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Nanocellulose Membrane Technology & Membrane Bioreactors

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Overview

- Introduction to Membrane Bioreactors (MBRs)
- MBR as platform for Novel Denitrification Pathways
- Synthesis and Performance of Nanocelluose Membranes
- Conclusions and Future Work

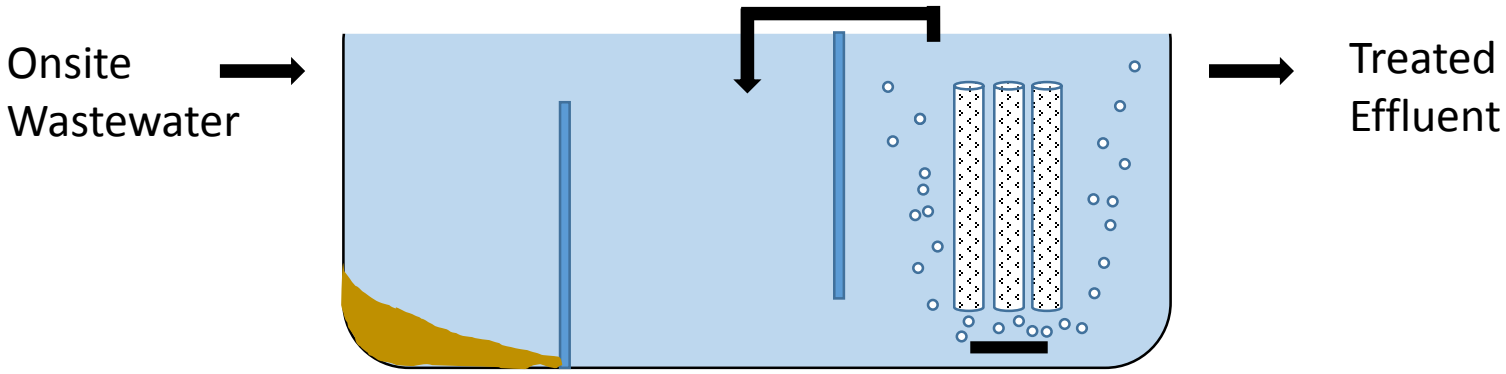
Membrane Bioreactors

Advantages:

- **Smaller reactor size;**
- **Elimination of settling/clarification;**
- **Smaller footprint;**
- **High-quality effluent**
- **Platform for Novel Denitrification Pathways.**

Disadvantages:

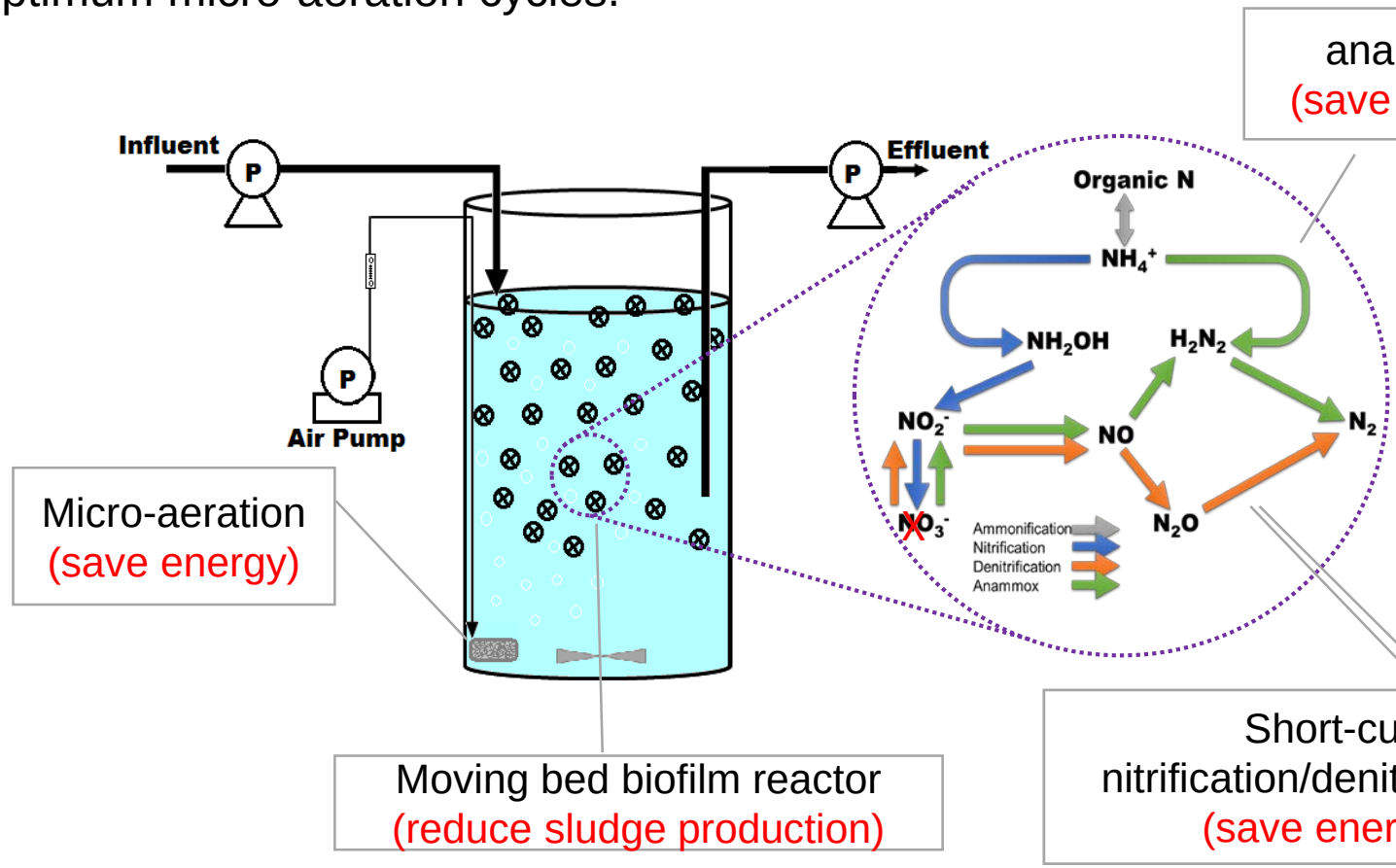
- **Membrane fouling**
- **Membrane cost**



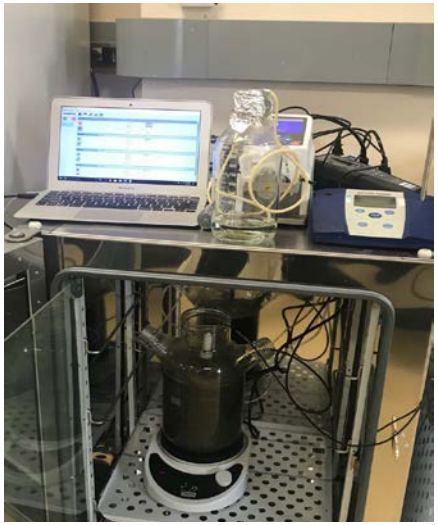
$NO_3^- \rightarrow N_2$ $NH_3 \rightarrow NO_3^-$

