



**PERFORMANCE EVALUATION OF A SALT WATER POWER CELL**

**BY**

**ATANZE SAMUEL HENRY (16PY1011)**

**A FINAL YEAR PROJECT SUBMITTED TO THE DEPARTMENT OF PHYSICS  
NATURAL SCIENCES,  
KOGI STATE UNIVERSITY, ANYIGBA, KOGI STATE, NIGERIA**

**IN**

**PARTIAL FUFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE  
DEGREE OF BACHELOR OF SCIENCE (BSc.) IN PHYSICS  
MARCH, 2020.**

### CERTIFICATION

This project work has been read and approved as having satisfied the requirement for the award of the degree of Bachelor of Science (B.Sc. HONS) in physics in the department of physics, Faculty of Natural Sciences, Kogi State University, Anyigba.

.....

.....

Mr. Kingsley Omatola  
(*project supervisor*)

Signature and Date

.....  
.....

Dr. Isaiah Ochala  
(*Head of Department*)

Signature and Date



.....  
.....

.....

Prof. A. B.C Ekwealor  
(*External Examiner*)

Signature and Date

### DEDICATION

This project is dedicated to God almighty, my help and sustenance. And to my wonderful parents, late Pastor Atanze Bernard and Deaconess Faith Suleman.

## ACKNOWLEDGEMENTS

My sincere thanks goes to the department of physics, my wonderful HOD, Dr. I. Ochala, my esteemed lecturers and most especially, my project supervisor, Mr. Kingsley Omatola. I would also use this opportunity to appreciate my friends and family. Atanze Blessing, Atanze Daniel, Atanze Esther, Nicholas Atanze, my very supportive uncles, Atanze Onesimus and Atanze Jeremiah and their families and also the suleman family for their support and care. My sincere thanks goes to aunt's Mafo and Comfort, mummy J, mummy Joseph and uncle Victor. My sincere thanks goes to Foursquare students fellowship, KSU, Anyigba chapter, the birthplace of kings. To Emmanuel Oloruntoba, Aguda Atinuke, John Mukaila, Favour idakwoji, Cynthia, Favor Timai, James Olufemi, Victor John, Kefas, Mimah, Esther, and a whole host of wonderful persons too numerous to mention. To my friends and course mates, Daniel Isah, Phillip, Farouq, Favor, Joy, Jacob, Aminu, Victor, ATM, Adams and every other colleague of mine, I say thank you for four years of glamour. I would do this again and again but as we all know, time happens to all life. It is my hope that we meet in better places in the years ahead of us.

## ABSTRACT

*This research work presents an evaluation of the performance of a saline based power cell. To achieve this, a series of experiments were performed to ascertain the output voltage and current of the cell. To understand its level of conductivity, variations in some important physical conditions were observed and the limits of its parameters, stretched to ascertain that upon construction, the power cell would be safe, clean, renewable and a green source of energy. The results computed in this report proved affirmative to the hypothesis that a salt water power cell is a technology to be embraced for a green and energized earth.*

## TABLE OF CONTENTS

### Page

Title page	i
Dedication	ii
Certification	iii
Acknowledgement	iv
Abstract	v
Table of Content	vi
List of Tables	vii
List of Figures	viii
References	ix
<b>CHAPTER ONE</b>	
<b>INTRODUCTION</b>	<b>1</b>
1.1 Aim and Objectives	2
1.2 Scope of the study	2
1.3 Significance of the study	2

## CHAPTER TWO

### BACKGROUND TO THE STUDY 3

2.1 Solid-Electrolyte Interphase	3
2.2 History of the battery	4
2.2.1 Volta's battery	4
2.2.2 The lead acid battery	4
2.3 Electrochemistry	5
2.3.1 Discharged	5
2.3.2 Negative plate reaction	6
2.3.4 Positive plate reaction	6
2.4 Charging	7
2.5 Electrolysis	7
2.6 Timeline	10
2.7 Advantages of the salt water	11

## CHAPTER THREE

### MATERIALS AND METHODS 12

3.1 Materials	12
3.2 Methodology	13
3.2.1 Variations	13
3.2.2 Variation with time	13
3.2.3 Variation in salinity	14
3.2.4 Temperature Variation	14
3.2.5 Temperature coefficient	15

