FUNCTIONALIZED PDMS FOR MEMBRANE SEPARATIONS OF VOCS FROM WATER

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RESEARCH QUESTION

This project seeks to examine membranes for use in separations to facilitate the removal of volatile organic compounds (VOCs) from water and, more specifically, to gauge the performance of different functionalization of PDMS in the membranes, measuring molar permeance, flux, and selectivity when removing VOCs from a water sample.

METHODS

This project uses pervaporation, a process combining permeation and evaporation, as the method of separation of volatile organic compounds (VOCs) from water.

Process:

- Fabricated membrane via drawdown casting
- Cut 16 cm^2 square out of membrane sample
- Set up the crossflow cell with the 16 cm^2 membrane sample
- Set up peristaltic pump with sample solution
- Pulled vacuum on membrane with solution pumping for 1 hour to clear out excess solution from the system
- Weighed condenser after cleaning out any condensed solution, re-set up apparatus
- Pulled vacuum on sample (1 hour for pure solvents, 24 hours for solutions)
- Ran at least 2-3 runs on each membrane with each pure solvent and with solutions

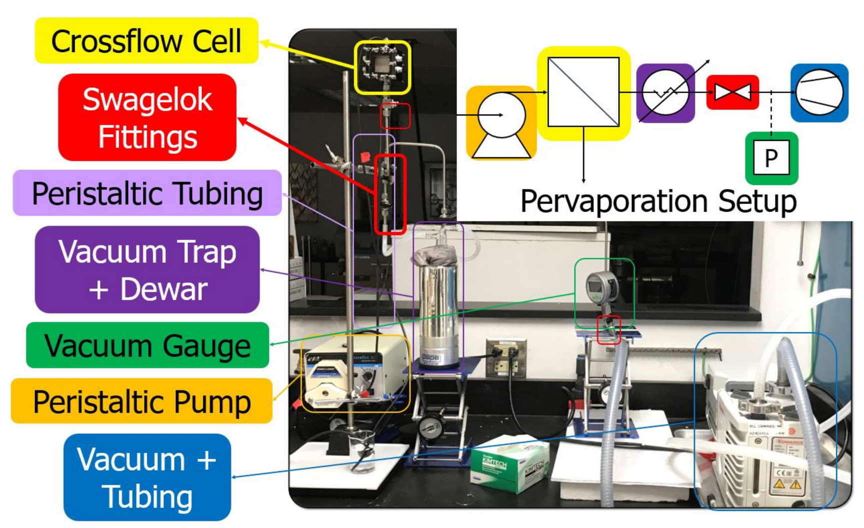


Fig. 1: Pervaporation setup.

$$Q = \frac{N}{Driving\ Force} = \frac{N}{P_{i,23°C}\gamma_i Y_i - P_{i,-78°C}} \qquad Selectivity\ A:B = \frac{Q_A}{Q_B}$$

Q = molar permeance of solvent
N = molar flux of solvent across the membrane
$P_{i,T}$ = equilibrium vapor pressure of i at T = 23 °C and -78 °C
γ_i = activity coefficient of i
Y_i = mol fraction of i in the feed

Q_A= permeance of solvent A
Q_B= permeance of solvent B

Fig. 2: Equation for permeance (left) and selectivity (right)

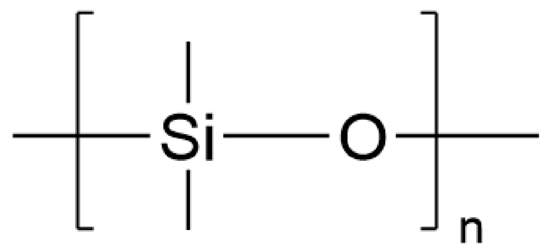


Fig. 3: Chemical structure of Polydimethylsiloxane (PDMS)

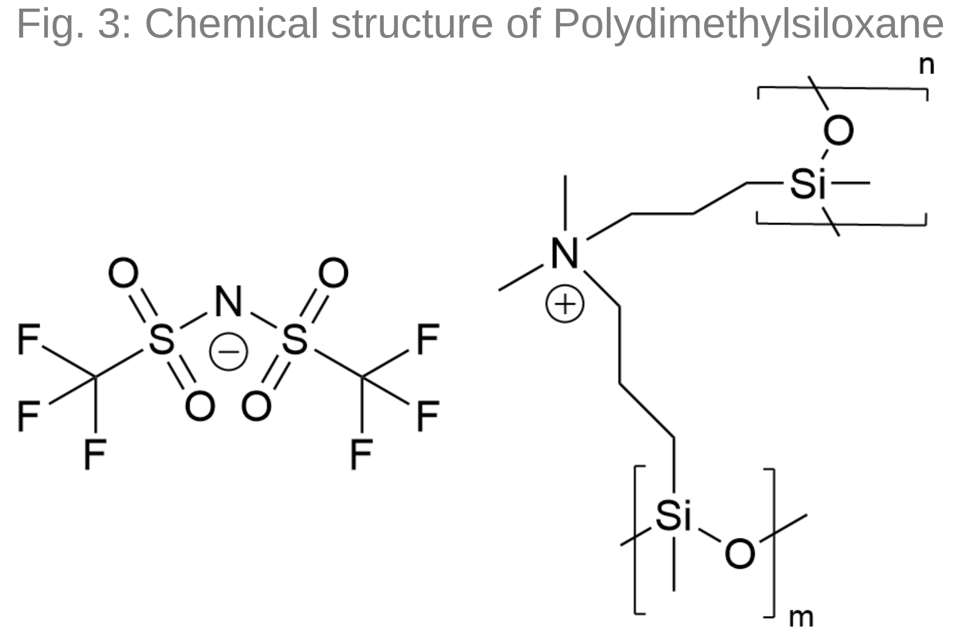


Fig. 4: Chemical structure of Quaternary Ammonium functionalized PDMS (QAMS)

