

## Membrane Properties of Composite Charged Membrane Consisting of Charged Mosaic Membrane and Ion Exchange Membrane

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### Introduction

Concentration or desalination of seawater by electro dialysis(ED) using ion exchange membranes has been established technologically and the technique to get salts or water from seawater, water containing minerals, waste solution and etc has been widely used[1]. Furthermore, recent development of electrodeionization system(EDI), which consists of ion exchange membrane, and ion exchange resin has provided ultra pure water to our society. In such two systems the ion exchange membrane plays an important role in relation to ion transport. Up to the present the technique of ED or EDI have been applied to get pure water or to remove contamination but the method is not always satisfied on practical application. There is a limit of current in interfacial surface between membrane and solution, so called the limiting current density, when one conduct the electricity. This phenomenon, however, is practically troublesome issue but is fundamentally interesting. In general concentration polarization takes place and finally at this limiting current the water splitting occurs in the electro dialysis system and the proton and hydroxide ion generated by water splitting are consumed as regeneration agents to renew the resins in EDI system.

Unsolved problem has been still remind regarding diffusion layer near the interface between the charged membrane and the surrounding electrolyte solution as mentioned above. In the diffusion layer, the ionic behavior is known to be quite different from that in bulk solution. Our goal is to make clear about ion transport near the surface of charged membrane. If such a problem would be solved, membrane science will advance forward with great step.

As a fresh method to investigate such phenomena the electrochemical procedure in this study was adopted. The chronopotentiometry which can follow the rapid transport in the interface of membrane is an electrochemical characterization method that detects the electric potential response of a system to an imposed current.

### Experiments

**Membrane:** In this study the composite charged membrane consisting of charged mosaic membrane and normal cation or anion exchange membrane was used. The preparation of composite charged membrane is follow: on the charged mosaic film the solution including either one

of two charged components of mosaic membrane was cast and laminated. The schematic picture is indicated in Fig.1. The top is the cation or anion exchange membrane layer, the middle is charged mosaic membrane layer and the bottom is supported layer which has no any function as membrane but gives only reinforcement to membrane.

**Measurement:** The composite charged membrane was fixed between two half glass cells and two Ag/AgCl electrodes were introduced into each cell as shown in Fig.2. Measurement in 0.01M KCl solution was carried out by Potentiostat/Galvanostat instrument(HOKUTO DENKO HSV-100) and mainly chronopotentiometry was examined with regard to four kinds of membranes, that is, cation-, anion- cation composite- and anion composite membranes. An example about anion exchange membrane is indicated in Fig.3. In Fig.3 as the applied current increased near and above the limiting current density, it was observed that the corresponding potential suddenly changes at certain time. The time at which the potential changes was defined as transition time,  $\tau$ .

## Results and Discussion

The results were indicated in Fig.4. in which the relations between the transition time,  $\tau$  in Fig.3 and the square of current density,  $i^2$  were given. The relation was linear and when the normal charged membranes, that is, cation or anion exchange membrane with composite charged membrane were compared at the same current density, the transition time,  $\tau$  of composite charged membrane was smaller than that in ion exchange membrane as shown in Fig.4. This means the ion movements near interface of composite charged membrane are active or in other words the diffusion layer near the interface is thinner than that of normal ion exchange membrane. If this is true, the composite charged membrane is more effective in practical case such as electrodialysis because the resistance of interface between membrane and solution reduces. In addition, the slopes of plots in Fig.4 also would give the information about the ionic behavior near interface. To know the phenomena in Fig.4 in more detail, we tried to analyze the results on electrochemical basis.

According to the literature[2], the transition time,  $\tau$  in transition layer can be related to transport number as follows:

$$\tau = \frac{\pi D_{KCl}}{4} \frac{1}{i^2} \left( \frac{C_0 F}{t_i - t_i} \right)^2 \quad (1)$$

Eq.(1) also is similar to well-known Sand equation in electrochemistry.

From consideration about the limiting current density, the thickness of diffusion layer,  $\delta$  can be obtained as the following classical equation.

$$\delta = \frac{FC_0 D}{i(t_i - t_i)} \quad (2)$$

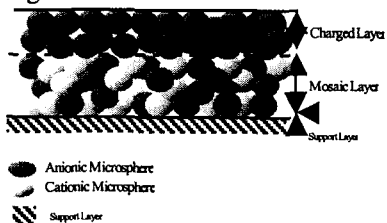
Eq(1) and Eq(2) being combined, one can get the expression regarding diffusion layer. Estimated

diffusion layer thickness,  $\delta$  were given as a function of current density in Fig.5. As it is apparent from the results,  $\delta$  of composite membrane is smaller than that of normal ion exchange membrane. This result is very important. If the composite charged membrane is employed instead of normal ion exchange membrane in electrodialysis, it can be anticipated that the thickness of diffusion layer will be reduced and the limiting current density will increase. As a result, production using electrodialysis will be advanced further.

## References

- [1] T.Sata, Ion Exchange Membranes, Chapter 6, The Royal Society of Chemistry (2004).
- [2] J.J.Krol, M.Wessling, H.Strathmann, Chronopotentiometry and overlimiting ion transport through monopolar ion exchange membranes, J.Membr.Sci., 162(1999) 155.

Fig.1. Schematic Model



Schematic Model of Composite Membrane

Fig.3. Chronopotentiometry of

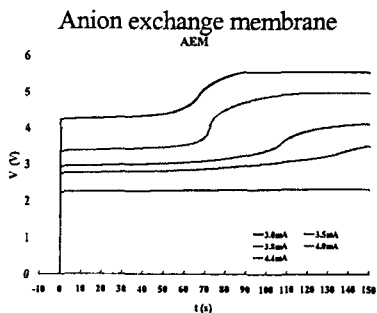


Fig.5. Diffusion Layer

Dependence of diffusion layer thickness on current density

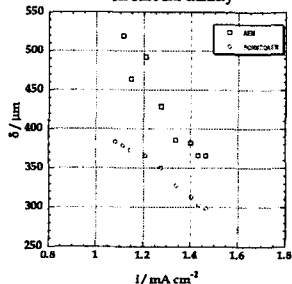


Fig.2. Measuring System

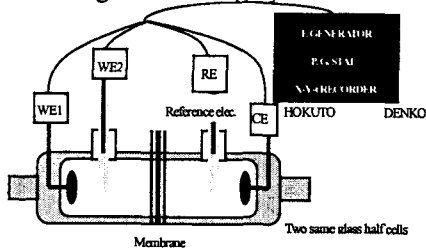


Fig.4. Transition Time