## CHAPTER FOUR

### RESULTS AND DISCUSSIONS 17

4.1 Results	17
4.2 Discussions	22
4.2.0 Performance evaluation of the power cell with varying salinity	22
4.2.1 Performance evaluation of the cell with varying time	22
4.2.2 Performance evaluation of the cell with varying temperature	22
4.3 Temperature Coefficient	23

## CHAPTER FIVE

### CONCLUSION 24

### LIST OF TABLES

Table 4.1.0 Voltage – Current values for Day 1	18
Table 4.1.1: Voltage – Current values for Day 2	18
Table 4.1.2: Voltage – Current values for Day 3	19
Table 4.1.3: Voltage – Current variations with Temperature	19

### LIST OF FIGURES

Figure 4.1: Graph of Voltage against Temperature	20
Figure 4.2: Graphical representation of the temperature coefficient	20

## CHAPTER ONE

### 1.0 INTRODUCTION

Energy is one of the basic needs of man. It is needed for electricity, motive power and heating (cooking and drying). The world needs more energy to meet socio-economic development requirements and enhance global living standards (BP, 2019; IPCC, 2012). In 2018, the global energy demand rose by 2.3%, the fastest in the last decade (IEA, 2019). By 2040 it is forecasted that the use of various sources of energy will increase including the nonrenewables such as coal, gas, and oil (BP, 2019). Around 1.1 billion people (14% of the global population) have no access to electricity (IEA, 2017). Many of those without access are found in rural areas, and more than 95% of those living without electricity are in countries in developing Asia and sub-Saharan Africa (ibid). To date, several communities are still found off-grid and don't have access to electricity (ibid) to light their homes or power, even small devices. In 2015, the solar-powered electricity has reached around 227 GWe, about 1% of all energy used globally (WEC, 2016). However, one of the major drawbacks affecting the utilization of solar energy and indeed all renewable sources of energy is the unavailability of a reliable, durable and non-toxic energy storage (battery) system to be of use when the renewable source is available (Green Match, 2019; Renewable Resources Co, 2016). The solution to this problem is the invention of a battery which can serve as a bank for generated energy. The use of saltwater (brine) as an electrolyte in a power cell is an affordable way to hoard energy even in large quantities over a long period of time. In this project, we hope to explore the possibilities that lie ahead of a fully energized Nigeria and planet Earth by the use of a salt water battery as a means of energy storage.

## **1.1 Aim and Objectives**

The aim of this project is to assess the voltage and current characteristics of a salt water power cell using copper (positive) and zinc (negative) electrodes with respect to time, salinity and temperature.

### **Objectives**

1. To evaluate the output voltage and current from different salt to water ratios.
2. To evaluate the change in output voltage and current from different salt to water ratios over a period of seven(7) days.
3. To evaluate the change in output voltage and current in relationship with temperature change.

## **1.2 Scope of study**

In this project we hope to study the output voltages and current for a salt water battery when its electrolyte is varied with time and salinity over the space of seven days.

## **1.3 Significance of the study**

One major problem facing the energy sector is the use of toxic materials for both utilization and storage of energy. In a planet of over seven (7) billion people, the need for energy cannot be overemphasized. However, our dear planet is few eons from extinction if we do not resolve to other ecofriendly, renewable, efficient, abundant and reliable sources and storage media of energy. This study seeks to reveal, probably the lasting and only solution to a greener and more energized earth. Salt water, abundant and non-toxic in nature is the best option for a better energy sector.



## CHAPTER TWO

### 2.0 Background to the study

Salt water battery uses a concentrated saline solution as its electrolyte. They are non-flammable and easy to recycle than lithium ion or lead acid batteries that use toxic materials for storage of energy. In 2008, a Professor from Carnegie Mellon university, Professor Jay Whitacre invented his salt water battery and later founded Aquion energy , a company that produced such batteries in large scale. Aquion Energy batteries are classified as standard goods without any special handling requirement in shipment. Its life span is not reduced when not in use.it has an optimal operating temperature range of  $-5^{\circ}\text{c}$  to  $40^{\circ}\text{c}$  and is marginally affected by temperature changes [www.gizmag.com,2015.]

A different design used an electrolyte that has a salt to water ratio of six to one, nearly saturated, such that it could also be called a *water in salt* battery.

