Electrospun Membranes Yield Pore Results

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Introduction

Membrane distillation (MD) is a water treatment system. A heated, contaminated feed stream and cooled, clean distillate stream flow on either side of a hydrophobic membrane [1]. The difference in vapor pressure causes water to evaporate from the feed stream and condense into the distillate stream. MD can utilize low-level energy sources that are currently entirely wasted, making it a better fit for the reality of climate change than wastewater systems like reverse osmosis [2].

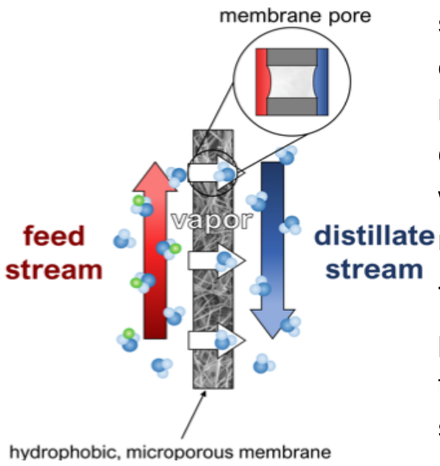


Figure 1 Diagram of Membrane Credit: Allyson McGaughey

The hydrophobic membrane permits vapor to pass through, but not liquid; thus, salts and other contaminants remain in the feed stream. However, if liquid penetrates membrane pores, the contaminated feed stream will mix directly with the clean distillate stream.

Methods

In this work, we characterized the contact angle, pore size, and liquid entry pressure (LEP) of MD membranes and tested them in MD to study the relationship between pore size, contact angle, and wetting resistance.

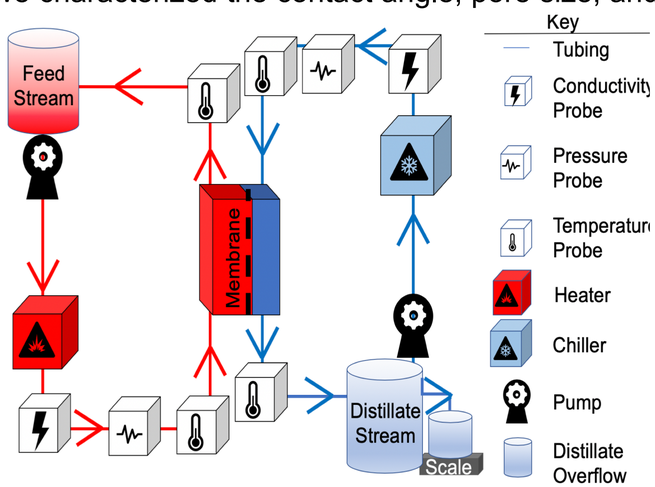


Figure 2 MD test system. Credit: Pearson Mewbourne

Results

The Young-Laplace equation is used to model the LEP of a membrane:

$$LEP = -\frac{2B\gamma_{lv}\cos(\theta)}{r}$$

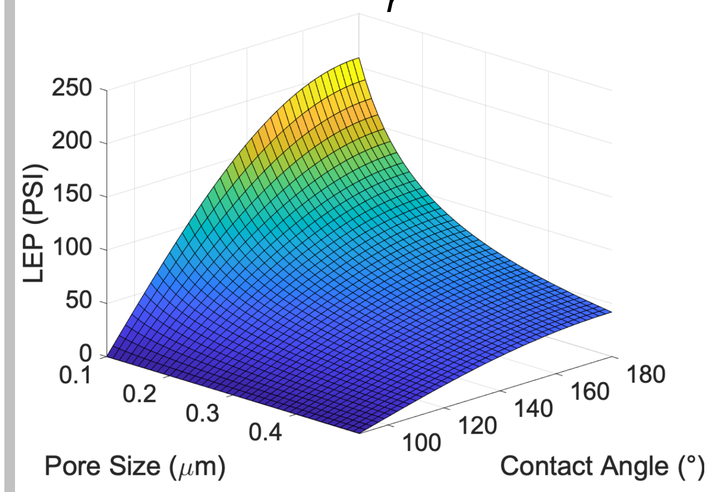
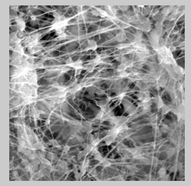
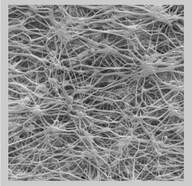
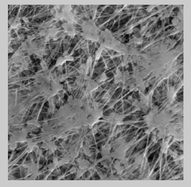
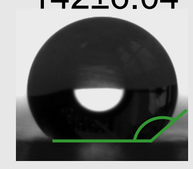
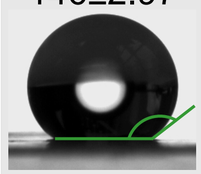
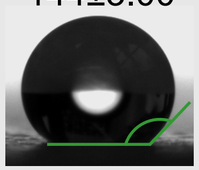


