Forward osmosis with membrane distillation using tetrabutylphosphonium based LCST-type ionic liquid as osmotic agent for seawater desalination

Junzhe Quan*, Sanskrita Madhukailya, Dr. Leila Moura, Dr. Timken Hye-Kyung, Prof. John D Holbrey

1. Introduction

Background

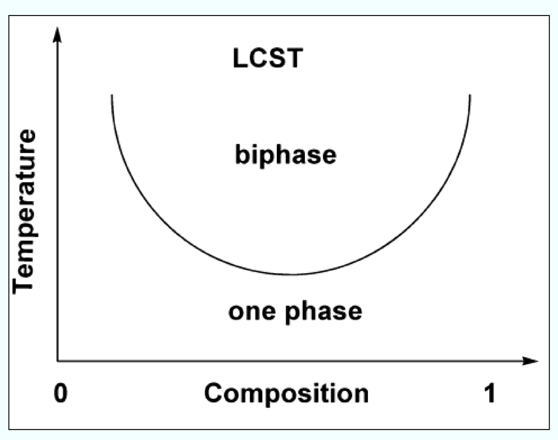


Fig - Phase diagram of LCST

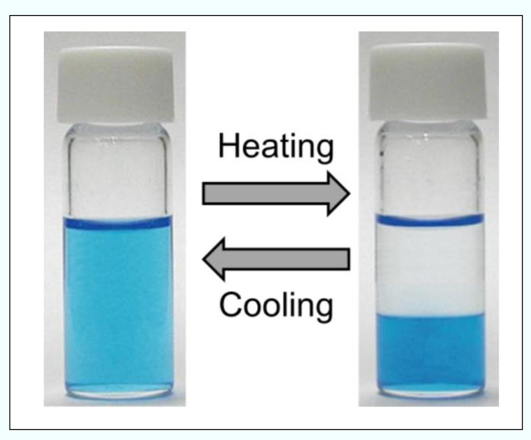


Fig - Example of LCST Behaviour[1]

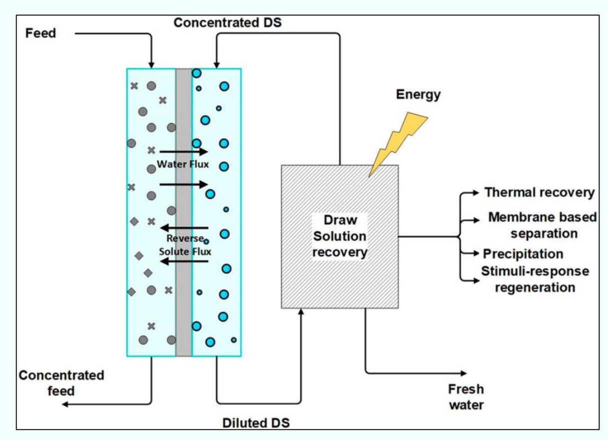


Fig – Mechanism of forward osmosis process[2]

