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Characteristics of Ion-Exchange Membranes for Electrodialysis on the Basis of Irreversible Thermodynamics

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Abstract

Three transport quantities (electrical conductivity, apparent transport number, permeability coefficient) and the membrane thickness describe the performance of ion-exchange membranes in electrodialysis. The relationship between these parameters and the efficiency of energy conversion in that process is given. Two systems are discussed – with one membrane and with a pair of cation- and anion-exchange membranes. It is found that both systems are analogous and can be discussed in terms of the same equations.

The experimental data for a polystyrenesulfonate membrane and perfluorosulfonate Nation membranes in aqueous solutions of NaCl are presented. The maximum conversion of energy for these membranes is in the range of 0.6 to 0.9 (for $\bar{c} \leq 0.5$ mol/dm^3) and depends to a great extent on the concentration. At the high coupling, which these membranes show ($q > 0.97$), the further increase of conversion of energy can be achieved only by improving their electrical conductivity.

Introduction

The aim of this work is to present what irreversible thermodynamics can offer in the estimation of ion-exchange membranes intended for electrodialysis (*ED*). The basis of the paper are ideas comprised in [1] and earlier in [2].

In the frame of irreversible thermodynamics, three basic transport parameters characterizing an ion-exchange membrane are defined here:

- electrical conductivity, κ^*,
- apparent transport number of counterions, $\bar{t}_{1,app}$, and
- permeability coefficient, P^*.

As the basic unit of an *ED* stack is a pair of cation- and anion-exchange mem-