

Facilitation of Up-Hill Transport of Na⁺ Ion through Cation Exchange Membranes

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Summary

Characteristics and mechanism of up-hill transport for alkaline metal ions against their concentration gradients have been reported in detail in the report¹⁾ of Salt Science Research Foundation in 1994. In this study, for one of purposes to effectively concentrate and separate materials with ion exchange membranes, facilitation of the up-hill transport of Na⁺ ion through the cation exchange membranes was investigated under various conditions, and the mechanism of up-hill transport for the metal ions through the cation exchange membranes was reconfirmed.

The cation exchange membranes of two types such as PSA/PVA membranes prepared from poly(styrene sulfonic acid) (PSA) and poly(vinyl alcohol)(PVA) and ISBN/PVA membranes prepared from poly(isobutylene altanative co-maleic anhydride)(ISBN) and PVA were employed for the up-hill transport experiments of Na⁺ ion.

When one solution is basic and another acidic across a cation exchange membrane, transports of the up-hill transported metal ions against their concentration gradients will be significantly governed by (1)capacity of the cation exchange group which plays a role of fixed carrier, (2)denseness of the cation exchange membrane, (3)H⁺ ion concentration as a conjugated energy, and (4)behavior of the anion species of a pH adjusting reagent in the acidic side(A side).

In the case of (1), the increase in the concentration of fixed carrier increased the transport fraction of Na⁺ ion, but if the carrier concentration was too high, the transport fraction of Na⁺ ion was decreased due to a reverse diffusion of Na⁺ ion from A side to the basic side(B side) based on a remarkable swelling of the membrane.

In the case of (2), when the denseness of membrane was given by the heat treatment, the reverse diffusion of the up-hill transported Na⁺ ions was disturbed and consequently the transport fraction of Na⁺ ion was increased.

In the case of (3), the increase in the H⁺ ion concentration could keep a pH difference between the both sides for a long period and increased the transport fraction of Na⁺ ion.

In the case of (4), when three kinds of halogenated hydrogen, HCl, HI, HBr were used as a pH adjusting reagent, the transport fraction of Na⁺ ion was the order Cl⁻>I⁻>Br⁻ and was dependent on the size of hydrated radius of halogen ions. Also when benzene sulfonic acid and poly(styrene sulfonic acid) were employed as a pH adjusting reagent, the transport fraction, transport rate and transport time of the up-hill transported Na⁺ ion were significantly improved. These results were discussed from the viewpoints of an electric chemical potential gradient and transport mechanism.