SYNTHESIS OF POLYMERS TO MAKE MEMBRANES FOR WATER PURIFICATION

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RESEARCH QUESTION

This project seeks to examine the effect of using different functionalizations of polydimethylsiloxane (PDMS), fabricated into a membrane, on the efficacy of the membrane in removing volatile organic compounds (VOCs) from water.

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 in Teflon plate or via drawdown casting
- Cut 16 cm^2 square out of membrane sample and measured the thickness of this square
- 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 a solution of 2 wt% ethanol in water

Efficacy of membranes was measured from flux, permeance, permeability, and selectivity (calculated using pervaporation data).

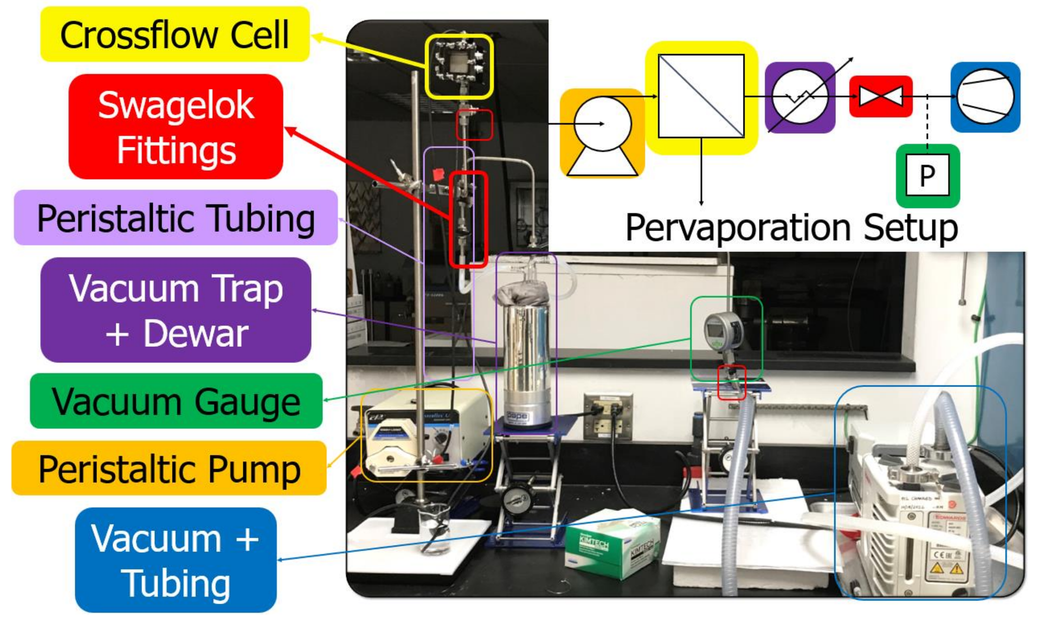

Fig. 1: Pervaporation setup.

$$Q = \frac{N}{Driving\ Force} = \frac{N}{P_{i,23°C}\gamma_i Y_i - P_{i,0°C}} \qquad Selectivity\ A{:}B = \frac{Q_A}{Q_B}$$

N = molar flux across the membrane
$P_{i,T}$ = equilibrium vapor pressure of i at T = 23 °C and 0 °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)