Materials and methodology

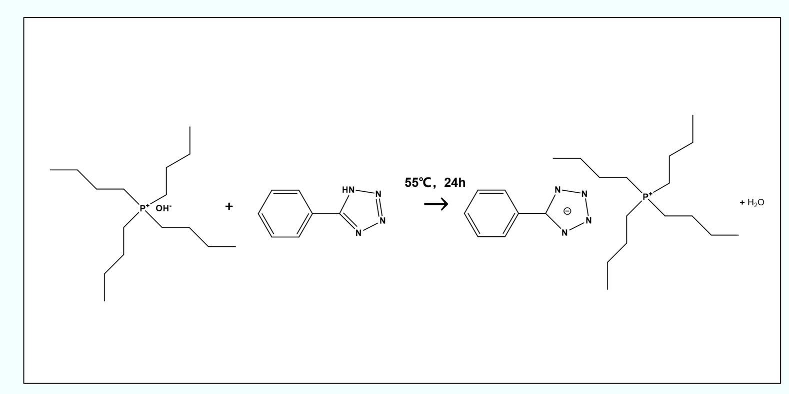


Fig – Preparation of tetrabutylphosphonium 5-phenyltetrazolate

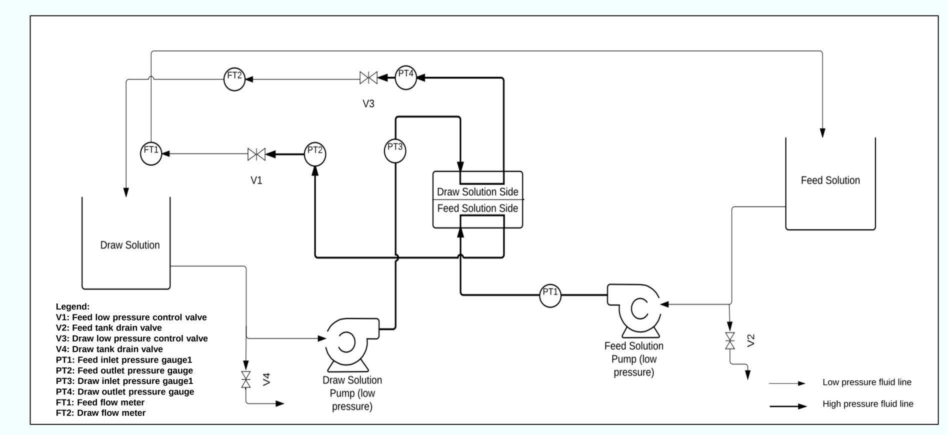


Fig – Lab-scale FO test system Outline

Lower critical solution temperature (LCST) is the critical temperature below which the components of a mixture are miscible for all compositions. Cai and co-workers at Nanyang Technological University[3] described a kind of use of ionic liquid(IL) draw fluids for forward osmosis desalination and reported efficient reuse and recycling, separation, and decreases in low-level energy consumption. The process makes use of LCST phase behavior between the ionic liquids and water system, where solutions of the ionic liquid in water separate on heating into two separate phases. To predict the influence of system salinity on LCST behavior, we investigated it and found that there is a strong negative correlation between salinity(sodium chloride) and LCST.

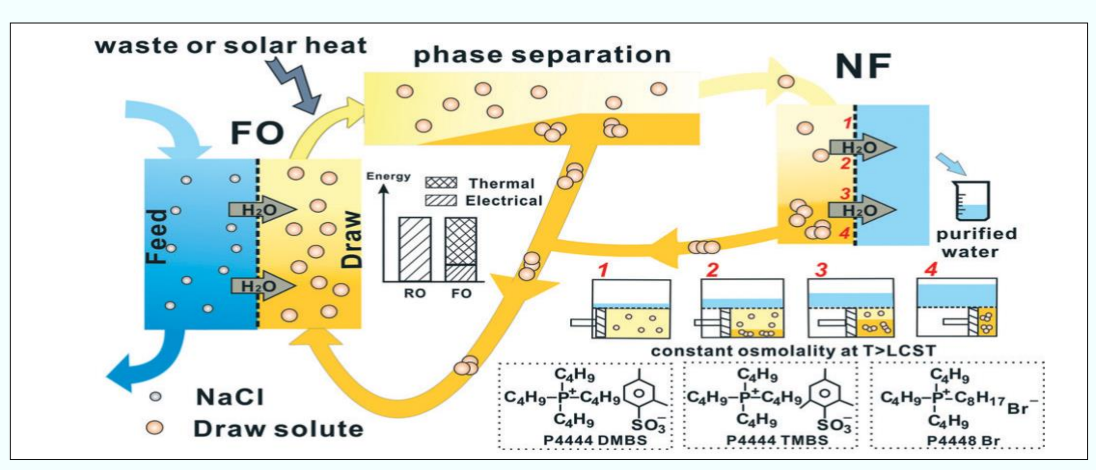


Fig - Schematic representation of FO desalination using LCST IL[3]

