iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VIII Month of publication: August 2020

DOI: https://doi.org/10.22214/ijraset.2020.30904

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VIII Aug 2020- Available at www.ijraset.com

Design and Development of Aluminium Air Battery

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Abstract: A battery is a device consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars. Batteries come in many shapes and sizes, from miniature cells to huge battery banks. During the last few decades, environmental impact of the petroleum-based transportation infrastructure, along with the fear of peak oil, has led to renewed interest in an electric transportation infrastructure. The carbon footprint and other emissions of electric vehicles varies depending on the fuel and technology used for electricity generation. The electricity may be stored on board the vehicle using a battery, flywheel, or super capacitors. Hence the development of different type of battery power EV started. Aluminium–air batteries (Al–air batteries) produce electricity from the reaction of oxygen in the air with aluminium. They have one of the highest energy densities of all batteries. However, an electric vehicle with aluminium batteries has the potential for up to eight times the range of a lithium-ion battery with a significantly lower total weight. This is ecofriendly in nature with greater availability. With low cost we can generate more electricity.
Keywords: Zn, Li Batteries, Aluminum Air battery, d-electron bonding

I. INTRODUCTION

When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical energy [1],[2] [3]. Batteries come in many shapes and sizes.

Batteries convert chemical energy directly to electrical energy. In many cases, the electrical energy released is the difference in the cohesive or bond energies of the metals, oxides, or molecules undergoing the electrochemical reaction. For instance, energy can be stored in Zn or Li, which are high-energy metals because they are not stabilized by d-electron bonding, unlike transition metals [4]. Batteries are designed such that the energetically favourable redox reaction can occur only if electrons move through the external part of the circuit.

A battery consists of some number of voltaic cells. Each cell consists of two half-cells connected in series by a conductive electrolyte containing metal cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode, to which cations (positively charged ions) migrate. Cations are reduced (electrons are added) at the cathode, while metal atoms are oxidized (electrons are removed) at the anode. Some cells use different electrolytes for each half-cell; then a separator is used to prevent mixing of the electrolytes while allowing ions to flow between half-cells to complete the electrical circuit [5], [6]. Each half-cell has an electromotive force (emf, measured in volts) relative to a standard. The net emf of the cell is the difference between the emfs of its half-cells. Thus, if the electrodes have emfs E_1 and E_2, then the net emf is $E_1 - E_2$in other words, the net emf is the difference between the reduction potentials of the half-reactions.

The electrical driving force or ΔV_{bat} across the terminals of a cell is known as the terminal voltage (difference) and is measured in volts. The terminal voltage of a cell that is neither charging nor discharging is called the open-circuit voltage and equals the emf of the cell. Because of internal resistance, the terminal voltage of a cell that is discharging is smaller in magnitude than the open-circuit voltage and the terminal voltage of a cell that is charging exceeds the open-circuit voltage. An ideal cell has negligible internal resistance, so it would maintain a constant terminal voltage of E until exhausted, then dropping to zero.

A. Problem Formulation

During the last few decades, environmental impact of the petroleum-based transportation infrastructure, along with the fear of peak oil, has led to renewed interest in an electric transportation infrastructure. EVs differ from fossil fuel-powered vehicles. The electricity they consume can be generated from a wide range of sources, including fossil fuels, nuclear power, and renewable sources such as tidal power, solar power, hydropower, and wind power or any combination of those. The carbon footprint and other emissions of electric vehicles varies depending on the fuel and technology used for electricity generation. The electricity may then be stored on board the vehicle using a battery, flywheel, or super capacitors. Hence the development of different type of battery power EV started.

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B. Solution for the Problem

Metal air battery have much higher energy density than Li-ion battery. There are different types of metal air battery. Generally Batteries are quite heavy. This prevent batteries from being source of energy in many different appliances and applications. Where being Lightweight is crucial. An Aluminium air Battery overcomes this issue. As it uses air as cathode and reducing its weight. Energy produced per unit weight of the battery is very high compared to other conventional batteries.

