# Characterizing Membrane Distillation Membranes Under Wetting/Nonwetting Conditions

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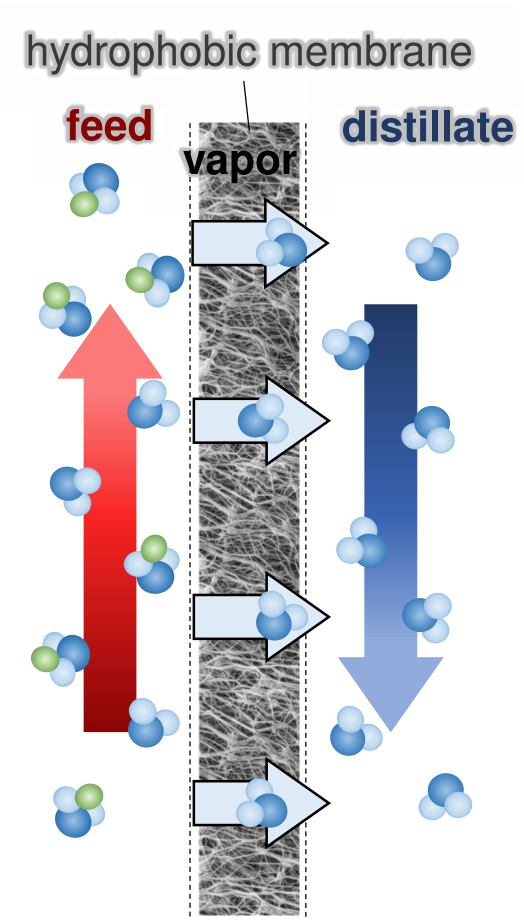
## Introduction

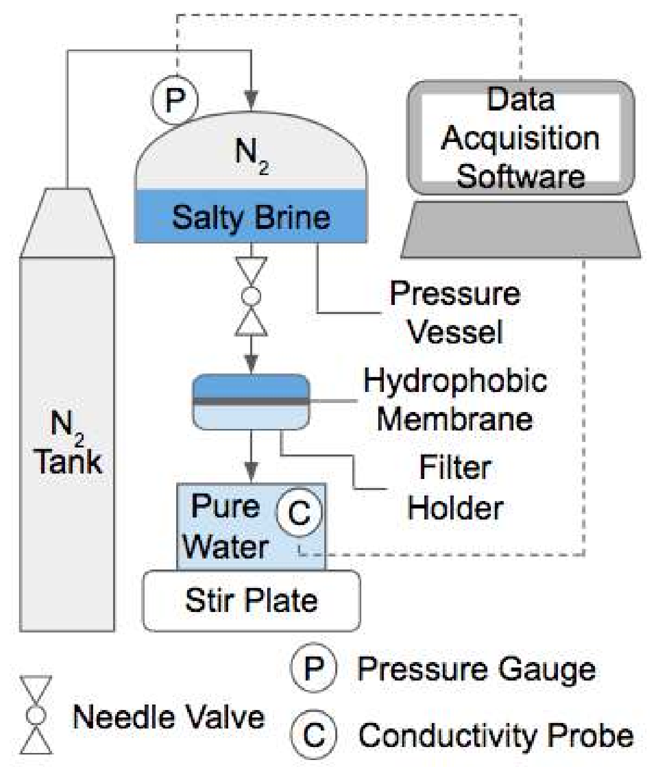
Membrane distillation (MD) is a thermally driven process that can be used to obtain pure water from wastewater streams [1]. MD membranes are thin, polymeric materials that have the ability to filter out unwanted materials, including dissolved salts, by only allowing water vapor to pass through the membrane [2]. It is crucial that the membrane has high hydrophobicity, or strong repulsion against liquid water, to prevent the membrane from getting wet. If membrane wetting occurs, salts and other contaminants smaller than the pore size will seep through the membrane pores, impurifying the product water. An important membrane characteristic that quantifies a membrane's hydrophobicity is liquid entry pressure (LEP). LEP is the pressure that is required to push liquid through the membrane, causing membrane wetting [3].




## Objective & Impact of Professor's Research

The Childress Research Group investigates environmentally friendly and energy-efficient ways to improve water treatment technologies including membrane distillation (MD) and pressure retarded osmosis (PRO). MD uses a thermal gradient to purify water and PRO uses an osmotic gradient to create energy. These two technologies produce pure water and energy without leaving as much carbon footprint than traditional water treatment. Full scale MD and PRO facilities can provide high quality water for numerous people, lower energy consumption, and minimal pollution.