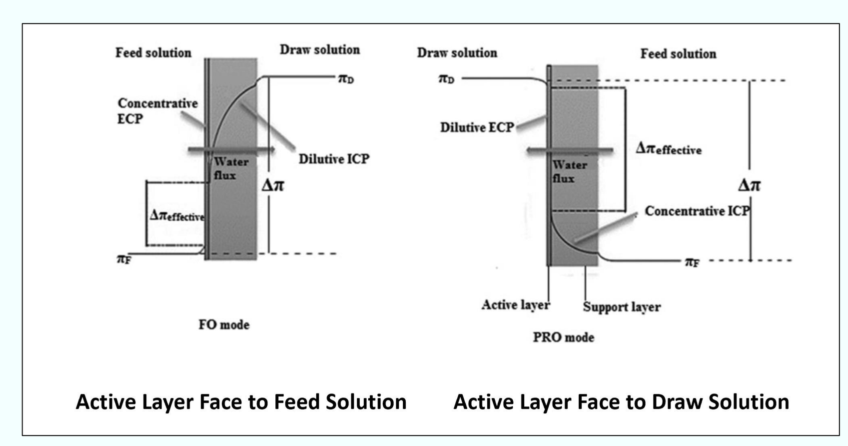


Fig – Scheme of FO mode and PRO mode

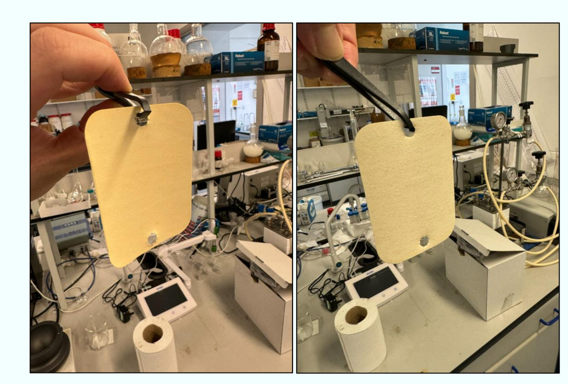
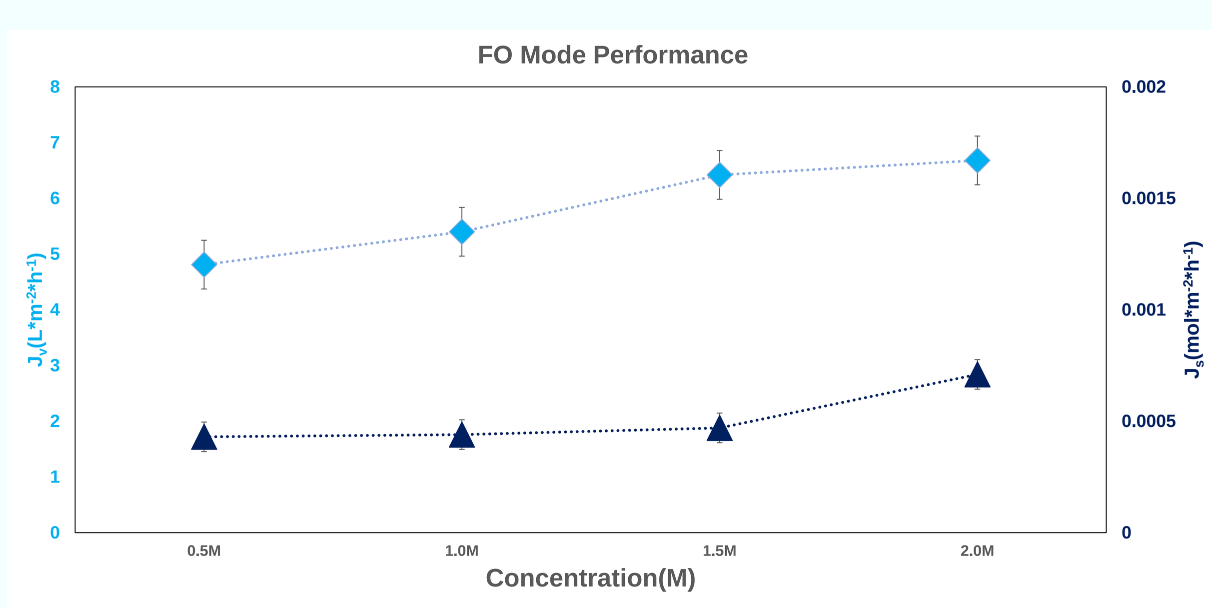
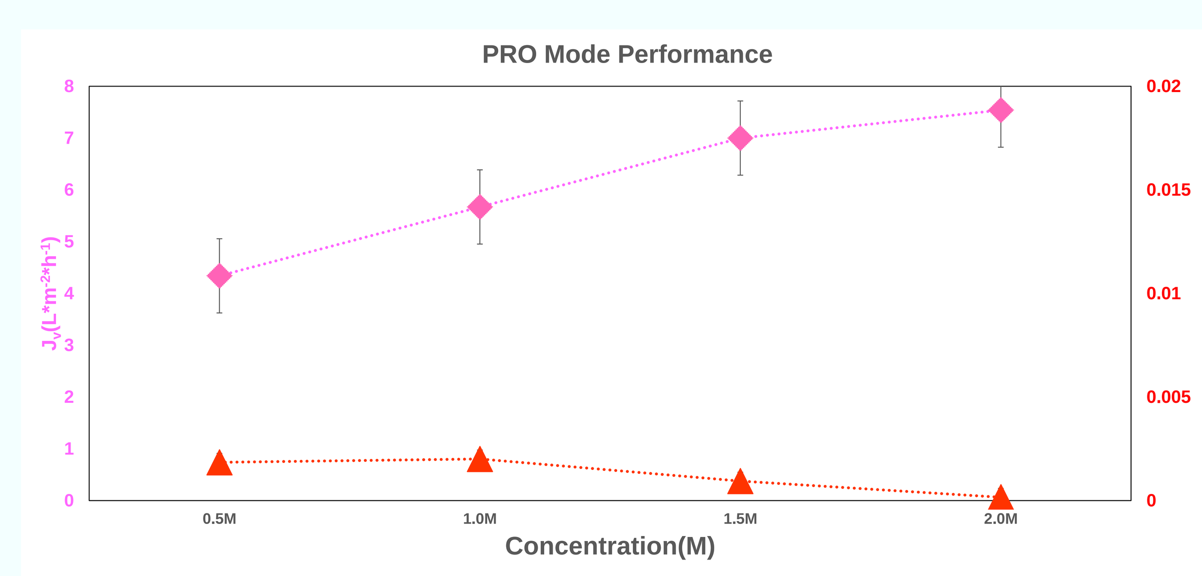


