SELECTIVE ION TRANSPORT THROUGH POLYMER MEMBRANES

Ernand Alzenor, Kyoungmin Kim & Daniel Hallinan

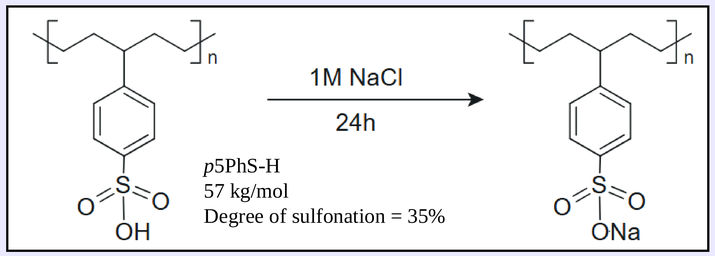
Department of Chemical & Biomedical Engineering, FAMU-FSU College of Engineering

INTRODUCTION

- Developing cost-effective and environmentally friendly water purification technologies remains a challenge.
- Cation-exchange membranes (CEMs): low waste generation, selective ion separation and cost effective.
- This study examines the characteristics of polymer membranes subjected to cation exchange with sodium ions, focusing on water content and ionic conductivity.
- The membranes underwent a 24-hour exchange in a sodium chloride solution, confirmed by acid-base titration.

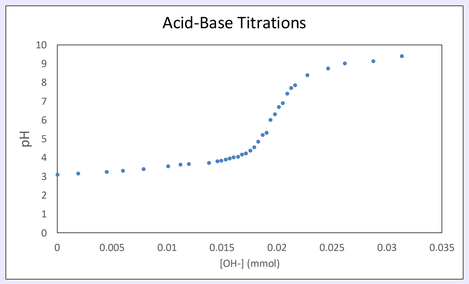
METHODOLOGY

Materials



*p*5PhS-H
57 kg/mol
Degree of sulfonation = 35%

Ionic Exchange Capacity



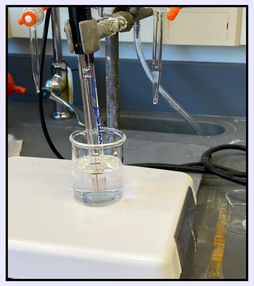
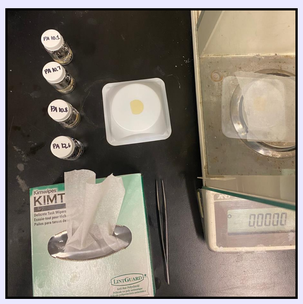


Figure 1 - Acid-Base Titrations after ionic exchange between *p*5PhS-Na & NaCl

$$\mathrm{IEC} = \frac{C_{NaOH} V_{NaOH}}{M_{dry}}$$

$$\begin{aligned} C &= \text{Conectration} \\ V &= Volume \\ M &= Mass \end{aligned}$$

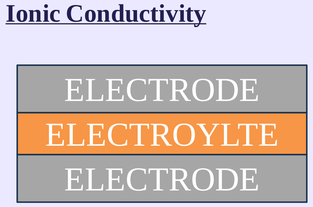
Water Content



$$\mathrm{WC} = \frac{M_{wet} - M_{dry}}{M_{dry}}$$

METHODOLOGY

Ionic Conductivity



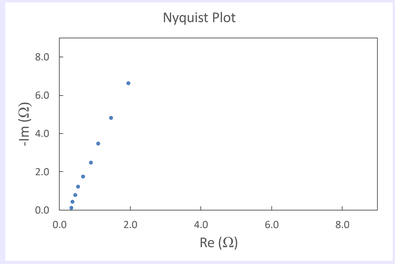
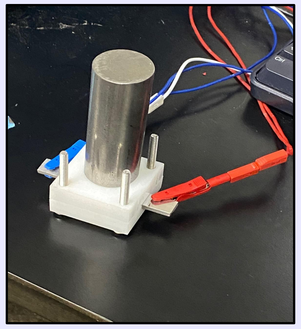
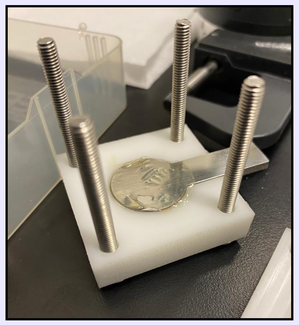


