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Entitled

Performance of ultrasound-assisted forward osmosis membrane process in desalination of seawater

by

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Abstract

The objective of this study was to investigate the effect of using ultrasound technology on water flux through forward osmosis membrane when applied for seawater desalination. A synthetically prepared solution simulating seawater characteristics was used. Parameters considered in the investigation included membrane cross-flow velocity (0.25 and 1.0 cm/s), flow configuration (co-current versus counter-current), direction of ultrasound waves relative to the membrane side (active layer versus support layer), and type of draw solution (NaCl versus $MgCl_2$). Furthermore, a two-level factorial design was considered in the analysis of the results obtained from the experimental work. This study revealed that applying a continuous ultrasound frequency of 40 kHz was effective in enhancing water flux especially when the ultrasound source faces the membrane active layer, irrespective of the used draw solution. The highest water flux enhancement (70.8% with NaCl draw solution and 61.9% with $MgCl_2$ draw solution) occurred at the lower cross-flow velocity and with the ultrasound waves facing the membrane active layer. It was also observed that the use of ultrasound generally caused an adverse effect on the water flux when the ultrasound waves faced the membrane support layer. Moreover, applying the ultrasound at the membrane support layer increased the reverse solute flux. For all the tested cases, higher water flux enhancement was observed with NaCl as a draw solution compared to the cases when $MgCl_2$ was used as a draw solution. Based on the factorial design analysis, cross-flow velocity and use of ultrasound have a positive effect on water flux enhancement for both draw solutions. However, the velocity effect on water flux enhancement was more pronounced than that of the ultrasound. The effect of flow configuration was statistically insignificant for both draw solutions. The interaction effect between cross-flow velocity and ultrasound was statistically significant for both draw solutions. However, the interaction between cross-flow velocity and flow configuration was only significant for the case of $MgCl_2$. The three-way interaction was insignificant for both draw solutions.

Keywords: Forward Osmosis, Ultrasound, Water flux, Concentration polarization, Fouling, Scaling, Seawater, Factorial design.