Data Article

Assessing biomimetic aquaporin membrane for forward osmosis desalination process: A dataset

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A B S T R A C T

This paper presents the performance of aquaporin forward osmosis membrane using chemical fertilizers as a draw solution. The comprehensive evaluation conducted for five conventional fertilizers ((CO (NH₂)₂, KCl, CaCl₂, (NH₄)₂SO₄) and (NH₄)₂HPO₄) as draw solutions. The diluted fertilizer can be used directly for farming as fertigation. In this process, DSs do not need to be recovered and it is a single step desalination process. The data include the characterization of the intrinsic properties of the membrane samples and their performance under FO and PRO modes of operations. In addition, the data for various draw solution concentration under feed solution with deferent total dissolved solids (TDS) were evaluated. For example, a water flux of 17.5 L m⁻² h⁻¹ and 23.92 g m⁻² h⁻¹ reverse solute flux (RSF) was achieved under the FO operation mode for 3 M KCl.

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Fig. 1 presents the SEM images for the top surface rejection layer and non-woven backing fabric support for Aquaporin FO membrane. The Biomimetic FO membrane top surface (rejection layer) which is formed by AQPs proteins is similar to conventional thin film composite membrane polyamide layer in terms of topology.

Table 1. Presents the AQPs membrane characterization. Figs. 2 and 3 present the membrane performance in terms of water flux in the FO mode with five different fertilizers as DS different using 10 gr/L and 20 gr/L NaCl as FS, respectively. The performance was in the following order: KCl>(NH₄)₂SO₄>CaCl₂>(NH₄)₂HPO₄>Urea. Fig. 4 also shows the amount of wasting draw solute through phenomenon called reverse solute flux (RSF). The RSF plays a central role in the valuation of the FO process in terms of economic measure and membrane fouling tendency. Figs. 5—9 present the performance of each specific DS with five different concentration of feed solution (0—5—10—20—35 g/L NaCl) in terms of water flux in FO operation mode.

Finally, Fig. 10 shows the membrane performance in FO and PRO modes using DI water as FS at different Molar concentration for 2 selected fertilizers, KCl and (NH₄)₂SO₄. In the PRO mode, the net gain water flux was more compared to the FO mode. This indicates the effect of ICP in the PRO mode is less than FO mode of operation. The raw data presented in the supplementary file. All other data is within this article.

### 1. Data

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### 2. Experimental design, materials, and methods

#### 2.1. Feed and draw solutions preparation

(NH₄)₂CO, KCl, CaCl₂, (NH₄)₂SO₄, (NH₄)₂HPO₄ were used as draw solutions provided by (SAMCHUN, Korea). 0.5, 1, 2, and 3 M molar concentration levels were prepared. DI water and NaCl (5-10-20-35 g/L) were prepared as a feed solution (FS).
**Fig. 1.** SEM images for the top rejection layer and non-woven backing fabric support for the virgin Aquaporin FO membrane in this study.

**Table 1**
Characterisation of AQPs FO membrane.

| Membrane ID | Thickness (µm) | Porosity (%) | Contact angle (°) |
|-------------|----------------|--------------|-------------------|
| AQPs        | 135 ± 2.0      | 69           | 51                |

**Fig. 2.** Comparison of the water flux for different fertilizers as a DS at different concentrations using 10000 mg/L NaCl as feed solution in the FO mode.
2.2. Measurement of intrinsic properties of the membrane

Intrinsic properties of the Biomimetic-FO membrane were determined by RO testing mode by utilizing the FO membrane cell and applying hydraulic pressure (0–5 bar). Water permeability (A value) was calculated based on the following equation:

$$ A = \frac{\Delta V_A}{\Delta t_a \times A_m \times \Delta P} $$

(1)

Water permeability was obtained by placing DI water in the FS container and adjusting hydraulic pressure of 5.0 bar. $\Delta V_A$ is the acquired permeate water over a specific time, $\Delta P$ is the applied hydraulic pressure difference and $A_m$ and $\Delta t_a$ is the membrane area.

Fig. 3. Comparison of the water flux for different fertilizers as a DS at different concentrations using 20000 mg/L NaCl as feed solution in FO mode.

Fig. 4. Comparison of RSF of five fertilizers as DS at different concentrations using DI water as FS in the FO mode.
NaCl rejection property of the Biomimetic-FO membrane was calculated by the following equation.

\[ R = \frac{C_f - C_p}{C_f} \times 100\% \]  

(2)

where \( C_f \) and \( C_p \) are the amount of NaCl concentrations for the feed and permeate container [1,2].

The salt permeability coefficient (B) was calculated by the following equation:

\[ B = \frac{A(1 - R)(\Delta p - \Delta \pi)}{R} \]  

(3)

where \( A \) is water permeability, \( R \) is the salt rejection, \( \Delta p \) is the applied pressure and \( \Delta \pi \) is the osmotic pressure difference for the Aquaporin FO membrane [3–6].

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**Fig. 5.** Performance of KCl in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.

**Fig. 6.** Performance of (NH₄)₂HPO₄ in terms of water flux at different M concentrations of DS and FS with 0–5–10–20–35 g/L NaCl.
2.3. Substrate characterization

The membrane morphologies were assessed using (FE-SEM, MIRA3-LMU model, Czech Republic) a high-resolution Schottky Field Emission Scanning Electron Microscope.

Membrane porosity ($\varepsilon$) was calculated by weighing the wet mass ($W_1$) and the dry mass ($W_2$) of membrane samples based on the following equation:

$$
\varepsilon = \frac{(W_1 - W_2)/\rho \pi}{\left[\frac{W_1 - W_2}{\rho \pi}\right] + \left[\frac{W_2}{\rho m}\right]} \times 100\%
$$

(4)
where \( \rho_i \) is the density of the used wetting solvent, and \( \rho_m \) is the density of the membrane sample. The thickness of the membranes was measured by a digital micrometer (293–330 Mitutoyo, Japan).

## 2.4. Membrane tests under FO and PRO processes

Performance tests under the FO and PRO processes were assessed in the designed FO cell presented in Fig. 11 provides a useful area of 6.2 cm\(^2\) with 2 cm in width, 3.1 cm in length and 0.3 cm in depth on both sides. The reverse solute flux (RSF) was assessed by observing the electrical conductivity (EC)
applying a multimeter (Lutron-CD4303, Germany) where deionized water is used as feed water [7,8] (see Fig. 12).

3. Application for fertigation

The desalinated water via FO process using fertilizer as a draw solution can be used directly for farming as fertigation [9,10]. In this process, draw solutions do not need recovery and directly will be used for farming [11,12]. Thus that is a single-stand desalination process [10,11].
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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104482.

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