Lithium-Air Rechargeable Batteries Using MnO_2-Carbon Based Air Electrode

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Lithium-Air Rechargeable Batteries Using MnO_2-Carbon Based Air Electrode

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Rapid growth of portable electronic devices in the market for various application leads to the development of high energy-density storage devices. Recently, metal-air batteries have been attracting much attention because of its extremely high specific capacity. The reason for such high specific capacity is that metal with high capacity was used as an anode electrode and there is no use of active material for cathode and hence, these batteries are extremely larger capacity than that of the current Li-ion battery. Among the various metal air battery system, Li-air battery is the most attractive one since the cell discharge reaction between Li and oxygen to yield Li_2O ($4Li + O_2 = 2Li_2O$) has a theoretical discharge voltage of 2.91V and theoretical specific energy of 5200 Wh/kg. In practice, actually oxygen is not stored in the battery and the theoretical specific energy excluding oxygen is 11140 Wh/kg, which is much higher than that of all advanced batteries proposed and even higher than that of fuel cells. Abraham and Jiang reported a Li-air battery using nonaqueous electrolyte [1]. However, due to low oxygen solubility in non aqueous electrolyte, the power density of Li-air battery using non aqueous electrolyte is low [2-3]. In the Li-air batteries, the non-aqueous electrolyte at the anode side is used in order to eliminate the dangerous reaction between metallic lithium and water. Recently, Li-air rechargeable battery was reported by using MnO_2 for air electrode [4]. In this study, we have investigated charge and discharge property of this cell and the electrode reaction was analyzed. For discharge process, it seems like that Li_2O is formed during discharge, however, for the charge, high potential of 4.2V is requested.This seems to be a result of formation of Li_2CO_3.

In the present work, the electrochemical characterizations were carried out using swagelok type cell. The cathode was prepared by casting a mixture of Ketjen black carbon, EMD (electrolytic manganese oxide) and PTFE (poly tetra fluoro ethane) (mol ratio of 85:5:10) and then mixture was pressed onto a stainless steel mesh and lithium foil was used as an anode electrode separated by a porous polypropylene film (Celgard 3401). The cell was gas tight except for the stainless steel mesh window that exposed the porous cathode to O_2. The electrolyte used was 1M LiTFSI-EC:DEC (3:7 by volume) (lithium bis (trifluoromethanesulfonyl) imide- ethylene carbonane: diethylene carbonate) supplied by Kishida Chemical Co. Ltd.,. Charge-discharge performance was carried out at the voltage range of 4.5V-2.0V at a constant current of $0.1 mA/cm^2$.

Figure 1 shows the charge discharge curves of lithium/air battery using MnO_2-carbon electrode. It shows that the initial discharge capacity of 1758mAh/g during the first cycle which is similar with that reported by Bruce et al [4]. Further charge discharge measurement shows the capacity increased to 1915 mAh/g. However, much larger charge potential is requested for achieving the reversible capacity during second cycles.

Figure 2 shows ex-situ XRD of porous KB:MnO_2:PTFE (85:5:10) electrode before charge and after discharge to 2.0V. Ex-situ XRD of KB:MnO_2:PTFE (85:5:10) electrode shows the diffraction peaks from each component. After discharge to 2.0V, ex-situ XRD pattern of KB:MnO_2:PTFE (85:5:10) electrode shows a sharp peak around 33.8°, suggesting the formation of Li_2CO_3. Therefore, high charge potential requested could be assigned to a decomposition of Li_2CO_3. During the charge process, ketjen black carbon reacts with oxygen to form Li_2CO_3 which reduce the cycle life of Li-air battery. On the other hand, when we used Pd/MnO_2 for cathode, charge and discharge potential of 3.7 and 3.1V, respectively was observed. Therefore, higher reversibility was obtained by modifying air electrode with Pd.

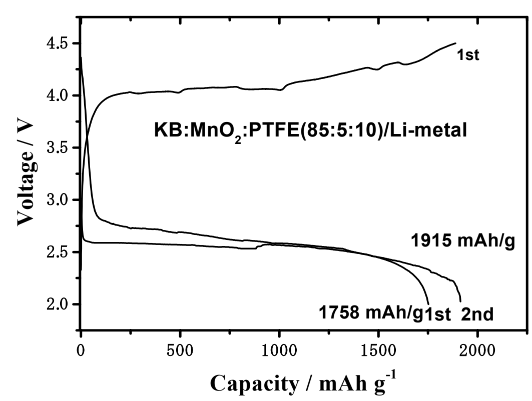

Figure1.Charge discharge curves of KB:MnO_2:PTFE (85:5:10) vs. Li at the voltage range of 4.5V-2.0V.

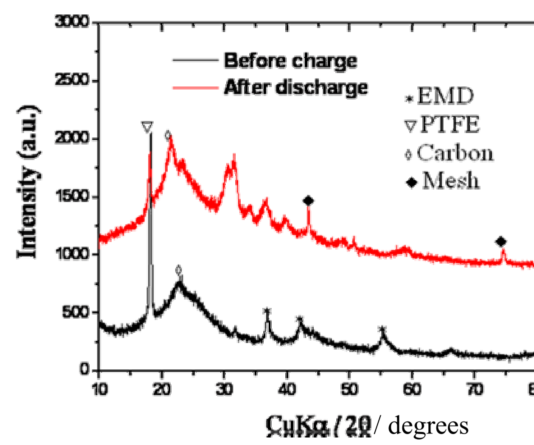

Figure 2 Ex-situ XRD of KB:MnO_2:PTFE (85:5:10) electrodes before charge and after discharge to 2.0V.

Acknowledgements
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References

[1] K. M. Abraham and Z. Jiang, J. Electrochem. Soc., **143**, 1 (1996).
[2] J. Read, J. Electrochem. Soc., **149**, A1190 (2002).
[3] J. Read, K. Mutolo, M. Ervin, W, Behl, J. Wolfenstine, A. Driedger, and D. Foster, J. Electrochem. Soc., **150**, A 1351 (2003).
[4] T. Ogasawara, A. Debart, M. Holfazel, P. Novak and P. G. Bruce, J. Am. Chem. Soc., **128** (4), 1390 (2006).