Fouling of Membrane Distillation for a Brackish O&G Produced Water

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Introduction

The **goal of this study** is to evaluate how the water recovery process of membrane distillation is limited by inorganic species and to determine if they block the pores of the membrane. The **objectives of our study** are to:

(1) Identify the recovery limit of membrane distillation for a brackish O&G produced water
(2) Model the change in bulk solution chemistry during the water recovery process through equilibrium modeling
(3) Characterize membrane fouling by inorganic species during the recovery process

Materials and Methodology

The membrane distillation set up used draw water that was kept at 20°C. The feed water was kept at 65°C and consisted of the following salts:

- NaCl – 2397 mg/L
- $CaCl_2$-$2H_2O$ – 3925 mg/L
- $MgSO_4$-$7H_2O$ – 2637 mg/L
- $NaSO_4$-$10H_2O$ – 1381 mg/L
- $NaHCO_3$ – 1280 mg/L

Both the draw and feed used DI water. The draw system was placed on a scale to measure the change in mass every minute as water entered the system through the membrane. In order to get the entire system to crash in a timely manner the starting concentration of the feed water was 1.5x the initial salt concentration listed above.

Computer simulations of the precipitates were created with the *Visual MINTEQ 3.1* program. A scanning electron microscope and energy dispersive spectroscopy were later used to determine the ions that were present on the membrane.

