FO-MBR WITH NANOFILTRATION SCORES HIGH ON QUALITY AND LOW ON FOULING

Water Convention 2011 – Best Poster Winner (1st Runner Up)

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Forward osmosis membrane bioreactor (FO-MBR), followed by a re-concentration process, is a combination of the FO and MBR processes to produce clean product water from wastewater and was actively studied as it could potentially have lower energy cost compared to conventional MBR. In 2011, the National University of Singapore won First Runner Up in the Best Poster Award for their study in determining the quality of product water under different mean cell residence times (MCRTs) and investigating the effects of membrane fouling on FO-MBR. Results showed that FO-MBR with a nanofiltration post-treatment process over 3-, 5- and 10-day MCRTs produced product water that could meet WHO guidelines and the FO membrane had low fouling propensity.

Winning the award had further deepened Dr Zhang's interest in R&D and he continued doing research and development on water membrane products till today. Currently working on membrane development at Aquaporin, Dr Zhang opined that "the water industry will keep evolving toward the direction of low energy, low cost and high quality for producing water including drinking water and industrial water…(and) membrane product development (with) high water permeability, low fouling, high strength and high solute removal rate are the directions which commercial companies are moving toward which correlate with low energy consumption, low cost and high quality."

Looking back on his experience at the SIWW 2011, Dr Zhang felt that Water Conventions draws researchers from institutes and companies to present and exchange on their work, and the tradeshow also attracts companies to promote their products and generate potential sales and collaborations during event and that this "research plus commercial traits make the Water Convention different from other conferences which might only focus on one part."

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Performance of Low-Fouling Forward Osmosis Membrane Bioreactors with Different Mean Cell Residence Times

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Summary

Currently forward osmosis membrane reactor (FO-MBR) is actively studied for reclaim used water into industrial water or high quality water with further treatments. FO-MBR, followed with a reconcentration process, is a combination of FO process and MBR process to produce clean product water from wastewater. Because FO process utilizes the chemical osmotic pressure to produce effluent instead of suction force, the energy cost of FO-MBR is lower compared with the conventional MBR. However, there are limited studies on fouling and performance of FO-MBR, which is elucidated in this study. This stidy shows that FO-MBR with NF had high TOC and COD removal efficiencies, and TDS and conductivity value were acceptable. All three FO-MRS which three different MCRTs had salt accumulation which affected the system performance. FO membrane had low fouling propensity and the fouling was insignificant.

Keywords

forward osmosis; fouling; membrane bioreactor; nanofiltration; chemical oxygen demand; total dissolved solids

Introduction

The forward osmosis (FO) process is a membrane process that utilizes the natural osmosis phenomenon for the transport of water from a dilute solution to a more concentrated solution, across a highly selective membrane. The driving force of this process is provided by the osmotic pressure difference between the two solutions, and hence no external pumping pressure is required, which is the significant advantage over the other pressure-driven membrane processes. FO process has been studied and proposed for use in various fields, particularly in water reclamation and wastewater treatment (Cath et al., 2006). Recently, the FO process had been proposed for wastewater treatment and reclamation with a couple of journal publication involving preliminary work (Cornelissen et al. 2008; Achilli et al. 2009) on osmotic-membrane bioreactor or forward osmosis membrane bioreactor (FO-MBR). While MBR uses suction force to produce effluent, FO-MBR utilizes an osmotic driving force from the draw solution for water transport across the FO membrane, which dilutes the draw solution. When the draw solution is sufficiently diluted, a post-treatment process, e.g., nanofiltration (NF) or reverse osmosis (RO), could be used to reconcentrate the draw solution simultaneously, producing a high quality product water. In a previous study, Na_2SO_4 was selected as a suitable draw solution for the FO process with NF as post-treatment for reconcentration of draw solution (Tan and Ng 2010).

With this, a laboratory-scale FO-MBR process should be studied to optimize its operating conditions, as the conditions used in previous FO-MBR studies were only suitable for small laboratory-scale system (Cornelissen et al. 2008l; Achilli et al. 2009). Up to now, there are limited studies on the performance and membrane fouling of FO-MBR. Therefore, the objective of this study is to determine the quality of product water under different mean cell residence times (MCRTs) and to investigate the effects of membrane fouling on FO-MBR.

Materials and Methods

Three laboratory-scale FO-MBRs with NF post-treatment for the reconcentration of the draw solution were conducted with different MCRTs, namely 3-, 5- and 10-day. Schematic diagram of the system is given in Fig. 1. The feed water for FO-MBR was collected from Ulu Pandan Water Reclamation Plant, Singapore, and seed activated sludge from the same plant was seeded into the reactors at the start of operations. The hydraulic retention time (HRT) was 6 h. An offline backwash scheme, using 0.5M NaCl solution for 1 h, was adopted once weekly. 0.7M Na_2SO_4, was chosen as the draw solution for the systems based on the results from Tan and Ng (2010).

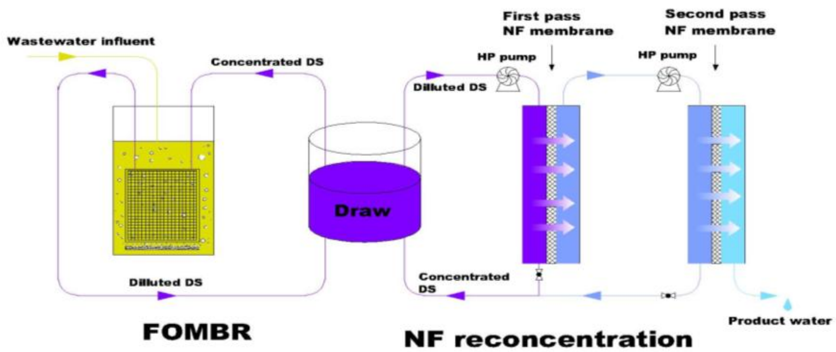

Figure 1. Schematic diagram of FO-MBR with NF process.

Results and Discussions

Results on quality of product water showed that the removal efficiencies of TOC and COD are both above 97.6% for all three MCRTs. Conductivities and total dissolved solids (TDS) of the final product water for the three MCRTs are all lower than 500 us/cm and 400 mg/L, respectively, which both meet the World Health Organization (WHO) drinking water guideline. Results on membrane fouling showed that all the three FO membranes under different MCRTs had very low fouling propensity regardless of the MCRT during the 80 days operation. The concentration of mixed liquor volatile suspended solid (MLVSS), extralcellular polymeric substance (EPS) and soluble microbial product (SMP) did not exhibit a large effect on fouling of the FO membrane. The scouring effect of aeration reduced the amount of organic matter depositing on the membrane surface. The concentration of MLVSS kept decreasing and finally reached a concentration of around 1000, 1100, 1300 mg/L for the 3-, 5-, 10- days MCRT respectively. This is due to the salt accumulation in the mixed liquor, which may affect the viability of the biomass. The concentration of EPS decreased as the MCRT increased while the concentration of SMP increased with the increase of MCRT. Water flux of 10-d MCRT shows the most significant reduction compared with that of 3- and 5-d MCRT. The reduction of water flux could be due to the reduction of the effective osmotic pressure difference across the membrane, when salt is accumulated in the mixed liquor, and membrane fouling. From the normalized water flux results, it is showed that the water flux decline caused by membrane fouling is minimal as compared with that reduced by the decrease of the effective osmotic driving force. In conclusion, FO-MBR has high TOC and COD removal and TDS and conductivity of product water meet WHO guidelines. Besides, FO membrane fouling is very low and independent from the concentration of MLVSS, EPS and SMP.

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