## Methods

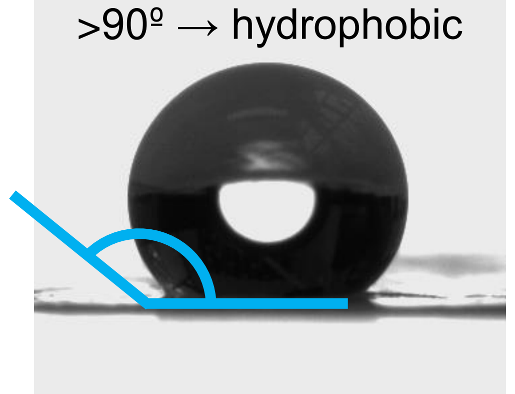



To determine LEP, a nitrogen tank was attached to a pressure vessel with a pressure gauge to measure pressure. The NaCl solution was placed inside the vessel, and traveled in a tube to a filter holder with a hydrophobic PTFE membrane inside. The filter holder was placed over a beaker containing deionized (DI) water and a conductivity probe. The beaker was placed on a stir plate to ensure complete mixing. Pressure was increased in small increments, approximately every 5 minutes. When the LEP was reached, salt water passed through the membrane. So, a sharp increase in the conductivity of the DI water shows that the membrane is wetted. All of the performance data was measured with a bench-scale MD system already built.

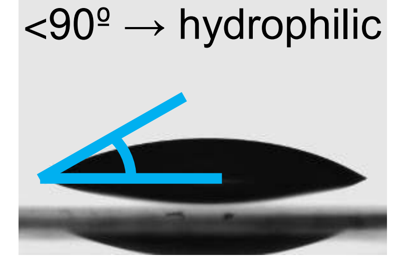
## Results

### Preliminary Membrane Characterization

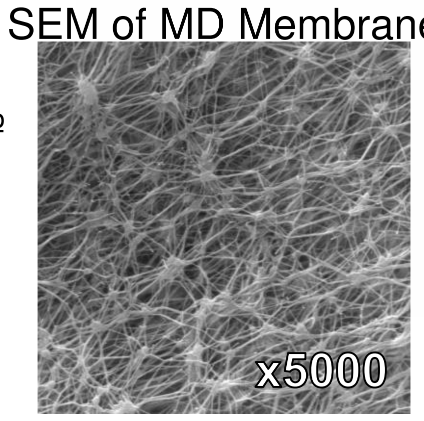
MD Membrane
Contact Angle = 141.8±3.9º
>90º → hydrophobic