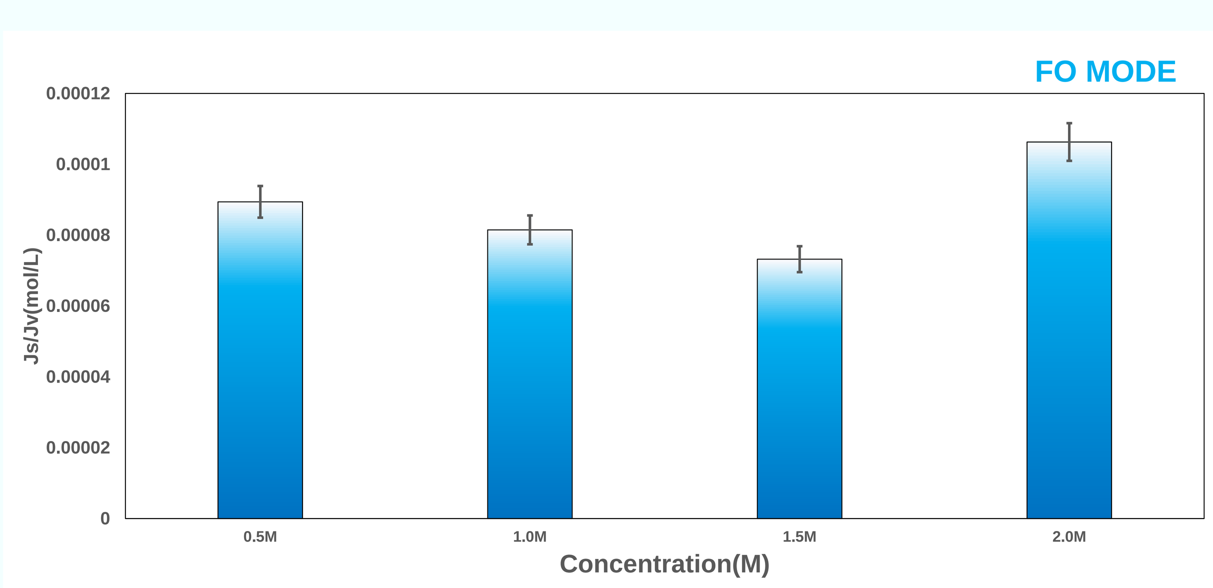
Fig - Active Layer (Left) and Support Layer (Right)