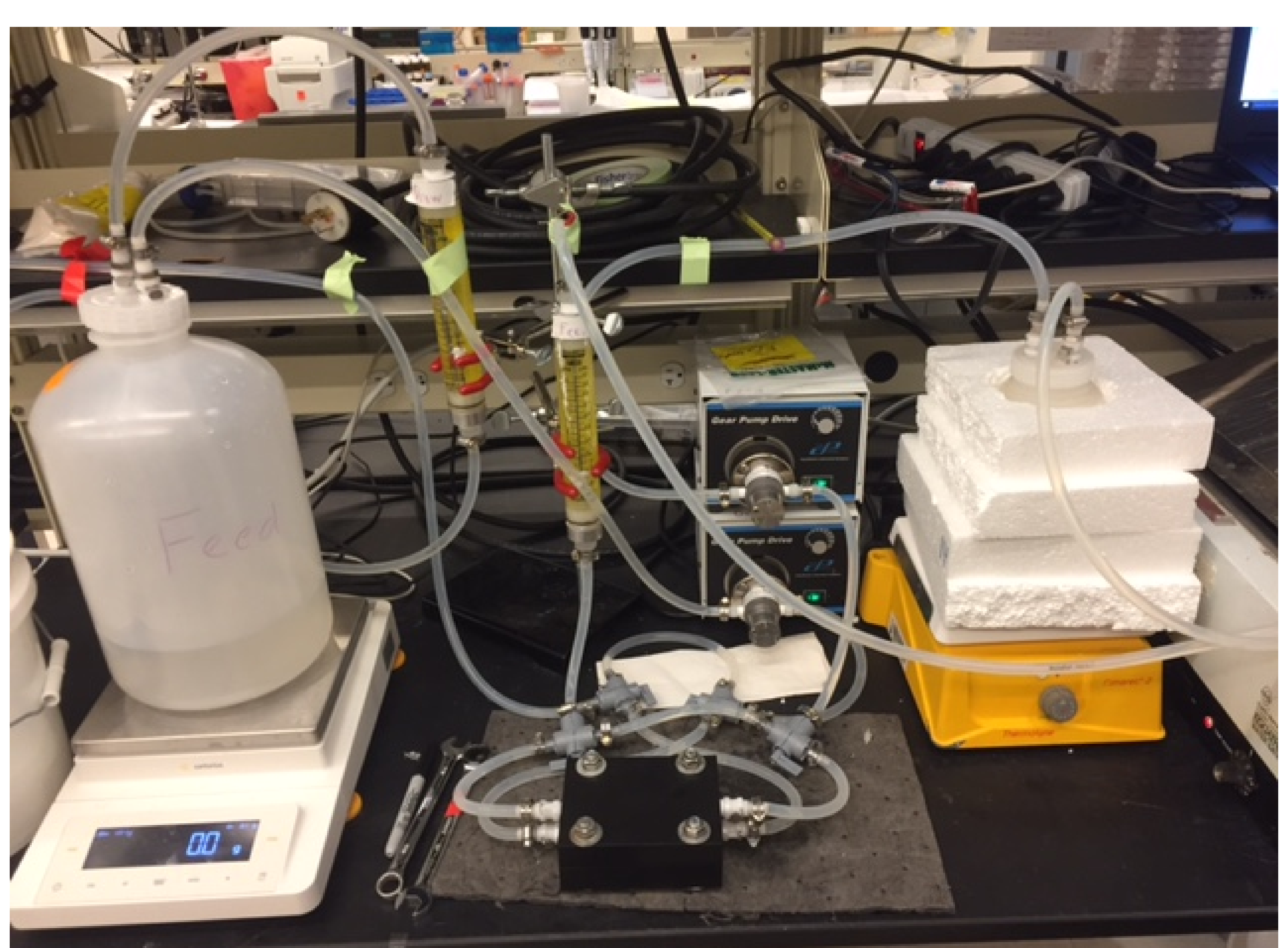

Fig. 1- Lab setup.

