

Biohybrid Melanized Cellulose Nanofiber Foams Towards Water Purification

Kevin J. De France, Anh Tran-Ly, Francis Schwarze, Gustav Nyström

Assistant Professor, Department of Chemical Engineering
Queen's University, Canada



De France Lab
Natural Nanocomposites



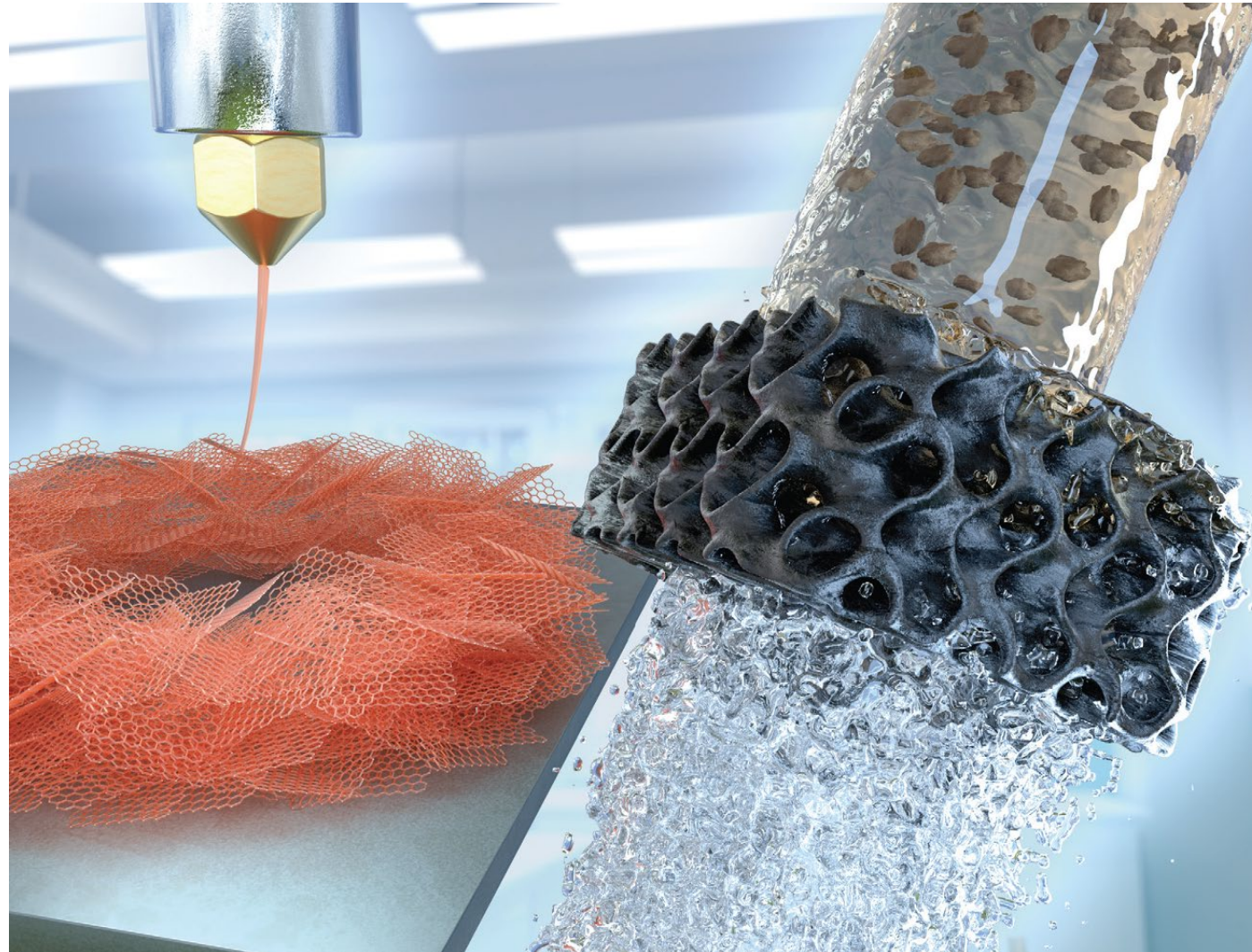
Materials Science and Technology



Foams & Aerogels for Water Purification



Materials &
Fabrication

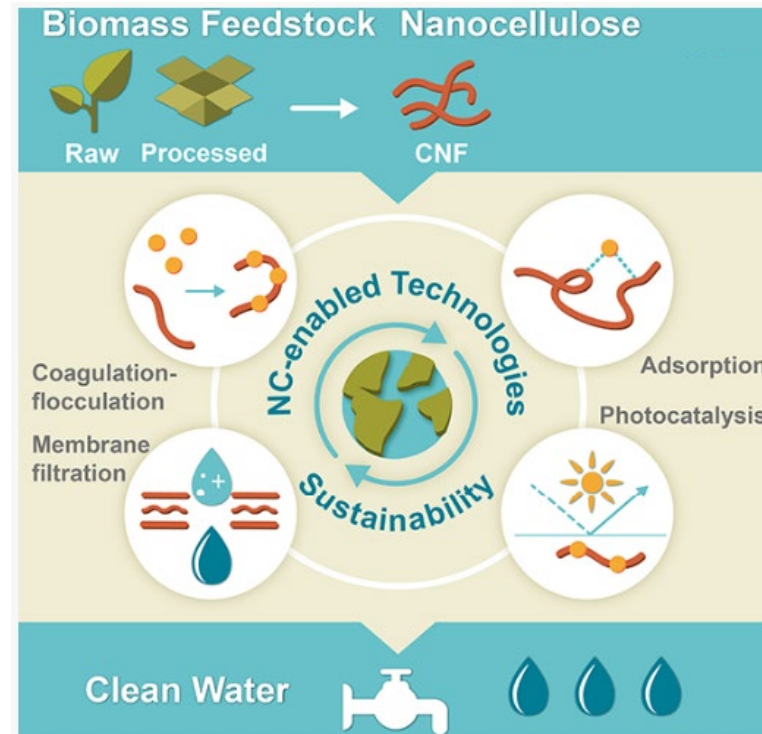


Treatment
& Filtration

CNF Foams for Water Purification

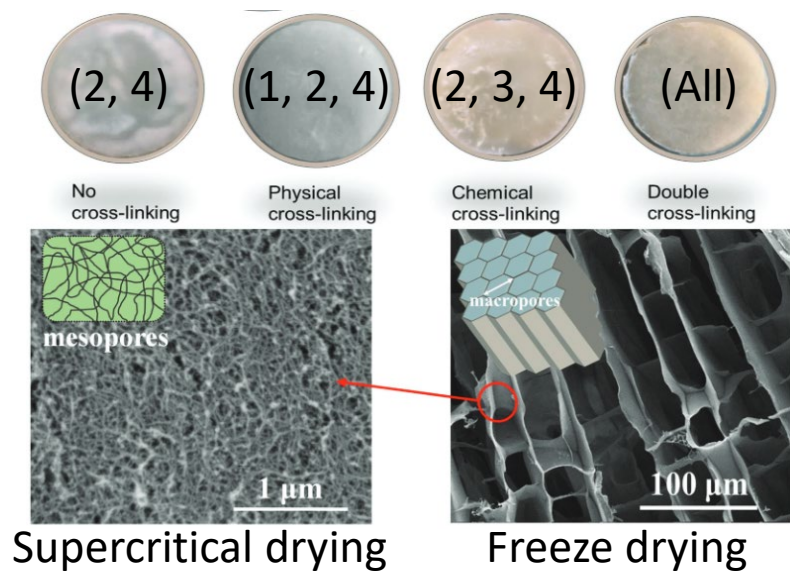