### 2.1 Solid-Electrolyte Interphase

In 2015, researchers from the University of Maryland and the Army research laboratory claimed that they had induced the cell to form a solid-electrolyte interphase (SEI), the first for an aqueous electrolyte. The SEI allows the aqueous lithium-ion battery to operate at higher voltages and self-discharge more slowly. The high salt concentration allows the interphase to form. It raised the maximum voltage for such a battery from 1.23V to about 3V. At 2.4V, the batteries specific energy was approximately 100 watts-hour/Kg and it displayed consistent performance over 1000 charge/discharge cycles. The device operated at both low (0.15Coulomb) and high (4.5Coulomb) discharge and charge rates respectively. In September 2017, researchers stated they were able to raise the voltage to 4.0 volts. In May 2019 researchers published, High specific capacity for a densely packed stage-1 graphite intercalation compound which can form reversibly in water-in-

basalt electrolyte to give an even larger 4.2V.[U.S. Army Research Laboratory".[www.arl.army.mil](http://www.arl.army.mil)”,2019]

## **2.2 History of the battery**

### **2.2.0 Volta's Battery**

Some of the first batteries used were inventions of the Italian scientist, Alessandro Volta around 1800. Volta used salt-water, silver and zinc to generate electricity. He made his “voltaic pile” battery with units of salt water-soaked paper sandwiched between a silver disk and a zinc disk. He stacked up this basic unit to create a battery with significant voltage. The term for such basic units is called cells. Similar batteries have been made across the years including the aquion batteries and projects from tertiary institutions. Although Aquion Energy is the first company to provide salt water based batteries for utilization of energy, most of the ideas behind these batteries are as a result of Voltas battery.

### **2.2.1 The lead acid battery**

The French scientist Nicolas Gautherot observed in 1801 that wires that had been used for electrolysis experiments would themselves provide a small amount of "secondary" current after the main battery had been disconnected. In 1859, Gaston Planté's lead–acid battery was the first battery that could be recharged by passing a reverse current through it. Planté's first model consisted of two lead sheets separated by rubber strips and rolled into a spiral. His batteries were first used to power the lights in train carriages while stopped at a station. In 1881, Camille Alphonse Faure invented an improved version that consisted of a lead grid lattice, into which a lead oxide paste was pressed, forming a plate. This design was easier to mass-produce. An early manufacturer (from 1886) of lead–acid batteries was Henri Tudor.[WIKIPEDIA ]. This battery uses a gel electrolyte instead of a liquid allowing the battery to be used in different positions

without leaking. Gel electrolyte batteries for any position were first used in the 1930s, and in the late 1920s, portable suitcase radio sets allowed the cell vertical or horizontal (but not inverted) due to valve design. In the 1970s, the valve-regulated lead–acid battery (VRLA, or "sealed") was developed, including modern absorbed glass mat types, allowing operation in any position. It was discovered early in 2011 that lead–acid batteries did in fact use some aspects of relativity to function, and to a lesser degree liquid metal/molten salt batteries such as the Ca/Sb and Sn-Bi also use this effect. [ *Ede, Andrew (2017)*]

## 2.3 Electrochemistry

### 2.3.0 Discharged

A lead–acid cell with two lead sulfate plates.

Fully discharged: two identical lead sulfate plates and diluted sulfuric acid solution

In the discharged state both the positive and negative plates become lead(II) sulfate (PbSO<sub>4</sub>), and the electrolyte loses much of its dissolved sulfuric acid and becomes primarily water. The discharge process is driven by the pronounced reduction in energy when 2 H<sup>+</sup>(aq) (hydrated protons) of the acid react with O<sup>2-</sup> ions of PbO<sub>2</sub> to form the strong O-H bonds in H<sub>2</sub>O (ca. –880 kJ per 18 g of water). This highly exergonic process also compensates for the energetically unfavorable formation of Pb<sup>2+</sup>(aq) ions or lead sulfate (PbSO<sub>4</sub>(s))

#### 2.3.1 Negative plate reaction

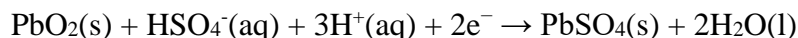


The release of two conducting electrons gives the lead electrode a negative charge.

