Design of Magnesium-Air Battery for the Optimization of Voltage Output

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Abstract. It is well known the voltage output of magnesium air battery is low against volume of the battery. There is a lot of research being done on magnesium alloying to overcome the corrosion of metal and on the improvement of power of the battery, but there is no study on the optimization of the voltage output of the battery. In this study, various experiments are conducted to optimize the voltage output. Experiments were designed to see a change in voltage output with varying gap distance and to understand a relation between voltage output and concentration of electrolyte.

Introduction

Generation of energy is necessary for human being to live. And most of the energy used by humans is made from the fossil fuels. However, the use of fossil fuels causes the severe environmental pollution and the fossil fuels will run out in decades. These facts indicate the need for new forms of clean energy to replace fossil fuels. Due to the high specific energy, metal-air batteries are emerging as candidates to replace fossil fuels [1,2,3,4,5].

Among metal-air batteries, magnesium-air battery is considered environmentally friendly because of their use of salt water as an electrolyte and high value of magnesium hydroxide, a byproduct. Furthermore, magnesium air battery is receiving attention because magnesium has the property such as the low density, high chemical reactivity, high theoretical specific energy, high theoretical energy density (3.8Ah/cm\textsuperscript{3}) [6,7,8]. Besides, magnesium is also the one of the most abundant metals on the Earth. Despite these benefits of magnesium, however, there is a need to overcome many barriers to the battery development such as the improvement of corrosion, discharge property and etc. [9,10,11].

One of the biggest problems with using magnesium cells is voltage output. In other words, the problem is that the voltage output to the volume of the battery is relatively smaller than other batteries. In this paper, the relationship between the concentration of the electrolyte and the voltage output and the variation of the voltage output due to the variation in the distance between the cathode and the anode to optimize the voltage output were discussed.

Experimental

In this study, plate of AZ31 (supplied by Haiyang, South Korea) alloy was used as the Magnesium air battery anode. Sodium Chloride was used as solute of electrolyte (supplied by DAEJUNG Chemicals, Assay: 99.9%). The magnesium air battery cathode was supplied by Ions Lab, South Korea. The voltage output was observed by charge and discharge test system (WBCS3000M1, WonA Tech, South Korea).

Result and Discussion

Relationship between the Gap Distance and the Voltage Output

To investigate the variation of the voltage output as the gap distance between the anode and the cathode, 5A current has been applied to magnesium air battery. The gap distance was varied from...
0.5mm to 4.5mm and the concentration of NaCl in H2O was 16wt.%. (Fig.1) The voltage output was varied little from 0.5mm to 1.5mm. Although there is a decrease of voltage output from 1.5mm to 3.5mm, it can be interpreted that the performance of about 90% relative to the result of section 1 is within the measurement error range. However, the voltage output is significantly reduced as the gap distance exceeds 3.5mm.

![Figure 1. Scheme of a common magnesium air battery.](image)

In a cell, the reaction occurs as in (2) below. The negative ion (OH⁻, hydroxide) produced by this reaction is transferred to the anode through the electrolyte and reacts with the metal (Mg-3%Al-1%Zn, AZ31) to produce magnesium hydroxide and electrons. However, as the gap distance increases, higher internal resistance makes it difficult to move the negative ion through the electrolyte to the anode (Fig. 3). This in turn results in a reduction in the voltage output of the magnesium air battery and a reduction in the power of the battery.

Anode: \( \text{Mg} + 2\text{OH}^- = \text{Mg(OH)}_2 + 2e^- \) \hspace{1cm} (1)

Cathode: \( \text{H}_2\text{O} + 1/2\text{O}_2 + 2e^- = 2\text{OH}^- \) \hspace{1cm} (2)
Relationship between the Gap Distance and the Voltage Output

The voltage output of the battery was measured, varying the concentration of the electrolyte. The current was 5A and the gap distance was 0.5mm. The concentration of NaCl in H2O was varied from 10wt.% to 26wt.%. The voltage output at 18wt.% showed the highest value, and as the concentration increased, the output voltage tended to decrease. In general, increased concentration of electrolyte leads to increased electrical conductivity. Further research is needed on these findings.
Summary

The voltage output optimization of magnesium air battery was investigated in terms of gap distance and concentration of electrolyte. The increase in distance affects the reduction of the output voltage by increasing the internal resistance in the movement of the anions in the electrolyte. The optimum gap distance range is 0.5mm-1.5mm.

The voltage output is maximum at a concentration of 18wt.%. However, this shows a different pattern from the trend of conductivity caused by the solubility, and further research is expected.

The amount of water decreases as the battery’s reaction progresses. This in turn leads to an increase in electrolyte concentrations. Thus, controlling the change in the electrolyte concentration of the battery being reactive will also be a challenge in optimizing the voltage output.

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References


