Comparison of Fouling by Extracellular Polymeric Substances and Polysaccharides in Forward Osmosis

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Introduction

- Biofouling significantly deteriorates separation performances in membrane-based desalination. In particular, extracellular polymeric substances (EPS) form integral components of biofilms, representing up to 95% of the biomass.
- Forward osmosis (FO) process has attracted a growing interest for its potential in low-energy water desalination and treatment. The biofouling is less severe in FO process, due to the use of osmotic pressure gradient as the driving force, as compared to other membrane separations, e.g. reverse osmosis, which utilizes hydraulic pressure.
- Previous studies on membrane fouling commonly used alginate as the model polysaccharide, which is atypical of most bacterial EPS in seawater desalination.

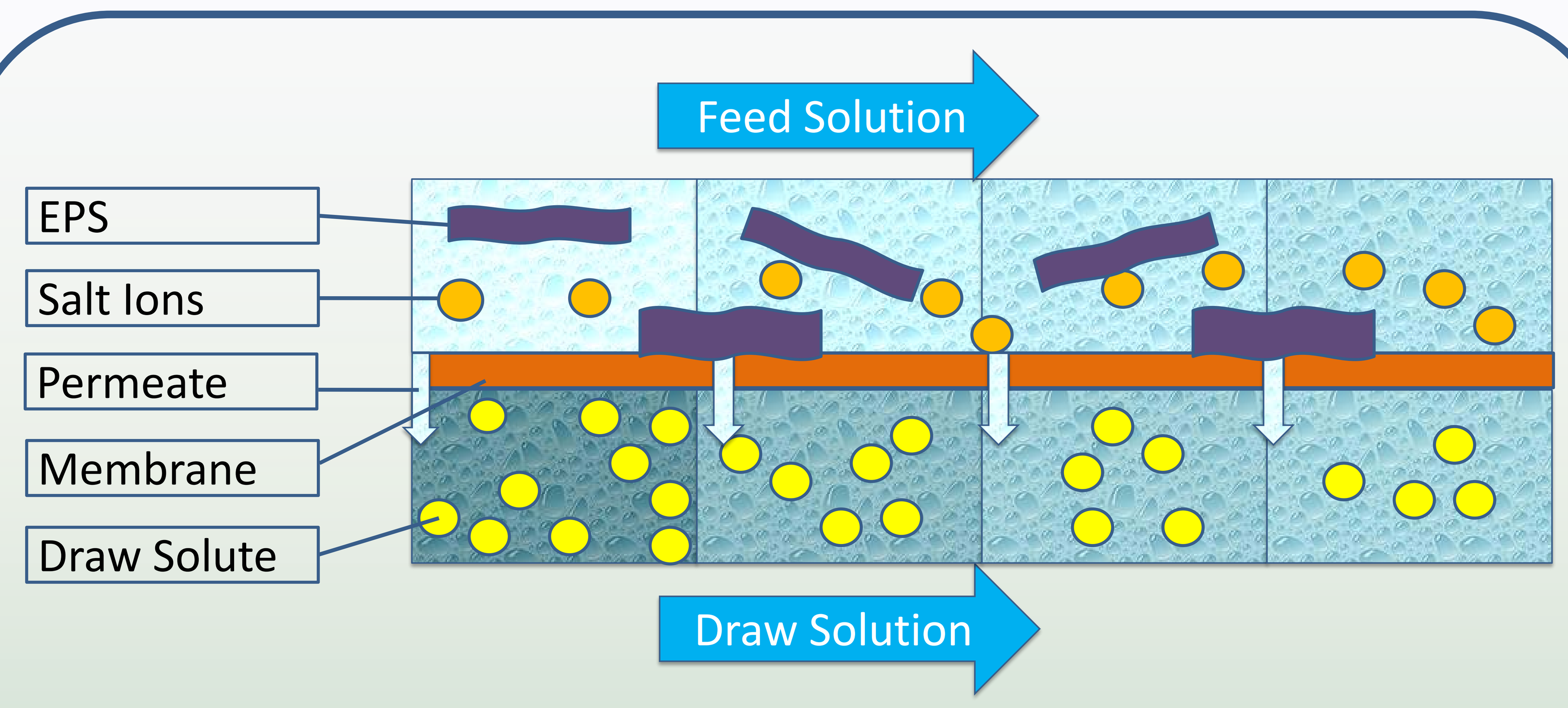

Fig.1 Biofouling in the FO process

- **Aim of the study** -- find the **best model polysaccharide** representative of EPS in FO fouling by comparison of fouling caused by commercial **polysaccharides (alginate, xanthan** and **pullulan)** and **isolated EPS from the bacteria RSW 14 in raw seawater** and **FSW 6 in filtered seawater**.

Methods

Forward osmosis experiment

Fouling tests were performed in the FO system, as shown in Fig. 2.

Operational conditions:

- Draw solution = saturated NaCl solution, which ensures **constant draw osmotic pressure**.
- Cross-flow velocity of both feed and draw solutions, 8.5cm/s;
- Temperature of both feed and draw solutions, 25±1°C;

Feed solution composition

- Baseline = Ca^{2+}, 1mM; Ionic strength of feed solution, 50mM by adding NaCl.
- Fouling test = Baseline + polysaccharides or isolated EPS at a concentration of 0.2g/L.

