

Liquid mining of lithium from brines using a hybrid forward osmosis – freeze concentration process driven by green deep eutectic solvents

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S. 1. DESs vs. aqueous solutions of their individual discrete components as DS

The superior performance of the DESs compared to their individual discrete components in aqueous solutions as the DS in FO was demonstrated upon comparing the results presented above with those obtained when using aqueous solutions of ethylene glycol (EG), levulinic acid (LA), and choline chloride (ChCl) at a concentration of 3.5 M, as well as a non-ChCl-based DES, namely CaCl₂: 2 EG (30% wt. water). In this comparative analysis, we evaluated and compared key parameters, including water flux (J_w), reverse solute flux (J_s), and the final lithium concentration (g/L) in the FS. Figure S. 1. (a and b) represents the water flux (L/m²/h) at the room temperature and flowrate of 0.4 LPM in the AL-FS mode. The water flux for LA, EG, ChCl, and CaCl₂: 2 EG was 3.75, 5.98, 13.00, and 17.57 L/m²/h, respectively. CaCl₂: 2 EG showed the highest water flux compared to the three aqueous DSs (LA, EG, and ChCl), which can be explained by the fact that the high ionic conductivity of the DESs results in higher osmotic pressures [1]. Figure S. 1. (c and d) presents the reverse solute flux (mol/m²/h) results for the aforementioned DSs in AL-FS mode, proving that the DESs present lower reverse solute fluxes compared to aqueous inorganic DSs.

Lithium concentration measurements in the FS after 6 h of FO operation are also presented in Figure S. 1. (e and f). Among the aqueous inorganic DSs tested, ChCl showed the best performance, reaching to a final lithium concentration of 5.31 g/L. In comparison, the DES DSs tested, namely CaCl₂: 2 EG and ChCl: 2 EG, led to significantly higher final lithium concentrations of 7.37 and 9.6 g/L, respectively. Overall, based on the data presented in Figure S. 1., aqueous solutions of the individual components of the DESs (i.e., LA, EG, and ChCl) presented lower water flux and higher reverse solute flux compared to their DES mixtures.

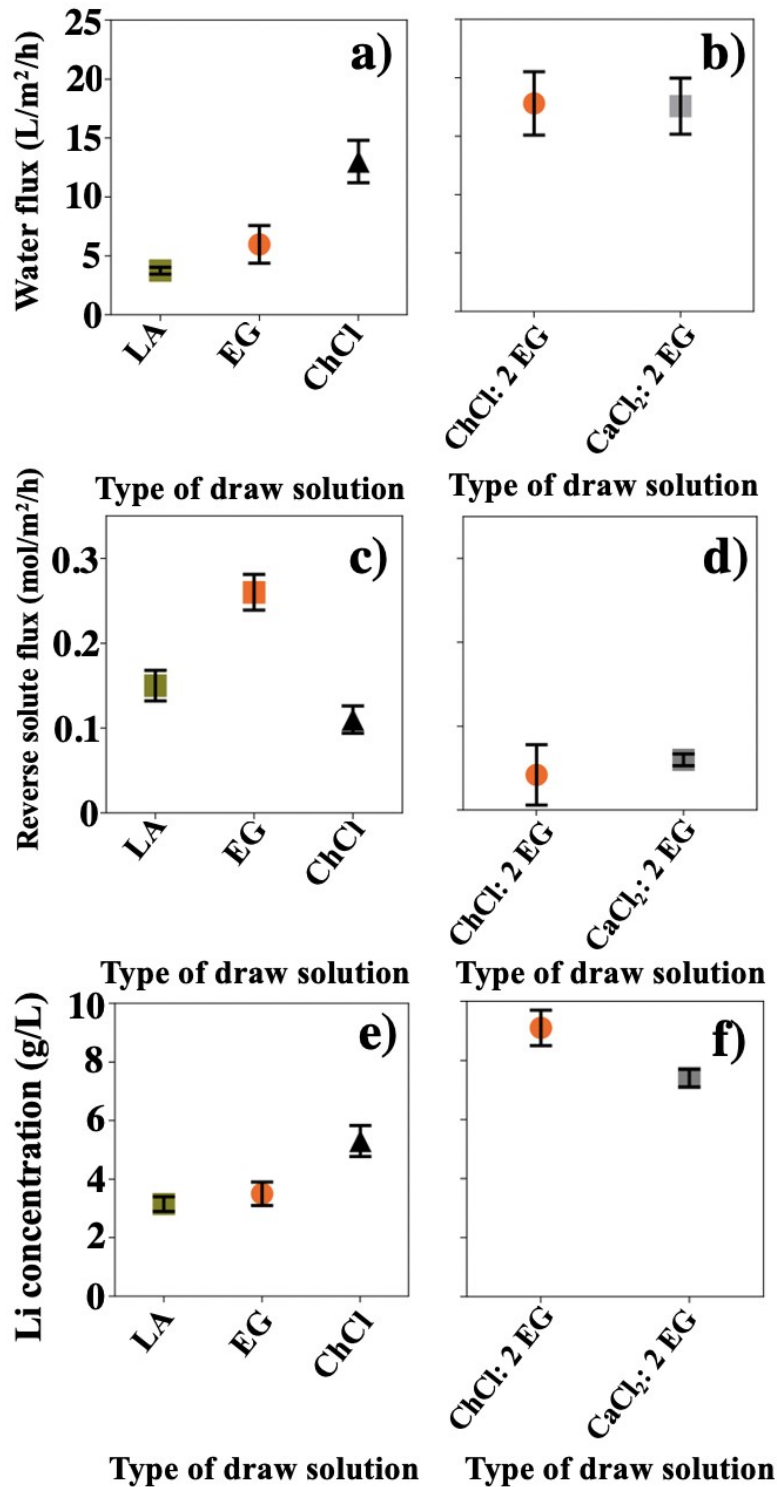


Fig. S. 1. Water flux (L/m²/h) using (a) 3.5 M aqueous ethylene glycol (EG), levulinic acid (LA), choline chloride (ChCl) DS, and (b) calcium chloride: 2 ethylene glycol (CaCl₂: 2 EG) and choline chloride: 2 ethylene glycol (ChCl: 2 EG) deep eutectic solvent DS (30% wt. water). A simulated lithium brine was used as the FS. Reverse solute flux (mol/m²/h) using (c) 3.5 M aqueous EG, LA, ChCl DS, and (d) CaCl₂: 2 EG and ChCl: 2 EG (30 wt.% water) deep eutectic solvent DS. DI water

was used as the FS. Final Li concentration (g/L) results when using (e) 3.5 M aqueous EG, LA, ChCl DS, and (f) CaCl₂: 2 EG and ChCl: 2 EG (30 wt.% water) deep eutectic solvent DS. A simulated lithium brine was used as the FS. The FO operation was carried out for 6 h at room temperature, AL-FS mode, and DS and FS flowrates of 0.4 LPM.

References

- [1] S. Dutta and K. Nath, “Prospect of ionic liquids and deep eutectic solvents as new generation draw solution in forward osmosis process,” *Journal of Water Process Engineering*, vol. 21. Elsevier Ltd, pp. 163–176, Feb. 01, 2018. doi: 10.1016/j.jwpe.2017.12.012.