As electrons accumulate they create an electric field which attracts hydrogen ions and repels sulfate ions, leading to a double-layer near the surface. The hydrogen ions screen the charged

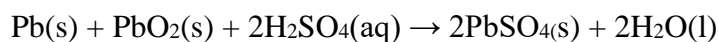
electrode from the solution which limits further reaction unless charge is allowed to flow out of electrode.

### 2.3.2 Positive plate reaction



taking advantage of the metallic conductivity of  $\text{PbO}_2$ .

The total reaction can be written as



$$E=2.05\text{V}$$

The net energy released per mol (207g) of  $\text{Pb}(\text{s})$  converted to  $\text{PbSO}_4(\text{s})$ , is ca. 400 kJ, corresponding to the formation of 36g of water. The sum of the molecular masses of the reactants is 642.6 g/mol, so theoretically a cell can produce two faradays of charge (192,971 coulombs) from 642.6 g of reactants, or 83.4 ampere-hours per kilogram (or 13.9 ampere-hours per kilogram for a 12-volt battery). For a 2-volt cell, this comes to 167 watt-hours per kilogram of reactants, but in practice a lead–acid cell gives only 30–40 watt-hours per kilogram of battery, due to the mass of the water and other constituent parts.

## 2.4 Charging

Fully recharged: Lead dioxide positive plate, Lead negative plate, and concentrated, aqueous sulfuric acid solution. In the fully charged state, the negative plate consists of lead, and the positive plate is lead dioxide. The electrolyte solution has a higher concentration of aqueous sulfuric acid, which stores most of the chemical energy. Overcharging with high charging voltages generates oxygen and hydrogen gas by electrolysis of water, which bubbles out and is

lost. The design of some types of lead-acid battery allows the electrolyte level to be inspected and topped up with pure water to replace any that has been lost this way.

## 2.5 Electrolysis

The word "electrolysis" was introduced by Michael Faraday in the 19th century, on the suggestion of the Rev. William Whewell, using the Greek words ἤλεκτρον [ἔ:lektron] "amber", which since the 17th century was associated with electric phenomena, and λύσις [lýsis] meaning "dissolution". Nevertheless, electrolysis, as a tool to study chemical reactions and obtain pure elements, precedes the coinage of the term and formal description by Faraday. In the early nineteenth century, William Nicholson and Anthony Carlisle sought to further Volta's experiments. They attached two wires to either side of Volta's battery and placed it in a tube filled with water. They noticed when the wires were brought together that each wire produced bubbles. One type was hydrogen, the other was oxygen. [*Science History Institute, 2016.*]

In 1785 a Dutch Scientist named Martinus Van Marum created an electrostatic generator that he used to reduce tin, zinc and antimony from their Salts using a process later to be known as electrolysis. Though Martinus Van Marum unknowingly produced electrolysis it was not until 1800 when William Nicholson and Anthony Carlisle discovered the process of how electrolysis works.[*The supplement to Encyclopedia Britannica 3rd edition (1797),*]

When it comes to the beginning of the study of electrolysis, the roots come back to Luigi Galvani's experiments in 1791 with frog legs. His thought was that by placing an animal muscle between two dissimilar metal sheets it could produce electricity. Responding to these claims, Alessandro Volta conducted his own tests. This would give insight to Humphry Davy's ideas on electrolysis. Humphry Davy went on to create Decomposition Tables from his preliminary experiments on Electrolysis. The Decomposition Tables would give insight on the energies needed to break apart certain compounds.

In 1817, Johan August Arfwedson hypothesised there was another element, Lithium, in some of his samples, but he could not isolate it from the component. It was not until 1821 when William Thomas Brande used electrolysis to single it out. Two years later, he streamlined the process using lithium chloride and potassium chloride with electrolysis to produce lithium and lithium hydroxide.

During the later years of Humphry Davy's research, Michael Faraday became his assistant. Thus, while studying the process of electrolysis under Humphry Davy, Michael Faraday discovered two Laws of Electrolysis. [*The history of Electrochemistry, 2019*]

The first law States: " The mass of a substance produced at an electrode during electrolysis is proportional to the number of moles of electrons (the quantity of electricity) transferred at that electrode."

The Second Law States: "The amount of electric charge required to discharge one mole of substance at an electrode is equal to the number of elementary charges on that ion."

