Concentration of salts through various polymer membranes by up-hill transport

T. Uragami

Faculty of Engineering, Kansai University, Suita, Osaka, 564-8680, Japan

Cation exchange membranes with sulfonic acid groups and anion exchange membranes containing amino groups, insoluble in acidic and basic aqueous solutions, were prepared from poly (styrene sulfonic acid) (PSA) and poly (vinyl alcohol) (PVA) and chitosan (Chito) and PVA, respectively. Using the PSA/PVA membranes in a diaphragm cell, one side being adjusted to be acidic and the other basic, it was possible to transport Na^+ ions through the PSA/PVA membranes from the basic-side (B-side) to the acidic-side (A-side) against the concentration gradient of Na^+ ion between both sides of the PSA/PVA membrane. In the Chito/PVA membranes, Cl^- ions could be transported against its concentration gradient from the A-side to the B-side. Their up-hill transports of Na^+ and Cl^- ions were significantly influenced by the pH difference and electric potential difference between both sides of the membrane.

1. INTRODUCTION

Concentrations of salts by up-hill transport against their concentration gradients of Na^+ and Cl^- ions through cation- and anion-exchange membranes were investigated under various conditions and mechanisms for the up-hill transport of those ions are discussed. Furthermore, improvements of the up-hill transport efficiency were studied from the viewpoints of chemical and physical structure of the ion-exchange membrane, and electrostatic-chemical transport conditions.

2. EXPERIMENTAL

PSA was synthesized by the method reported in a previous paper[1]. Chito had free amino group of 92%. PVA, produced by Kuraray Co. Ltd., was an average degree of polymerization, 725 ± 25 and degree of saponification 88 ± 1 mol%. Transport experiments were carried out at 25°C under magnetic stirring, using a diaphragm cell consisting of two detachable parts.

3. RESULTS AND DISCUSSION

3.1 Up-hill transport of Na^+ ion

Changes in the concentration of the Na^+ ion with

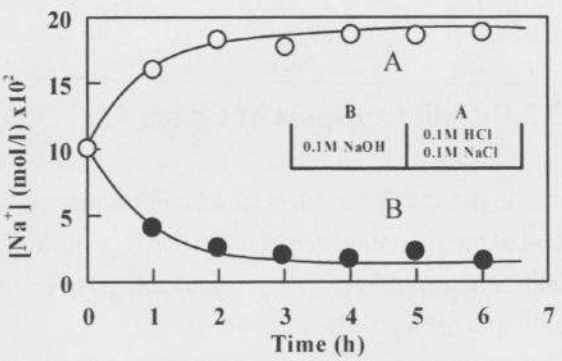

Figure 1. Change of the Na^+ ion concentration on both sides of the PSA/PVA membrane with time. Membrane, PSA/PVA = 2/3; temperature of heat treatment, 100°C, 3h.

time on the A- and B-side of the PSA/PVA membrane are shown in Figure 1, in which initial NaOH on the B-side was 0.1M and initial NaCl and HCl on the A-side were 0.1M, respectively. The concentration of the Na^+ ion on the A-side, which was acidic, increased; in contrast, that on the B-side decreased with time. Since the initial concentration of the Na^+ ion was the same on both A- and B-side, the increase of the Na^+ concentration on the A-side suggests up-hill transport of the Na^+ ion from the B-side to the A-side through the PSA/PVA membrane. As can be seen from Figure 2, up-hill transport fraction of Na^+ ion was significantly dependent on an initial pH on the A-side as an initial pH on the B-side was kept constant and that on the A-side was changed, and greater as pH difference between the A- and B-side was larger.

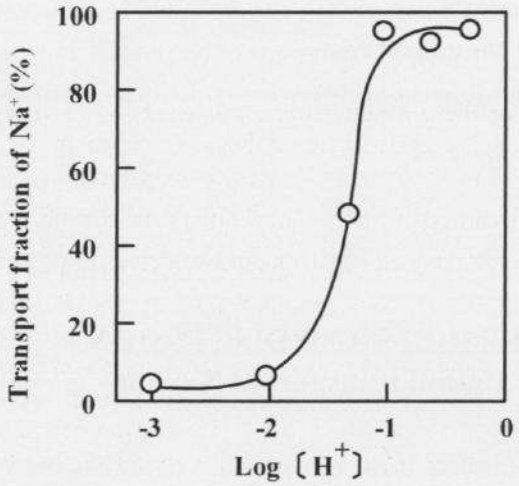

Figure 2. Transport fraction of Na^+ ion plotted against the initial H^+ ion concentration on the A-side.

3.2 Up-hill transport of Cl^- ion

As shown in Figure 3, in the Chito/PVA membrane, up-hill transport direction of the Cl^- ion was vice versa, and its transport fraction was remarkably governed by an initial pH on the B-side.

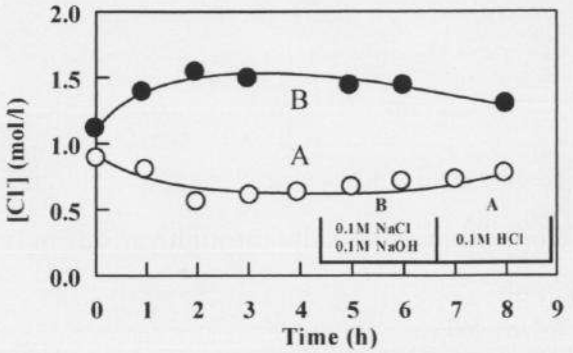

Figure 3. Change in the concentration of the Cl^- ion on both side of the Chito/PVA membrane.

In the up-hill of Na^+ and Cl^- ions by the PSA/PVA and Chito/PVA membranes, respectively, it was found that sulfonic acid and amino groups in those membranes played an important role in fixed carriers. Mechanisms for the up-hill transports of Na^+ and Cl^- ions through the PSA/PVA and Chito/PVA membranes, respectively, are discussed in detail from the viewpoint of an electrostatic interaction between the fixed carrier and the transporting ion. The fact that the up-hill transport of those ions did not depend on only the fixed carrier made using a neutral membrane from PVA clear, and it was suggested that an electrostatic-chemical potential gradient between both sides of the membrane was very important. Furthermore, in order to improve the efficiency in the up-hill transport of Na^+ and Cl^- ions, the effects of the carrier concentrations in the PSA/PVA and Chito/PVA membranes, the membrane denseness and the electrostatic-chemical potential gradient were investigated, and their mechanism is also discussed in detail.

REFERENCES

1. T. Uragami, M. Fujimoto and M. Sugihara, Polymer, 22 (1981) 240.