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Performance evaluation in concentrating PEG solutions using forward osmosis membrane and different draw solutions

Y.J. Zhao, L.F. Liu*, L. Jie, F.L. Yang

Dalian University of Technology, China

Polyethylene Glycol (PEG) has excellent property in lubricating, moisture retention, dispersion and antistatic charge applications. It has wide application in many industries, especially in solar and semiconductor industries. Huge amount of wastewater containing 2-3% PEG (MW150-300) in these industries was produced each year. It has been calculated that to produce 1 ton PEG, indirectly, 8.6 tons oil was consumed. Therefore, recovering PEG from wastewater not only reduces pollution but also conserves resources. However, PEG has good solubility in water and good compatibility with a number of organic groups, this makes it difficult to recover, using traditional separation methods.

Pressure-driven membrane process, such as Reverse osmosis (RO) and nanofiltration technology have a lot of innovation and improvement in recent years. But it also has some limitations such as high energy consumption, membrane fouling and so on. During PEG concentrations, concentration polarization was serious. The water flux will decline rapidly, so the technical feasibility is greatly reduced. It is especially important to find a low-cost and effective method to recover PEG.

Forward osmosis (FO) is a novel membrane process driven by the osmotic pressure gradient across a semi-permeable membrane. This process is featured with high quality water recovery after the cycling of draw solution by RO, and as only water permeate into the draw solution (DS), DS contains no organic pollutants which make RO operation simpler. In some cases, there is even no need to treat the draw solution, such as when sucrose draw solution is used, it can be directly used for fermentation or beverage, which is energy saving without the need for RO or NF.

In this paper, the performance of FO (using the only commercial FO membrane from Hydration Technologies Inc. (HTI)) in concentrating PEG (MW200-300) solution, using three types of draw solution $CaCl_2$, NaCl and sucrose solution were evaluated, and the effect of draw solution, feed solution (FS) concentration and membrane orientation were investigated. The FO tests were carried out using a three chambered unit, the middle centred chamber is for draw solution with the FO membrane separating the feed solution in the neighbering chambers. The total membrane area was 200 cm^2.The size of the middle compartment is 20cm×5cm×1.9cm (length × width × depth), and the lateral compartment's size is 20cm×5cm×0.5cm (length × width × depth).

The order of the osmotic pressure with the same concentration DS from low to high is sucrose, sodium chloride and calcium chloride. The accumulated water permeation profile (Figure 1a) showed the same order. Water fluxes for three types of draw solution are very different. The water flux with the same concentration of sucrose and sodium chloride (0.5 M) was 1.2LMH and 2.8LMH, respectively. The water flux of 2M $CaCl_2$ was much higher than two other draw solutions, 5.2 LMH. There is back permeation of ions from DS to feed PEG solution which increase the conductivity from 10.9μs/cm to 80.2μs/cm when 2M $CaCL_2$ was used. FO with sucrose solution has lower permeation, but it can be used, because for fermentation or beverage, subsequent reverse osmosis treatment was not required. Also, there is no back diffusion of ions from DS to FS to increase the conductivity.

Experiments showed that with active layer towards the feed solution, the FO had better permeability. For 3% or 18% PEG solution, the concentrating profiles are shown in Figure

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1b.DS flow rate is at 5.8LMH, FS flow rate is 8.9LMH. FS volume is 2.5L. With 2M $CaCl_2$ draw solution, PEG can be concentrated from 3 wt% to 30 wt% within less than 3000min.

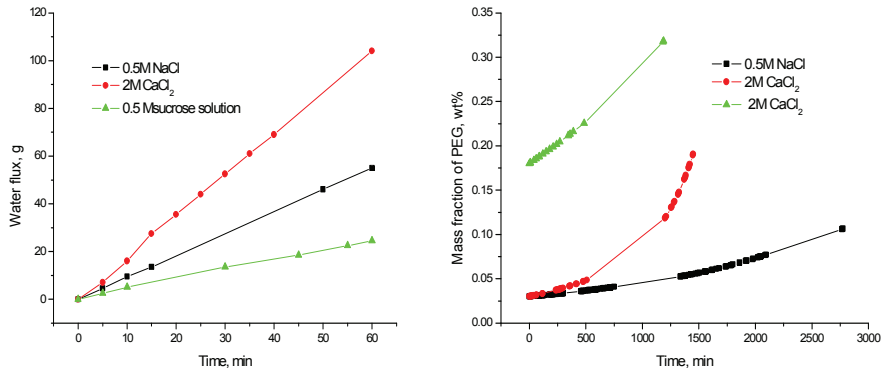

Figure 1 (a,b) Influence of draw solution on water flux and concentration of PEG

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