Electrodialysis desalination process in conditions of mixed convection

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ABSTRACT

An emergence of the gravitational convection in electromembrane systems (EMS) is experimentally detected with a number of methods. Gravitational convection, caused by density gradient due to concentration polarization, can presumably destroy the undisturbed layer and cause overlimiting electric current over EMS. But there are a number of experiments questioning the role of gravitational convection. The study is based on the two dimensional mathematical modeling of time-dependent nonisothermal transport of binary electrolyte in a desalination channel of EMS in intense electric current modes. The model developed by authors takes into account a combined effect of gravitational and forced convection, as well as Joule heating of the solution and a heat transfer through membranes. The model is based on Navier–Stokes, Nernst–Planck, and Fourier partial differential equations transformed by an original decomposition method to the system appropriate for computer simulation. Results of the simulation show the domination and the significant influence of gravitational convection on the ion transfer when Richardson number $Ri = Gr/Re^2 > 300$ (for horizontal oriented membranes channel) and $Ri > 1,000$ (for vertical).

Keywords: Mass transfer; Electromembrane system; Purification of water solutions; Water treatment; Forced convection; Gravitational convection; Mathematical modeling; Boundary value problems; Partial differential equations

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