During the time of Maxwell and Faraday, concerns came about for electropositive and electronegative activities.

In November 1875, Paul Émile Lecoq de Boisbaudran would discover gallium using electrolysis of gallium hydroxide, producing 3.4 mg of gallium. That following December, he presented his discovery of gallium to the Academie des Science in Paris. [*Lecoq de Boisbaudran,(1875)*]

On June 26, 1886, Ferdinand Frederick Henri Moissan finally felt comfortable to perform electrolysis on anhydrous hydrogen fluoride to create a gaseous fluorine pure element. Before he could use hydrogen fluoride, Henri Moissan used fluoride salts with electrolysis. Thus on June 28, 1886 he performed his experiment in front of the Academie des Science to show his discovery of the new element fluorine. In the cost of trying to find elemental fluorine through

electrolysis of fluoride salts, many Chemists perished such as: George Gore, Pauline Louyet, and Jerome Nickels. [*University of North Texas, 2005.*]

Charles Martin Hall was from America and Paul Héroult was from France. In 1886 they both filed for American patents, with Héroult submitting his in May and Hall's in July. Hall was able to get his patent by proving through letters to his brother and family evidence that his method was discovered before the French patent was submitted. This became known as the Hall-Héroult process which benefited many industries because the price of aluminum had dropped from four dollars to thirty cents price per pound.[ *Beck, Theodore R. , 2015*]

Electrolysis is the passing of a direct electric current through an ionic substance that is either molten or dissolved in a suitable solvent, producing chemical reactions at the electrodes and decomposition of the materials.

The main components required to achieve electrolysis are:

I. An electrolyte: a substance, frequently an ion-conducting polymer that contains free ions, which carry electric current in the electrolyte. If the ions are not mobile, as in most solid salts, then electrolysis cannot occur.

II. A direct current (DC) electrical supply: provides the energy necessary to create or discharge the ions in the electrolyte. Electric current is carried by electrons in the external circuit.

III. Electrodes of metal, graphite and semiconductor material are widely used. Choice of suitable electrode depends on chemical reactivity between the electrode and electrolyte and manufacturing cost. Historically, when non-reactive anodes were desired for electrolysis, graphite (called plumbago in Faraday's time) or platinum were chosen. They were found to be some of the least reactive materials for anodes. Platinum gives way to corrosion very slowly compared to other materials and graphite crumbles. It can produce carbon dioxide in aqueous

solutions but otherwise does not participate in the reaction. Cathodes may be made of the same material, or they may be made from a more reactive one since anode wear is greater due to oxidation at the anode.

## 2.6 Timeline

1785 – Martinus van Marum's electrostatic generator was used to reduce tin, zinc, and antimony from their salts using electrolysis.

1800 – William Nicholson and Anthony Carlisle (view also Johann Ritter), decomposed water into hydrogen and oxygen.

1808 – Potassium (1807), sodium (1807), barium, calcium and magnesium were discovered by Humphry Davy using electrolysis.

1821 – Lithium was discovered by the English chemist William Thomas Brande, who obtained it by electrolysis of lithium oxide.

1834 – Michael Faraday publishes his two laws of electrolysis, provides a mathematical explanation for his laws, and introduces terminology such as electrode, electrolyte, anode, cathode, anion, and cation.

1875 – Paul Émile Lecoq de Boisbaudran discovered gallium using electrolysis.

1886 – Fluorine was discovered by Henri Moissan using electrolysis.

1886 – Hall–Héroult process developed for making aluminium

1890 – Castner–Kellner process developed for making sodium hydroxide [*The history of Electrochemistry* [Http:www.Wikipedia.com](http://www.Wikipedia.com)" ECS .]



The process of electrolysis is very important in all power cells with aqueous electrolytes. However one major defect to this cells is their inability to maintain ecologically friendly reactions upon their activations. The salt water battery however has the upper hand as it addresses this crucial and delicate aspect of energy utilization and hoarding.

## **2.7 Advantages of the salt water battery**

- Its electrolyte is abundant in nature.
- Its reactions (electrolysis, reduction and oxidation) do not pose ecological threats.
- It is cost efficient.
- If connected in series, it can hoard even greater amounts of energy.

