Solar Membrane Desalination

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Introduction

The project focusses on controlling scaling resistance in solar membrane distillation by monitoring the role of temperature, hydrodynamic conditions and concentration polarization. The researcher hypothesized that the maximum solar water production efficiency will be found in a medium between scaling resistance and high flux. The objectives of this research are characterizing the tradeoff between flux and scaling resistance, investigating the fundamental mechanism of inorganic fouling on self-heating surfaces, and determining the scaling propensity of self-heating membranes. The results of this study will inform the development of more resilient solar desalination systems for off-grid water treatment.

Figure 1: The imbedded reverse osmosis unit empowered by solar panels

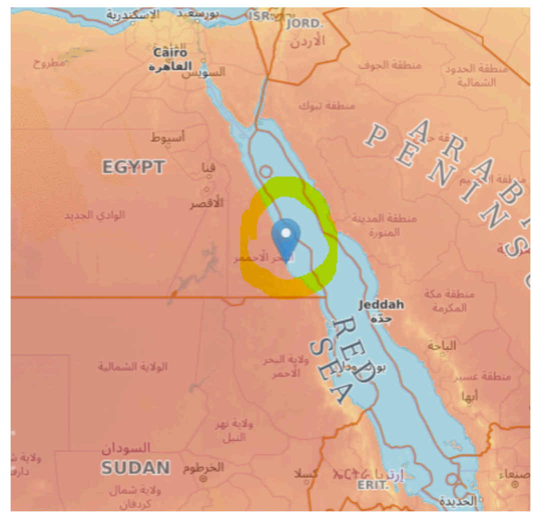

Figure 2: The testing site: Shalateen, Egypt

Research Question & Objectives

Research question: Does a high or low flux allow for maximum solar desalination production efficiency?

Objectives:

1. Manipulating the feed water temperature in 10℃ to determine scaling behavior in the solar membrane distillation

1. Isolating the effect of temperature from water flux by keeping the temperature gradient constant (ΔT= 20℃)

Methodology

1. A synthetic 1L salt solution is made according to NEWT's brackish solution.
2. The temperature of the heated water bath is adjusted.
3. The system is turned on for 15 minutes with the valves to the solar membrane closed to allow the salt solution to come to temperature.
4. After 15 minutes, the temperature of the salt solution and the draw bottle are recorded, and the difference of temperature is recorded.
5. The valves to the solar membrane are opened and the system is allowed to run for 24 hours.
6. On the next day, the system is turned off and the membrane is extracted, air dried and taken to imaging.

