Original Research Article

Copper-Zinc Battery's Performance with Different Electrolytes

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Abstract: This research evaluates how different electrolytes affect the voltage output of a battery. As one of the few types of devices capable of storing electrical energy, batteries are extremely efficient and reliable. They are widely adopted in a great number of devices, hence they are important to our daily life. How to construct better batteries will always be one of the most crucial challenges of our developments in energy. In this research we tested two different salt solutions, NaCl solution and KOH solution, on a Cu-Zn cell to see which works better.

Keywords: NaCl Electrolyte; KOH Electrolyte; Cu-Zn Battery; Effect of Different Electrolytes on Battery Voltage Output

1. Introduction

The Copper-Zinc battery[1] adopts an electrolytic cell structure. It is easy and cheap to produce. Advantages of a Cu-Zn battery include scalability, long life, efficiency, and abundance of materials to produce them. Although Cu-Zn batteries offer unique advantages, they do have a major drawback: lacking the ability to electrically recharge because Zinc is not easily oxidized. To charge such a battery, the ions inside it have to be changed, including the electrodes. It is definitely not a cheap alternative but certainly doable. Instead of searching for a rechargeable method, I will focus on comparing different electrolytes – In this case, a Sodium Chloride solution and a Potassium Hydroxide solution. A typical battery of this kind utilizes the potential[2] difference between two different metals to produce electricity through a built-up cell voltage. For instance, a setup with Copper and Zinc electrodes should theoretically produce 1.1 volt in open circuit voltage for electricity, if we analyze the theoretical standard potentials for Copper and Zinc.

In this research paper, we use home-available tools and common materials to construct a Copper-Zinc battery. The idea here is to investigate the role of the electrolyte on the battery cell voltage in case of variations from 0.8V to 1.2V, as suggested by our experimental data. As an outcome of this research paper, we will gain first insights on whether such a battery can be made at home, how effective it is, and what can be done to enhance their performance. The two electrolytes we tested are a NaCl solution and a KOH solution.

Figure 1 shows the structure of the Cu-Zn battery used in this research: a bridge insulates and suspends stripes of Copper and Zinc, and hangs onto the rim of a beaker. This diagram shows how simple it is to construct a Cu-Zn cell, which is a great advantage.

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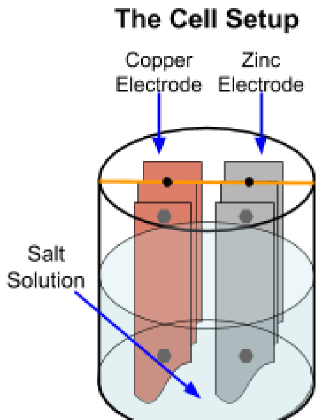

Figure 1

Note: We excluded the multimeter/voltmeter from the diagram concerning simplicity and neatness of it. In our case, we connected the positive lead to the Copper stripes and negative lead to the Zinc stripes.

Figure 2 shows the electrode assembly. We used three stripes of both Copper and Zinc to make a multi-layer electrode. By doing this we increased the total energy output of the battery and thereby the battery life (if ran on a constant load).

2. Experiment

Our battery setup consists of a multimeter, a 500 mL beaker and an electrode assembly. To make the electrolytes, we dissolved 35 g of NaCl and 35 g of KOH flakes with water to make a 500 mL NaCl solution and a 500 mL KOH solution. The electrode assembly, as shown in **Figure 2**, is constructed with Copper and Zinc plates, secured and insulated by a strut. In the first test, we used the NaCl electrolyte. Upon activating the battery, we observed the voltage produced by the setup, and recorded the voltage reading over 5-minute intervals over the next hour using the multimeter. To test the KOH electrolyte, we cleaned the electrode and repeated the same steps as we did for the NaCl electrolyte.

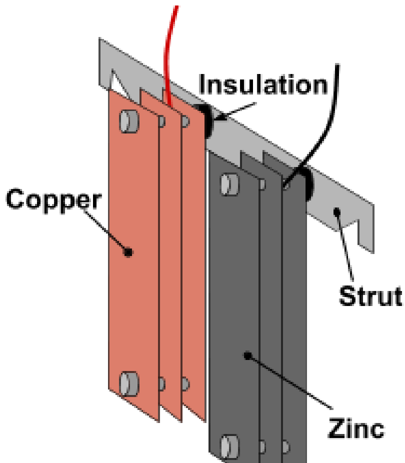

Figure 2

Note: Multiple thin layers of electrode material also increase the surface area of electrodes, which is better compared to a single piece of metal of the same mass.