Flux Crashing Early

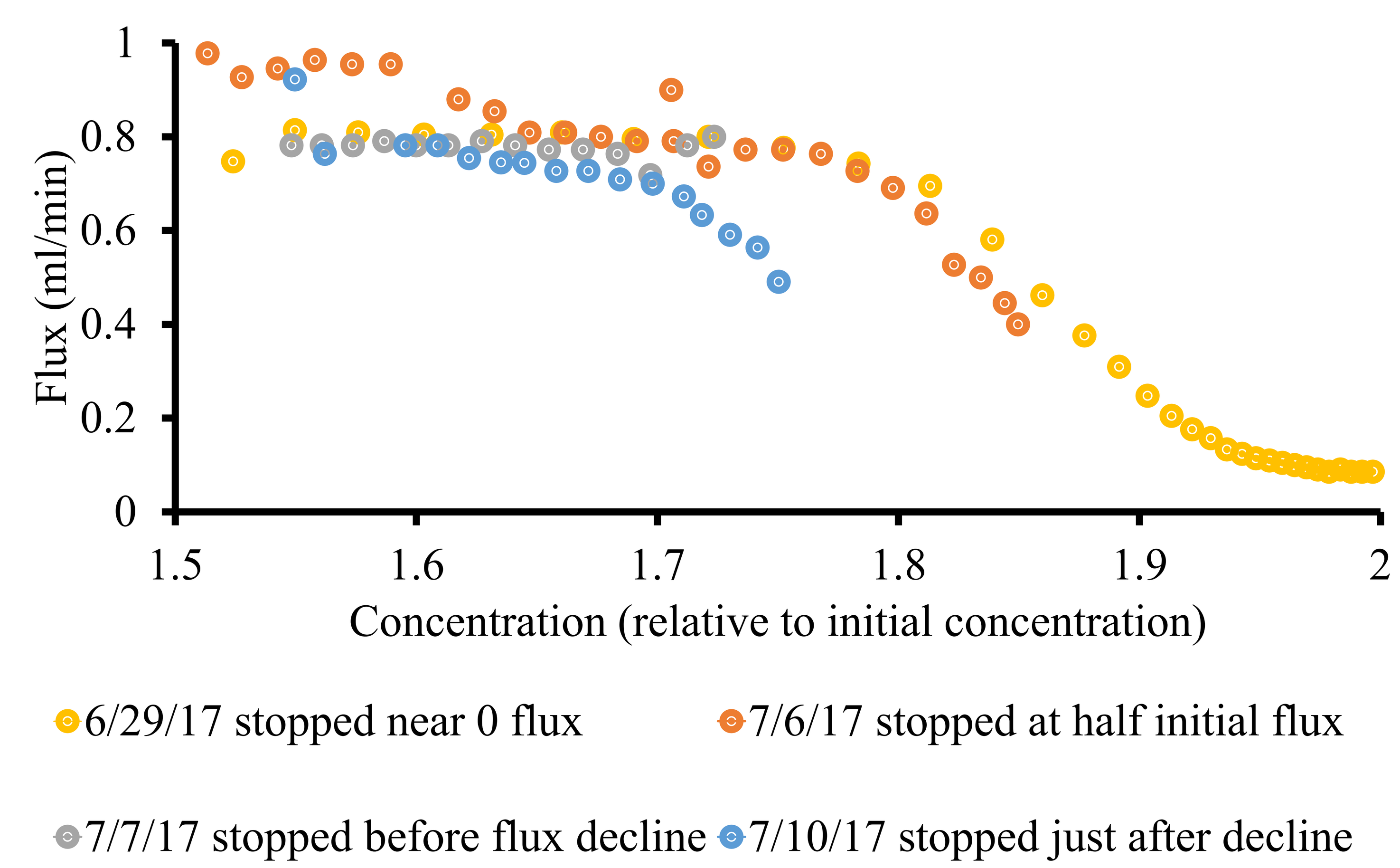

Fig. 3- Flux through membrane as relative salt concentration increases

Conclusions

- The average flux would start to drop around 1.7 to 1.8 times the initial concentration.
- The experiment was stopped at different points relative to the crash point to later analyze the precipitate build up at different concentrations.

Model of Mineral Precipitation

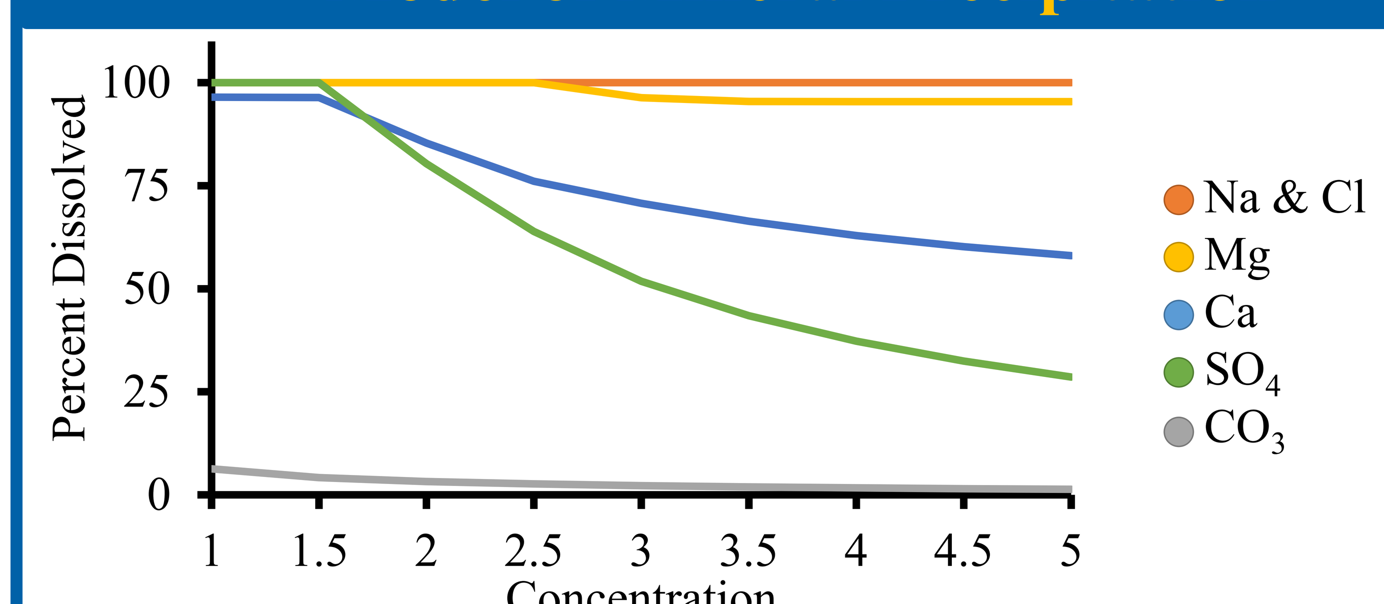

Fig. 4- Percentage of ions dissolved in water per ion concentration

Conclusions

Three new solids should precipitate out of the system:

- Calcite (CaCO3) starts to precipitate immediately.
- Gypsum ($CaSO_4$-$2H_2O$) starts to precipitate at 2x concentration.
- Dolomite ($CaMg(CO_3)_2$) starts to precipitate at 3x concentration.