- Large surface area & porosity
- Chemical functionality
- Surface charge
- Bio-based & biodegradable
- Readily processable

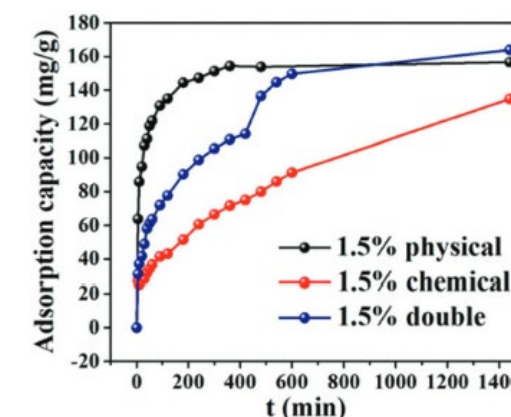
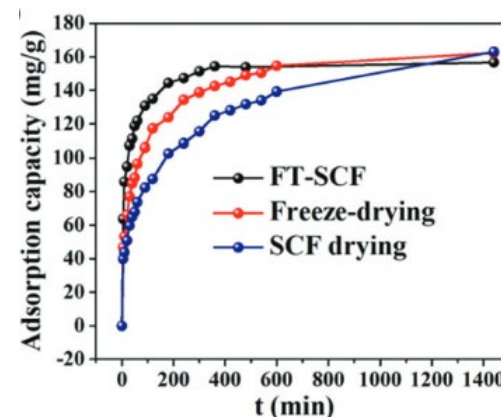
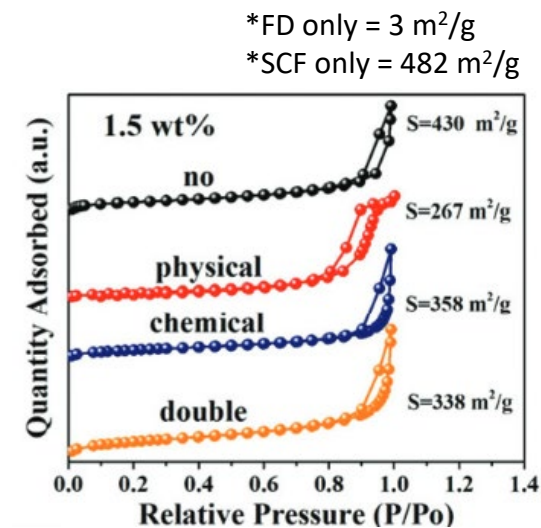
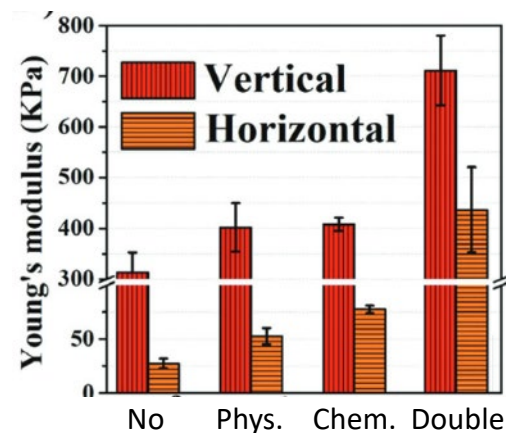


- Wet strength & stability
- Selectivity
- Antifouling
- Reusability & regeneration

CNF Foams: Improving stability via processing



- Step 1: Physical crosslinking (HCl)
- Step 2: Freeze drying
- Step 3: Chemical crosslinking (MDI)
- Step 4: Supercritical drying

