Study of the rectangular cross-flow flat-sheet membrane module for desalination by vacuum membrane distillation

Abstract

This work presents a study of the heat and mass transfer performance of desalination in a laboratory-scale rectangular cross-flow flat-sheet membrane module by vacuum membrane distillation (VMD) experiments. Results show that the traditional Nusselt and Sherwood correlations, which are frequently employed in the membrane distillation literature, are not suitably used to estimate the heat and mass transfer coefficients in the VMD system for Reynolds numbers ranging from 150 to 1400. In this study, it was observed that approximately 30% of the experimental data fit well with semi-empirical correlations whose empirical constants are $a=2.76\times10^{-3}$, b=0.97 and c=3.7909. The heat transfer process is limited by the resistances in the feed boundary layer and the membrane. The heat transfer resistance in the membrane increases when that in the feed boundary layer decreases and vice versa. More than 50% of the heat transfer resistances occur in the liquid feed phase at feed flow rates below 1200 mL/min, whereas the remaining occur in the membrane itself. At feed flow rates that exceed 1200 mL/min, the heat transfer resistance in the membrane becomes dominant. The Knudsen-viscous resistance controls the mass transfer through the membrane while the mass transfer resistance in the liquid feed phase is absent.