II. WORKING PRINCIPLE

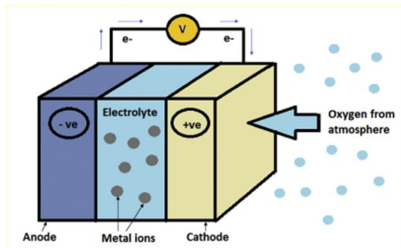

Fig. 1: Block diagram of the prototype

1) The anode(oxidation)half-reaction is $Al + 3OH^{-} \rightarrow Al(OH)_3 + 3e^{-}$
2) The cathode(reduction)half-reaction is $O_2 + 2H_2O + 4e^{-} \rightarrow 4OH^{-}$
3) The total reaction is $4Al + 3O_2 + 6H_2O \rightarrow 4Al(OH)_3$
4) Where air cathode made up of silver/graphene based catalyst and block CO_2 from air to go inside only O_2 will enter to chamber

A. Manufacturing Process

1) Cut a piece of aluminium foil that is approximately 7cm * 5cm
2) Prepare a saturated salt-water solution: Dissolve salt in a small cup of water until some salt remains on the bottom of the cup.
3) Fold a paper towel into fourths, dampen it with the solution, and then place the towel on the foil.
4) Add a heaping spoonful of activated charcoal on top of the paper towel. Pour some of the salt-water solution onto the charcoal until it is dampened throughout.
5) Make sure the charcoal doesn't touch the foil directly; you should have three distinct layers, like a sandwich. This is your aluminium–air cell.
6) Prepare your electrical device for use. The above procedure is shown in figure 2.

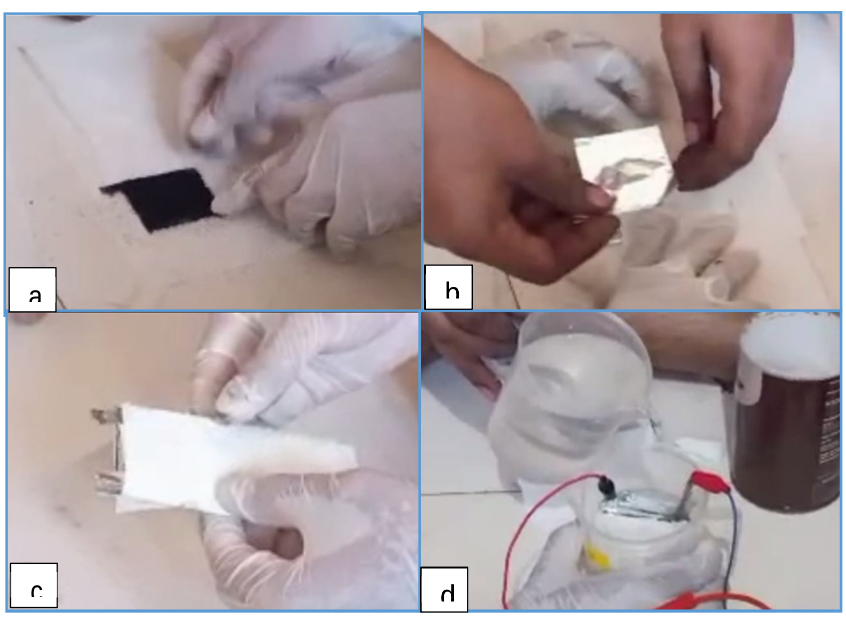

Fig. 2: a – carbon layer; b – aluminium foil; c – wrapping; d – solution poured into cell

III. RESULTS AND OBSERVATIONS

A. The battery gives the required voltage instantly.
B. Hence the battery can be used where instant electricity is required.
C. After few days the salt deposits found on the terminals.
D. The voltage found reducing as the reaction between the anode cathode and electrolyte solution. The deposition of salt was found more as the day progressed.

The prototype battery made from above procedure tested. A single cell produced 0.7V at an instant. After few minutes it produced the voltage up to 1V. The same type of cells is connected in series and parallel to the required voltage and current level.

Fig. 3: The battery generating up to 1 V

IV. SUMMARY

Aluminium–air batteries produce electricity from the reaction of oxygen in the air with aluminium.