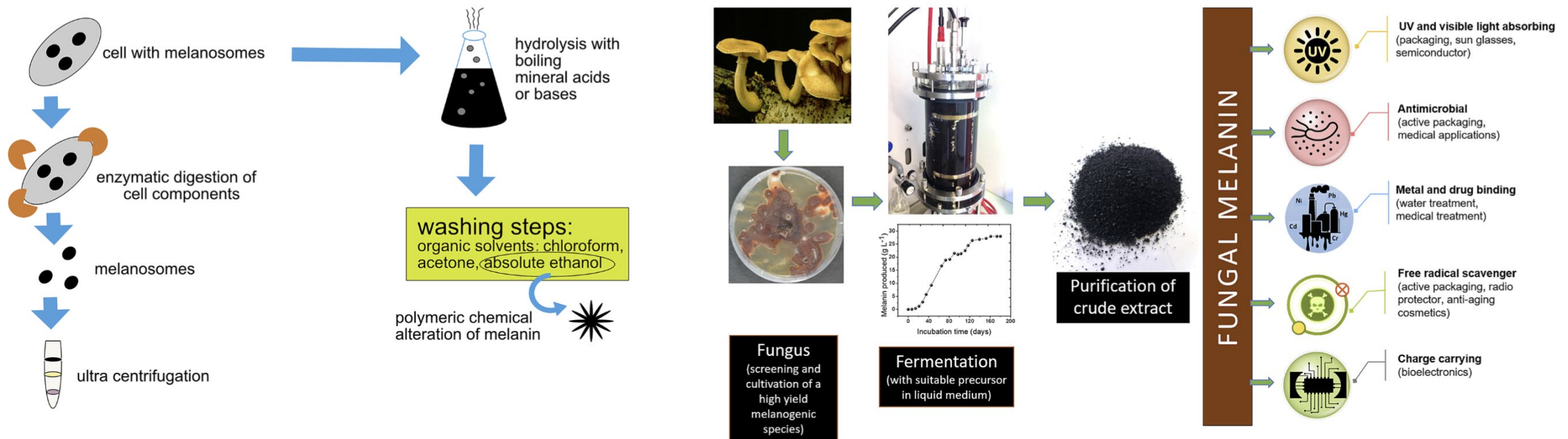


Additive to improve CNF adsorption and physical properties simultaneously?

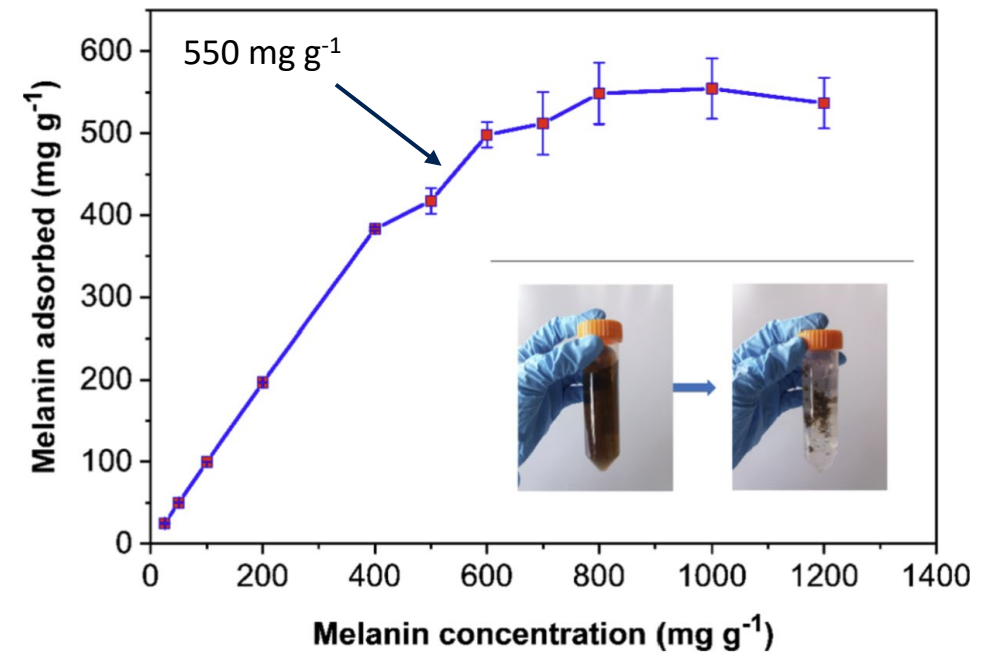
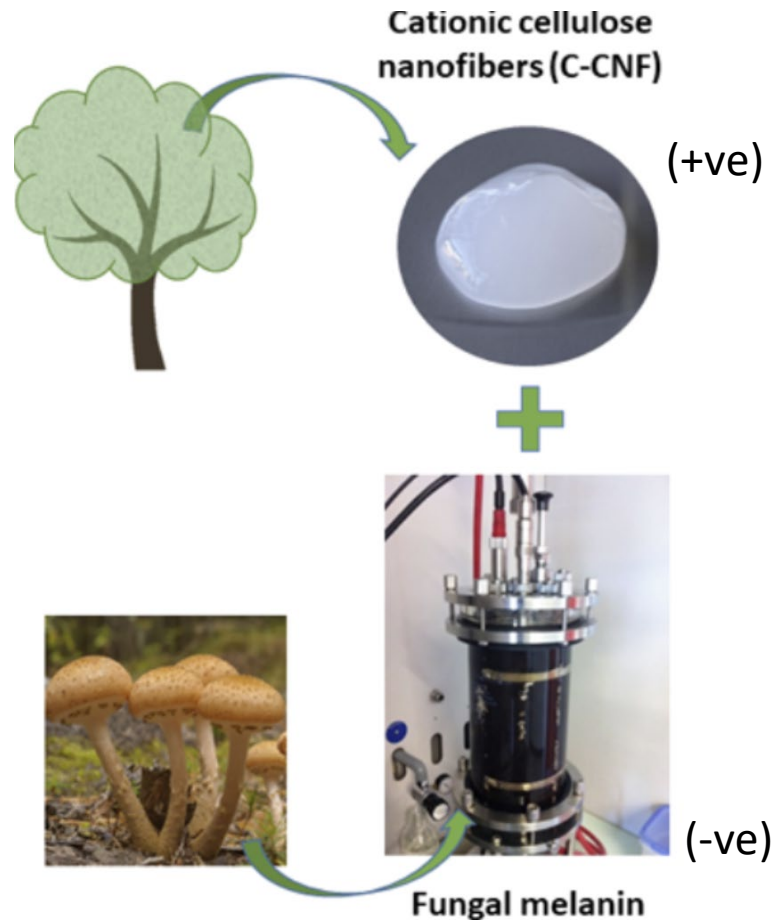
Fungal Melanin



