SCIENCE MENTORSHIP PROGRAMME

FORWARD OSMOSIS PROCESS FOR CLEAN WATER PRODUCTION USING MAGNESIUM SULPHATE

New Shi Lin Serene, Wee Lay Kit, Zhan Bailu
Mentors: A/P Ng How Yong, Tan Chien Hsiang

ABSTRACT AND INTRODUCTION

The forward osmosis (FO) process is being studied as an alternative membrane technology for water reclamation due to its low energy requirement and high water recovery. The FO process requires a draw solution that has a higher osmotic pressure than the feed solution. It utilizes an osmotic pressure gradient across a highly-selective membrane, such that only water can permeate from the feed solution through the selective membrane via osmosis to the draw solution.

AIM

The main objective for this project is to investigate the feasibility of using , $MgSO_4$ as the solute for the draw solution in the FO process. Compared to the other draw solutes, $MgSO_4$ can be easily removed via nanofiltration (NF) to produce clean water and $MgSO_4$ can be reused as the draw solute.

HYPOTHESIS

It is hypothesized that among the draw solutions investigated, $MgSO_4$ solution is an ideal draw solution for the FO process. It is predicted that $MgSO_4$ will generate a high osmotic pressure due to its relatively high solubility in water as compared to the other solutes investigated in this study.

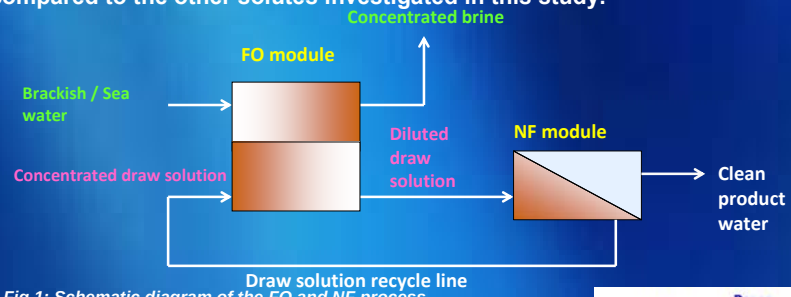

Fig 1: Schematic diagram of the FO and NF process

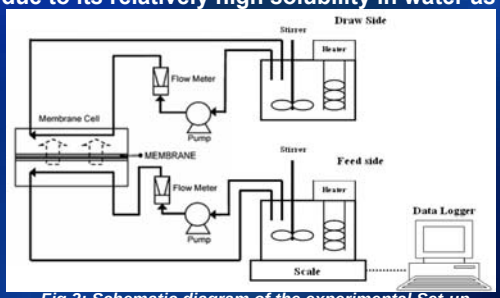

Fig 2: Schematic diagram of the experimental Set-up

MATERIALS AND METHODS

- Lab-scale FO cell measures water flux of draw solutes
- Feed solution: 0.5M NaCl (simulates seawater)
- Draw solutions (3.0 to 5.0 M) : glucose, fructose, magnesium sulphate, magnesium chloride, calcium chloride, potassium chloride
- Orientation of FO membrane: normal/reverse mode

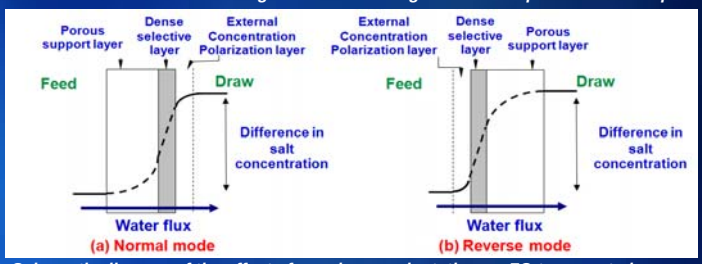

Fig 3: Schematic diagram of the effect of membrane orientation on FO transport phenomenon

RESULTS AND DISCUSSION

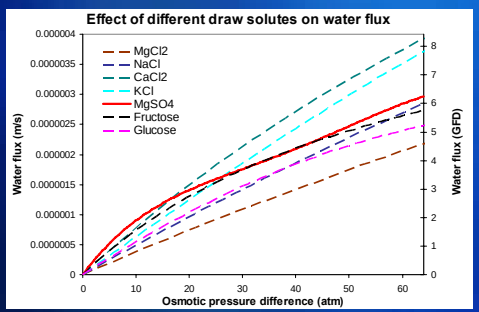

Fig 4: Graph of effect of different draw solutes on the water flux (m/s)

- $CaCl_2$, KCl, $MgCl_2$, NaCl: Cl- anions are small, → incomplete NF removal
- Glucose and fructose: easy NF removal but lower water flux
- $MgSO_4$: 3rd highest water flux, efficiently removed via NF → Best draw solute

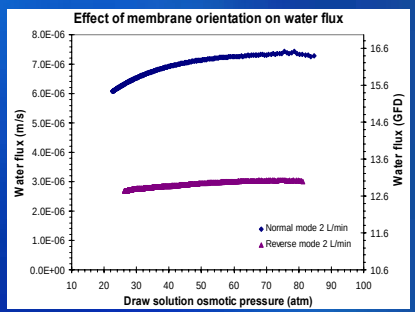

Fig 5: Graph of effect of membrane orientation on the water flux

- Water flux (normal mode)> Water flux (reverse mode)
- Internal Concentration Polarization (ICP) of feed solution in normal mode < ICP of draw solution in reverse mode

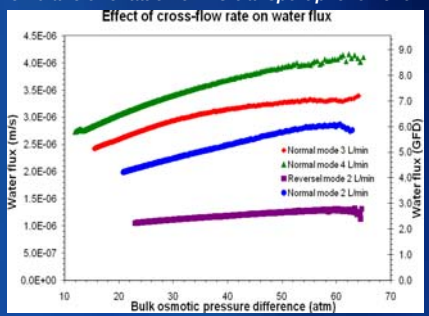

Fig 6: Graph of effect of flow rate on the water flux

- Higher cross-flow rate → higher water flux
- Cross-flow rate↑, Turbulence in flow channel ↑, External Concentration Polarization↓.

CONCLUSION

The FO process can be an alternative membrane technology for water reclamation due to its low energy requirement and high water recovery. It is comparable to the reverse osmosis (RO) process in terms of water flux and it utilizes significantly lower amount of energy. Additional improvements can be made to the FO membrane structure to further increase the water flux.

FURTHER RESEARCH

- Reduce impact of ICP experienced by making the porous layer as thin as possible but still ensuring enough support for the entire membrane
- Develop new draw solute that can achieve higher osmotic pressure than MgSO4 and can be removed with a more energy efficient technology

ACKNOWLEDGEMENTS

We would like to extend our utmost gratitude to our mentors, Asst Prof Ng How Yong, Mr Tan Chien Hsiang as well as Mrs Susan Chew for providing us with much guidance and concern throughout the course of the project.

REFERENCES

[1] Batchelder, G.W. Process for the demineralization of water. US Patent 3, 171,799, 1965.
[2] D.N. Glew, Process for Liquid Recovery and Solution Concentration, US Patent 3,216,930, 1965.

All diagrams and figures are created by authors.