Platform for Novel Denitrification Pathways

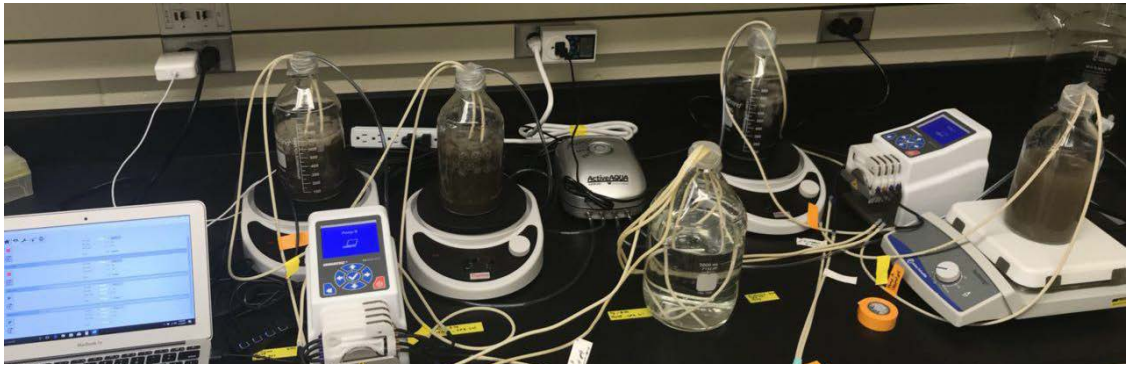
Achieve efficient nitrogen removal from onsite wastewater using a bioreactor with optimum micro-aeration cycles.



Lab-scale MBR development for nitrogen removal

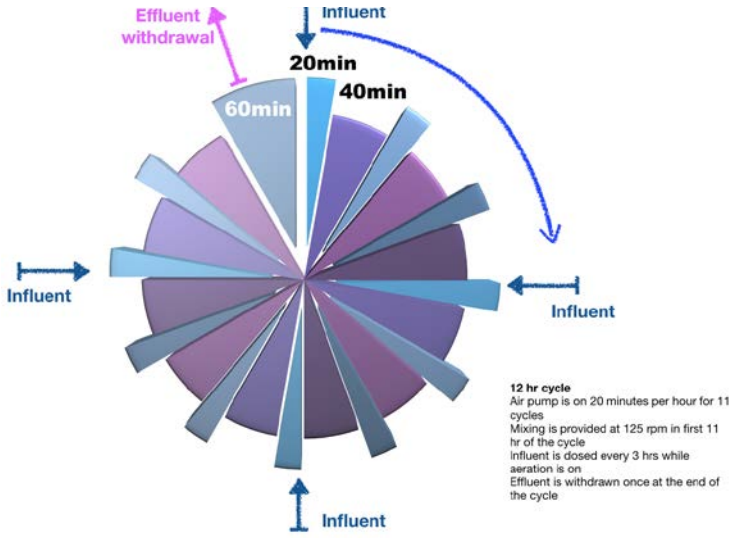


Bioreactor with intermittent aeration to study nitrogen removal via short-cut nitrification/denitrification



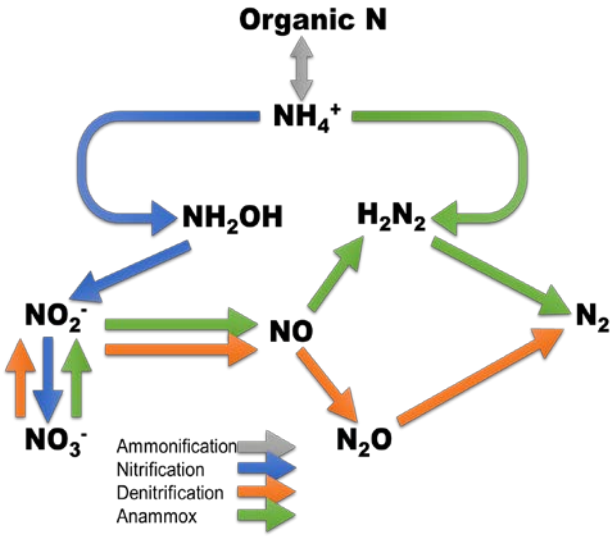
Moving bed biofilm reactors to study different carriers for nitrogen removal in biofilm

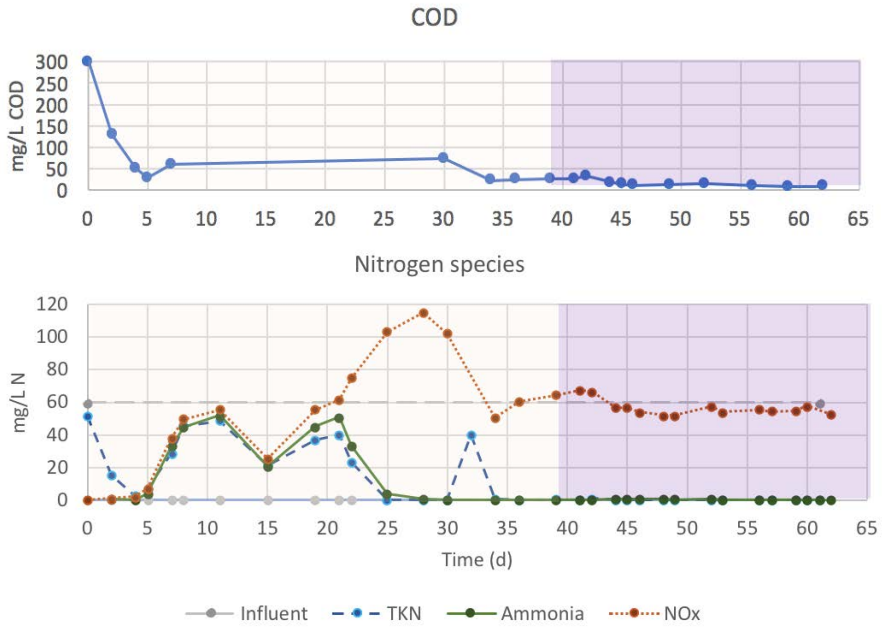
Intermittent aeration is applied to achieve both nitrification (oxic) and denitrification (anoxic) with the available carbon in the influent, and the microbial species for efficient nitrogen removal are enriched during this process.