Figure 3 LEP graphed with varying values of Contact Angle and Pore Size. Credit: Pearson Mewbourne

LEP is greatest when pore size is minimized and contact angle is maximized. Pore size is more important in determining LEP as it is the denominator in the equation. Pore size is inversely proportional to LEP.

	Donaldson (Commercial)	QM022 (Commercial)	0QL822120 (Electrospun)
SEM Image			
Contact Angle (°)	142±6.04 	146±2.97 	144±3.00 
LEP (PSI)	19	30	16

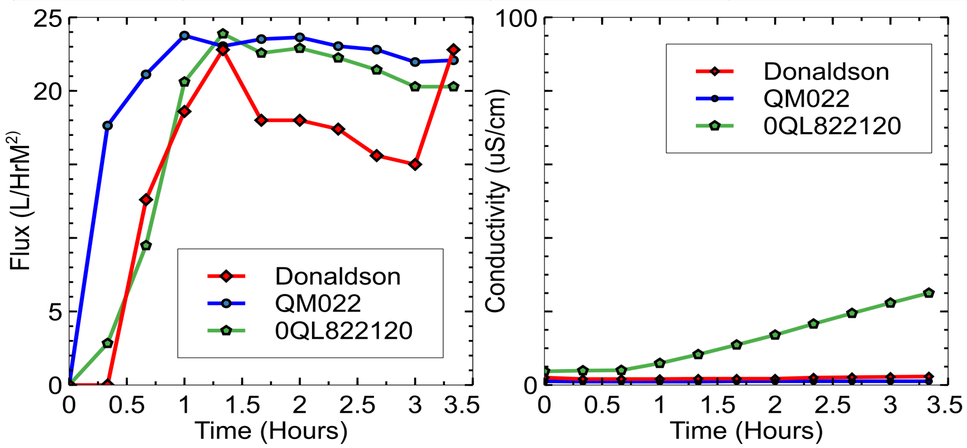


Figure 4 Performance tests of the three membranes. Credit: Pearson Mewbourne

Conclusions

The results from this study indicate that the Young-Laplace equation is inaccurate. Given actual pore sizes from Image J software, the equation predicted the LEP of the Donaldson, QM022, and 0QL822120 membranes to be 7, 46, and 10 psi, respectively. In actuality, however, these values were 19, 30, and 16, respectively. Additionally, this experiment showed that the QM022 membrane had a higher LEP and contact angle than the electrospun membrane, meaning that the QM022 could withstand higher pressures, increasing its durability and longevity. In future work, membrane manufacturers should focus on decreasing the pore size of electrospun membranes to remain competitive with or even surpass the performance of commercially available membranes.

What I learned

Data analysis software like Microsoft Excel, Veusz, and ImageJ, scientific skills such as proper lab safety and practices, and research skills like performing a literature review or create an annotated bibliography.

Acknowledgement

Thank you to my SHINE mentors, Allyson McGaughey and Sophia Plata. Thank you to my lab mates Sarah Burke, Max Edelstein and Andrew Sung. Thank you to Dr. Katie Mills for making this wonderful program a reality.

References

1. Mcgaughey, A. L., Gustafson, R. D., & Childress, A. E. (2017). *Effect of long-term operation on membrane surface characteristics and performance in membrane distillation*.
2. Tijing, L. D., Choi, J.-S., Lee, S., Kim, S.-H., & Shon, H. K. (2014). Recent progress of membrane distillation using electrospun nanofibrous membrane. *Journal of Membrane Science*, *453*.