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Mechanisms of transfer of ionic solutes through composite polymer nano-filtration membranes in view of their high sulfate/chloride selectivities

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ABSTRACT

A number of nano-filtration membranes exhibit quite high rejections of sulfates (98–99%) accompanied by quite moderate rejections (sometimes as low as 10–20% and even less) of chlorides from highly concentrated electrolyte solutions like sea water or various brines. In this communication, it is shown that this phenomenon can hardly be explained within the scope of commonly accepted model of nano-filtration where the barrier layer is considered a nano-porous medium, and, accordingly, there is a considerable convective coupling between the transfers of solutes and solvent. The very high experimentally observed sulfate/chloride selectivities turn out hardly reconcilable with the quite moderate values of rejection of NaCl. It is suggested that this phenomenon can be explained by the solution-diffusion mechanism of solute transfer across very thin and practically non-porous barrier layers. The approach of rejection to non-100% apparent saturation values observed experimentally can be explained by the concentration polarization. To verify this hypothesis, studies have been carried out of pressure-driven rejection of various single-salt electrolyte solutions (NaCl, Na_2SO_4 and $CaCl_2$) by two commercial composite nano-filtration membranes (NF270 and NF200) in a cross-flow setup equipped with GE SEPA CF II test cell with the possibility of independent variation of trans-membrane pressure difference and cross-flow velocity. The experimental data could be very well fitted by the solution-diffusion-film model, the stagnant layer diffusion permeability depending in a reasonable way on the cross-flow velocity and solute bulk diffusion coefficient.

Keywords: Membrane; Nano-filtration; Sulfate; Chloride; Solution-diffusion-film model; DSP model; Spiegler–Kedem model

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