No Magnesium Present

Membrane with only DI Water.

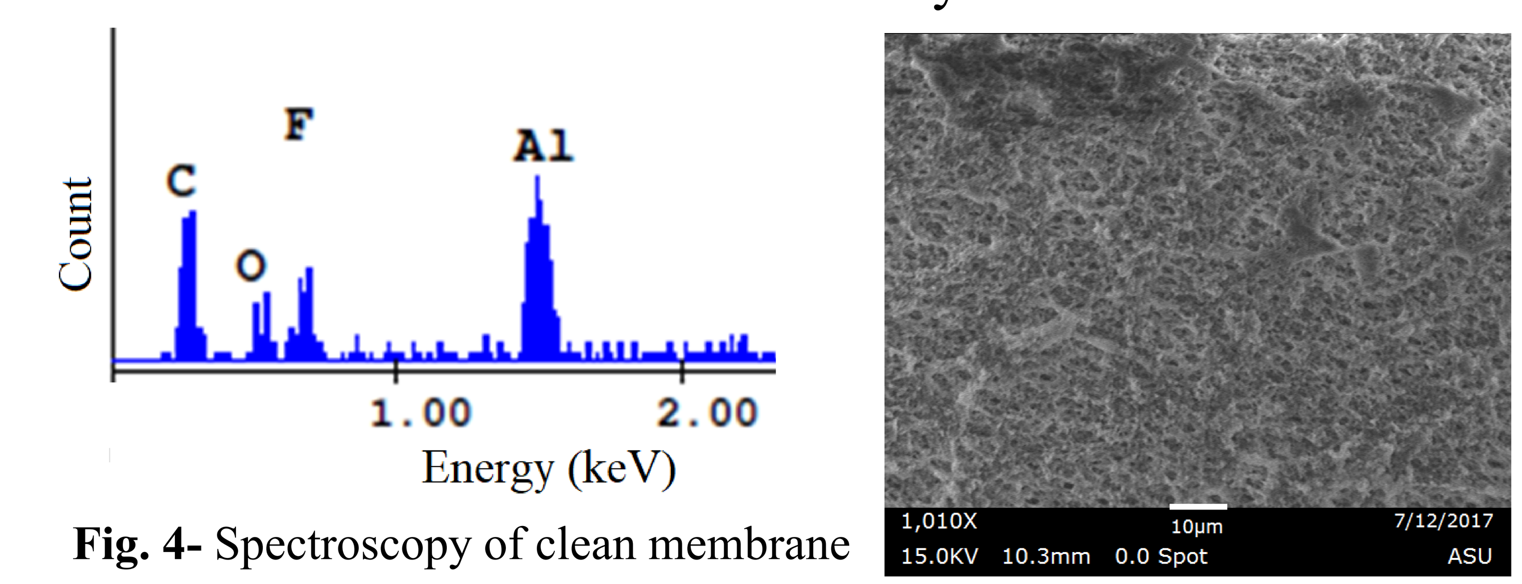

Fig. 4- Spectroscopy of clean membrane

Membrane during a run that reached 3.2x concentration.

