



Modeling in desalination—electro-dialysis reversal

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ABSTRACT

The first innovative model is developed in electro-dialysis reversal (EDR) desalination. First, theoretical limiting current density (LCD) determination is fitted and validated with four test-runs literature lab data. The goodness of fit and validation of LCD is statistically high with overall r^2 0.966 at $p < 0.001$. Second, a sensitivity analysis is done to study the most sensitive parameter in EDR with the LCD to its six modeling parameters; it was found that transport numbers of ions in membrane (t_{im}) and in solution (t_{is}) are rate limiting. Third, the model is constructed with emphases on LCD, concentration potential (CP), and total area of resistances of both membrane and solution to highlighting these two limiting parameters. Fourth, the model is fitted, verified, and validated with six different sets of both desalting energy and TDS in concentrate data from five literatures including 59 measured data points with five different feedwater characteristics. The values of five parameters ($t_{Ca^{++},m}$, $t_{Mg^{++},m}$, $t_{Na^+,s}$, $t_{Ca^+,s}$, $t_{Mg^{++},s}$) are generated from 30 model-runs. A new parameter, area resistance of solution, is found by model. Area resistance of solution increases with the increasing of mean-ions-resident time (MIRT_c) in concentrate of EDR in the same polar reversal interval; so as the desalting energy. The acids and anti-scalant adding in concentrate increases the area resistance of solution in model and increases desalting energy in pilot scale literature data. Literature data proves, there are not acids and anti-scalant adding requirement and no water leakage, if EDR is operated at MIRT_c < 130 min. By operating EDR at MIRT_c < 130 min, 3.2–31% of desalting energy can be saved, with the evidence of measured literature pilot scale desalting energy data, due to the lower area resistance of solutions in EDR, without requirement of adding acids and anti-scalant, and no water leakage.

Keywords: Acid; Anti-scalant; Concentration Potential; Limiting current density; Mean ions resident time in concentrate; Total area resistances of solution

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