Figure 2 – Nyquist plot measured from electrochemical impedance spectroscopy of *p*5PhS-Na





$$\kappa = \frac{Thickness}{(Area)(Resistance)}$$

RESULTS

Sample	Water Content		IEC (mmol/g)	κ (mS/cm)
	1M NaCl	DIW		
p5PhS-Na	1.30 ± 0.15	0.70 ± 0.11	2.20 ± 0.15	5.11 ± 2.57
Nafion 117[D]	0.20	0.32	0.93	0.035

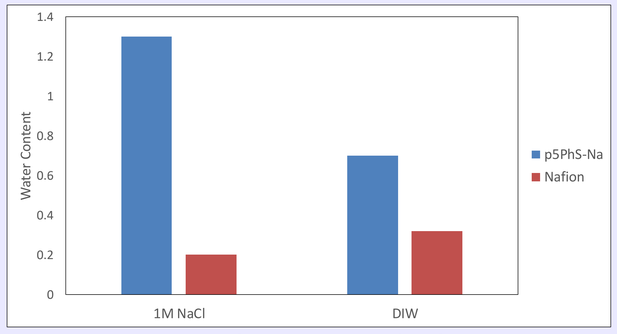


Figure 3 - Bar graph of water content of Nafion & p5PhS-Na

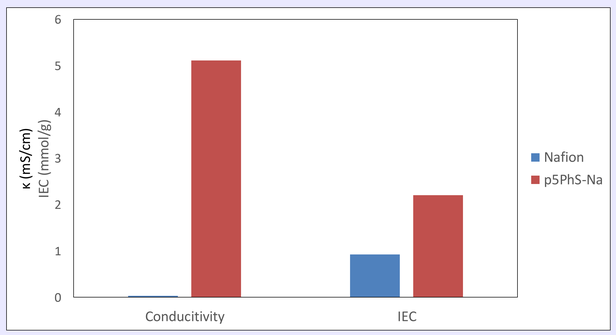


Figure 4 - Bar graph of ionic conductivity & IEC of Nafion & p5PhS-Na

REFERENCES

A. Elozeiri, Alaaeldin AE, et al. "Water content of ion-exchange membranes: Measurement technique and influence on the ion mobility." Journal of Membrane Science 698 (2024): 122538.
B. Geise, Geoffrey M., et al. "Water purification by membranes: the role of polymer science." Journal of Polymer Science Part B: Polymer Physics 48.15 (2010): 1685-1718.
C. Izquierdo-Gil, M.A., et al. "Water Uptake and Salt Transport Through Nafion Cation-Exchange Membranes with Different Thicknesses." Chemical Engineering Science, vol. 72, 2012, pp. 1–9. Elsevier
D. Sigwadi R, Dhlamini MS, Mokrani T, Nemavhola F, Nonjola PF, Msomi PF. The proton conductivity and mechanical properties of Nafion®/ ZrP nanocomposite membrane. Heliyon. 2019 Aug 27

ACKNOWLEDGEMENTS

I would like to thank Dr. Satheeshkumar Chinnadurai for synthesizing the polymer membranes used in this research. I would like to thank Dr. Justin Kennemur for allowing me to use the acid-base titration set-up at the laboratory he works in. I would also like to thank all of the members of the Dr. Hallinan lab for their support and guidance.

CONCLUSION

- The water content, ion exchange capacity, and ionic conductivity were measured.
- The results indicate that *p*5PhS-Na which had more hydration and ionic exchange capacity than Nafion had a worse electrochemical performance. Based off the results, electrochemical performance is expected to decrease from an increase in hydration and ionic exchange capacity.
- Future research on polymer membranes will be to test the permeability of the polymer.