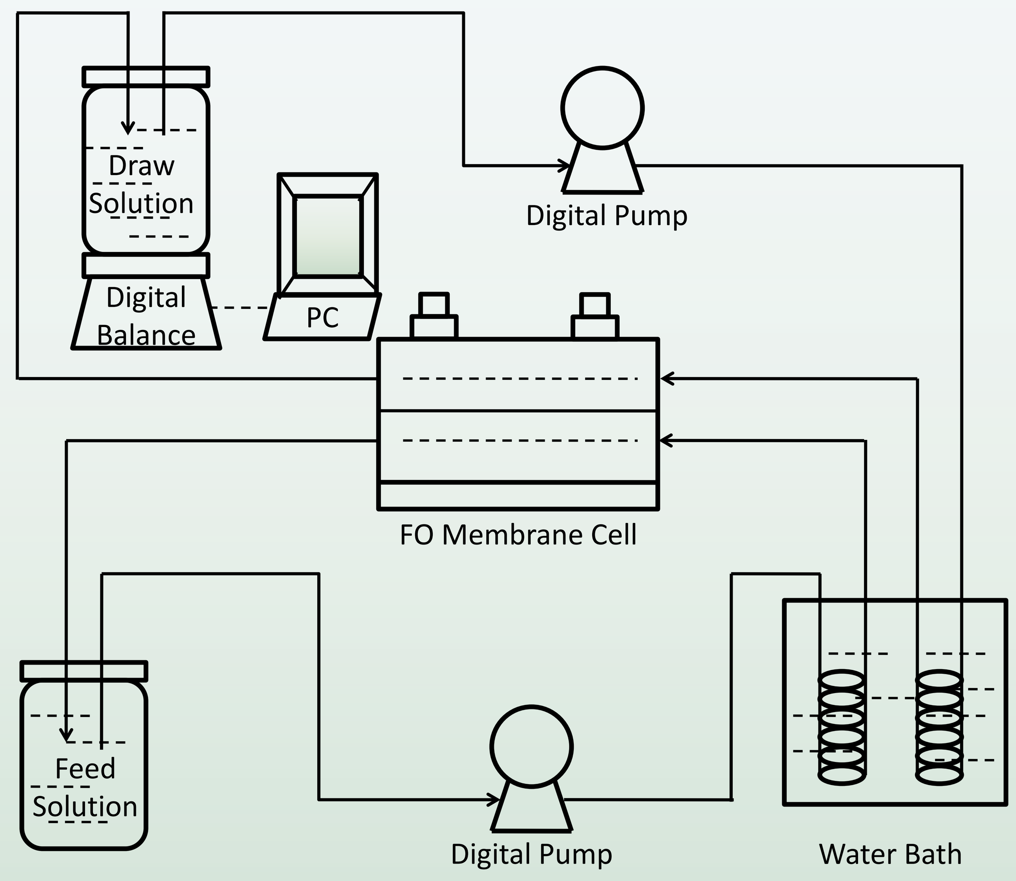

Fig.2 Schematic diagram of FO system

EPS isolation and purification

Grow cultures on liquid media
↓
Centrifuge cultures to pellet cells
↓
Precipitate EPS with acetone
↓
Dissolve EPS precipitate in DI water
↓
Dialyse EPS against DI water for 2d

Results & Discussion

- EPS produced by bacteria RSW 14 and FSW 6 appear to be unusual because they do not cause fouling (Fig.3). Further research is being conducted to ascertain whether the extraction method has changed their properties.
- The degree of fouling is related to viscosity of polysaccharide and EPS solutions (Eq.1 and Fig.4). The xanthan feed solution, with the highest viscosity, caused the most severe fouling. The EPS and pullulan solutions, showing similarly low viscosities, caused no fouling. Alginate, caused medium fouling, which could be attributed to the formation of loose Ca-alginate gels.
- Among the three polysaccharides, pullulan behaved the most similarly to EPS.