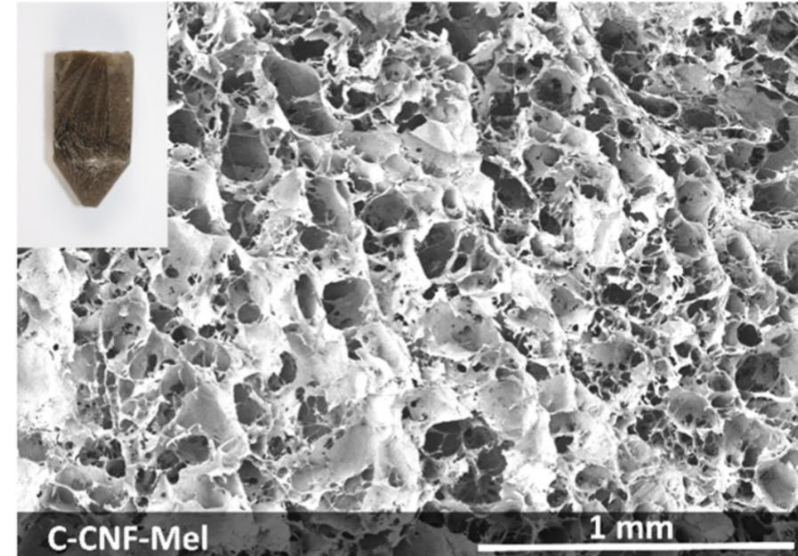
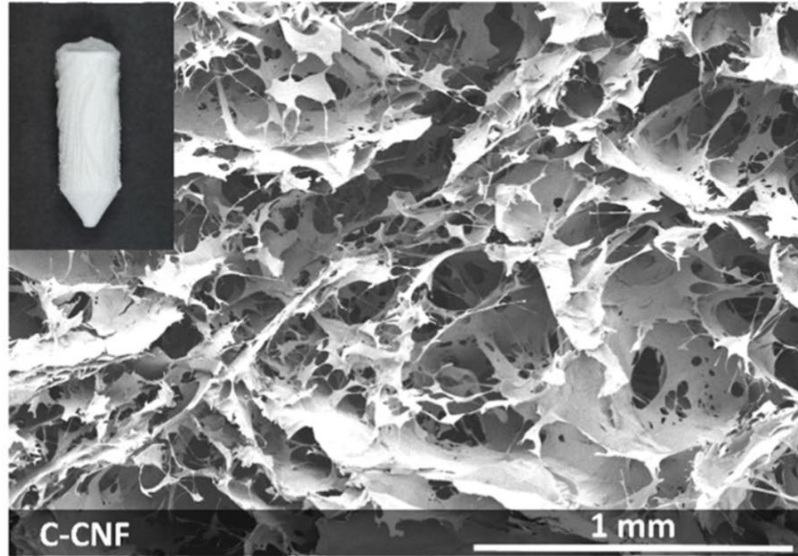
- Naturally occurring pigment biopolymers with broad functionality
- Conventionally extracted from animal ink / hair / feathers (\$\$\$)
- Can also be biosynthesized by several microorganisms



CNF-Melanin Complexation

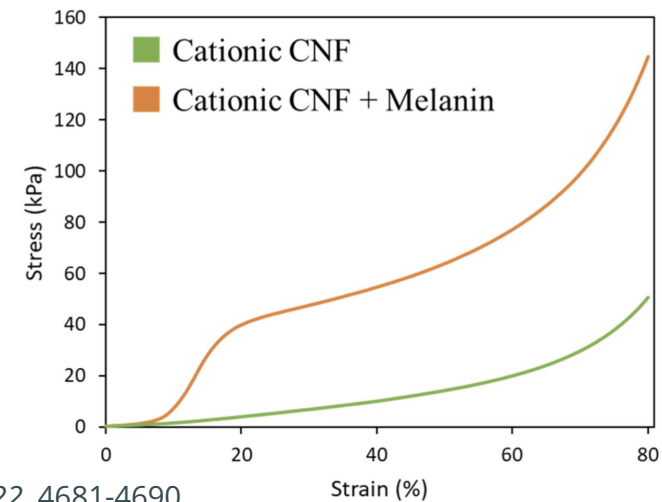


CNF-Melanin Foams: Physical properties



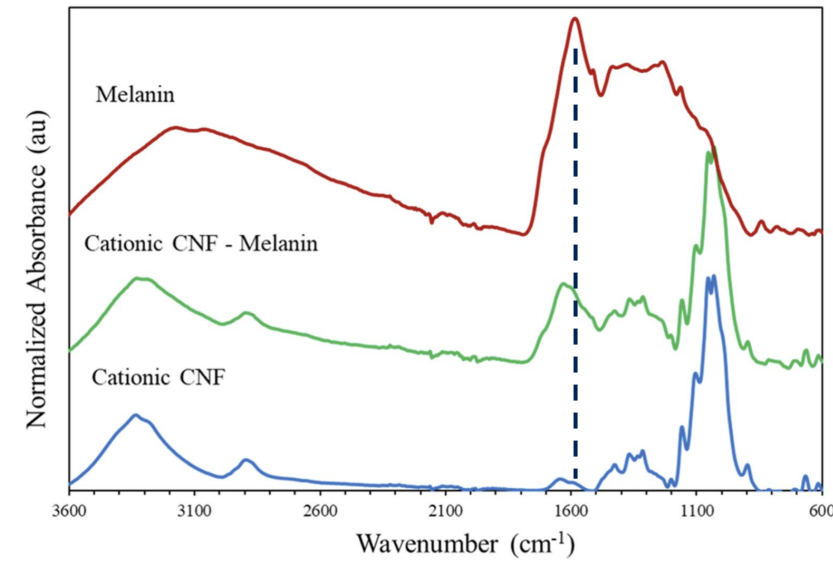
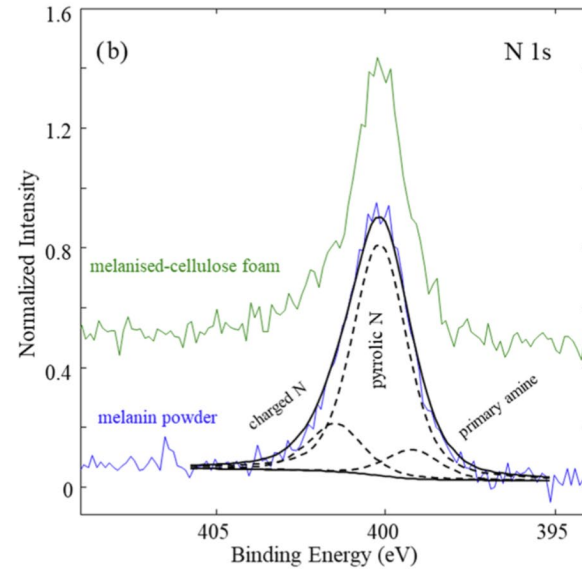
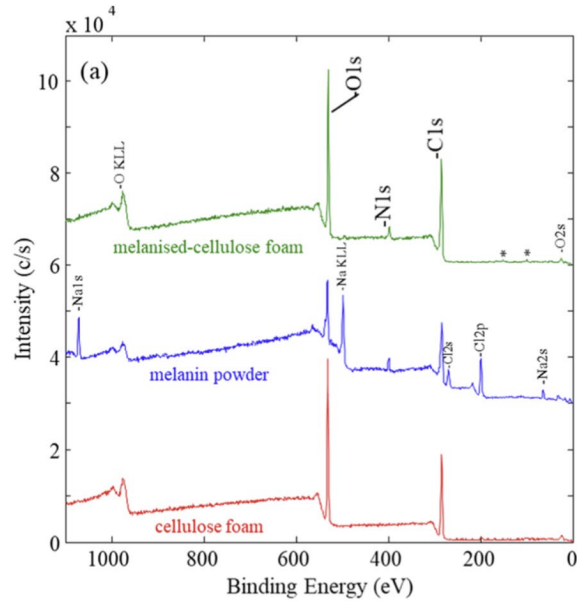
	melanin	C-CNF	C-CNF-Mel
ζ potential (mV)	-47.7	+56.4	-32.6
BET surface area ($\text{m}^2 \text{g}^{-1}$)		16.4	8.5
shrinkage (%)		22.6 ± 2.1	3.2 ± 0.1

