Water-repellency Effect of Graphite Felt used for Trickle-bed Cathode to Electrochemically Produce Hydrogen Peroxide Through Reduction of Oxygen

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Hydrogen peroxide is a useful material that can bleach pulp without forming chlorinated organic compounds. It is used in other processes such as advanced waste-water treatment. Hydrogen peroxide was produced by electroreduction of oxygen in an alkaline solution using the trickle-bed electrode. The trickle-bed electrode of graphite felts with oxygen gas was used for an on-site electrochemical production of hydrogen peroxide. Graphite felts have some advantages of low cost and easy maintenance for the electrode exchange, however they have the disadvantage of lower current efficiency compared to the gas-diffusion electrode.[1] In the felt cathode of gas-liquid flow when the gas flow rate was extremely larger than the liquid flow rate, the felt surface was considered to be partially wet. The effective surface area of the electrode was found to be several percentages of an apparent surface area of the felt.[2] To improve the electrode performance of the felt cathode, the water-repellency was processed to the felts using poly(tetrafluoroethylene) (PTFE) dispersion. The content of PTFE in the treated felt was changed from 0 to 60%.

Fig.1 shows a schematic diagram of trickle-bed electrode. To evaluate the effective surface area of the electrode, two approaches was made in base of the model simulation of the overpotential profile in the cathode bed and Nyquist plot by alternate-current impedance.

Fig.2 shows the effect of PTFE content on current efficiency. Since the content of PTFE affected the hydrophobicity of the surface of the felt, the wettability was changed with the PTFE treatment. Thus the current efficiency of producing hydrogen peroxide maximized for the felt of the PTFE content of 15%. The current density achieving the current efficiency more than 90% was increased up to 800 A/m^2 using the felt of PTFE 15% treatment compared to the untreated felt. This might be caused by decreasing thickness of the liquid film on the felt and the enhancement of the solubility of oxygen in the PTFE particle.

Fig.3 shows the simulation of overpotential profile in felts of different PTFE contents at 300 A/m^2. The overpotential had its minimum negatively at 15% PTFE felt. Fig.4 shows the effect of PTFE content on capacity of double-layer capacitor and the effective surface area of the electrode. The effective surface area of electrode had its maximum at 15 % of PTFE content and its tendency was just similar with the change in the capacity of the double-layer capacitor.

[1] N.Yamada, T. Yaguchi and M. Sudoh, *Electro-chemistry*, **69**, 154-159 (2001)
[2] M. Sudoh, M. Yamamoto, T. Kawamoto, K. Okajima and N. Yamada, Proceedings volume 99-39 of ECS, pp.207-218 (2000)

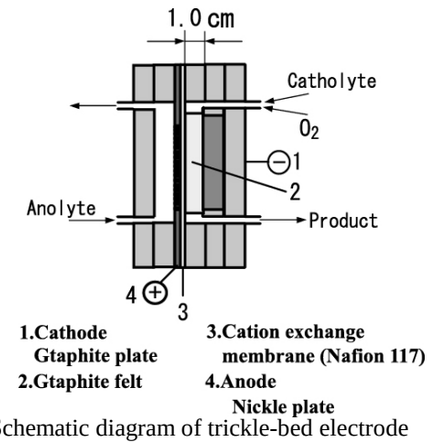

Fig.1 Schematic diagram of trickle-bed electrode

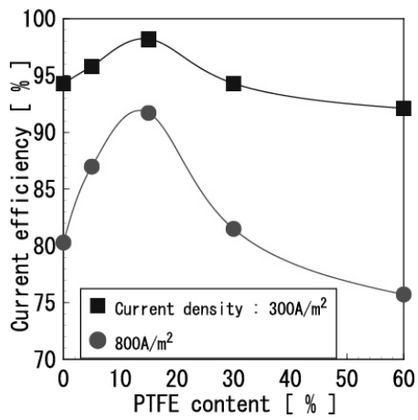

Fig.2 Effect of PTFE content on current efficiency

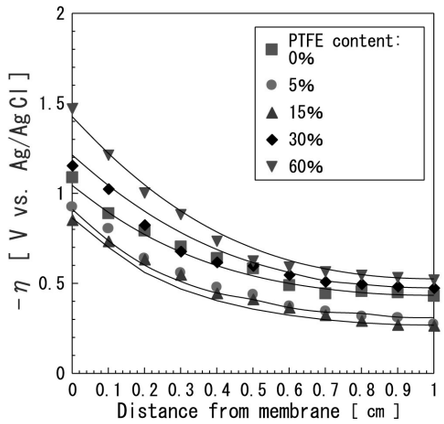

Fig.3 Simulation of overpotential profile in bed at 300 A/m^2

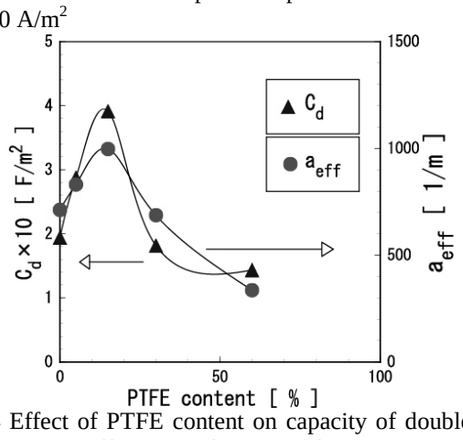

Fig.4 Effect of PTFE content on capacity of double-layer capacitor and effective surface area of electrode