A. They have one of the highest energy densities of all batteries.
B. An electric vehicle with aluminium batteries has the potential for up to eight times the range of a lithium-ion battery with a significantly lower total weight.
C. It is possible to mechanically recharge the battery with new aluminium anodes.
D. This is eco-friendly in nature with greater availability.
E. With low cost we can generate more electricity.

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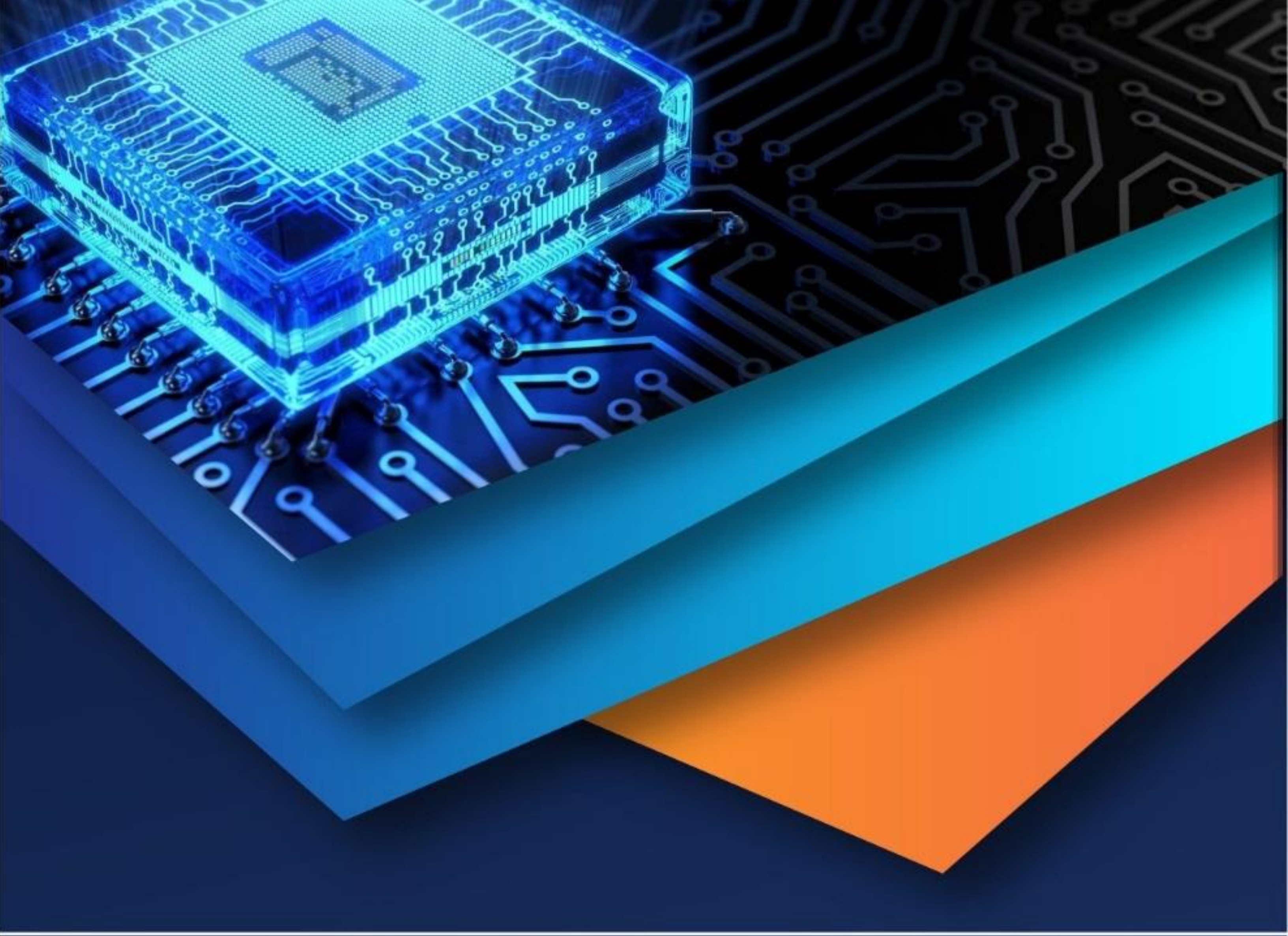

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