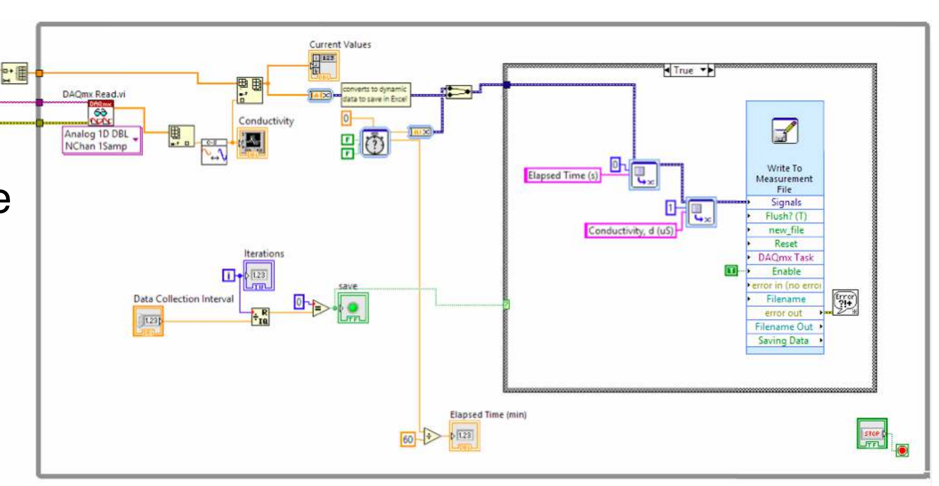


Ex. Hydrophilic Membrane
Contact Angle = 31.2º
<90º → hydrophilic



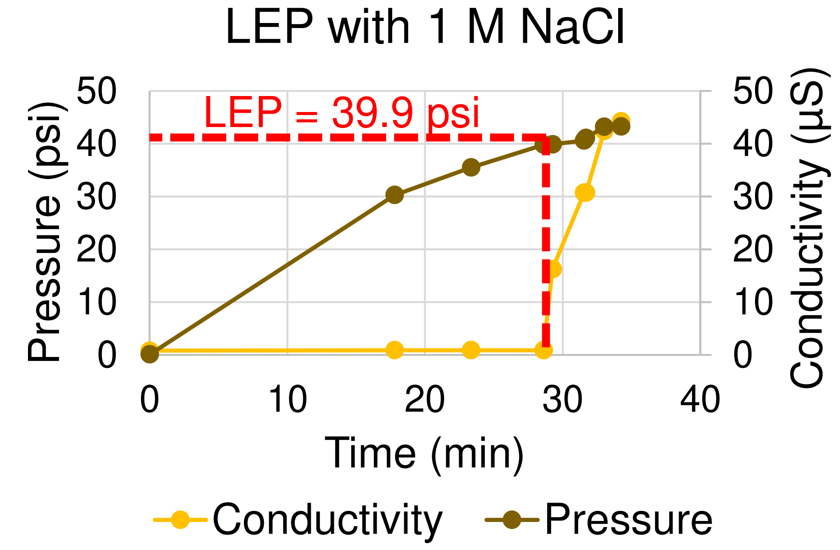
SEM of MD Membrane

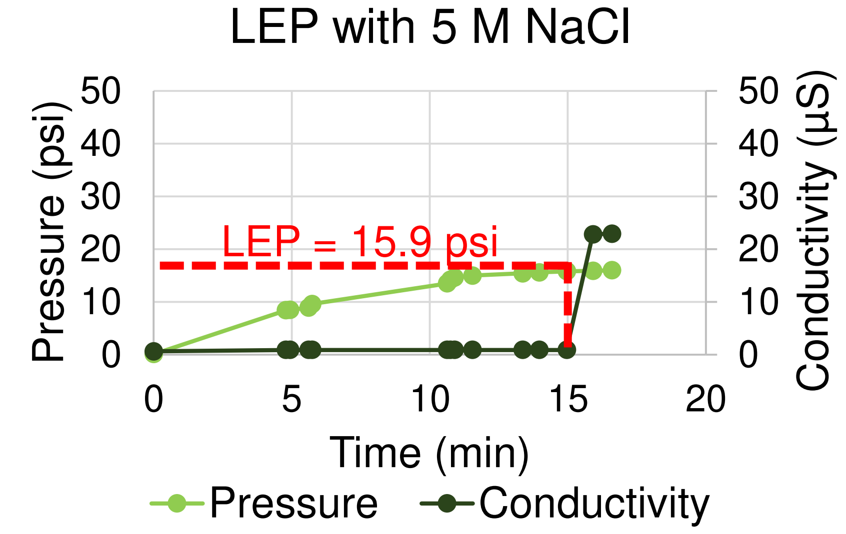


Data Acquisition Software Program (Written in LabVIEW)

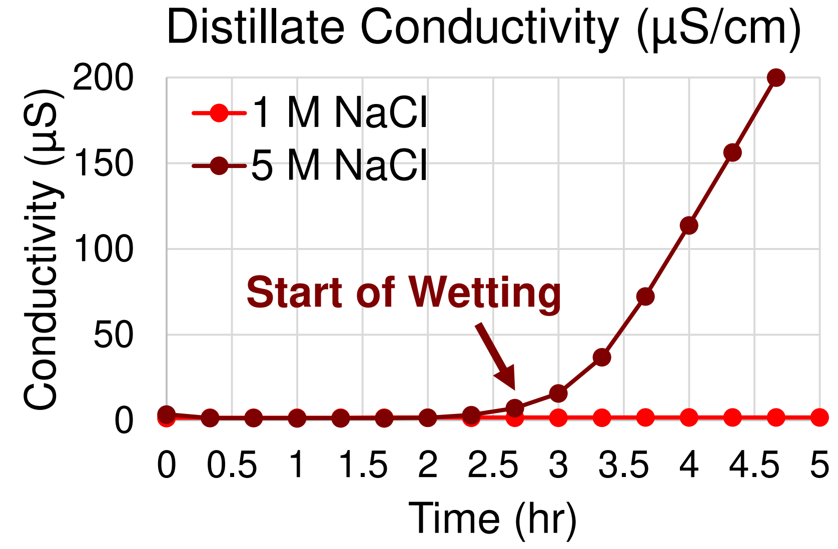
### Membrane Characterization Under Wetting and Non-Wetting Conditions