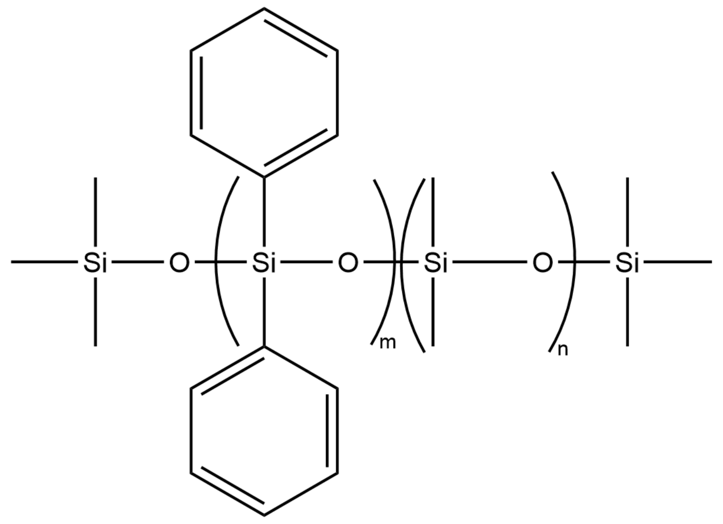

Fig. 3: Chemical structure of PDMS-Polydiphenylsiloxane (PDPS) copolymer

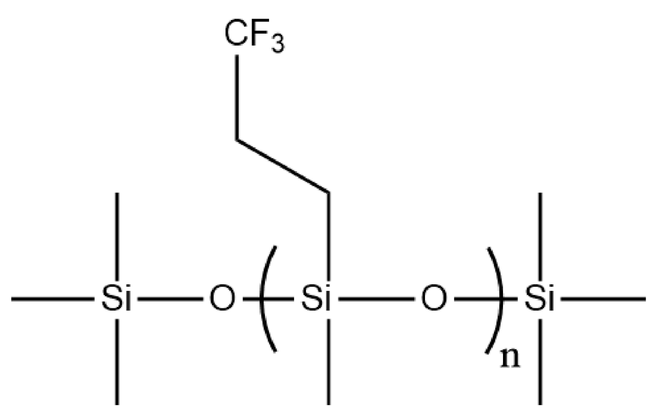

Fig. 4: Chemical structure of PDMS-Poly(3,3,3-trifluoropropylmethylsiloxane)

OBSTACLES

- Some of the membranes have been very weak, and have broken before all needed data is collected
- Due to only working 10 hours a week, has been difficult to collect a lot of data as runs can take a while (both setup and actual experiment time)

FINDINGS

- PDMS-PDPS Co-polymer and TFPMS both show promising selectivity for ethanol and methanol in pure sample testing, and both show promising selectivity data for Ethanol in 2 wt% EtOH:Water solutions
- Very little difference between liquid nitrogen and dry ice for condensing volatiles
- Standard plastic petri dishes do not work well for making PDMS-PDPS membranes, Teflon works much better
- For drawdown casting, organic solvents like ethanol help with release membrane from substrate

