a postdoc researcher on protein engineering with professor David A. Tirrell at the University of Massachusetts. In 1997 van Hest started working at DSM (Geleen), first as a researcher and later as group head in the development of new material concepts. In 2000 Van Hest was appointed as full professor at Radboud University Nijmegen. As of September 2016, he holds the chair of Bio-organic Chemistry at TU/e. Over 30 PhD candidates have gained their doctorates under his supervision. He has published over 300 scientific articles (H-index 57) and is (co-)inventor of 17 patents and patent applications. Jan van Hest is also the joint founder of the start-ups Encapson, FutureChemistry, Noviosense and Noviotech.

## PRESENTATION:

**Innovative encapsulation strategies using polymer-based compartments**

The loading of hydrophilic bioactive components into delivery vehicles is often difficult. For example, during the formation process of vesicles, cargo can be entrapped in the vesicular lumen. However, as the encapsulation is a statistical process and only a small percentage of the medium is entrapped in the vesicles, encapsulation is far from efficient. In this workshop lecture I will discuss a number of approaches followed in our group where we aim to achieve more effective cargo loading. First of all, I will present pH-responsive polymersomes that can be switched between an assembled and disassembled state. By performing the switching in the presence of cargo, encapsulation efficiency is improved. The second example involves the application of bowl-shaped vesicles or stomatocytes as carrier systems. These are produced out of spherical vesicles via a dialysis process. When dialysis is executed in the presence of cargo, this ends up in a more than statistical manner in the newly created nanocavity. Finally, I will report on coacervates as highly effective systems for the accumulation and release of proteins.

# PRESENTERS


## Clare Hoskins

Professor

School of Pure and Applied Chemistry

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Clare Hoskins is a Professor in the School of Pure and Applied Chemistry. She has published >50 peer-reviewed articles and filed 1 patent. Her research has been supported with over £3M by national (e.g. EPSRC, BBSRC/FAPESP, Wellcome Trust) and international (e.g. Newton-Bhabha & British Council, Iraqi Ministry of Higher Education and Scientific Research) research funding. Clare is the Chair of the Royal Society of Chemistry, Chemical Nanosciences and Nanotechnology Network, she is a committee member of the UK and Ireland Controlled Release Society and she sits on the British Council Grant Review Panel for Newton Grants. In 2019 Clare was awarded the Academy of Pharmaceutical Sciences 'Emerging Scientist' sponsored by Pfizer and also the North Staffordshire Medical Institute Researcher Award. Clare sits on the editorial board of numerous journals in her field, she leads a vibrant interdisciplinary research group within them of Bionanotechnology and Analytical Chemistry within the Technology Innovation Centre. Her research focuses on developing a range of multifunctional nanoparticles and their translation into medical therapies and agricultural products.

## PRESENTATION:

**Nano-ninja Programming for Pancreatic Cancer**

Pancreatic cancer is the 4th most aggressive cancer in the western world with less than 34% of patients surviving past 5 years. Lack of specific symptoms results in a delay in diagnosis. Nano-ninjas based on hybrid metallic nanoparticles offer a mechanism not only to track the particles progress in real-time, but also to trigger them with external stimulus to release their payload, offering a precision delivery route. Hybrid nanoparticles are composed of an iron oxide core surrounded by a rigid metallic shell. These particles undergo manipulation due to inherent magnetism of the core whilst laser irradiation of their shell results in localised heating due to exploitation of their surface plasmon resonance. Hence, they can be utilized as diagnostics using MRI, and laser irradiation can be used as an initiator for drug release. We have developed a series of 'theranostic assassins' based on hybrid nanoparticles which have shown potential for overcoming the challenges relating to pancreatic cancer, providing externally triggered site-specific delivery of therapeutic compounds. In this talk, I will give an overview of our progress to date, discuss the transferrable nature of these technologies and future studies needed before clinical translation can be achieved.

