# Membrane Distillation Spacers: Improving Performance by Novel Designs

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## Introduction to Prof. Childress' Lab

Membrane distillation (MD) is a novel, thermally-driven water treatment technology. The membrane only allows vapor to pass through because of its hydrophobicity, which means it tends to repel water [1]. MD can be used to produce high-quality water from complex wastewaters using alternative, "green" energies [1, 2]. A typical bench-scale MD system is shown in Fig. 1.

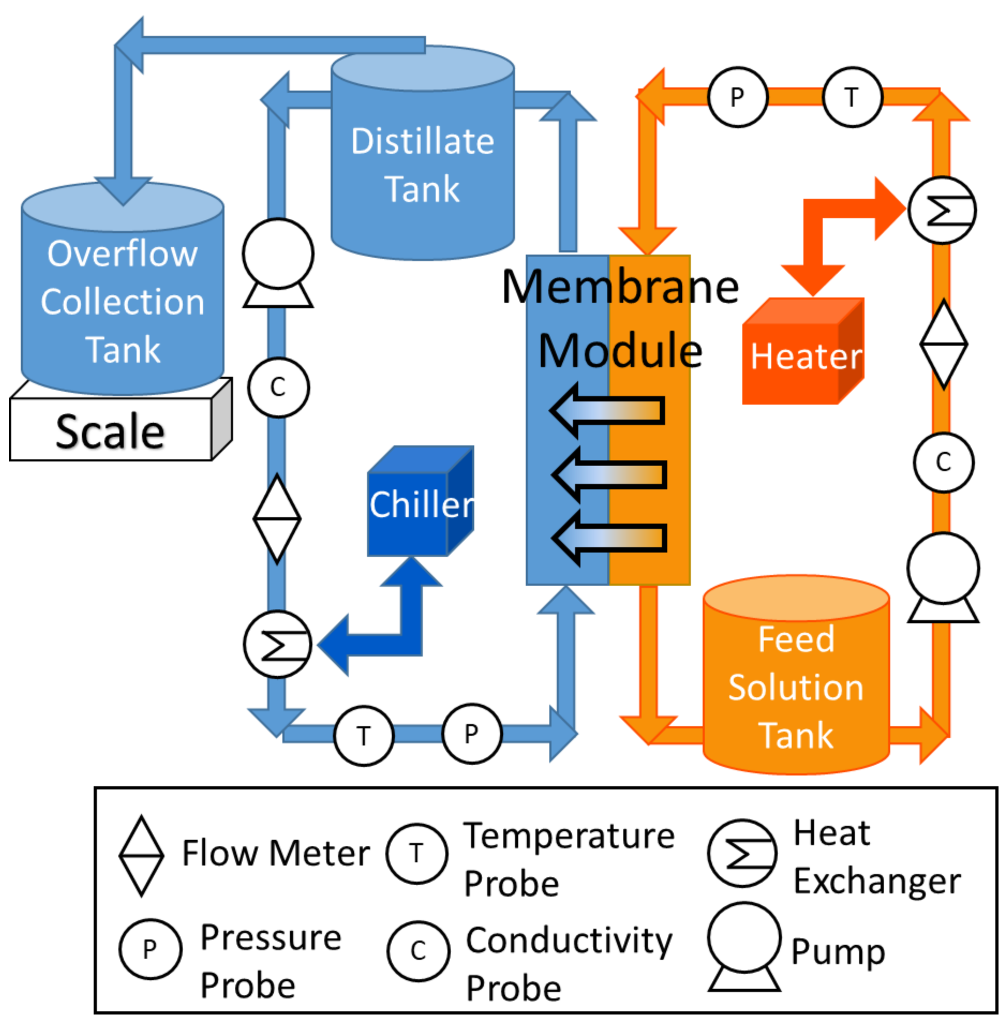


**Fig. 1.** Bench-scale MD system

Spacers are net-shaped polymer sheets that improve system performance [3, 4]. At the same time, spacers can increase fouling because they trap foulants from the feed solution [4].

## Hypotheses

In my research, I coated a spacer with an oleophobic coating to reduce oil fouling [5]. Oleophobic spacers have not previously been tested in MD.

I also designed a spacer to have a lower pressure drop and higher flux by decreasing the filament angle, increasing the mesh size to thickness ratio, and increasing the number of layers [3, 6-8].

