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Analysis of transmembrane electrical potential across nanofiltration membranes based on electrostatic and steric-hindrance model

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ABSTRACT

Transmembrane electrical potential (TMEP) across nanofiltration (NF) membranes was calculated analytically in single electrolyte solution –– NF membranes systems with electrostatic steric-hindrance (ES) model in this study. Moreover, a simplified expression with average membrane parameters was obtained to give explicit explanations by combining ES model and irreversible thermodynamics. The effects of electrolyte species with common co-ion Cl^- (KCl and $MgCl_2$), electrolytes concentration c, diffusion coefficient ratio of co-ion over counterion D_2/D_1, pore radius r_p, ratio of membrane thickness over porosity $\Delta x/A_k$, effective volume charge density X_w on TMEP were investigated. The results showed that with the existence of membrane potential, dependencies of TMEP on solution flux were nonlinear. When ξ_f^{-1} ($z_1v_1c_f/X_w$) was larger than 50 for 1-1 electrolytes and 100 for 2-1 electrolytes, TMEP tended to be constant and three potentials (TMEP, membrane potential and convection potential) crossed at $D_2/D_1D_i = 1.0$, which implied that the electrostatic effect could be neglected. When the isoelectric point of membranes is judged in different pH based on the zero point of TMEP, solutes with $D_2/D_1 = 1.0$ is recommendatory. Because when $D_2/D_1 > 1.0$, the zero point will locate on where X_w is negative, and when $D_2/D_1 < 1.0$, zero points will appear when X_w is positive, and only when $D_2/D_1 = 1.0$, the zero point of TMEP appears when membrane is neutral (X_w is zero). Moreover, a sufficient condition $t_{1m}/z_1+t_{2m}/z_2 = 0$ was proposed to explain the coincidence of zero point of membrane potential and minimum of reflection coefficient.

Keywords: Transmembrane electrical potential; Nanofiltration membranes; The electrostatic and steric-hindrance model; Irreversible thermodynamics

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