# PRESENTERS


## Sirshendu Misra

Post Doctoral Fellow

Mechanical and Mechatronics Engineering

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Sirshendu Misra completed his Ph.D. in 2023 from the Department of Mechanical and Mechatronics Engineering at the University of Waterloo under the supervision of Dr. Sushanta Mitra. In his Ph.D., he worked on various capillarity-driven processes, including developing the Liquid-Liquid encapsulation method, visualization of nanoscale thin liquid films, and characterization of droplet-surface interfacial interactions. He graduated from the Indian Institute of Technology (IIT) Kharagpur in 2015 with B.Tech (Hons.) in Mechanical Engineering and M.Tech in Thermal Science and Engineering. Alongside the expansion of the liquid-liquid encapsulation paradigm, his current research interest includes exploring the interface dynamics of bioactive matter. He also serves as the technology lead for SLE Enterprises B.V., a Dutch startup targeted at commercializing the liquid-liquid encapsulation platform.

## PRESENTATION:

**Impact-Driven Liquid-Liquid Encapsulation: A Versatile Paradigm for Robust and Efficient Wrapping**

Encapsulation is immensely relevant in multiple applications, including pharmaceutics, agriculture, food processing, and personal care. Encapsulation generates a protective outer layer around a core substance, which is crucial to safeguard an unstable component in an aggressive environment or to protect essential bio-active components for targeted drug delivery. We demonstrate the development of a robust liquid-liquid encapsulation framework where a thin layer of another shell-forming liquid stably wraps a liquid core analyte. The framework described herein is simple, ultrafast, robust, minimally restrictive, and low-cost. Encapsulation is achieved by a generalized impact-driven approach where a core droplet impacts an interfacial layer floating on a host liquid bath. Several practical use cases are demonstrated, including ultrafast encapsulation, shell-hardening, subsequent extraction/handling of the wrapped cargo, and forming encapsulated Janus droplets with similar/dissimilar core compositions.

# PRESENTERS


## Utsab Banerjee

Post Doctoral Fellow

Mechanical and Mechatronics Engineering

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Utsab obtained his Ph.D. and M.Tech from the Department of Mechanical Engineering, Indian Institute of Technology, Madras, India, in 2021 and 2015, respectively. During his M.Tech and Ph.D., he worked on passive and active manipulation of magnetic and non-magnetic interfaces on microfluidic platforms. Utsab obtained his bachelor's (B.E.) from the Department of Power Engineering, Jadavpur University, Kolkata, India. He is currently involved in research related to wetting and interfacial science.

## PRESENTATION:

**A new pathway for multi-shell and multi-core liquid-liquid encapsulation**

Liquid-liquid encapsulation, where a liquid shell wraps a liquid core, improves the bioavailability and dosage efficiency of the resulting encapsulated cargo. We demonstrate a framework showing the versatility of liquid-liquid encapsulation by combining the impact-driven technique and a Y-junction to fabricate multi-shell encapsulated cargo. Further, the hybrid technique facilitates the wrapping of non-magnetic liquid droplets by a magnetic shell layer, providing magnet-assisted manipulation of the encapsulated cargo. We could further wrap multiple magnetic liquid droplets in a polymer shell using a magnet-assisted liquid-liquid encapsulation technique, forming encapsulated Janus droplets with similar core compositions.

# PRESENTERS


## Monica Oliveira

Senior Lecturer

Mechanical and Aerospace Engineering

University of Strathclyde

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**Mónica Oliveira** is Senior Lecturer in the Department of Mechanical & Aerospace Engineering. She has a PhD in Chemical & Process Engineering from Heriot-Watt University (Edinburgh, UK), and a first degree in Chemical Engineering from the Faculty of Engineering of the University of Porto (Portugal). She held a postdoc position in the Non-Newtonian Fluid Dynamics Research Group at the Massachusetts Institute of Technology (Cambridge, MA, USA), after which she returned to the University of Porto to join CEFT (Transport Phenomena Research Centre), where she held a research position until 2012. Her research focuses on fluid flows and transport phenomena, in particular, the rheology of complex fluids, non-Newtonian fluid dynamics and microfluidics. Mónica publishes her research results in leading international journals including *Physical Review Letters*, *Physics of Fluids*, *Microfluidics & Nanofluidics*, *Soft Matter* and *Journal of Fluid Mechanics*. She is a member of both the Society of Rheology of the American Institute of Physics, and the British Society of Rheology.