Melanin improves structural integrity



A. Tran-Ly, K.J. De France, et al., *Biomacromolecules* **2021**, 22, 4681-4690
 T. Wu, N. Kummer, K. J. De France, et al., *Carbohydrate Polymers* **2021**, 251, 117021
 L. Severini, K. J. De France, et al., *ACS Omega* **2022**, 7 (1), 578-586

CNF-Melanin Foams: Surface composition



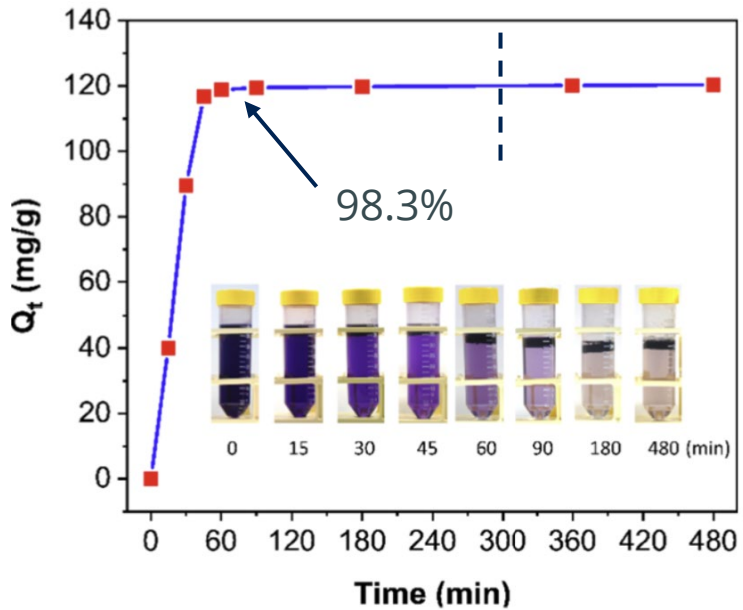
- XPS: (a) N peak in CNF-melanin foams; (b) no significant change in surface chemistry
- FTIR: increase in peak intensity around 1630 cm^{-1} (C=C, C=N, C=O vibrations)

