

# MODEL SIMULATION OF DEGRADATION OF OXYGEN-DIFFUSION CATHODE FOR CHLOR-ALKALI MEMBRANE CELL

Masao Sudoh, Kenji Nabekura,  
Ipppei Osaki and Keiichi Okajima

Department of Materials Science and  
Chemical Engineering, Shizuoka University  
3-5-1 Johoku, Hamamatsu, Shizuoka 432-8561, Japan

A novel soda electrolysis with oxygen depolarized cathode has been attracted recently because of its energy-saving of 30 % and also reduction of CO<sub>2</sub> emission. The NET-G process in Japan has succeeded scale-up of the gas-diffusion electrode and enhancement of its durability for several-years-operation.

To qualify electrode properties, alternate current impedance method and acceleration test were carried out. The oxygen-diffusion cathode was suffered from inclusion of the alkaline electrolyte into the pore of the porous electrode, which resulted in shift-up of the cathodic overpotential. The electrode coated with the charged membrane, such as Nafion, positively or negatively charged ionomer, was found to enhance its stability. Thin ionomer membrane suppressed the progress of wettability of the electrode and the degradation of electrode activity.<sup>1-3)</sup> The electrolyte inclusion into the electrode was confirmed to relate with the degradation.

The objective of this work is to simulate degradation phenomena of the cathodic polarization with model behavior of the electrolyte in the porous electrode.

The oxygen-depolarized cathode consists of a reaction layer loaded with catalyst and a gas-diffusion layer. In the gas-diffusion layers, oxygen transports according to Knudsen diffusion because of the pore-size less than 0.2 μm. The electrolyte penetrates in the pore of the porous electrode, and forms the thin layer on the electrode surface in the pore. With the progress of the electrolytic operation, the electrolyte gradually penetrates to inner side of the electrode, and the electrolyte film becomes thick up-to the flood condition.

A three-phase model of the gas-diffusion electrode shown in Fig.1 was adopted to simulate the cathodic polarization with considerations of the increase in film thickness (Model A) and the penetration of the electrolyte (Model B), as depicted in Fig.2. Figure 3 shows the simulation result between overpotential and current density for different holdups of the electrolyte in the pore. The cathodic overpotential was shifted up by the increase in the thickness of the electrolyte rather than the electrolyte penetration into the porous electrode.

- 1) M. Sudoh, T. Kondoh, N. Kamiya and K. Okajima, *J. Electrochem. Soc.*, **147**, 3739-3744 (2000).
- 2) K. Okajima, K. Nabekura, T. Kondoh, Y. Shibuya and M. Sudoh, Meeting Abstract of ECS Centennial Meeting, No.1119 (2002).
- 3) M. Sudoh, K. Okajima, T. Kondoh, K. Nabekura, 53rd Annual Meeting of International Society of Electrochemistry, Symposium 7, 5410 (2002).

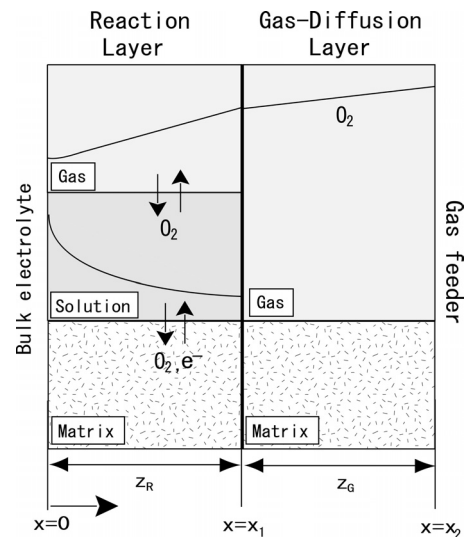


Fig. 1 Three-phase model of gas-diffusion electrode.

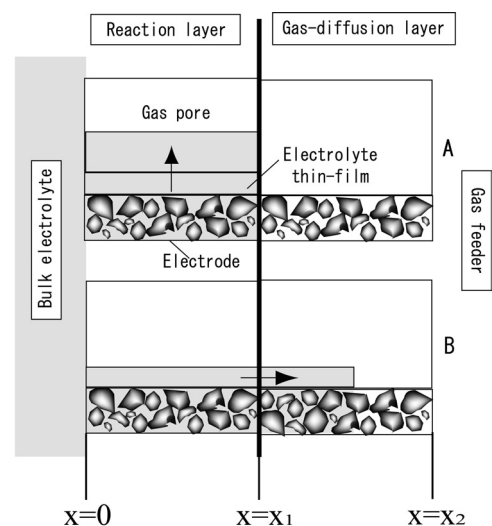


Fig. 2 Schematic diagram of degradation model of gas-diffusion electrode.

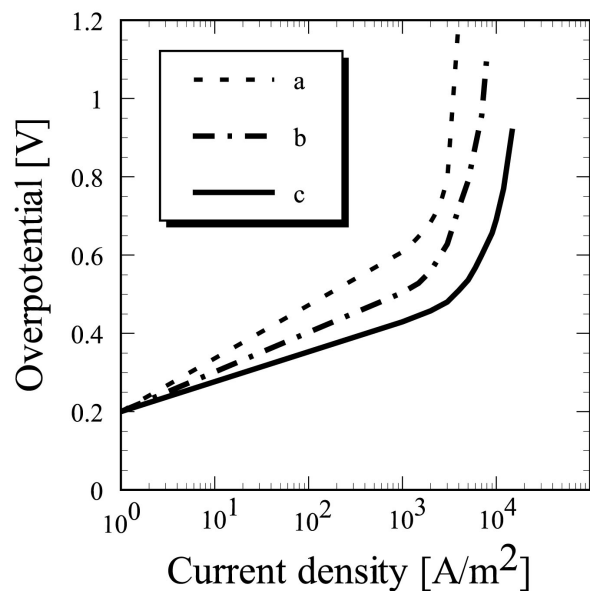


Fig. 3 Simulated overpotential vs. current density as a function of liquid hold-up of the reaction layer with values; a)  $4.0 \times 10^{-3}$ , b)  $3.0 \times 10^{-3}$  and c)  $1.5 \times 10^{-3}$ .