## PRESENTATION:

**Transport dynamics in microfluidic flows of complex fluids**

Many artificial and natural fluids contain macromolecules, particles or droplets that impart complex flow behaviour to the fluid. Their motion and flow dynamics are strongly affected by their interactions with the flow structure and often result in a non-linear relationship between stress and deformation. We exploit microfluidic flows, where we are able to achieve high and well controlled strain rates while maintaining inertia low, to explore a rich variety of dynamical behaviour in flows of complex fluids and to characterise the transport of bioparticles. We discuss achievement and limitations of our approaches for investigating the rich variety of dynamical morphological transitions and complex orientation dynamics of objects with a wide range of sizes, characteristics and behaviours of relevance in the biological world.

# PRESENTERS


## Veronika Magdanz

Assistant Professor

Systems Design Engineering

University of Waterloo

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Veronika Magdanz is an Assistant Professor in Systems Design Engineering since 2022 focusing on Biomedical Engineering. She obtained her doctorate from the University of Dresden in 2016 for the development of sperm-driven microrobots performed at the Leibniz Institute for Solid State and Materials Research IFW Dresden in Germany. Subsequently, she conducted research in metabolic and kinetic studies of sperm as well as sperm-templated microrobots at the Applied Zoology Department of TU Dresden. During her time as a Humboldt Fellow at the Institute for Bioengineering of Catalonia, she explored medical applications of flexible magnetic small-scale robots and the 3D bioprinting of muscle tissue. Her main research interest is in microrobotics for medical applications. This includes biohybrid approaches, such as harnessing functionalities of cells and other biological components for innovative solutions in medicine. Further, she works on the development of bioinspired artificial microrobots that are wirelessly controlled by magnetic fields.

## PRESENTATION:

**Active micro-robotic cell and drug delivery strategies**

This research aims to revolutionize medical interventions by using active transport to make cell and drug delivery more localized, as well as surgery less invasive. These strategies use motile cells and external magnetic fields as propulsion mechanisms and include microfabrication methods such as 3D printing, cell and enzyme encapsulation and nanoparticle-cell interactions.

# PRESENTERS


## Paolo Capobianchi

Lecturer

Mechanical and Aerospace Engineering

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Dr Paolo Capobianchi is a Lecturer in the Department of Mechanical and Aerospace Engineering at the University of Strathclyde. He holds a master's degree in Mechanical Engineering and a doctoral degree in Mechanical and Aerospace Engineering. Moreover, he has more than two years' postdoctoral experience matured at the University of Strathclyde under the guidance of Professor Marcello Lappa. His research interests embrace a range of topics related to the dynamics of multiphase flows such as the dynamics of droplets in both Newtonian and non-Newtonian fluids, hydrothermal instability and particle dynamics in liquid bridges, multiphase interfacial flows in microfluidics devices and theoretical and numerical modelling of ferrofluid interfacial flows. Dr Capobianchi has published several papers as first author in internationally recognised peer-reviewed journals such as Journal of Rheology, Journal of Fluid Mechanics and Physics of Fluids among others. Moreover, he has presented his work at international conferences in the field of non-Newtonian fluid mechanics, numerical methods for fluid flows, hydrodynamic instabilities, and rheology. Dr Capobianchi is a member of the British Society of Rheology (BSR) and the Società Italiana di Reologia (SIR). Additionally, he has been awarded two scholarships (funded by the University of Strathclyde and BSR) and one grant funded by the University of Strathclyde for a project aimed at establishing future collaborations with the Japan Aerospace Exploration Agency (JAXA).

## PRESENTATION:

**Shear rheology of dilute ferrofluid emulsions: modelling and computational analysis**

The rheological properties of dilute emulsions constituted by ferrofluid droplets dispersed in a non-magnetisable immiscible liquid were modelled using a bulk stress model and investigated numerically using a Volume of Fluid-Level Set approach considering uniform magnetic fields. The results revealed that, even for magnetic fields of relatively modest intensity, the rheological properties of the emulsion are significantly affected by the presence of the magnetic field. More specifically, it was observed that the magnetic field induces an increment of the effective viscosity of the emulsion and may be responsible for the reversal of the sign of the two normal stress differences in some circumstances. Comparisons between the predictions of the model and the numerical experiments were found to be in good agreement, providing evidence of the reliability of the approach in a wide range of flow conditions and magnetic fields of different intensities. Dedicated experiments are, however, deemed necessary to assess the capability of the proposed theoretical-numerical approach.