Current aeration pattern

Current stage and the next steps





Stage 1: Lab-scale bioreactor set-up and system start-up (***completed***).
Stage 2: Full-nitrification with synthetic onsite wastewater (***completed***).
Stage 3: Modify the aeration pattern to achieve simultaneous nitrification/denitrification (***current***).
Stage 4: Study the foulant properties on membrane unit, elucidate microbial community composition that governs the function of the reactor, and develop pilot-scale system at research trailer (next stage).

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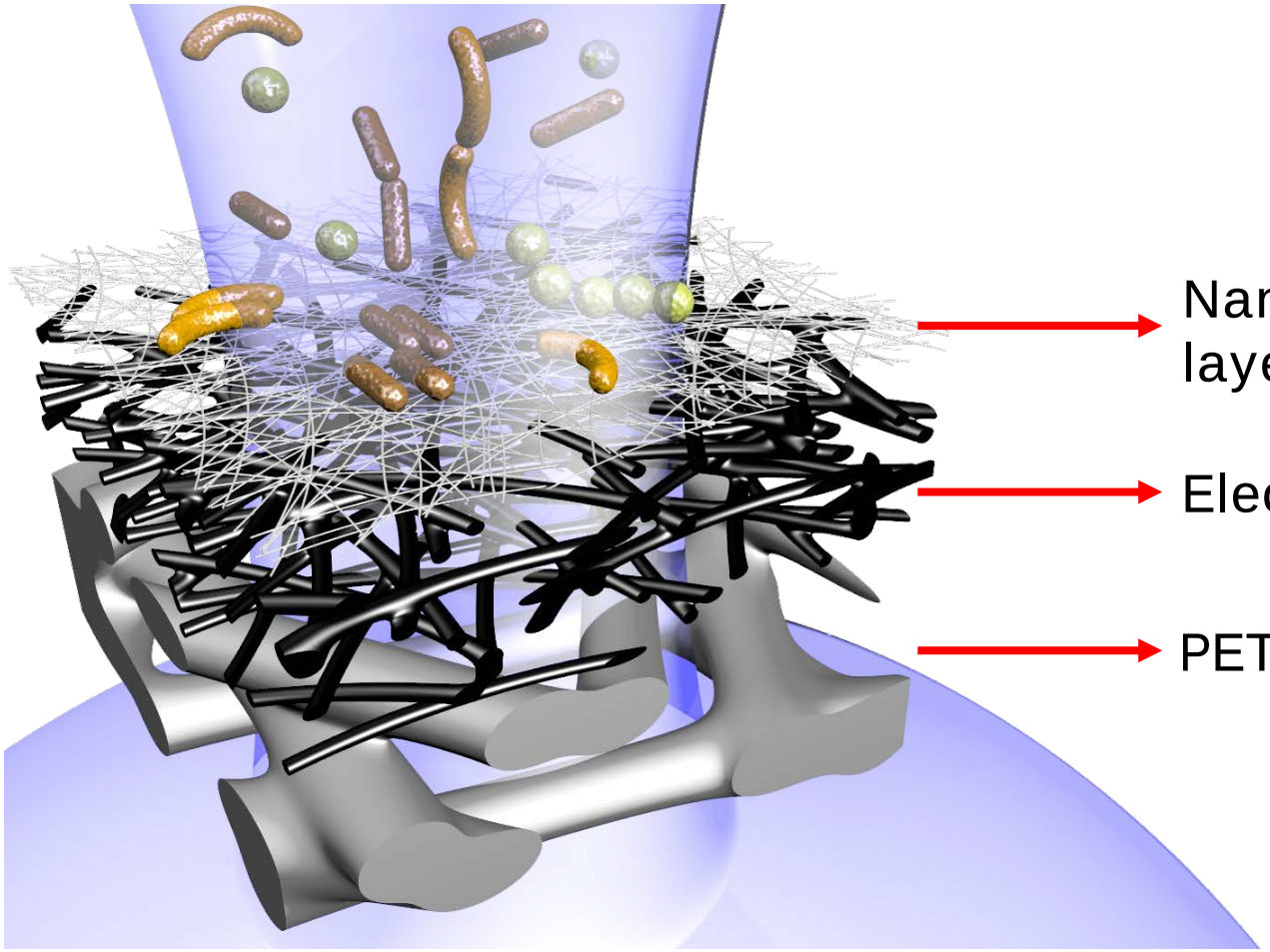
Electrospun – Cellulose Nanofiber (E-CNF) Membranes