OBSTACLES

- Due to limited time to conduct experiments, and the experiments themselves necessitating 24 hour runs in order to obtain measurable results, it has been difficult to collect large amounts of data
- When we were initially using a different condenser, we had trouble collecting Refractive Index data for permeates which is what we used to determine wt% of the permeate

FINDINGS

- Several different functionalizations of PDMS were examined for this project, including 10 wt% quaternary ammonium functionalized PDMS (QAMS), PDMS made from Sylgard-184, and RTV-16 PDMS.
- Selectivity for the quaternary ammonium (QAMS) and RTV-16 (PDMS) polymers show promising results, with selectivities much higher than previous membranes that were tested
- Sylgard-184 data is limited, as there were difficulties collecting refractive index data with the condenser that was originally being used, so more runs should be done to more adequately compare the three membranes
- Some limited testing was done with a different solvent for the RTV-16 membrane, and it was found that the selectivity of acetone for the membrane was significantly lower than for ethanol.
- Separations tests were conducted with methanol, but this data was not included as time limitations prevented the characterization of the permeate for these runs

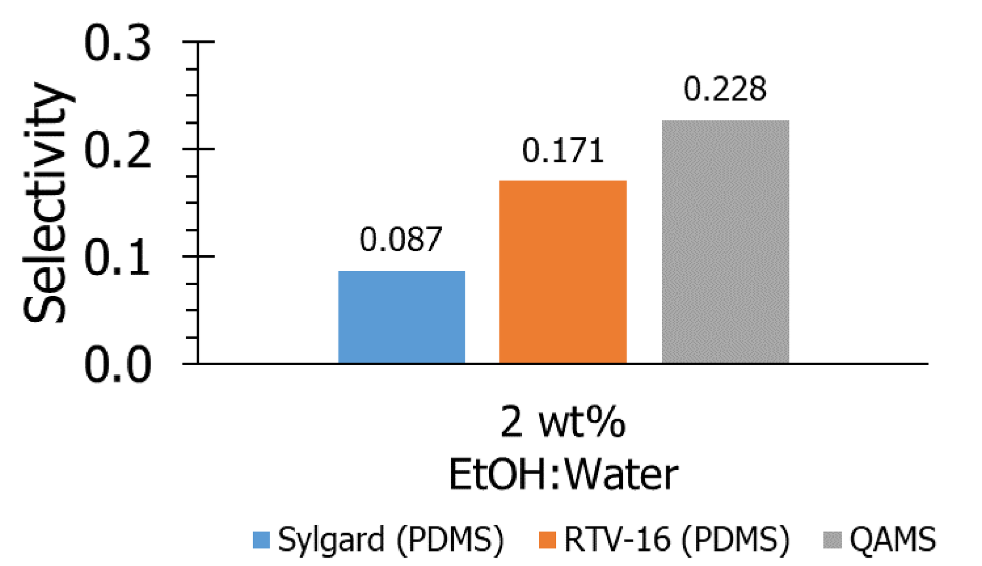
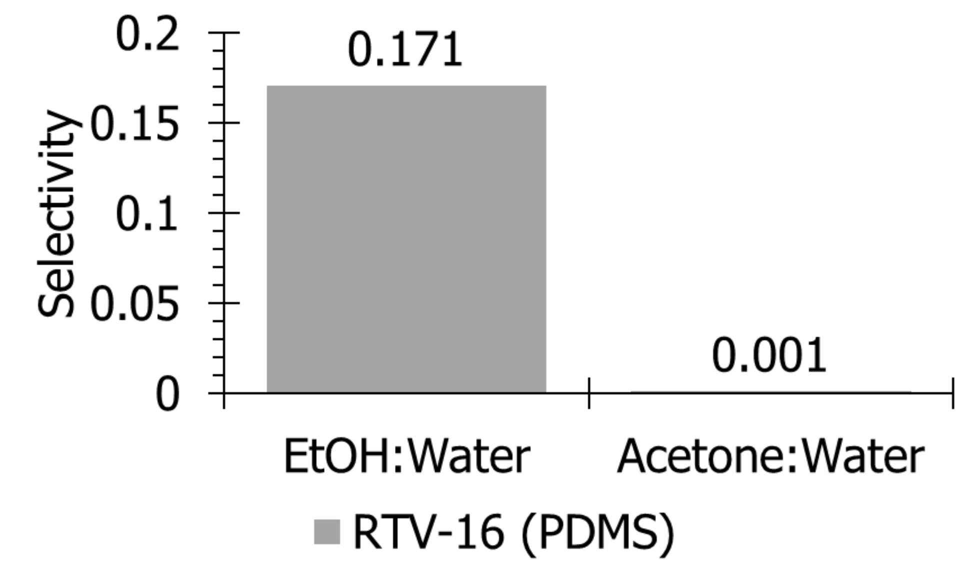


Fig. 5: Mean selectivity values for 2 wt% EtOH:Water solution



FUTURE WORK

- More solvents could be tested with all three of the membranes, to test which membranes can work effectively under different conditions
- Different weight percentages of each solvent could be examined, specifically by potentially flipping which solvent is the majority of the solution (2 wt% EtOH -> 98 wt% EtOH)
- Different functionalizations of PDMS could be examine and compared to each other.
- Other separations methods, such as microfiltration, could be explored to compare to the selectivity from the pervaporation data

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