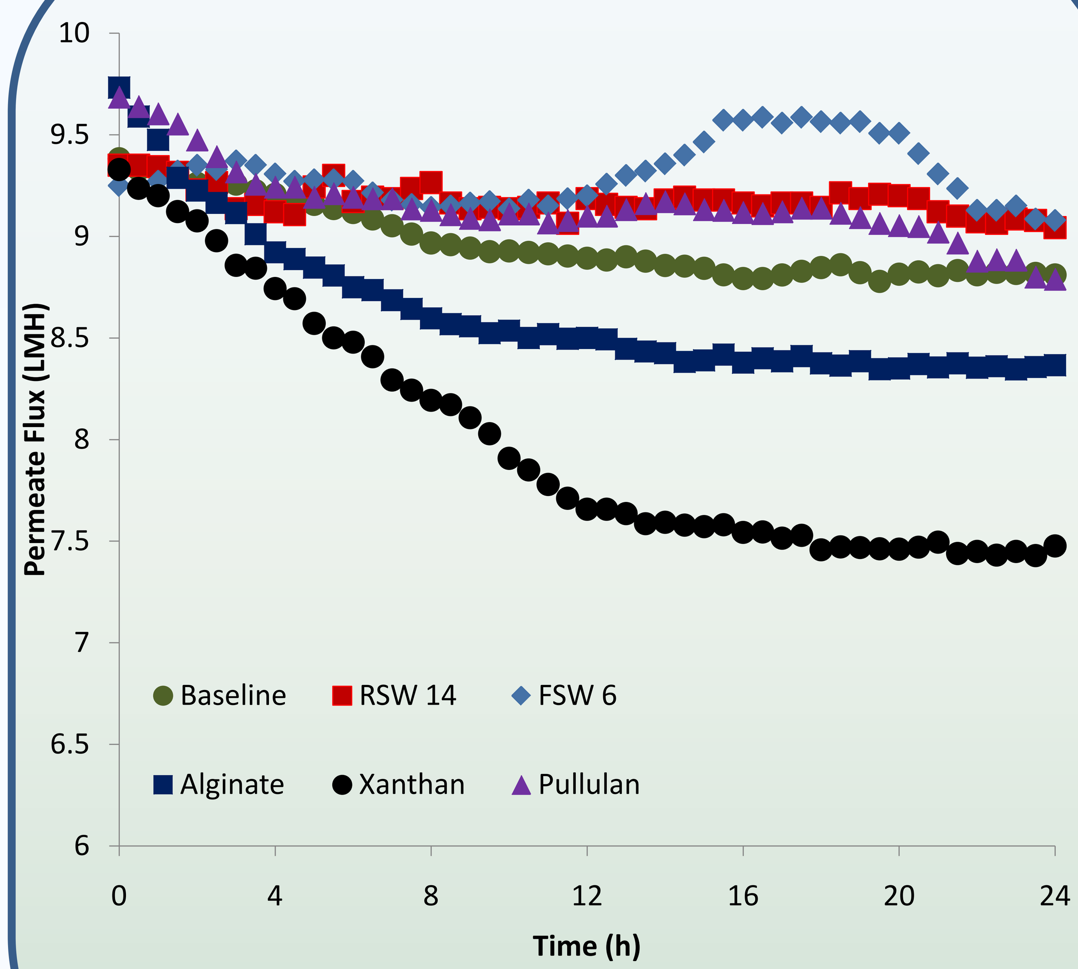

Fig.3 Permeate fluxes obtained from the polysaccharide and EPS fouling tests

Permeate flux is related to solution viscosity (μ), as shown in Equation (1)

$$J = \Delta\pi / (\mu \cdot R) \qquad (1)$$

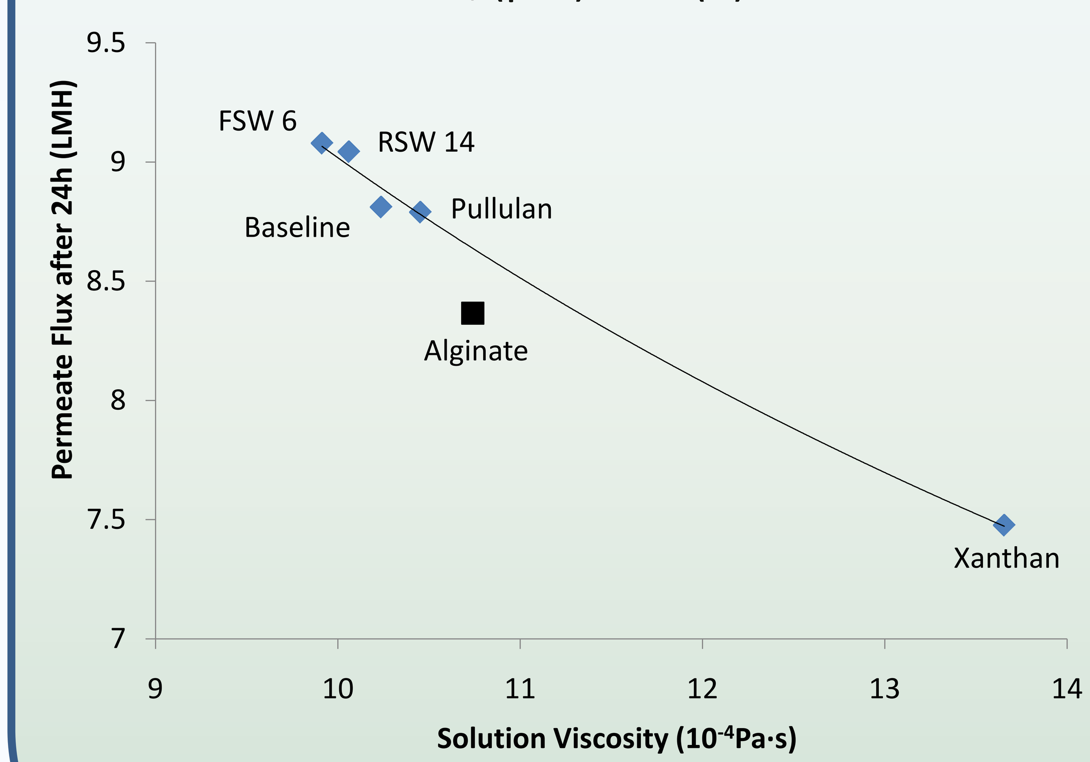

Fig.4 Correlation between permeate flux after 24h and solution viscosity

Conclusions

- Commercial polysaccharides and laboratory produced EPS fouled the membrane to different degrees likely due to the difference in their solution viscosities.
- Further research is required to study whether the mixtures of EPS behave differently to the individual EPS in the FO tests.

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