Nanocellulose barrier layer

Electrospun PAN mat

PET nonwoven substrate

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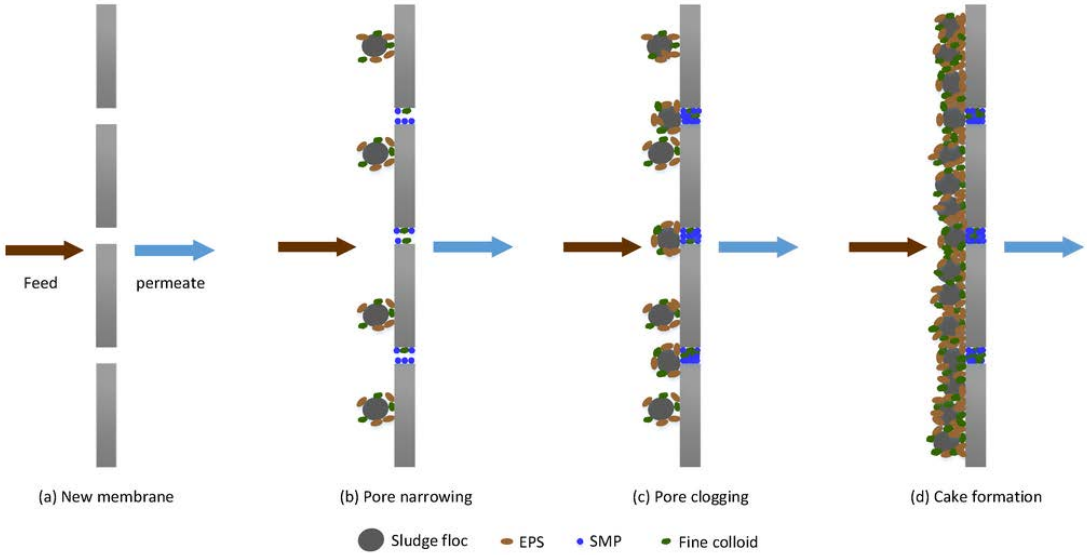
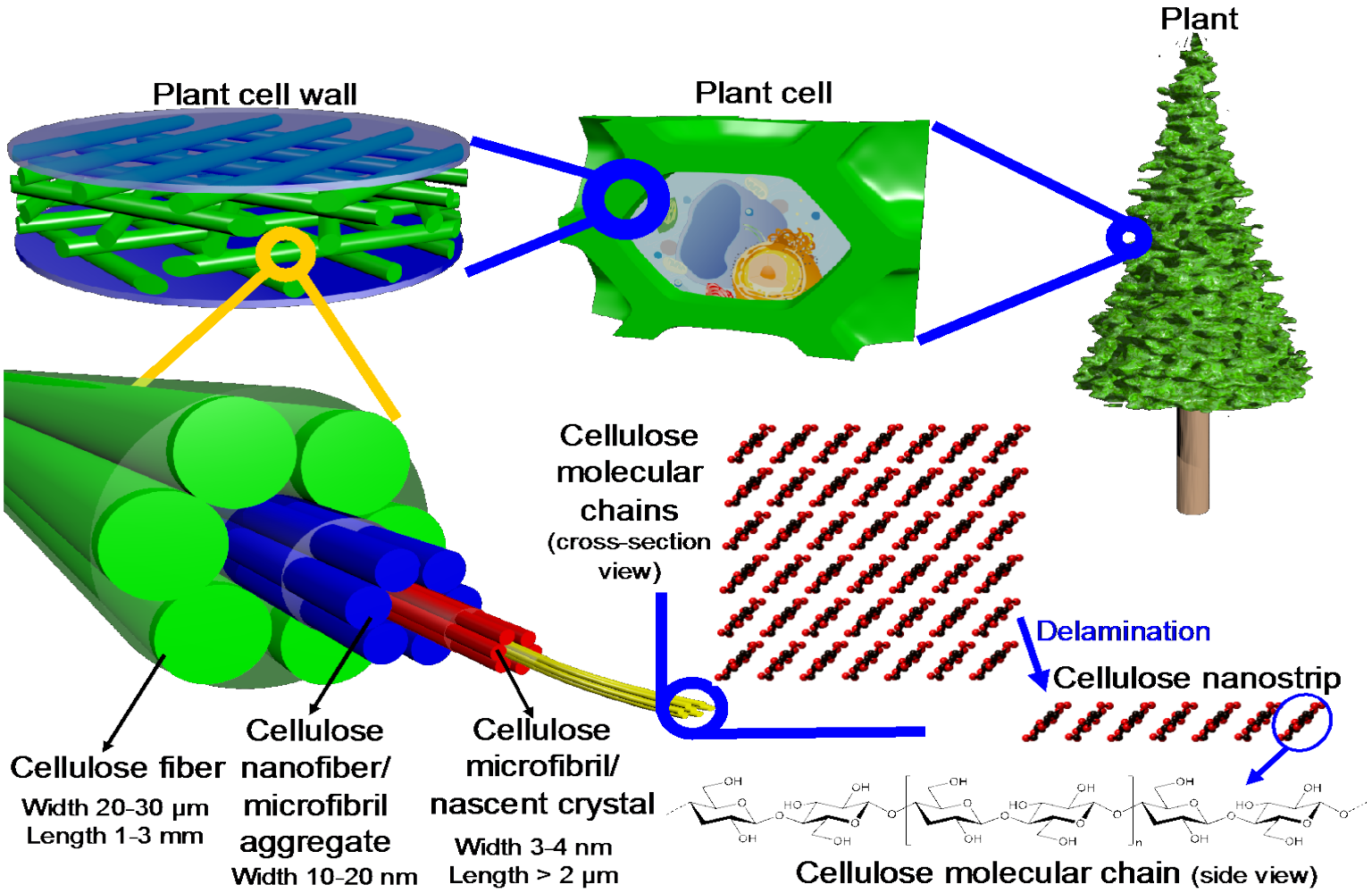
What is Fouling?

- **Foulants**
  - Suspended particulates and colloids
  - Soluble microbial products
- **Fouling**
  - Pore narrowing
  - Pore clogging
  - Cake formation



Cellulose Nanofiber Preparation



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Cellulose Nanofiber Preparation

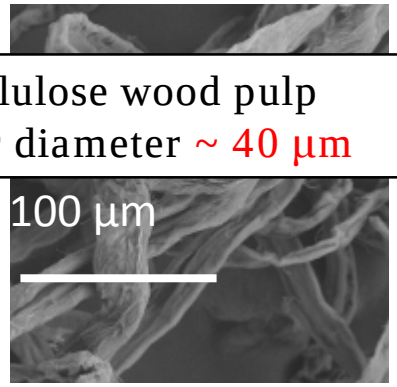
Cellulose nanofibers
Fiber diameter ~ 5-20 nm

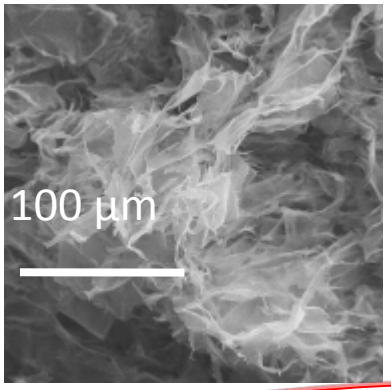
Oxidized cellulose fibers

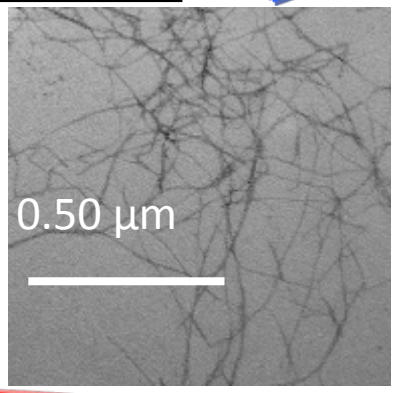
TEMPO/NaBr/NaClO

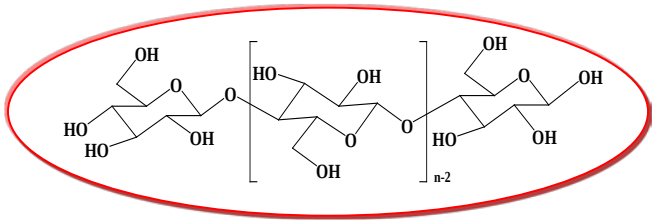
Mechanical treatment

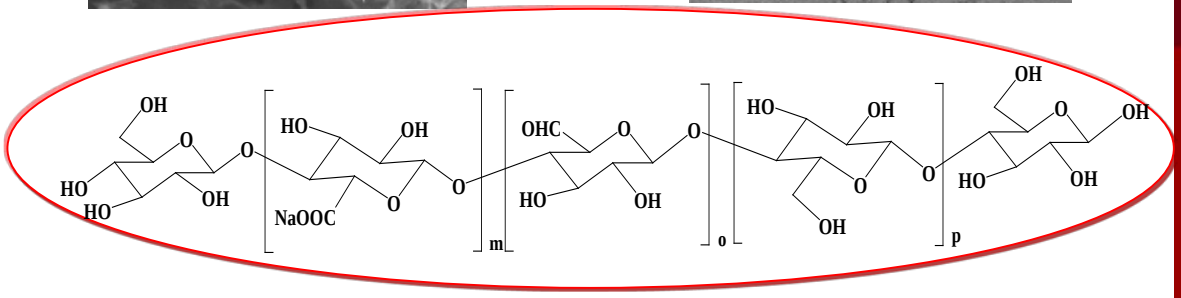
Cellulose wood pulp
Fiber diameter ~ 40 µm











