Effect of pH on produced water treatment using nanofiltration membranes: artificial neural network for performance assessment and steric hindrance pore model for flux variation evaluation

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Abstract

Experimental studies have shown that flux and ion rejection by nanofiltration (NF) are strongly influenced by feed pH. The novelty of this research is using the artificial neural network (ANN) in predicting ion rejection based on multiple variable experimental data for feed pH, pressure, and flux. With a number of independent variables affecting ion rejections, ANN is considered suitable compared with Spiegler–Kedem model for predicting the interrelation between variables with non-linear dependencies in a multi-ion environment. However, Spiegler–Kedem and steric hindrance pore models were used for explaining effect of pH on NF flux variations. Experiments were performed to demonstrate reuse of de-oiled produced water (PW) at different pH with salinity similar to seawater as smart water for enhanced oil recovery. Flux was higher at basic pH compared with acidic feed pH and varied due to pH-sensitive dissociable groups, which are protonated or deprotonated with changing pH. An ANN structure was designed that resulted in a close agreement between ANN predictions and experimental data with an agreement of above 95% for all membranes. The results are presented, and interpreted with respect to requirements for smart water, thereby reusing PW, and simultaneously expanding membrane applications in the oil industry.

Keywords: Artificial neural network; Nanofiltration; Spiegler–Kedem; Steric hindrance pore model; Produced water; Smart water