**Introduction:**

Aluminum-air batteries boast a high theoretical energy density. This presents the possibility of using them for a variety of uses. An aluminum-air battery can be built using a variety of different catalysts and electrolytes, each with advantages and disadvantages. Previously, a single cell battery with an electrolyte of 5M Sodium Hydroxide (NaOH), produced a voltage of 1.3V. This report will cover the electrochemistry of aluminum-air batteries, how to build one, and potential improvements.

**Electrochemistry:**

There are four components that must be present and can be modified to improve the performance of the chemical reaction in aluminum-air batteries. These components are aluminum, oxygen, an electrolyte, and a catalyst.

The chemical reaction occurring in aluminum-air batteries consists of two half-reaction those being the oxidation of Aluminum (Al) and reduction of Oxygen (O2). This results in the production of Aluminum Hydroxide (Al(OH)3) as well as the power generated. The equation for this reaction, in a aluminum-air battery is:

The anode oxidation half-reaction is Al + 3OH− → Al(OH)3 + 3e− −2.31 V

The cathode reduction half-reaction is O2 + 2H2O + 4e− → 4OH− +0.40 V

The balanced equation is 4Al + 3O2 + 6H2O → 4Al(OH)3 + 2.71 V

Various electrolytes can be used in a wide variety of values on the pH scale. Neutral salt solutions (usually Sodium Chloride (NaCl)) can produce a current, however these are not as effective as other electrolytes. Generally, when looking at building a simple home versions of aluminum-air batteries the electrolyte used is usually salt water. Acidic solutions produce a higher voltage but corrodes the Aluminum at a much faster rate. For this reason, alkaline solutions, generally Sodium Hydroxide (NaOH) or Potassium Hydroxide (KOH), are recommended.

The Oxygen Reduction Reaction is known to be a slow reaction. While aluminum-air batteries will still work, adding a catalyst can improve performance. The design outlined here does not include a catalyst, but potential improvement can be made using one. This will be discussed later.

**Construction:**

Components:

3D printed Case

5x aluminum sheets

4x polyethylene sheets

Wires

Pump and tubing

5M NaOH

Construction:

Inside a 3D printed case the aluminum and polyethylene sheets will be alternated, starting with the aluminum on the outside. The aluminum will be reacting in the battery with the polyethylene acting as a separator between each cell.

There is a hole in the center for both the top and bottom components of the 3D printed case. These will be used to pump the electrolyte solution, in this case NaOH, through the system. Through two additional holes, at the top of the case are run wires to connect either a voltmeter or whatever is being powered by the battery. Once the electrolyte begins pumping through the system the reaction will start.

**Potential Improvements:**

There are many different ways to build aluminum-air batteries with different advantages and drawbacks for each design decision. There are two major things to consider that could potentially improve the performance of the battery designed above, using a different electrolyte and the inclusion of a catalyst.

As discussed previously, various electrolytes can be used in aluminum-air batteries. The simplest batteries can use salt solutions, but both acidic and alkaline solutions provide better performance. The problem with acid solutions is that the Al corrodes to quickly, resulting in the battery not lasting as long. This leaves alkaline solutions as the best option. Primarily, two electrolytes have been proposed for use in aluminum-air batteries, those being NaOH and KOH. Both of these electrolytes are considered to have similar performance when building a battery.

The concentration of electrolyte also influences performance. The higher the concentration the faster the aluminum corrodes, but also the more voltage can be pulled out of the system. The design outlined here uses 5M NaOH, which is the upper end of the recommended range. The best performance is between 3M to 5M.

Another way to improve performance in an aluminum-air battery is by introducing a catalyst to increase the rate of reaction for the Oxygen Reduction Reaction. There are many different catalysts that can be used, but one category that generally has the highest performance are transition metal oxides. One material that is commonly used and relatively inexpensive is Manganese (IV) Oxide (MnO2).

**Conclusion:**

Aluminum-air batteries have been shown to produce sufficient power to drive devices of various size. This report has discussed the components and construction instructions needed to build one, with possible improvements on the design to improve performance.

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