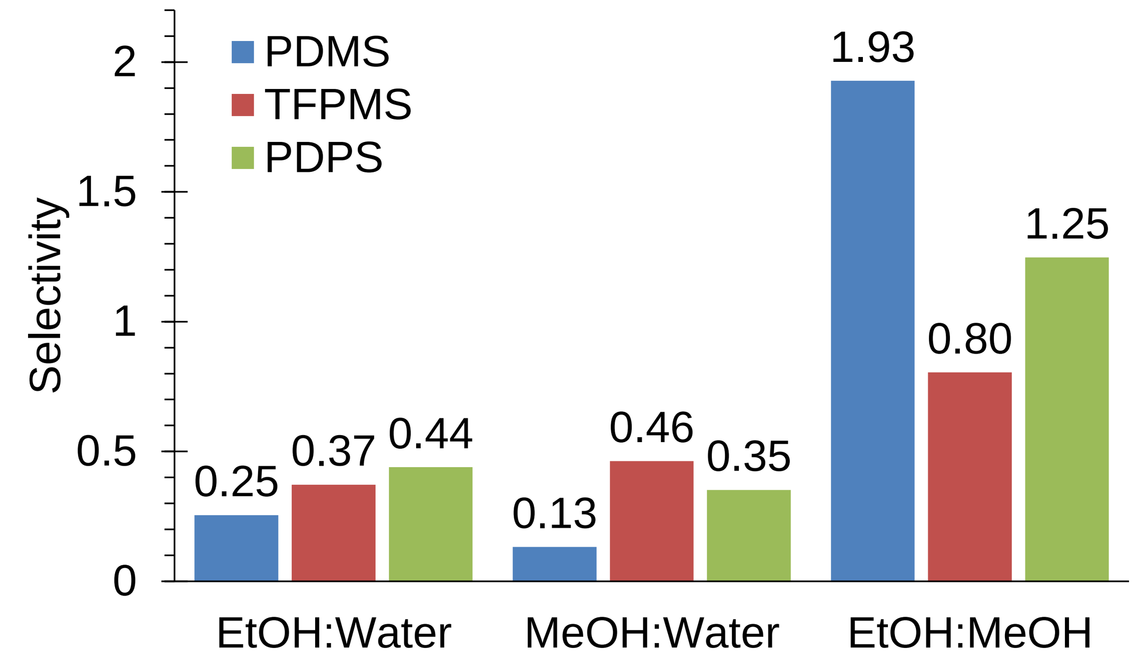

Fig. 5: Mean selectivity values for pure separations

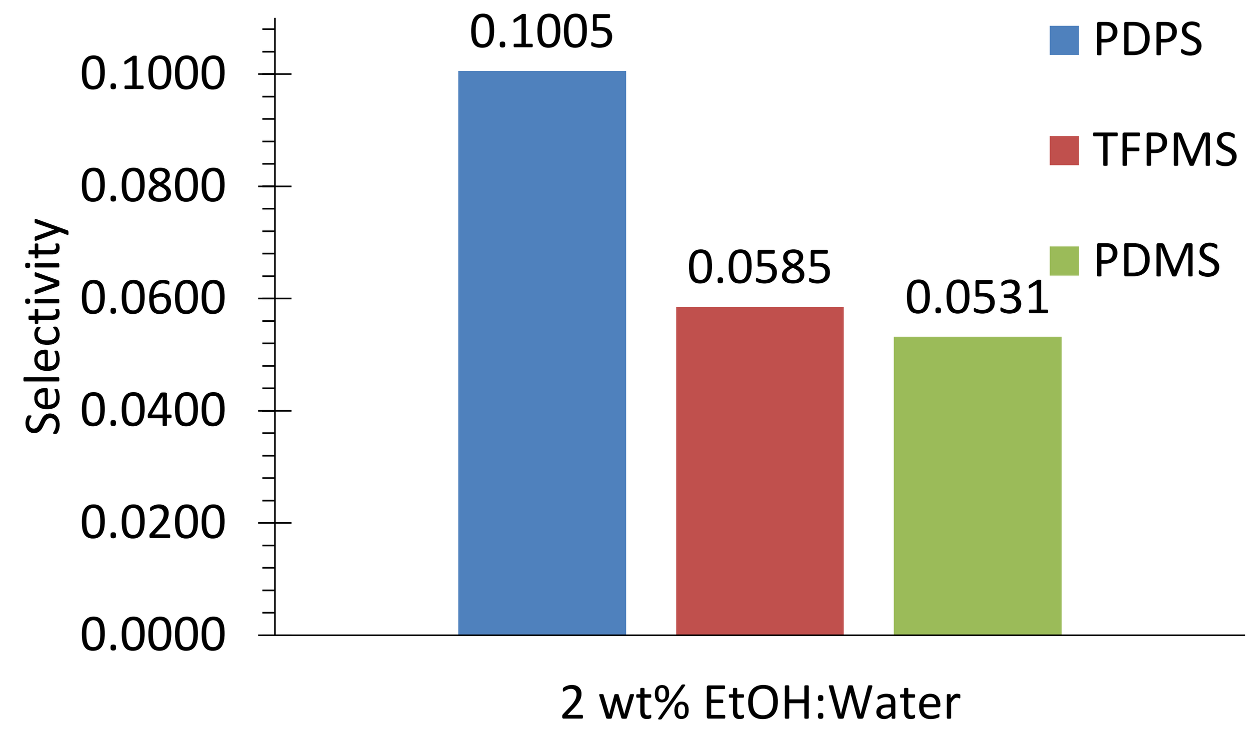

Fig. 6: Mean selectivity values for EtOH:Water separations

FUTURE WORK

- With the data collected so far, there is a clear path to continue research into the efficacy of these polymers
- More testing with 2 wt% ethanol, but also testing different wt%s, water in solution with methanol and other VOCs, as well as flipping the dominant solvent (i.e. 2 wt% water in ethanol)
- Additionally, other functionalizations of PDMS polymers could be explored with separations
- Other methods of separation, like microfiltration, could be explored in addition to further pervaporation tests

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