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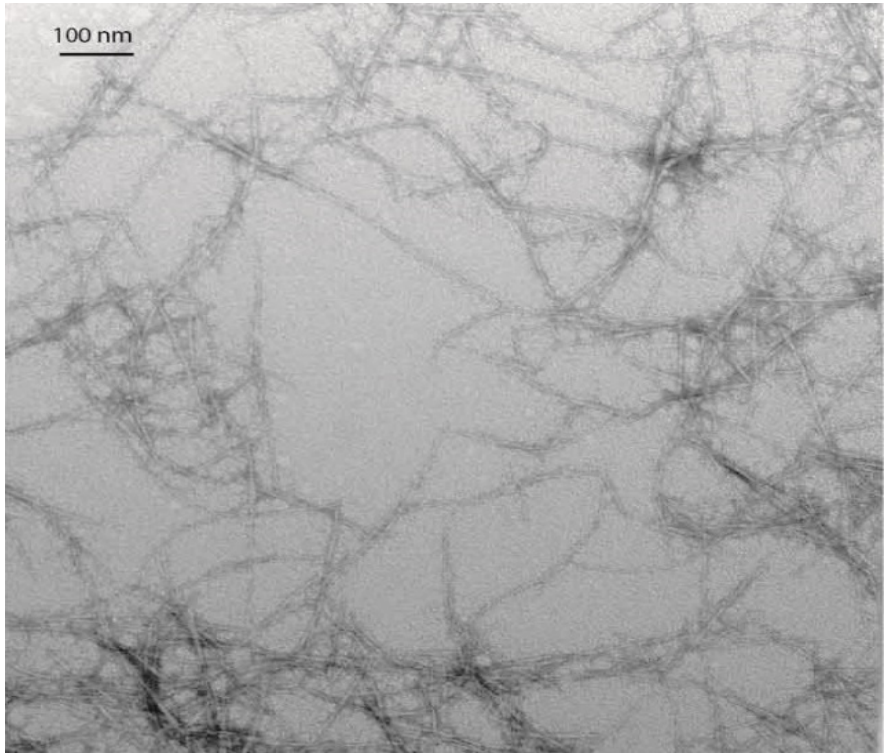
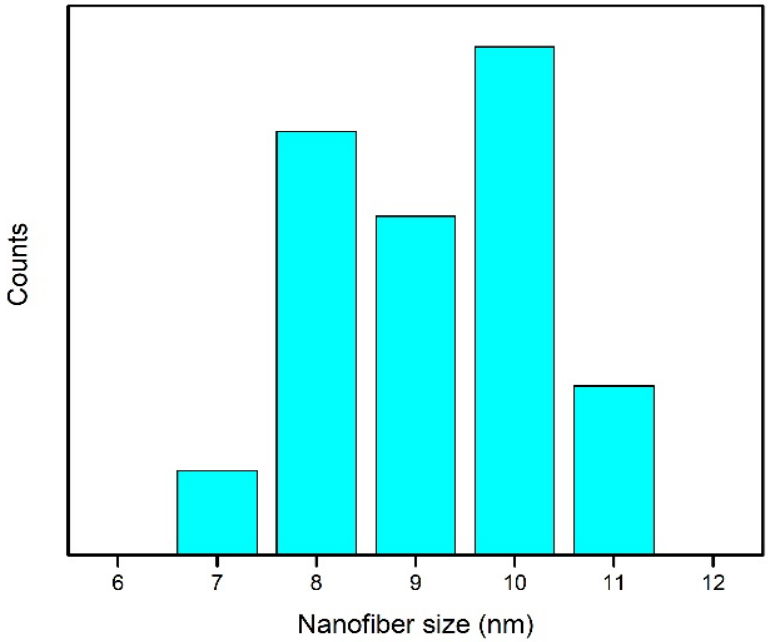
TEM image of the cellulose nanofibers





Cellulose nanofiber (~ 7 - 11 nm)

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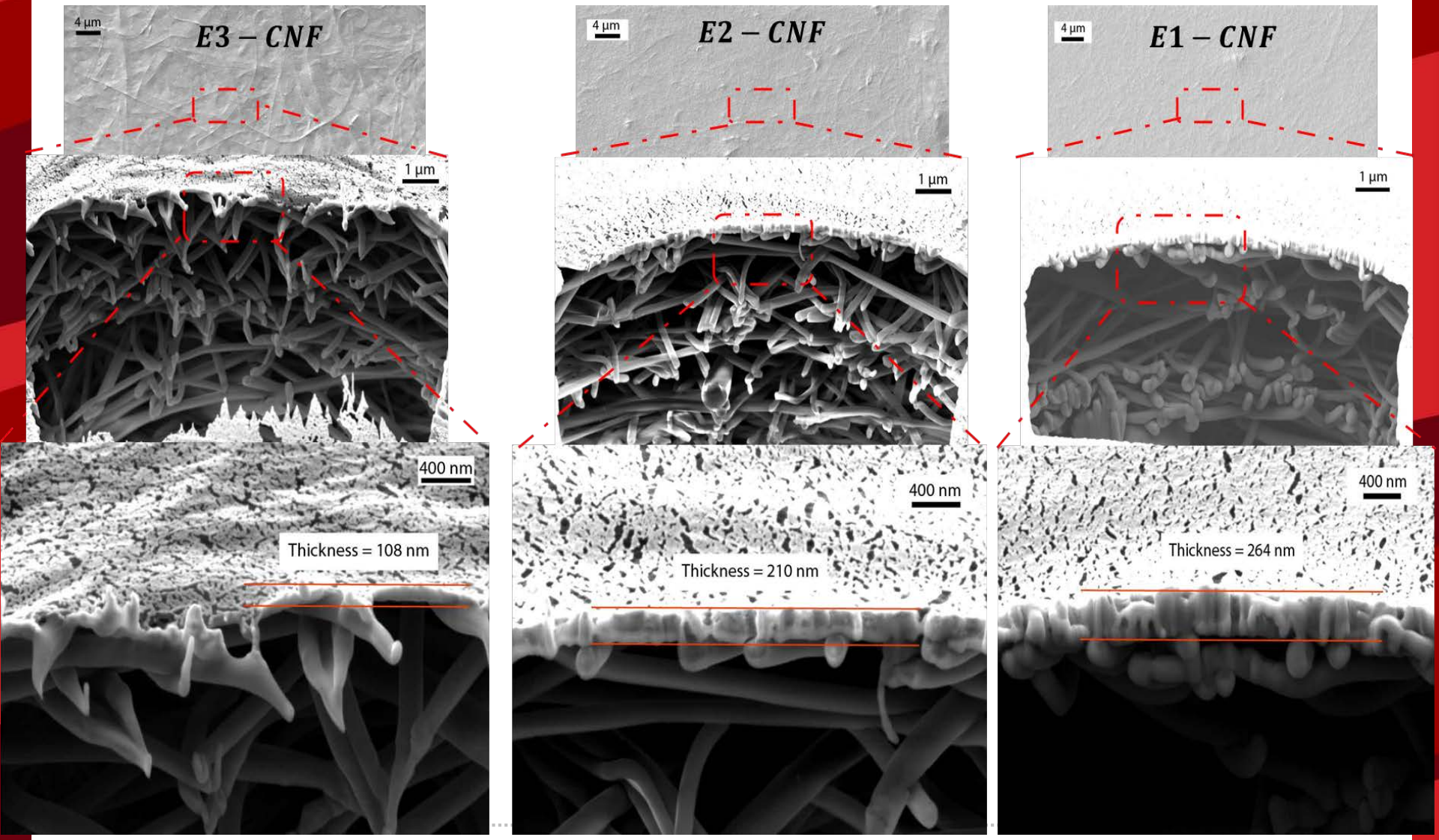
Cross-sectional SEM image of E-CNF