## Novel Spacer Geometry Results

The spacer design I created is shown in Fig. 2 and Fig. 3

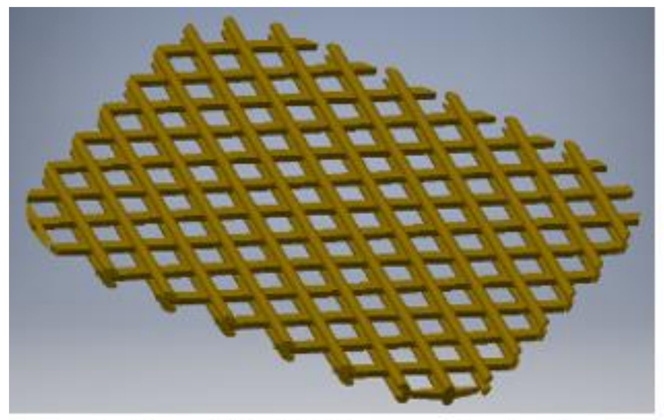

**Fig. 2.** 3D model of triple-layer spacer with square-shaped mesh

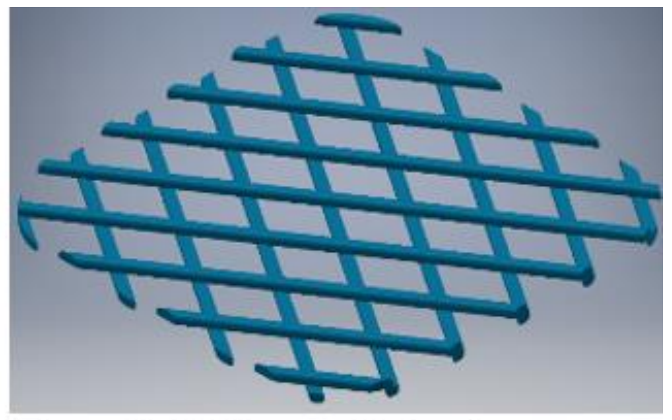

**Fig. 3.** 3D model of double-layer spacer with diamond-shaped mesh

The 3D printed spacers installed in the membrane module are shown in Fig. 4 and Fig. 5