Melanin remains functionally active / intact

CNF-Melanin Foams: Crystal Violet adsorption

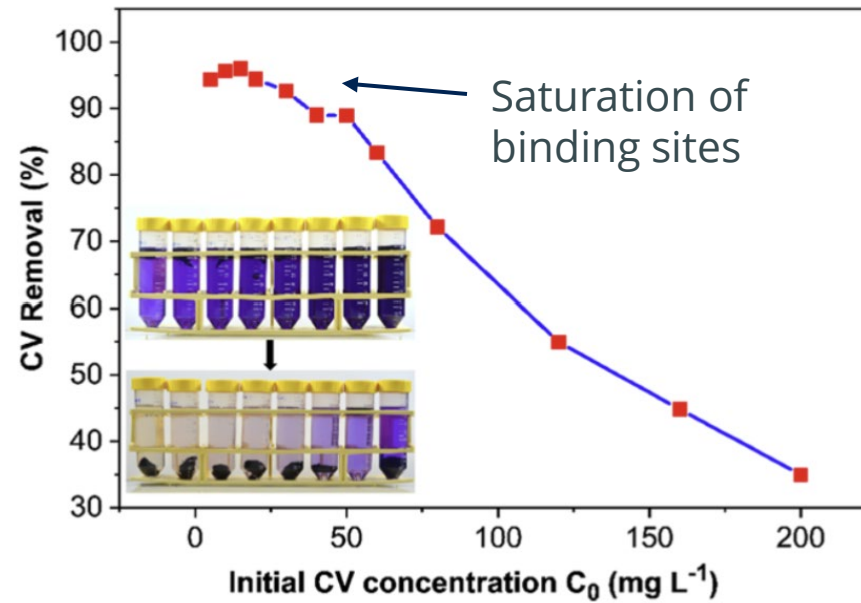


Effect of contact time



--- Typical time required to reach adsorption equilibrium

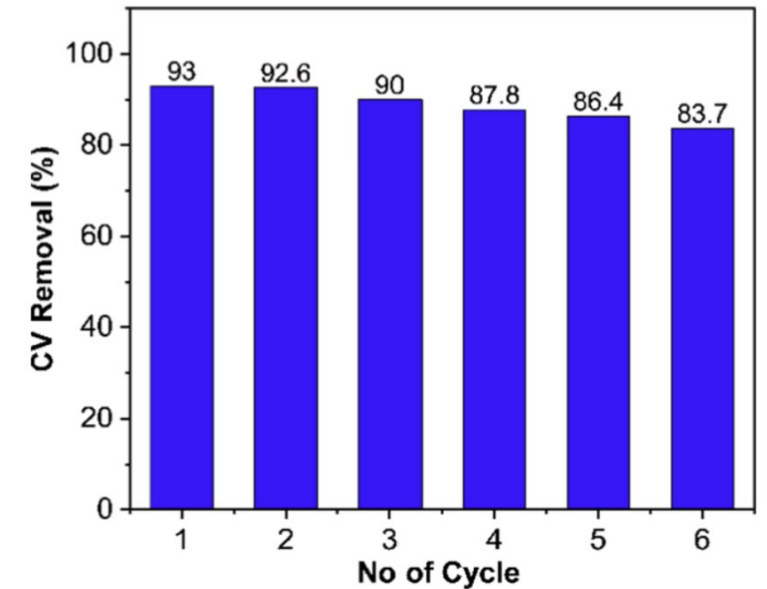
Effect of initial CV concentration



Adsorption is predominantly electrostatically-driven

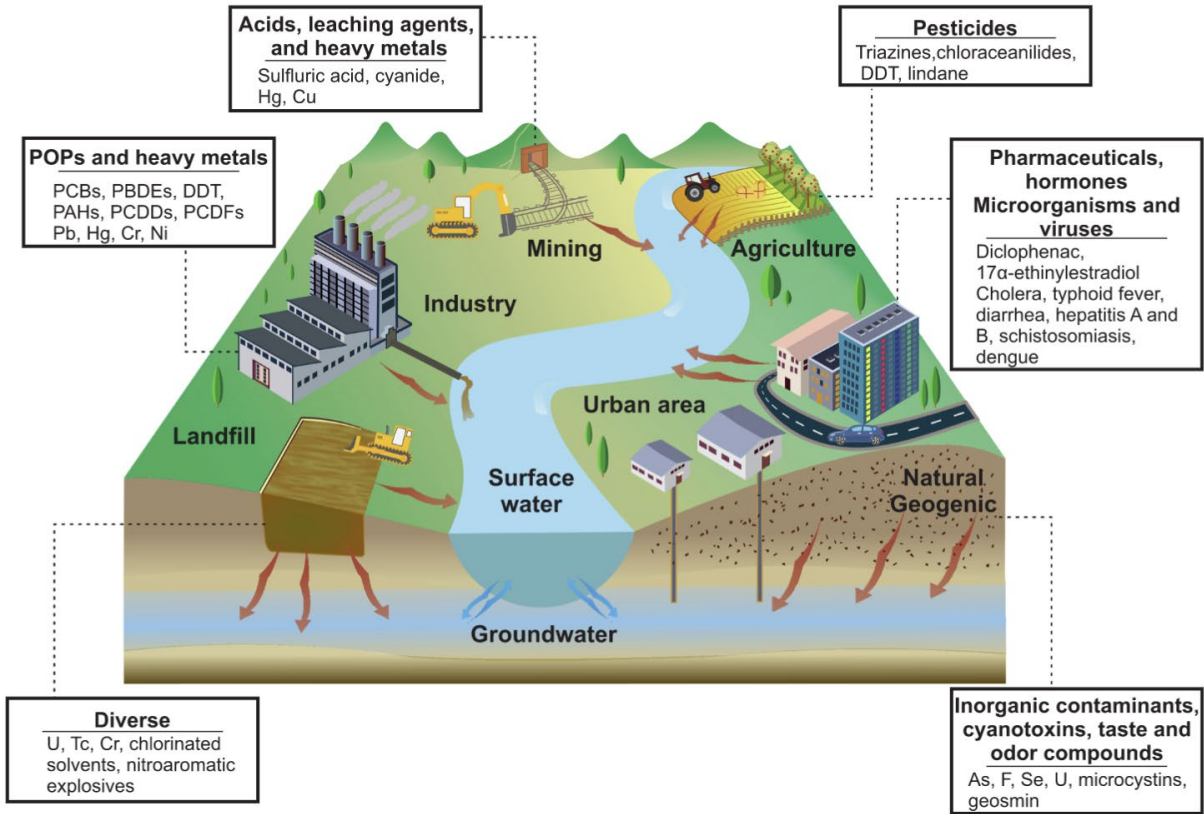
isotherm model	parameter
Langmuir	Q_m (mg g ⁻¹) 425.532

Foam reusability

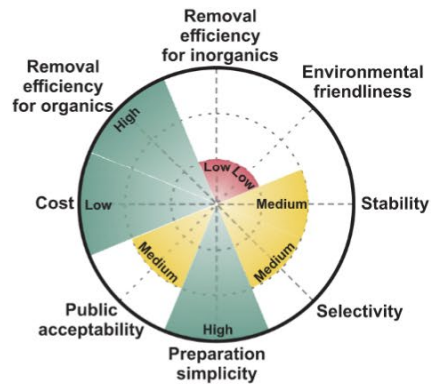


Removal of loosely bound melanin through the recycling process (0.1 M HCl, 90% EtOH)