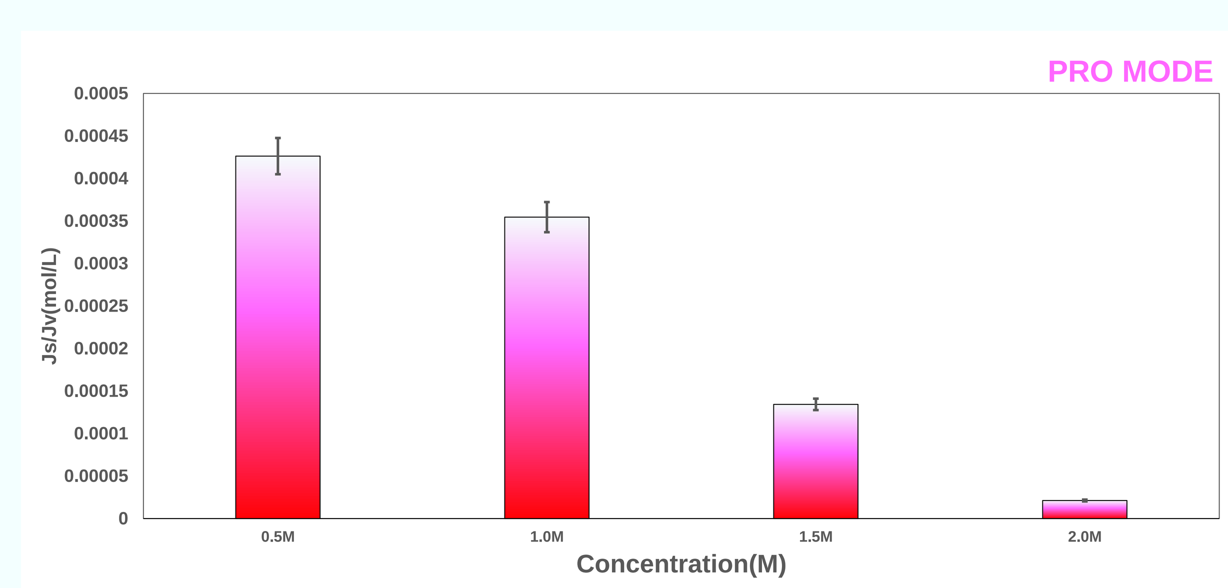
$[P_{4444}]$[Ph-tet] is tested in both DI water and model seawater from 0.5 M to 2.0 M concentration under both FO and PRO mode. (15L/h flow rate). TFC-PA membranes are used in this system. Each test is repeated for five times to delete the error.

2. Results and Discussion









3. Conclusion

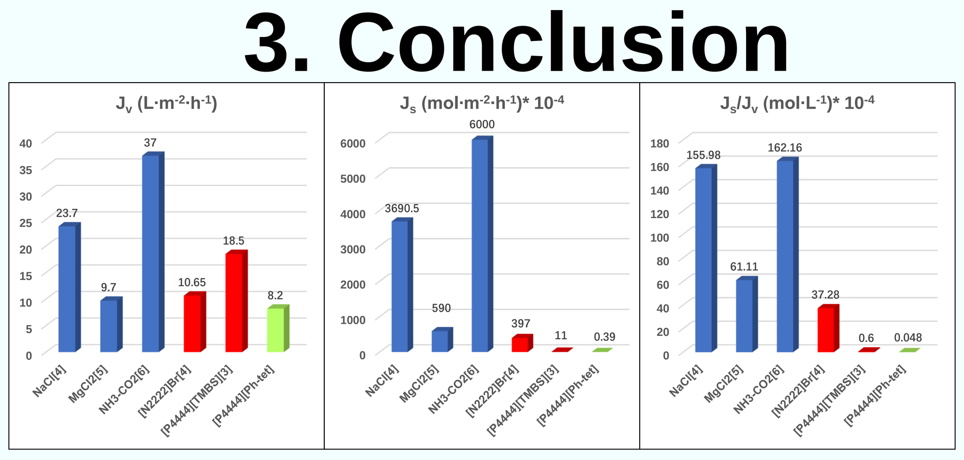


Fig- J_v,J_s,J_v/J_s comparison between traditional inorganic draw solute and IL draw solute

As for the $[P_{4444}]$[Ph-tet], the increasing Jv and Js trends are expected as higher driving force because of the higher chemical gradient resulting in higher osmotic pressure between feed solution and draw solution. Obtained Jv of $[P_{4444}]$[Ph-tet] shows similar water flux value with other kind of IL draw solute (Red in Fig) but lower than some traditional inorganic draw solute(Blue in Fig) just like NaCl[4] and NH_3-CO_2[5] solution. It can be explained by the large molecular size of IL resulting in a lower bulk aqueous diffusion coefficient which makes dilutive external concentration polarization (DECP) occurs more in draw solute side. Although its larger molecular size diminishes the water flux (Jv), this very attribute proves advantageous for its solute flux (Js). The increased molecular size results in a reduction in membrane diffusivity and back transport through the Thin-Film Composite Forward Osmosis (TFC-FO) membrane. Our material $[P_{4444}]$[Ph-tet] shows an excellent reverse solute flux compared with other thermo-responsive ionic liquids which means that in the same volume of water to be drawn, the loss of material is lowest for $[P_{4444}]$[Ph-tet]. However, the lower water flux also means the more energy consumption so it is necessary to find a balance between water flux and reverse solute flux when we choose draw solute.

4.References

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3. *Y. Cai, W. Shen, Ji. Wei, T. H. Chong, R. Wang, W. B. Krantz, A. G. Fane, X. Hu, Environ. Sci.: Water Res. Technol., 2015,* ***1****, 341-347.*
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