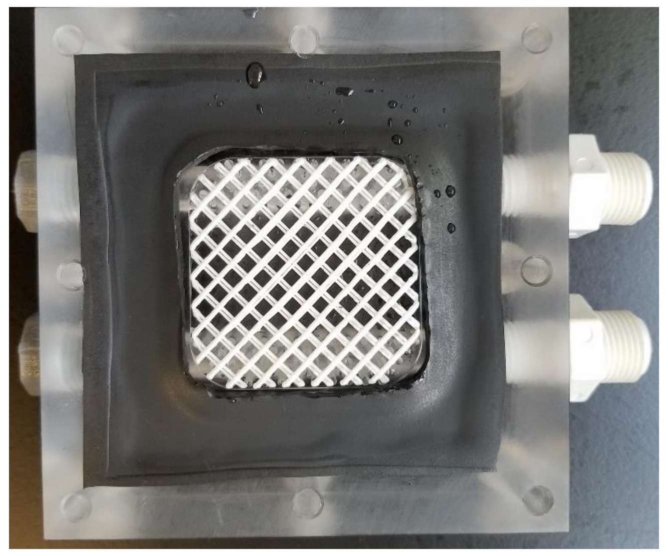

**Fig. 4.** 3D printed triple-layer spacer with square-shaped mesh

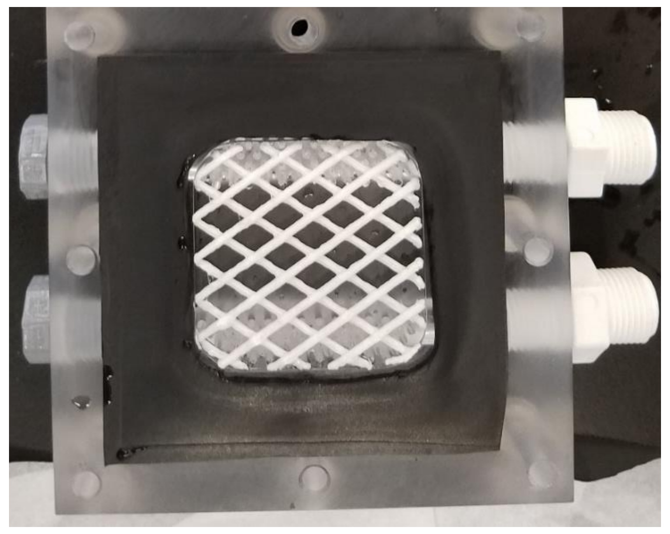

**Fig. 5.** 3D printed double-layer spacer with diamond-shaped mesh

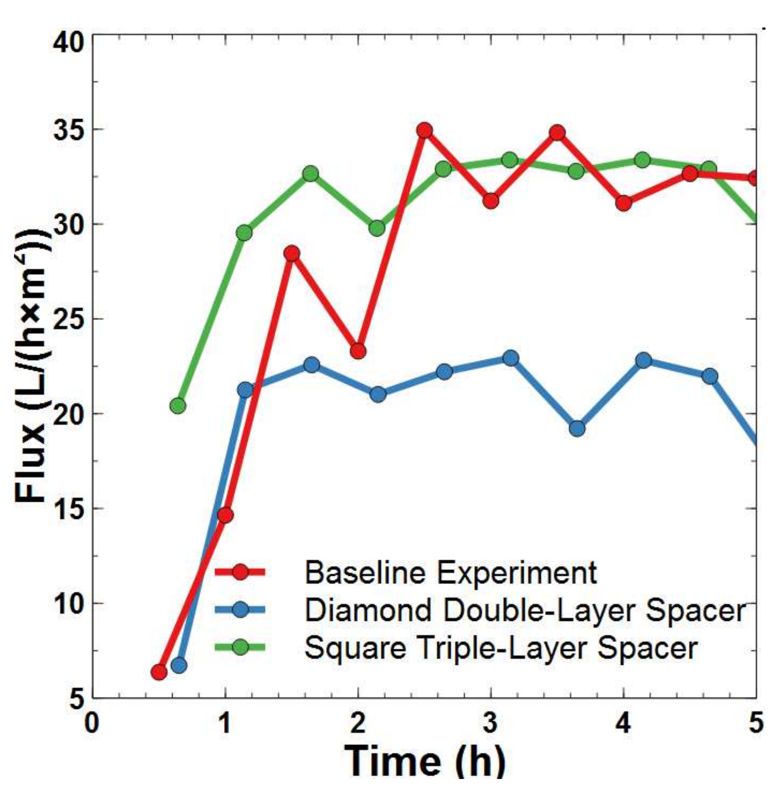


**Fig. 6.** Water flux over time

The double-layer diamond spacer gave a much lower flux than the baseline spacer, showing that the larger filament angle had a negative impact.

The triple-layer square spacer showed a similar flux as the baseline experiment, demonstrating that 3D printed spacers can perform as well as commercial spacers.

## Antifouling Spacer Results

Results of baseline experiment 1 M NaCl feed solution show stable flux around 30 $L/(h*m^2)$. The uncoated spacers with 1 M NaCl and 0.01% v/v mineral oil feed solution showed a low flux of around 10 $L/(h*m^2)$, which is possibly caused by oil fouling.

