*Desalination and Water Treatment*
www.deswater.com
doi: 10.5004/dwt.2018.22316

114 (2018) 19–30
May

# Optimization on the operating conditions of PRO process: towards improved net power density

Hongliu Wang[a,b,c], Yue Wang[a,b,c,*], Dongya Ma[a,b,c], Qian Zhang[a,b,c], Shichang Xu[a,c,*]

[a]*Chemical Engineering Research Center, School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, China, Tel. +86 22 85356553; emails: tdwy75@tju.edu.cn (Y. Wang), xushichang@sina.com (S. Xu), wanghongliu_@tju.edu.cn (H. Wang), mdy@tju.edu.cn (D. Ma), qian727318045@ tju.edu.cn (Q. Zhang)*
[b]*State Key Laboratory of Chemical Engineering, Tianjin 300072, China*
[c]*Tianjin Key Laboratory of Membrane Science and Desalination Technology, Tianjin 300072, China*

Received 26 November 2017; Accepted 5 April 2018

**ABSTRACT**

In the pressure-retarded osmosis (PRO) process, the power density was dramatically influenced by the operating conditions including the applied hydraulic pressure difference ($\Delta P$), the ratio of feed to draw flow rate ($V_F/V_D$), and the ratio of draw flow rate to membrane area ($V_D/S_m$). A theoretical model considering the non-ideal effects of concentration polarization, reverse salt flux, and pressure losses in draw side through the membrane module was developed to predict the water flux of the PRO, from which the power density and specific energy were predicted. The optimization of operating conditions was conducted by the theoretical model to meet the PRO process' predefined economic viability of about 5.00 W m$^{-2}$ for the power density. Experimental verification of the theoretical model was carried out when the applied pressure is <10 bar, which is the maximum pressure resistance of the forward osmosis membrane in the paper. The resulted optimal operating conditions were $\Delta P$ of 17 bar, $V_F/V_D$ of 0.8, and $V_D/S_m$ of 47 L min$^{-1}$ m$^{-2}$ using seawater–river system, under which the theoretical power density was 5.13 W m$^{-2}$, higher than the benchmark of 5.00 W m$^{-2}$. The error between the experimental and theoretical results was <5%, which demonstrated the theoretical model is reliable.

*Keywords:* Pressure-retarded osmosis; Operating conditions; Net power density; Osmotic power

* Corresponding author.