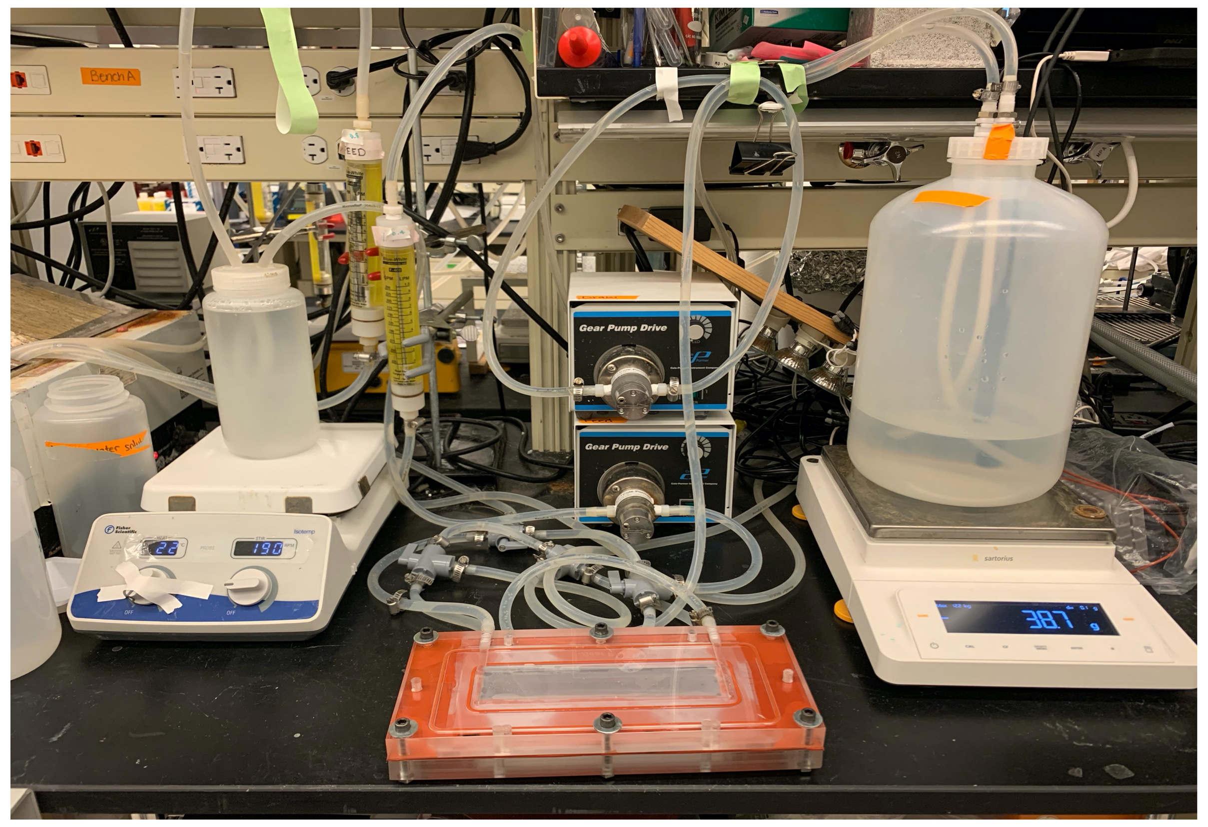

Figure 3: The membrane distillation set up in the ISTB 4 .

Table 1: NEWT Brackish Solution Specification.

Constituents	Concentration (mM)
Bicarbonate (HCO_3^-)	15.2
Calcium (Ca^{2+})	26.7
Chloride (Cl^-)	93.1
Magnesium (Mg^{2+})	10.7
Sodium (Na^+)	63.1
Sulphate (SO_4^{2-})	14.8

Results

The following graphs of average flux versus concentrations were obtained for various experimental trails of varying temperature differences. The first 10 minutes of the experiment was omitted as a result of large temperature change in the start of the experiment.

