Gas Permeability and Polarization Behaviors of Nickel-based Air Electrodes

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We have recently developed a bi-functional air electrode consisting of nickel and PTFE powder for rechargeable uses [1]. The electrode reactions are oxygen evolution and reduction during charge and discharge, respectively, and the permeability of oxygen in the electrode importantly affects the polarization behaviors. In fact, the polarization during charge and discharge depends on the preparation condition of the air electrode, which governs the macro- and micro-structures of the electrode. However, the gas permeability of the nickel-based air electrode has not been quantitatively evaluated, and its relationship to the polarization has been unknown. In this study, we developed the evaluation system of gas permeability of air electrodes, and applied it for the electrodes prepared in different conditions. Further, the polarization behaviors of each electrode were measured, and the relationship between the gas permeability and the polarization was examined.

The air electrode was composed of two kinds of nickel powders with and without the pretreatment to modify the surface with catalysts for oxygen evolution and reduction and PTFE powders. The pretreatment was carried out by impregnating nickel powders into the aqueous solution containing H_2IrCl_6 and H_2PtCl_6, drying at 393K, and heating at 743K so as to partially cover the surface of the nickel powder with platinum and iridium oxide. The modified and unmodified nickel powders were mixed with PTFE powders, and the mixture was molded on a nickel mesh sheet to form a disk. Then, the disk was heated at 643K for 12.5 min. under nitrogen atmosphere.

Figure 1 shows the schematic drawing of the evaluation system of gas permeability developed in this study. Initially, the linearity between the gas flow rate and the pressure difference for both sides of an air electrode was confirmed, and then the gas permeability of each electrode was compared using the gas flow rate when the pressure difference was 10 hPa.

In polarization measurements, the air electrode was mounted in a self-made PTFE holder, which allows the electrode to contact to an electrolyte on one side and to open to air on the other side. The electrolyte was a 7 mol dm^{-3} KOH solution. A platinum counter electrode and an HgO/Hg reference electrode were used. The electrode potentials for oxygen reduction and evolution at 100 mA/cm^2 were measured at 333K.

Figure 2 shows the relationship between the gas permeability and the oxygen reduction potential obtained for the air electrodes prepared in different conditions, in which the weight ratios of PTFE and nickel powders, the molding pressure, and the thickness of the electrode were varied. It can be easily understood that the oxygen reduction potential becomes more negative with decreasing gas permeability (in circle indicated). In the preparation conditions, the weight ratio of PTFE importantly affected the gas flow rate, resulting in the apparent variation in oxygen reduction potential. The molding pressure was also an important factor to determine the gas permeability. The relationship between the gas permeability and the polarization for oxygen evolution was further examined in this study, and the results will be also shown.

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Reference

1. M. Morimitsu, S. Ikeda, T. Ogawa, M. Matsunaga, S. Taniguchi, M. Takahashi, 204th ECS meeting, Abs# 218 (2003).

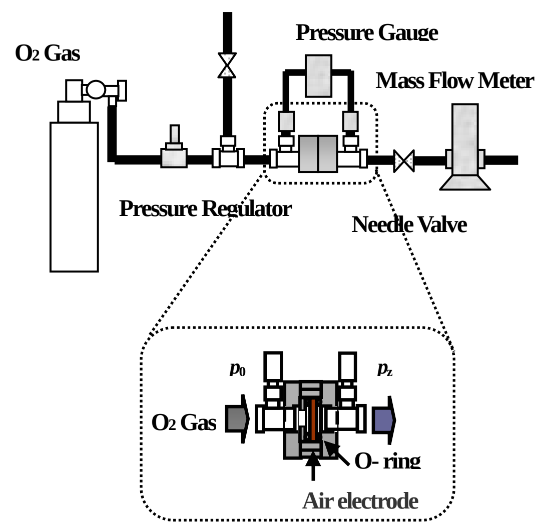

Fig. 1 Schematic drawing of the evaluation system of gas permeability.

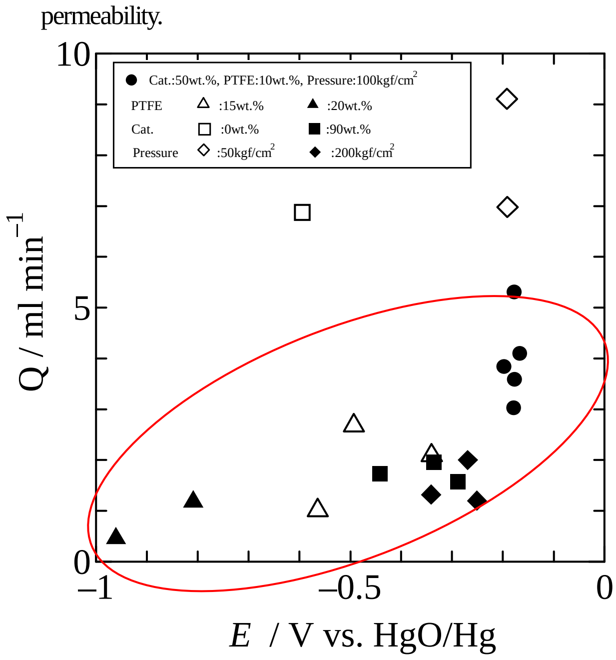

Fig. 2 Relationship between the oxygen reduction potential at -100 mA/cm^2 and the O_2 flow rate under $\Delta p = 10$ hPa.