Desalination and Water Treatment
www.deswater.com

doi: 10.1080/19443994.2013.807905

51 (2013) 6429–6443
October

Taylor & Francis
Taylor & Francis Group

Finite elements-based 2D theoretical analysis of the effect of IEX membrane thickness and salt solution residence time on the ion transport within a salinity gradient power reverse electrodialysis half cell pair

Etienne Brauns

VITO (Flemish Institute for Technological Research), Separation and Conversion Technology, Boeretang 200, 2400, Mol, Belgium
Email: etienne.brauns@vito.be

Received 18 March 2013; Accepted 3 April 2013

ABSTRACT

Reverse electrodialysis electrical power generation is based on the transport of salt ions through ion conductive membranes. The ion flux, equivalent to an electric current, results from a salinity gradient, induced by two salt solutions at significantly different concentrations. Such equivalent electric current in combination with the corresponding electrochemical potential difference across the membrane, equivalent to an electric potential, results in a battery equivalency. While having a co-current fluid flow of both solutions in the reverse electrodialysis cell pair compartments, a mathematical model needs to be based on both diffusion and convective mass transport equations in the compartments and on the, electromigration-based, ion transport through the membranes. The steady state salt ion flux through the membranes and the corresponding ion concentration distribution within the salt solution compartments of a reverse electrodialysis cell pair (in the absence of electrodes) was theoretically analysed by using two-dimensional finite element (FEM) modelling. Fundamental information on the effect of membrane thickness and fluid flow velocity was obtained. FEM simulations support the theoretical insight into reverse electrodialysis phenomena and thus assist in the planning/design of experimental work. The FEM approximation is superior with respect to a modelling of the combined effect of all complex and simultaneous ion transport mechanisms in the reverse electrodialysis cell pair compartments and ion conductive membranes. In fact, this first time reporting of a FEM modelling of a half cell pair obviously also includes the complex and dynamic drop in salinity gradient, between influent side and effluent side, over the height of the half cell pair compartments.

Keywords: Salinity gradient; Reverse electrodialysis; Finite element; Power; Model; Steady state; Flow; Concentration distribution; Diffusion; Electromigration