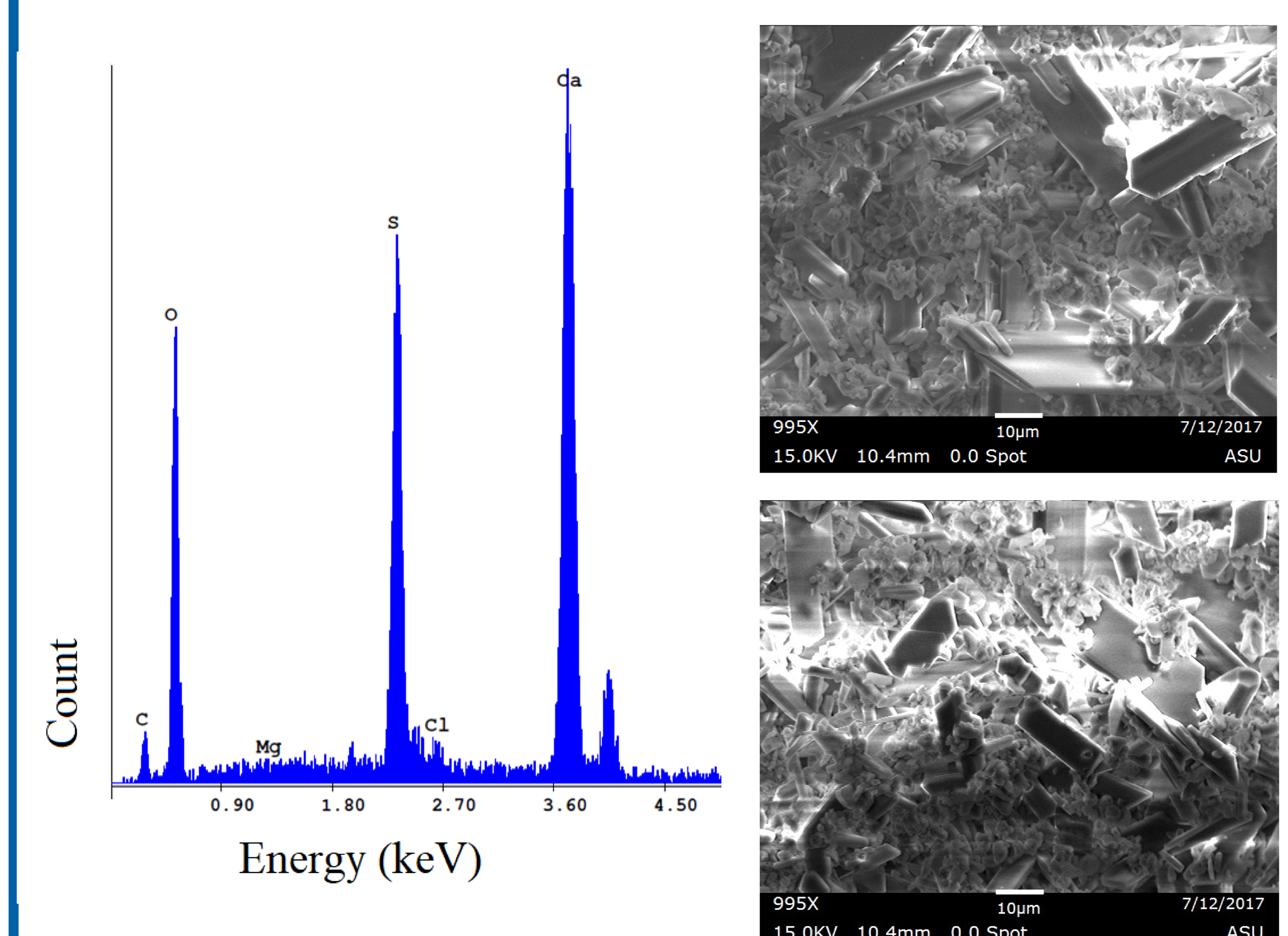

Fig. 5- Spectroscopy of membrane used for a high concentration run.

Conclusions

- Energy dispersive spectroscopy shows that all elements are present to create calcium and gypsum.
- Magnesium was not present indicating that Dolomite did precipitate.
- A noticeable amount of chlorine was present.
- SEM images show at least two different crystal formations. Calcium and dolomite have indistinguishable crystal structures.

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Moving Forward

- Ion exchange chromatography will better indicate the ions present in the precipitates.
- The data collected will be used as a baseline to compare the performance of Solar MDs to.