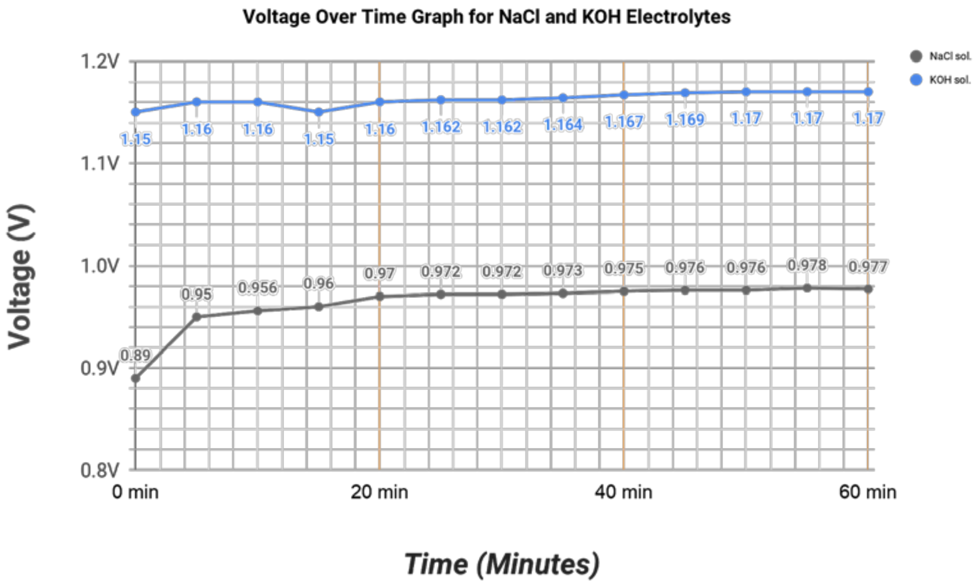

Figure 3. The experimental data of voltage produced by the cell versus time.

3. Results & discussion

Our testing reveals that compared with simple table salt, Potassium Hydroxide is the better electrolyte for a Cu-Zn battery, as proved by the fact that the KOH electrolyte is able to produce a high average voltage – 0.2 volts higher than what we measured from the NaCl setup. Specific values are referenced in the chart above. Although performances of our battery under different electrolytes differ substantially, we noticed a similar trend in voltage change over time for both setups: The cell initially produced a relatively low voltage, then gradually increased and stabilized around a higher value.

We find that the initial voltage measured with the simple salt electrolyte based on NaCl was 0.89 volts, and slowly rose to a steady 0.97 volts. This voltage stayed nearly constant for the remaining duration of 40 minutes. Similar to the NaCl cell, when Potassium Hydroxide was used as the electrolyte, we measured an initial voltage of 1.15 volts, which eventually increased to a stable 1.17 volts 45 minutes after the cell was initialized. We speculate that the electrodes were initially covered in a thin layer of oxides, which hindered the efficiency of the redox reaction[3] in our cell. Therefore, as the oxide layer slowly dissolved, we measured higher voltage readings.

Even though a maximum voltage of 1.17 volts was obtained with our Cu-Zn cell, many electrical applications require much higher voltage rating. To solve this issue, we simply need to connect multiple cells of this type in series. The total voltage output linearly increases as a function of the number of cells in the series. In this way, we can theoretically reach any voltage rating we need just by changing the number of connected cells. Although this proposal will definitely work, the efficiency and lifetime of is likely to decrease as more cells are added, since we cannot electrically recharge the cells.

In addition to adding more cells in series, we can also change the electrode material to increase voltage. The voltage measured from our Cu-Zn cell was the result of potential difference between Copper and Zinc. Because the same principle applies to other metals as well, we will be able to increase the voltage output of a single cell if we find two metals with a greater potential difference and use them as the electrodes.

4. Conclusion

In this research we constructed a Cu-Zn battery to test the hypothesis that it can be made with household materials and tools, and determined which of the two electrolytes, KOH or NaCl, is the better choice for the battery. Our result is successful, in that the voltage our battery produced was as high as 1.17 volts. Additionally, we confirmed that such a battery can be made from common materials and household tools. In terms of performance, we determined that Potassium Hydroxide is a superior electrolyte for the Cu-Zn battery compared to NaCl; we think this is because the OH– ions in the KOH solution are better at carrying charges and metal particles. It is also a good thought to keep in mind when designing a battery: when choosing electrolytes for a battery, those containing ions that can transport more charges per unit time might be worthy to consider. Since batteries are so widely adopted in a variety of devices today, it is important that designers pick the correct electrolytes so that the batteries they design can reach their full potential.

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