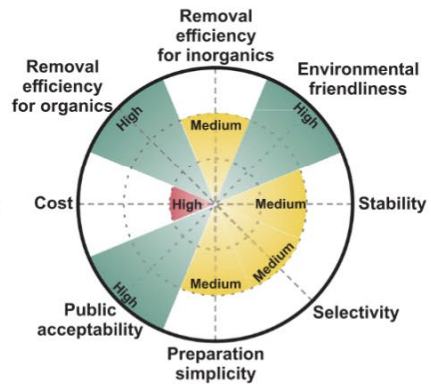
Future Directions in Water Treatment



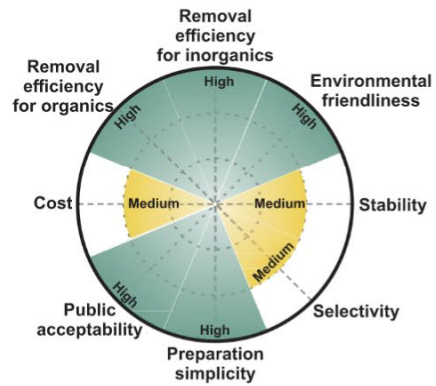
Activated carbon



Nanocellulose



Protein nanofibrils



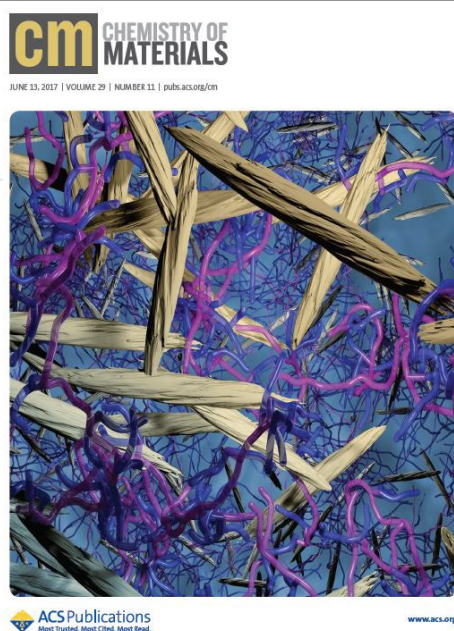
Conclusions



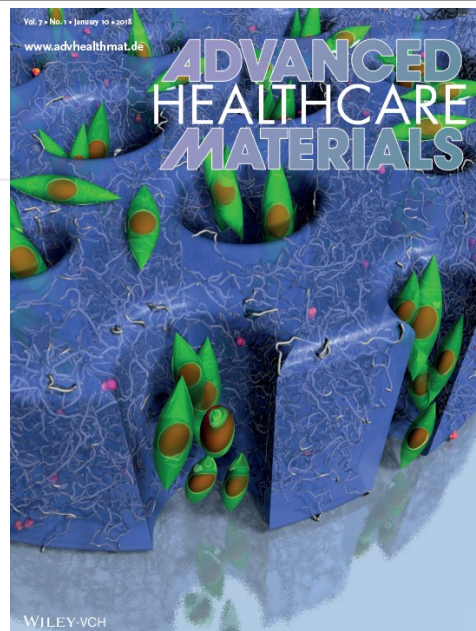
- Biohybrid foams successfully prepared via charge complexation
 - CNF → structural integrity
 - Fungal melanin → specific adsorption of cationic dyes
- Versatility & functionality of fungal melanin can enable biomaterial solutions in a variety of areas



Langmuir 2016, 32 (30)



Chem. Mat. 2017, 29 (11)



Adv. Health. Mat. 2018, 7 (1)



Mat. Today 2020, 37

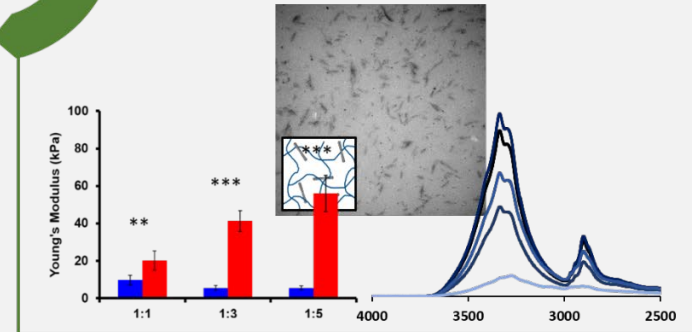
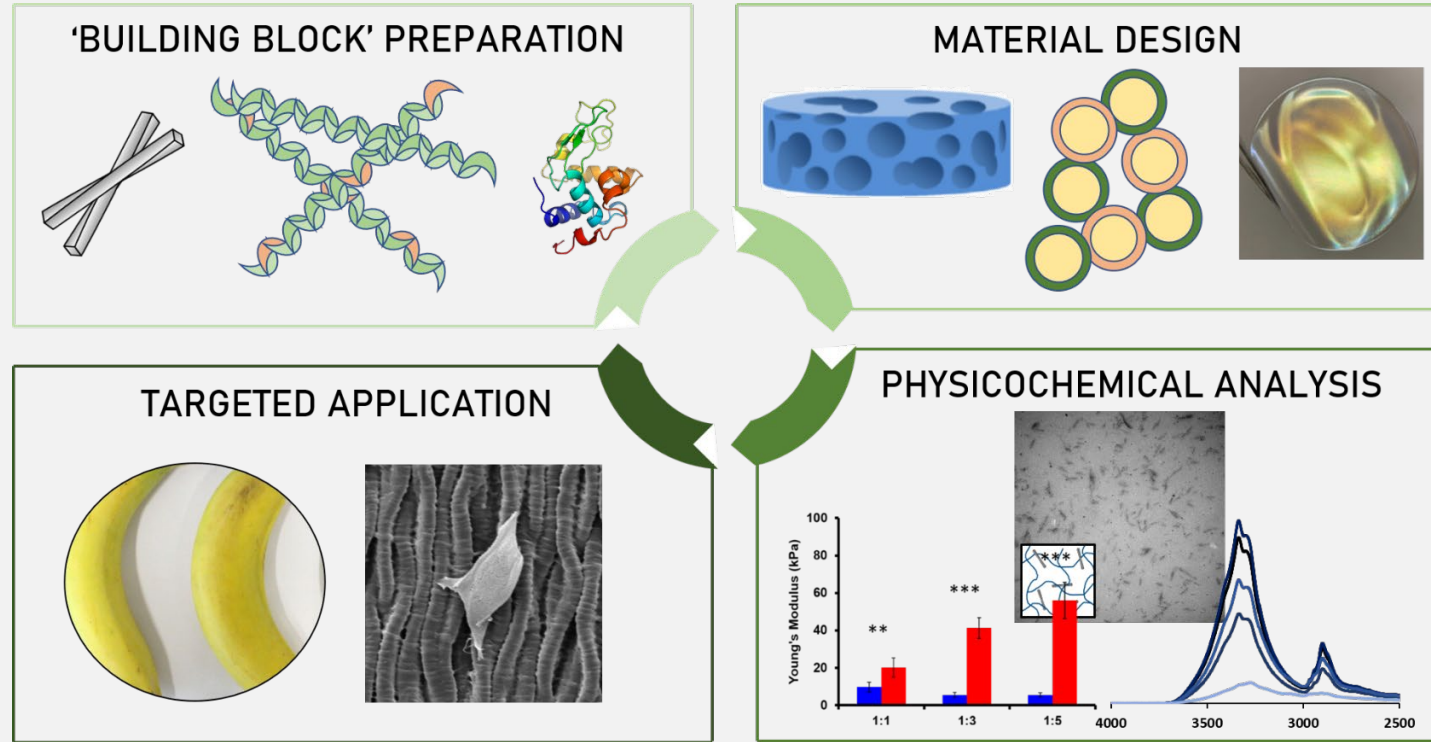
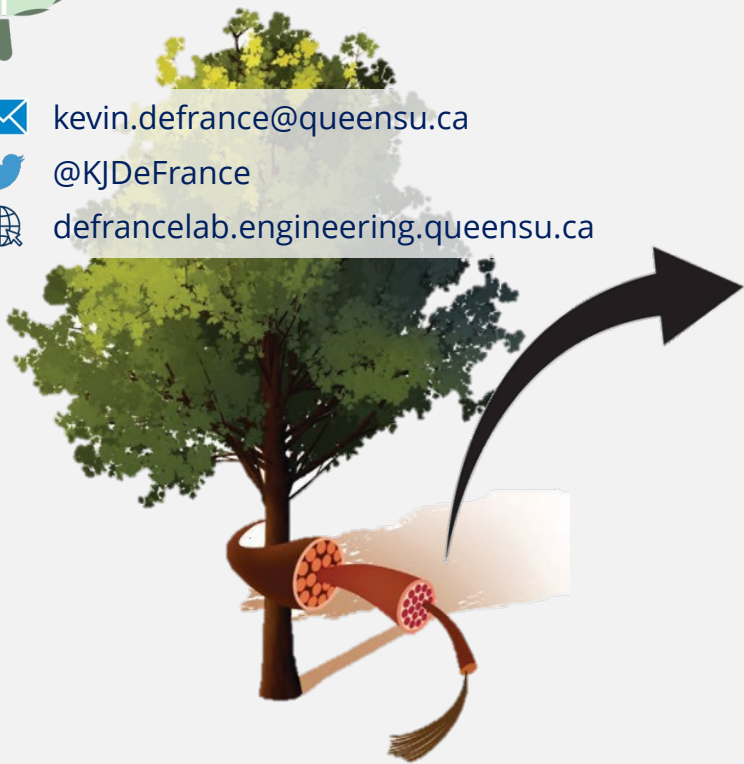