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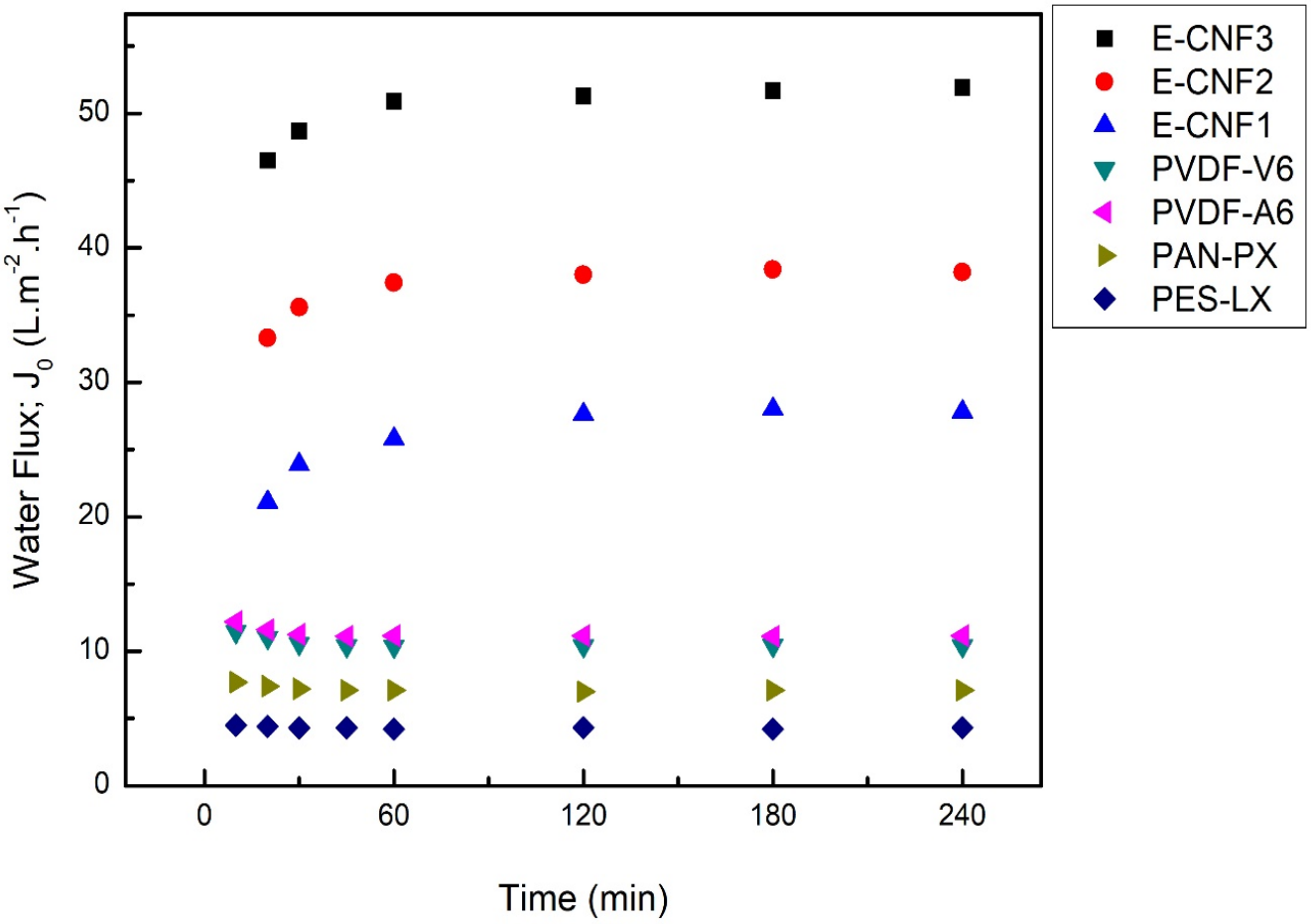
Clean Water Flux