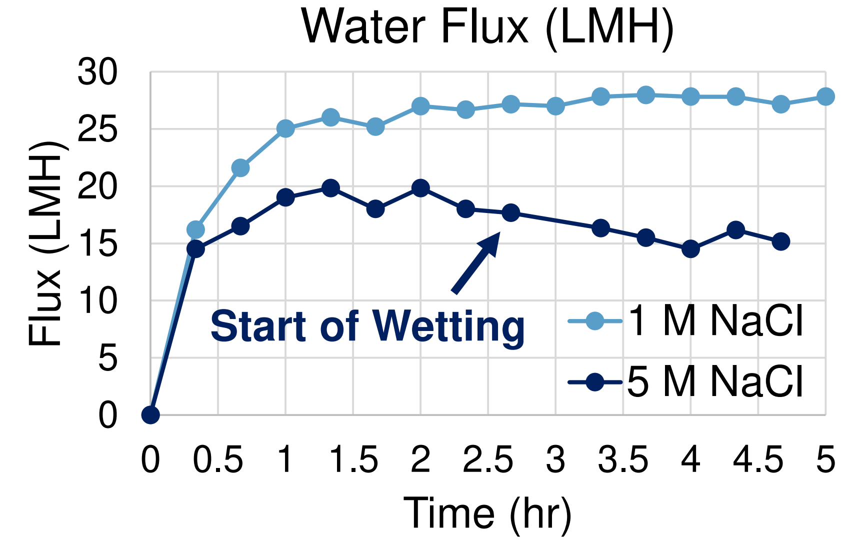


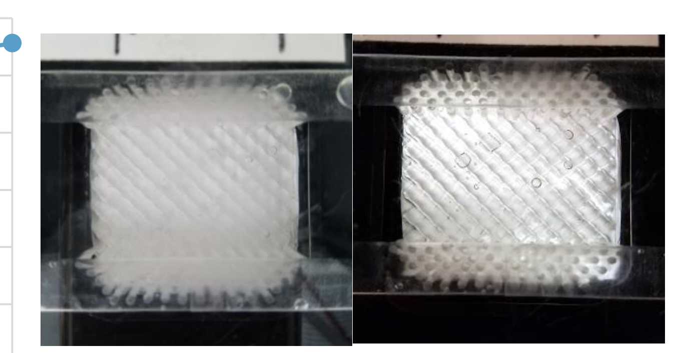




LEP System

### Membrane Performance Under Wetting and Non-Wetting Conditions



unwetted wetted

## Conclusion

The MD membrane was able to better withstand pressure with 1M NaCl than 5M NaCl. The lower LEP for the 5 M NaCl solution indicates that the membrane would wet faster than the 1M NaCl solution in an MD system operating under constant conditions. Water flux, the flow rate of water through a membrane, also decreases when wetting occurs. In conclusion, to treat higher salinity solutions membrane hydrophobicity should be improved.

## Acknowledgements

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References

[1] M. Rezaei, D. M. Warsinger, M. C. Duke, T. Matsuura, and W. M. Samhaber, "Wetting phenomena in membrane distillation: Mechanisms, reversal, and prevention," *Water research*, vol. 139, pp. 329-352, 2018.
[2] A. Deshmukh, C. Boo, V. Karanikola, S. Lin, A. P. Straub, T. Tong, *et al.*, "Membrane distillation at the water-energy nexus: limits, opportunities, and challenges," *Energy & Environmental Science*, vol. 11, pp. 1177-1196, 2018.
[3] G. Rácz, S. Kerker, Z. Kovács, G. Vatai, M. Ebrahimi, and P. Czermak, "Theoretical and experimental approaches of liquid entry pressure determination in membrane distillation processes," *Periodica Polytechnica Chemical Engineering*, vol. 58, pp. 81-91, 2014.