Investigation of noble metal catalysts as a cathode for Li-air battery

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**ABSTRACT**

Noble metal catalysts for oxygen reduction reaction were studied for cathode of Li-air battery. The electrochemical performance and impedance behavior were investigated for cathode sputtered with platinum or gold. Gold catalyst shows smaller overvoltage in oxygen reduction reaction. Constant current discharge shows stable cell voltage up to 10 hours for both catalysts. The impedance spectra typically consist of several semicircles followed with one capacitive response. The semicircles correspond to charge transfer or ohmic resistance in anode and electrolyte. The capacitive response is considered to stem from oxygen reaction which is smaller in gold cathode.

**INTRODUCTION**

With an environmental problem, electric vehicles attract attention in the automotive industry. Electric vehicles powered with rechargeable batteries have a severe limitation in their driving range. Maximum energy density of practical Li-ion batteries is estimated to be 250 Wh/kg, which is not enough to achieve a similar driving range by gasoline-fueled combustion engines. Accordingly new battery system which produces high energy density is strongly requested. Li-air batteries are one of the post-lithium ion batteries and deliver theoretical energy density of about 3500 Wh/kg. This battery currently uses organic liquid electrolyte such as carbonate-based solution. The battery with organic liquid electrolyte generally has a risk of fire, explosion, liquid leakage, solvent depletion and so on. To avoid these, solid electrolyte is tried to use in place of liquid counterpart in this study. Our Li-air battery eventually has a lamination of battery components which can be described as Li metal / polymer electrolyte / Li_{1.35}Ti_{1.75}Al_{0.25}P_{0.9}Si_{0.1}O_{0.9} (LTAP) / noble metal catalyst / air. The biggest problem of the battery is low rate performance. We have tried to develop a good catalyst for oxygen reaction at air cathode and thus, enhance power density of the battery. To form a good interface with the solid electrolyte, noble catalyst is sputtered on LTAP. Electrochemical properties of the cathode with noble metal catalysts were investigated.

**Experimental:**

Polymer electrolyte(PEO_{18}LiTFSI) was prepared from mixture of PEO, LiTFSI, BaTiO_{3} in acetonitrile for 10 h stirring under Ar gas, and drying for 10 h at 110 °C. Noble metal catalyst was sputtered on the LTAP masking 5 lines and 20 lines for 5 minutes under the vacuum. Li metal and PEO_{18}LiTFSI and LTAP sputtered with noble metal catalyst was sealed into an Al lamination envelope leaving a cathode surface open to air. Constant current discharge was used to study cathode performance. Cell resistance was analyzed by impedance spectroscopy.

**RESULT AND DISCUSSION**

Figure 1 shows discharge curve of the cell using Pt and Au as a cathode catalyst at 60 °C. Both catalysts could be discharged for 10 h. Overvoltage of Pt is larger than Au. Figure 2 shows impedance of after 1 h and 10 h of discharge. In both cases, capacitive response at low frequency region decreases with time. The results suggest that reaction speed is improved after a certain time of discharge. The total resistance is larger in case of Pt. With a viewpoint of impedance, Au is superior to Pt as a catalyst of cathode. However, OCV of Pt is higher than Au catalyzed cathode. The both cells using Pt and Au as air-electrode could be discharged for 4 hrs. The cell using Pt as air-electrode could be charged and discharged for 4 hours(Fig. 3). The cell using Au as air-
electrode could be discharged for 4 hours, but only 50% could be charged. It is necessary to investigate in details oxygen reaction mechanism on these catalysts.

**Fig. 1**: Time and Voltage curve at 60° for 10 h using Pt and Au.

![Time and Voltage curve at 60° for 10 h using Pt and Au.](image)

**Fig. 2**: Impedance of cell after 1 h and 10 h using Pt and Au.

![Impedance of cell after 1 h and 10 h using Pt and Au.](image)

**Fig. 3**: Charge and discharge property using Pt and Au air electrode.

![Charge and discharge property using Pt and Au air electrode.](image)

**Conclusion:**

The cell resistance depends on the number of sputtered lines. smaller number of lines, bigger air-electrode resistance was observed. However, larger number shows smaller resistance. The cell using Pt as air-electrode could be charged and discharged for 4 hrs. The cell using Au as air-electrode could be discharged for 4 hrs, but only 50% could be charged. The mechanism of air-electrode reaction will be revealed in further study on the effect of electrode structure and materials.

**REFERENCES**