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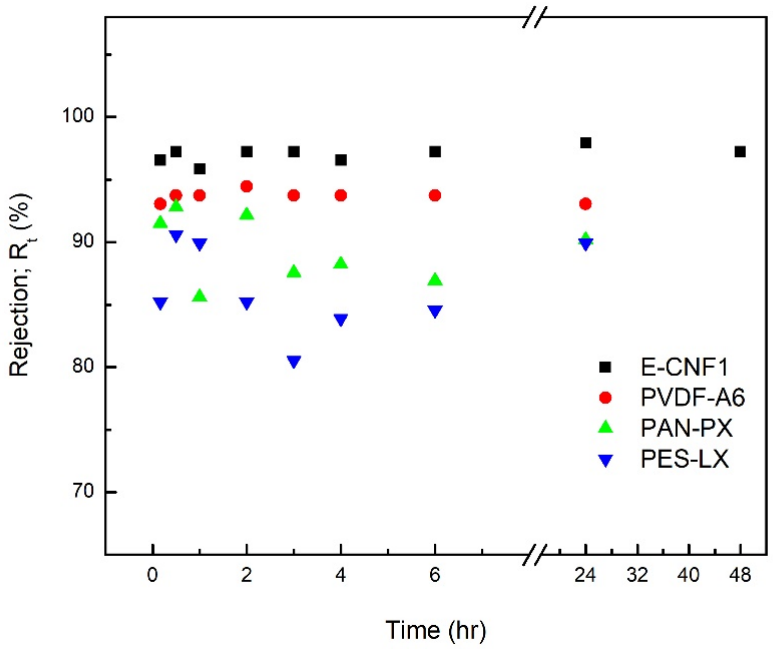
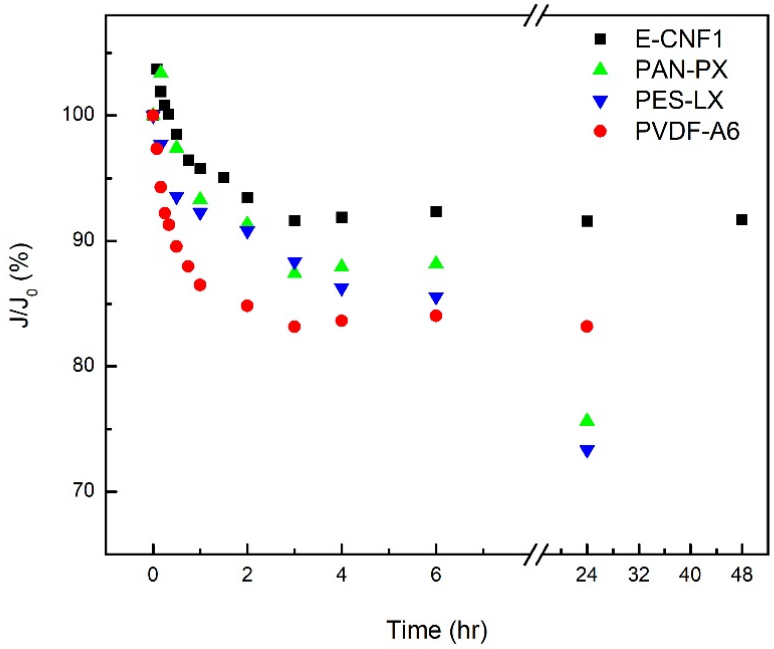
Fouling and Rejection





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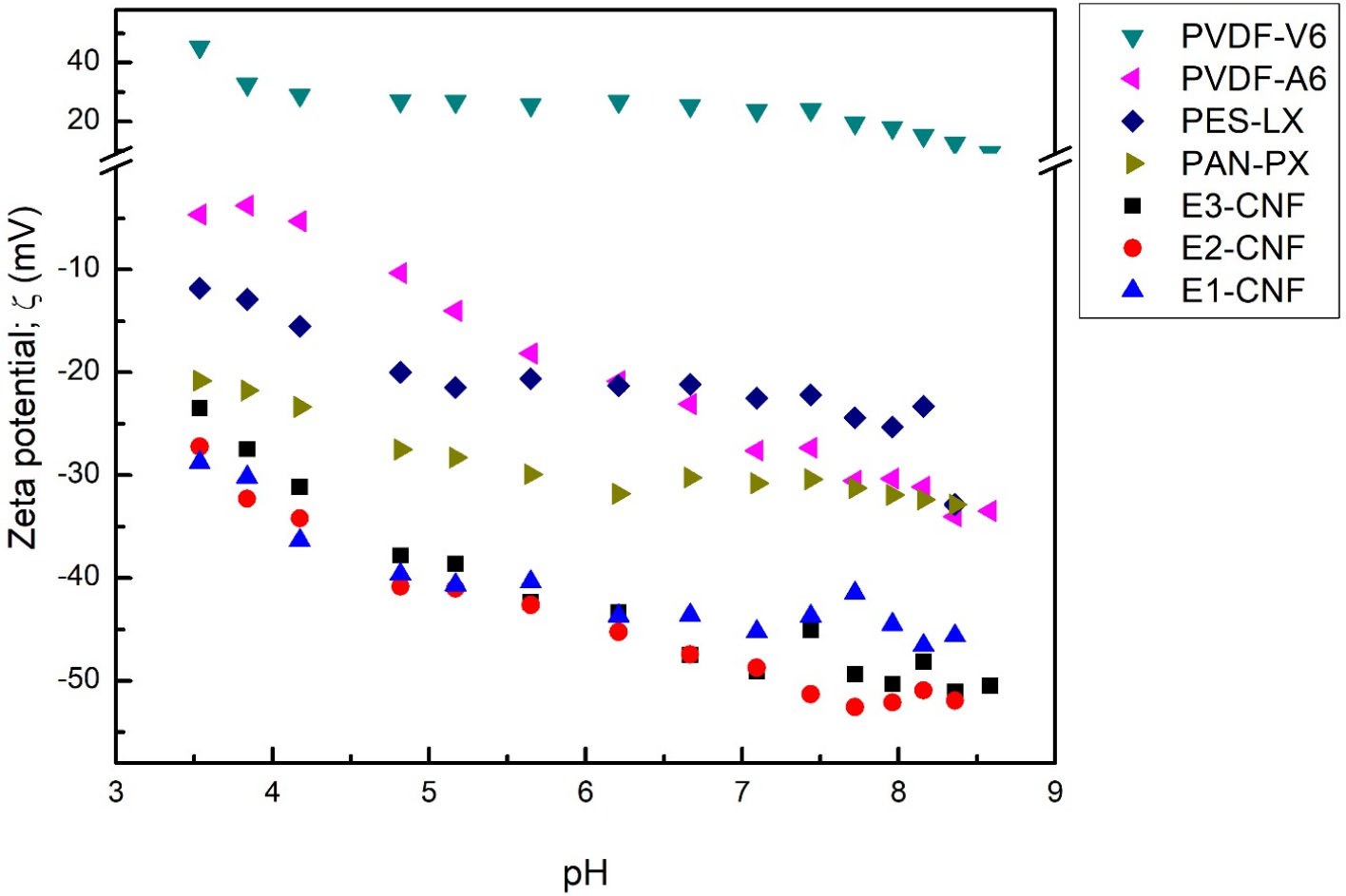
Zeta Potential