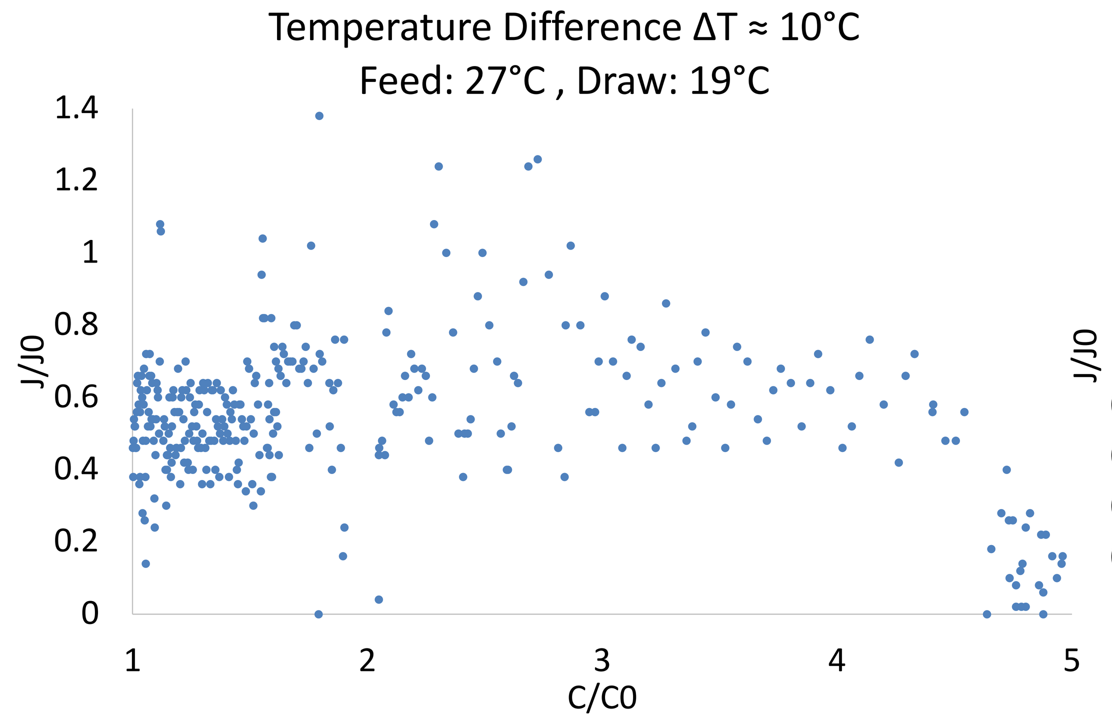

Figure 4: Graph of average flux versus concentration of ΔT ≈ 10°C

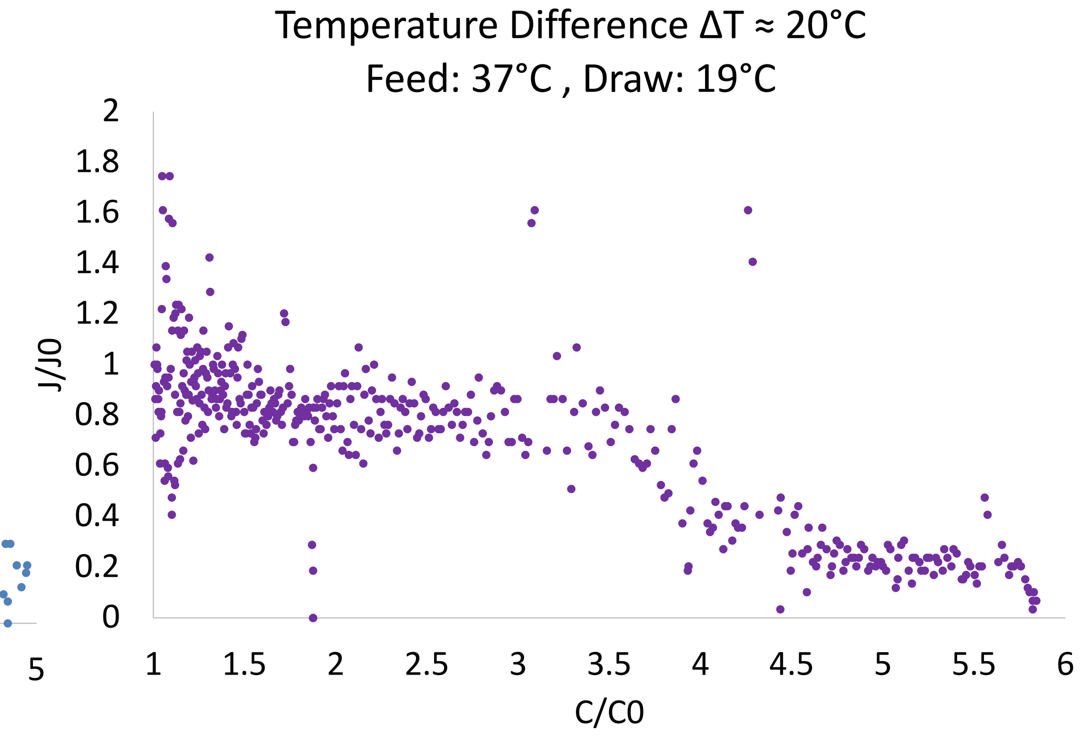

Figure 5: Graph of average flux versus concentration of ΔT ≈ 20°C

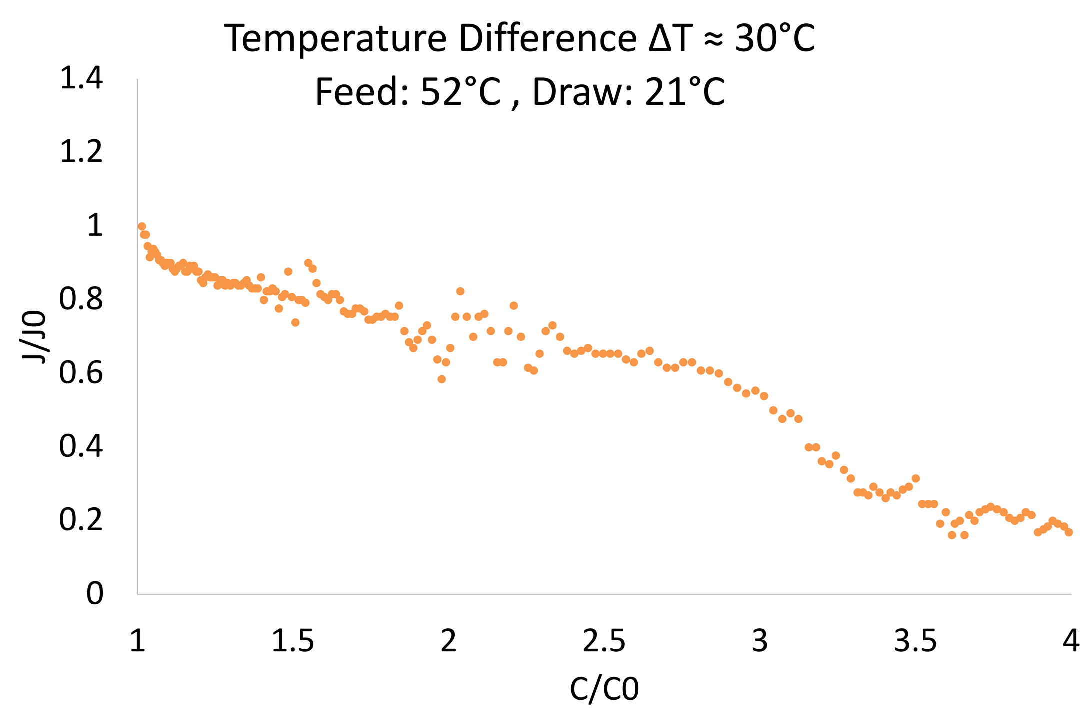

Figure 6: Graph of average flux versus concentration of ΔT ≈ 30°C

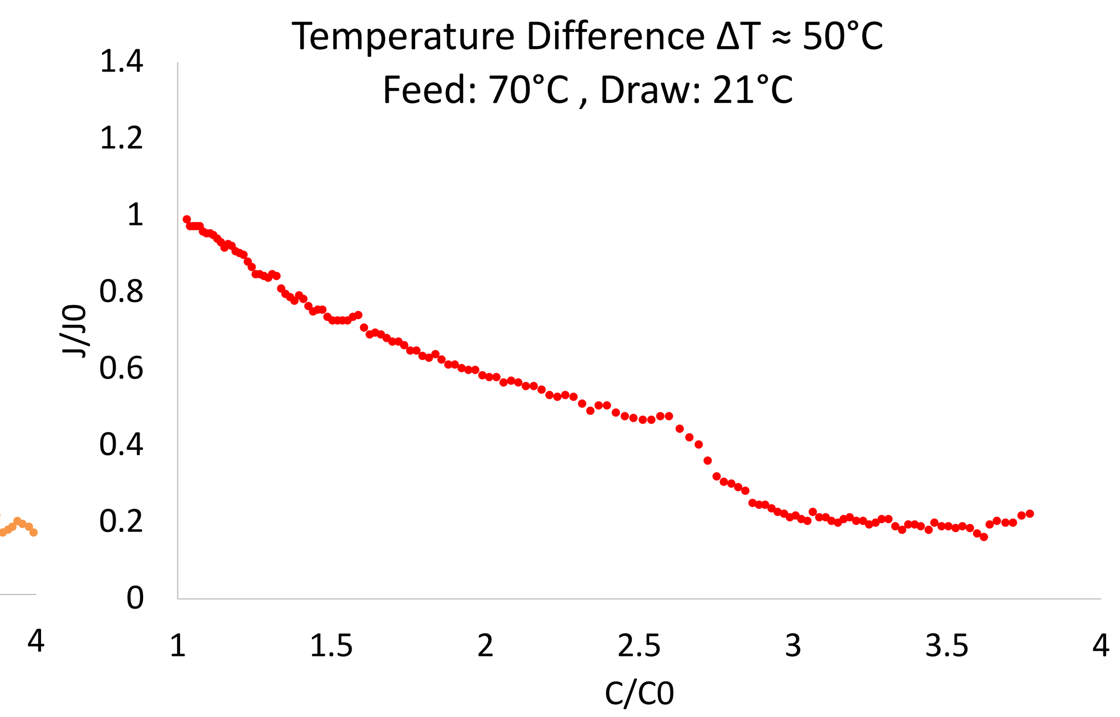

Figure 7: Graph of average flux versus concentration of ΔT ≈ 50°C

Discussion & Findings

- It is observed that the lower temperature difference of 10°C and 20°C have a slower flux decline. While the higher temperature difference of 30°C and 50°C has a clear rapid flux decline.
- Higher temperatures resulted in higher scaling of salts on the membrane and lower temperatures showed less scaling.
- A middle temperature of 20 °C in figure 5 demonstrates a slow flus decline at first and then a drop in flux at a Concentration of 3 .

Conclusion

- A clearer trend can be seen with the NEWT Brackish solution as compared to the synthetic Egypt salt solution. With this, experiments at the mid temperature level can be conducted to verify if the change in feed and draw temperature (but keeping the same temperature difference) will affect the flux and inorganic fouling.

Next Steps

- Varying different feed and draw temperature while maintaining a temperature difference of 20 °C will be conducted with the following temperatures:

Table 2: Feed and Draw temperatures for future experiments.

Feed (°C)	Draw (°C)
40	20
50	30
60	40
70	50

References

Fang Li, Jiahui Huang, Qin Xia, Mengmeng Lou, Bo Yang, Qing Tian, Yanbiao Liu, Direct contact membrane distillation for the treatment of industrial dyeing wastewater and characteristic pollutants,Separation and Purification Technology, Volume 195,2018,Pages 83-91,ISSN 1383-5866, https://doi.org/10.1016/j.seppur.2017.11.058

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