# PRESENTERS


## Hany Aziz

Professor

Electrical and Computer Engineering

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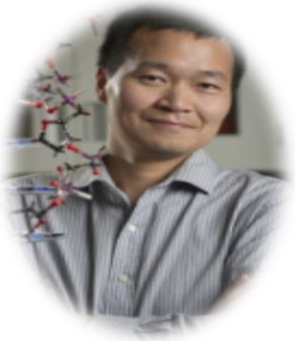
Hany Aziz is a professor in the Department of Electrical and Computer Engineering with a cross-appointment to the Department of Chemical Engineering. He served as the Associate Director of Waterloo's Nanotechnology Engineering program from 2015-2019. He is also Associate Director of the Giga-to-Nanoelectronics Centre. He previously held the appointment of NSERC- DALSA Research Chair in organic electronics. Professor Aziz's group conducts research in the interdisciplinary area of organic electronics and optoelectronics, including both electroluminescent (such as Organic Light-Emitting Devices or OLEDs and quantum dot LEDs ) and light harvesting (such as organic photovoltaics and optical sensing) materials and devices. The research spans a wide range of areas, ranging from studying fundamental phenomena in organic semiconductors (such as carrier injection and transport, exciton dynamics, and carrier-exciton interactions) to developing novel devices and fabrication technologies for next-generation electronics (such as flexible flat panel displays and printable electronics). Professor Aziz's research contributions are widely cited in the organic electronics community, resulting in over 150 peer-reviewed publications. He has several inventions, including the industry's benchmark long-life, thermally stable OLED, and contrast-enhancing Black Cathode™ Technology. He holds 51 U.S. patents. In 2020, he was awarded a University Research Chair.

## PRESENTATION:

**Encapsulation in Quantum-dot Light Emitting Devices: Looking Beyond Hermatic Sealing**

With the advent of mechanically flexible electronics ushered by the current use of organic light emitting devices (OLEDs) in mobile displays, the development of novel encapsulation technologies that provide sufficient hermatic sealing while still allowing for mechanical flexibility has been central to technology commercialization milestones. As we now look past OLEDs and at Quantum-dot LEDs for next-generation displays, encapsulation starts to play additional roles beyond providing hermatic protection. In this presentation, results from our investigations into the effect of encapsulation on "positive aging" in QLEDs, a peculiar behaviour that is widely observed in these devices but remains barely understood, will be presented. Results and perspectives related to the effect of encapsulation on charge conduction in hybrid (organic/inorganic) semiconductor materials – as is the case in QLEDs - will be discussed, highlighting the need for giving more attention to this subject in the pursuit of high-performance QLEDs.

# PRESENTERS




## Juewen Liu

Professor

Chemistry

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Over the past six years, Professor Juewen Liu has published over 200 research papers on DNA/lipid-based sensors and functional materials with a total citation number close to two thousand. Liu is a leader in the field of bionanotechnology. His lab employs DNA, liposomes, hydrogels, and various inorganic nanoparticles as building blocks to construct functional nanomaterials for analytical and biomedical applications. He is also interested in the biotechnology of combinatorial DNA aptamer selection. Liu joined the Department of Chemistry at the University of Waterloo in July 2009. Prior to his current appointment at University of Waterloo, he worked for two years as a postdoctoral fellow at the Center for Micro-Engineered Materials in the University of New Mexico, and the Advanced Materials Laboratory in Sandia National Labs, where he developed a novel drug delivery vehicle based on mesoporous silica nanoparticle supported phospholipid bilayers. He is currently interested in selecting functional DNA molecules for catalysis and molecular recognition, enzyme mimics using nanomaterials (nanozymes), adsorption of DNA and lipids on various nanoscale surfaces, and biosensor development.

## PRESENTATION:

**DNA aptamer-functionalized liposomes for drug encapsulation and delivery**

DNA aptamers are single-stranded DNA oligonucleotides that can selectively bind to target molecules. Our lab has selected DNA aptamers that can bind the surface of pig cornea and grafted these aptamers to liposomes loaded with a peptide drug that can treat dry eye diseases. The aptamer-functionalized liposomes showed a much longer retain time on cornea with low nanomolar dissociation constant. This system has been tested in human cornea cells and a rabbit dry eye disease model with efficacy comparable to a commercial eye drop.