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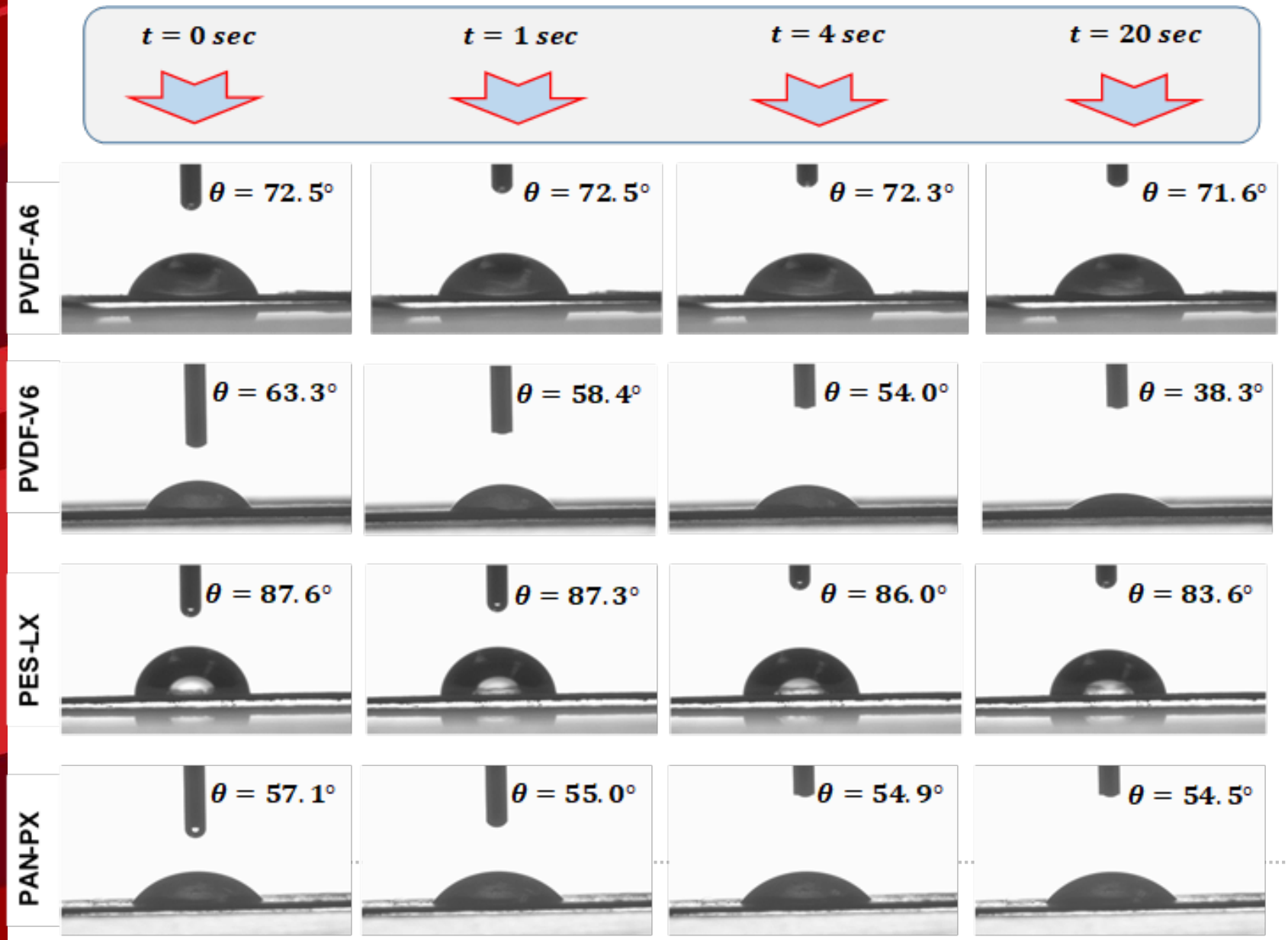
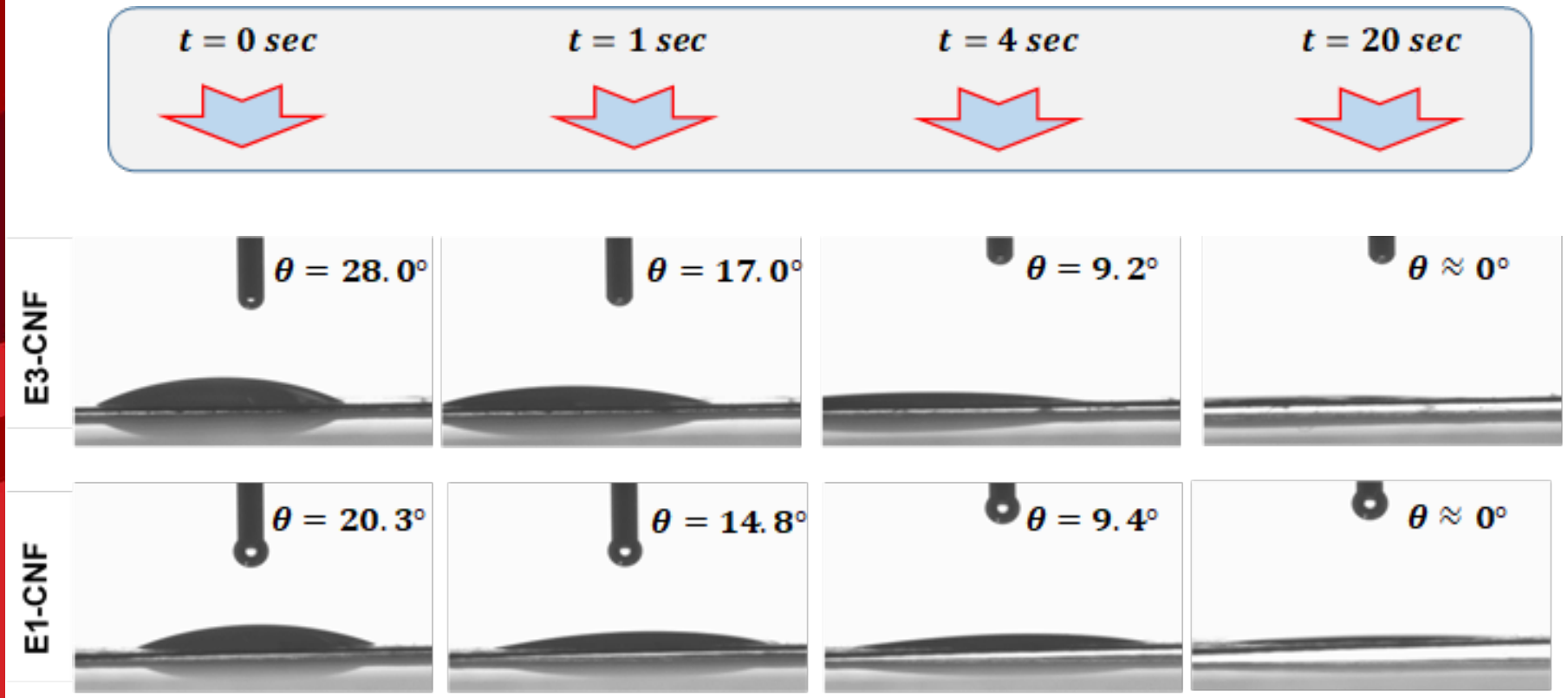
Contact angles of the conventional membranes



Contact angles of the hierarchical membranes



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Conclusion and Future Work

- Lab-scale MBBR-MBR system up-and-running and being used to explore simultaneous nitrification/denitrification
  - Relate microbial pathways to system function
  - Develop pilot-scale system at research trailor
- Nanocellulose membranes show superior flux, rejection, and fouling properties compared to conventional membranes
  - Integrate nanocellulose membranes into lab- and pilot-scale systems