Adv. Mat. 2021, 33 (28)



The De France Lab at Queen's University

✉ kevin.defrance@queensu.ca
 🐦 @KJDeFrance
 🌐 defrancelab.engineering.queensu.ca



Thursday 15 June 2023	
08:30 -10:00 <i>Session 29: CNC Applications I</i> <i>Session Chair: Adel Jalaei,</i> <i>University of British Columbia</i> <i>Room: Salon D</i>	08:54 Biopolymer-Stabilized Emulsions for The Encapsulation of Trichoderma Conidia Towards Biological Control - Kevin De France, Queen's University

7th in the world
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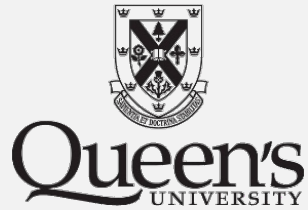
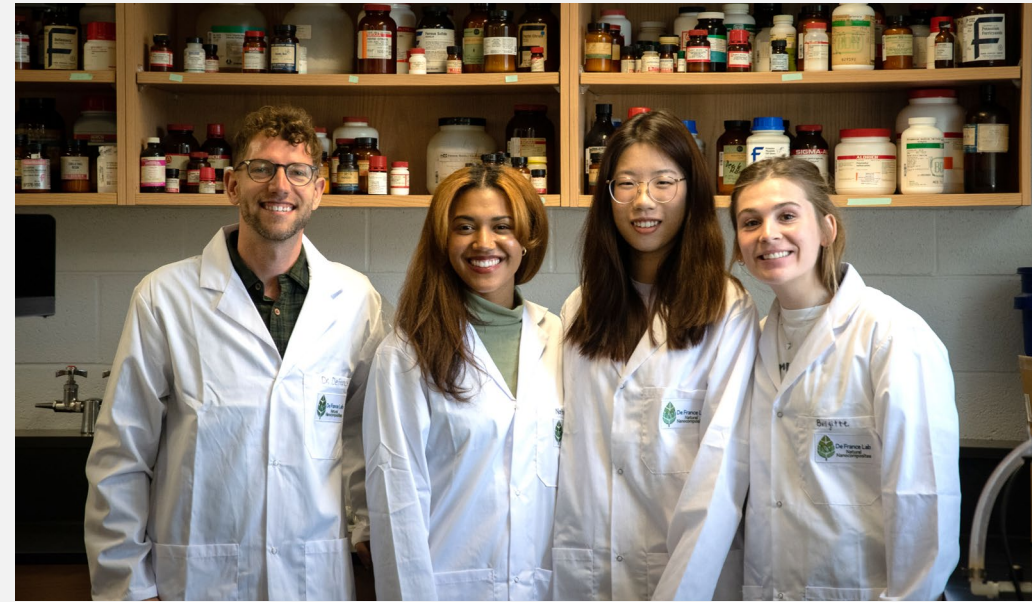
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✉ kevin.defrance@queensu.ca
🐦 @KJDeFrance
🌐 defrancelab.engineering.queensu.ca

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International Conference on Nanotechnology for Renewable Materials