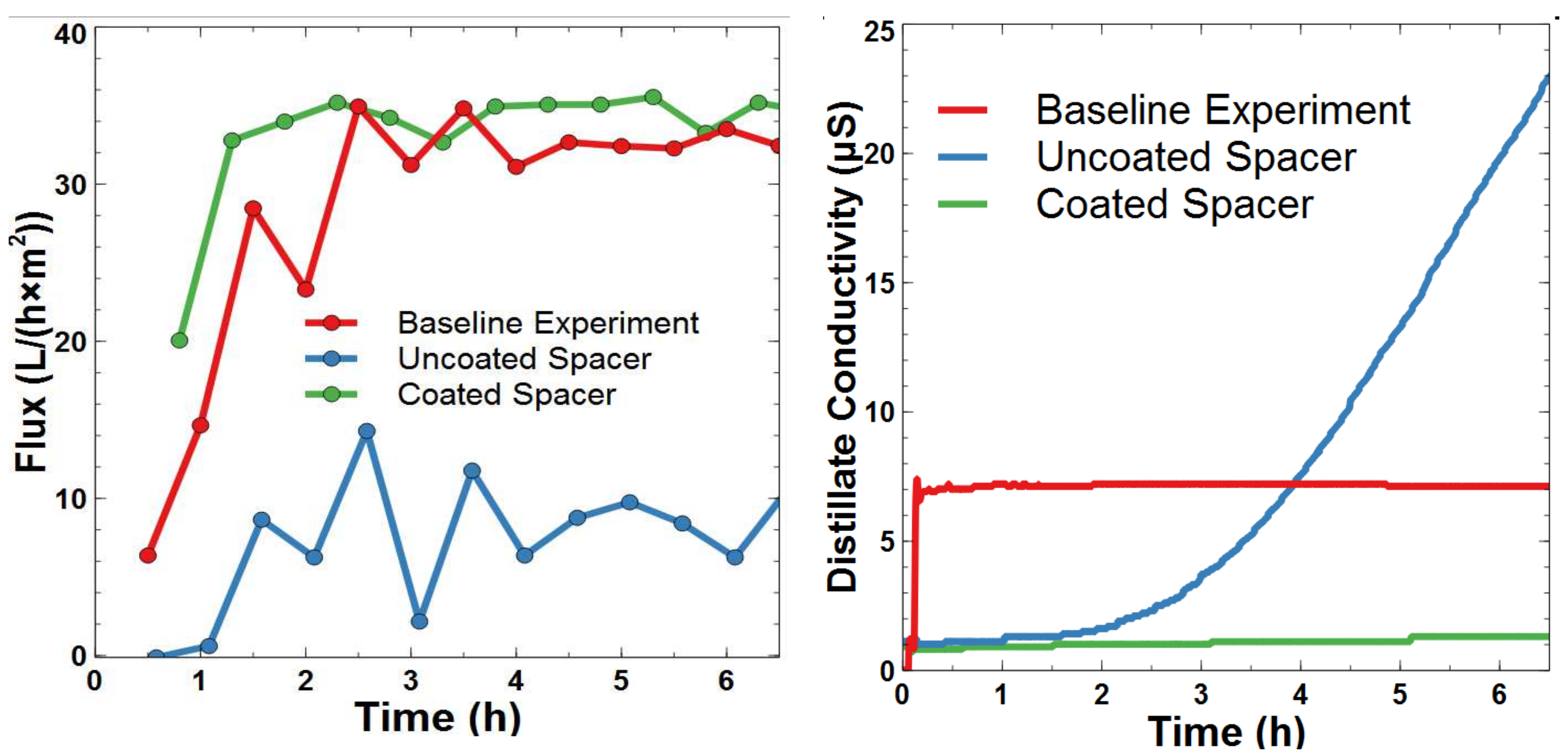


**Fig. 7.** Water flux and distillate conductivity over time

The baseline experiment and the experiment with oleophobic coated spacer showed a stable, low conductivity, while the distillate conductivity linearly increased for the uncoated spacer, indicating wetting occurred, which may have been caused by fouling. The oleophobic coating completely prevented oil fouling and wetting during the 6.5-hour experiment.

In future work, experiments should be repeated to verify the findings. A larger-scale MD run with coated oleophobic spacers should be done. Oil fouling test runs should be done on the two 3D printed spacers to see the effect of geometries on reducing oil fouling.

## Skills Learned

Matlab, Veusz, Operating Membrane Distillation, Lab Safety, Excel, Library Research, Annotated Bibliography, Measuring contact angle, Membrane Characterization (SEM), Technical Reading/Writing

## References

[1] A. Alkhudhiri, N. Darwish, and N. Hilal, Desalination, 2012.
[2] E. Drioli, A. Ali, and F. Macedonio, Desalination, 2015.
[3] A. Hagedorn, G. Fieg, D. Winter, and J. Koschikowski, Desalination, 2017.
[4] D. Warsinger, J. Swaminathan, and E. Guillen-Burrieza, Desalination, 2015.
[5] C. Boo, J. Lee, and M. Elimelech, Environ. Sci. Technol., 2016.
[6] T. Cath, V. Adams, and A. Childress, J. Memb. Sci., 2004.
[7] C. Koutsou, S. Yiantsios, and A. Karabelas, J. Memb. Sci., 2007.
[8] S. Al-Sharif, M. Albeirutty, A. Cipollina, and G. Micale, Desalination, 2013.

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