PROPERTIES OF ION EXCHANGE MEMBRANE IN LOW CONCENTRATION NaCl SOLUTIONS

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by

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Dedicated to my beloved daughter Feelanah

Certificate

This is to certify that the thesis entitled **"Properties of ion exchange membrane in low concentration NaCl solutions",** being submitted by Mr. Fasil Qayoom Mir to the Indian Institute of Technology Delhi, for the award of the degree of Doctor of Philosophy in Chemical Engineering, is a record of bonafide research work carried out by him. Mr. Fasil Qayoom Mir has worked under my guidance and supervision and has fulfilled the requirements for the submission of the thesis.

The results contained in this thesis have not been submitted in part or in full to any other university or institute for the award of any degree or diploma.

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Fasil Qayoom Mir

Abstract

Ion exchange membrane are exposed to low concentration salt solutions in many traditional applications like electrodialysis for desalination as well as in potential applications like reverse electrodialysis and microbial fuel cell. However, reported functional properties of commercial ion exchange membranes are determined in standard solutions of high NaCl concentration. Optimal design of these applications requires knowledge of effect of NaCl concentration (low values) and temperature on functional properties of ion exchange membrane. In this work, functional properties like limiting current density, counter-ion transport number (ionic selectivity) and resistance of a few commercial ion exchange membranes is determined in low concentration NaCl solutions.

Using chronopotentiometry, transport number of commercial cation (Selemion CMV and Neosepta CMX) and anion (Selemion AMV and Neosepta AMX) exchange membranes was determined. Transport number for the membranes didn't change measurably on increasing NaCl concentration from 0.017 M to 0.1 M. A new method of calculating variation of transport number with temperature from choronopotentiometry data was devised. Transport number decreased significantly (~20% for cation exchange and ~9% for anion exchange membranes) on increasing temperature by 20°C. Variation of transport number with temperature could be explained using a simple model which also provided value of Donnan potential. Donnan potential for the CMV, AMV, CMX and AMX membrane were found to be -411 mV, 324 mV, –311 mV, and 431 mV respectively.

Resistance of the membranes in low concentration NaCl solutions was determined using a modified scheme of impedance measurements. Resistance of all the membranes increased by an order of magnitude as the NaCl concentration was lowered from 0.5 M to

0.017 M. This is in contrast to the studies up to the previous decade reporting up to two-fold increase however similar to the very recent studies reporting an order of magnitude increase. Resistance of cation exchange membranes increased more than the anion exchange membranes. Variation of resistance with concentration could be explained very well using Kohlrausch law of conductivity which also provided value of the tortuosity of the membranes. Resistance of membrane exposed to aqueous solutions of different NaCl concentrations, which is the case in many applications, was also measured and the trend in experimental data could be explained very well using Kohlrausch law.

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