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# Female mate choice in Aidablennius sphynx, a fish with paternal care for eggs in a nest

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*Document Version*
Publisher's PDF, also known as Version of record

*Publication date:*
1994

Link to publication in University of Groningen/UMCG research database

*Citation for published version (APA):*
Kraak, S. B. M. (1994). *Female mate choice in Aidablennius sphynx, a fish with paternal care for eggs in a nest*. s.n.

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Download date: 12-10-2022

# Summary

The Maxwell-Stefan equation for mass transfer, which is a more general form of both the Nernst-Planck equation and Fick's law, has been used to describe the unit operations electrodialysis and ion exchange. The parameters required to describe these unit operations have been obtained from empirical relations, equilibrium measurements, dialysis experiments, limiting current experiments, electrodialysis experiments and ion exchange experiments.

Besides the results for the unit operations, which will be discussed separately below, literature data concerning Maxwell-Stefan diffusion coefficients in aqueous electrolyte solutions have been collected. These data formed the starting point for the discovery of the existence of negative Maxwell-Stefan diffusion coefficients in electrolyte solutions and their consistence with the thermodynamics of irreversible processes.

## Ion Exchange

The work on the ion exchange process consisted of two parts. Firstly, at low external salt concentrations ($\leq 0.1$ mol/l), the ion exchange kinetics of systems involving ions with large differences in their ionic mobilities were investigated. At these low salt concentrations the mass transfer rate of the ion exchange process is controlled by the mass transfer resistance in the diffusion film on the outside of the ion exchange particle. It was shown both experimentally and theoretically, that the ion exchange kinetics for the NaCl/HCl and $CaCl_2$/HCl systems were asymmetric, due to the potential difference which was generated by the difference in the ionic mobilities of the two cations. In the case where the hydrogen ion (with the larger ionic mobility) was diffusing from the solution into the ion exchange resin, the electrical potential enhanced the mass transfer and vice versa.

Secondly, at high external salt concentrations (1 mol/l), the breakthrough curves of a packed ion exchange column using the NaCl/HCl system were investigated. At these higher concentrations, the ion exchange process is controlled by the mass transfer resistance inside the ion exchange particle. The aim of this project was to determine whether or not the breakthrough curves could provide useful information concerning the Maxwell-Stefan diffusion coefficients in ion exchange resins. It was found that although not all the diffusion coefficients could be obtained, useful information concerning the cation-resin and cation-cation diffusion coefficients could be obtained from the breakthrough curves. It should however be noted that accurate information concerning column hydrodynamics, particle size and especially equilibrium data is a prerequisite for the determination of accurate diffusion coefficients.

In general it can be concluded from the work presented in this thesis, that the Maxwell-Stefan equation provides a suitable description for the ion exchange process.

## Electrodialysis

The number of parameters required for the complete description of the electrodialysis process is large, and hence a number of independent experiment were used, so that reasonable estimates of all the parameters could be obtained. In the first part of the