## **CHAPTER THREE**

### **3.0 MATERIALS AND METHODS**

#### **3.1 Materials**

The materials used for the research include

- Salt: Common table salt (sodium chloride), abundant in existence is the solute used for the preparation of the electrolyte.
- Water: Hydrogen di oxide( $H_2O$ ), another abundant resource is the solvent used for the preparation of the solution.
- A plastic vessel: This is used for holding the electrolyte before, during and after experiments.

- Copper and zinc: These are the materials used as electrodes for electron capture and release in the cell. Copper being the anode(positive electrode) and zinc being the cathode (negative electrode).
- A multimeter: This is an electronic measuring instrument that combines multiple functions; a combined ammeter, ohmmeter and voltmeter. The device was used to assess the voltage, current and resistive properties of the cell.
- Hot plate: This was used to vary the temperature of the electrolyte.
- Thermometer: For clarity and precision, we measured the temperature of the solution upon heating.
- Stirrer: this was used to stir the solution upon addition of the solute into the solvent so as to allow the proper dissolving of the solute into the solvent.
- Banana wires: These were connected to the terminals of the multimeter. They are then connected to the electrodes of the cell.
- Beaker: This served as a container for the electrolyte while the variations in temperature (using the hotplate) were carried out.

## 3.2 Methodology

The research was focused on the output current and voltage values for the power cell. A total of 29 setups were observed. It was an experimental research geared towards the study of the viable possibilities embedded in the use of saltwater as an electrolyte for energy storage. A plastic container was used in storing and holding the solution when experiments and observations were being taken.

### 3.2.1 Variations

To thoroughly investigate the voltage-current relationship of the brine based power cell, several variations were made.

### **3.2.2 Variation with time**

#### **Procedure:**

Step1: We made solutions of different Solvent - Solute ratios.

Step 2: Using the stirrer, we stirred the solution so as to allow the solute dissolve perfectly into the solvent.

Step 3: We then immersed the copper and zinc electrodes into the solution

Step 4: With a constant volume of the solvent and solute, using the multimeter, we then measured the output voltage and current of the power cell and recorded our readings for the first day.

Step 5: We then stored the solution in a plastic vessel for further use.

Step 6: We repeated the procedures for day 2 and 3

### **3.2.3 Variation in Salinity**

#### **Procedure:**

Step 1: We added 15g of the solute to 600ml of the solvent.

Step 2: Using the stirrer, we stirred the solution so as to allow the solute dissolve perfectly into the solvent.

Step 3: We then immersed the copper and zinc electrodes into the solution.

Step 4: Using the multimeter, we then measured the output current and voltage produced by the cell.

Step 5: With masses 30g and 45g, we then repeated the procedures and took our readings.

### **3.2.4 Temperature variation**

One of the major setbacks faced by lead acid and lithium ion batteries is that, at high temperatures, they run a high risk of exploding due to the toxicity of the electrolytic makeup of their power cells. To checkmate this defect, we subjected our battery to a series of test, checking the change in the voltage and current output while increasing the temperature. This is a very important test since one major setback faced by all batteries is their proneness to explosion when exposed to high temperature.

#### **Procedure:**

Step 1: We prepared the electrolyte using 600ml of water and 45g of salt in a beaker.

Step 2: Using the stirrer, we stirred the solution so as to allow the solute dissolve perfectly into the solvent.

Step 3: We then immersed our electrodes into the solution.

Step 4: At a low temperature of  $0^{\circ}\text{C}$ , we measured the current, voltage and resistance values of the cell and took our readings.

Step 5: Using the hot plate we increased the temperature of the solution to  $20^{\circ}\text{C}$  and recorded our output voltage and current readings using our multimeter.

Step 6: We repeated the procedures for temperatures,  $40^{\circ}\text{C}$ ,  $60^{\circ}\text{C}$ ,  $80^{\circ}\text{C}$ , and  $100^{\circ}\text{C}$ .

### **3.2.5 Temperature coefficient**

To understand the relationship between the change in in the magnitude of the resistance and the change in temperature, we vary the two quantities and plot a graph of resistance against temperature. The resultant slope of the graph is the temperature coefficient of the electrolyte.

Step 1: Using the readings obtained in 3.2.4 above, we plotted a graph of Resistance against Temperature.

Step 2: We then measured the slope of the graph.

The slope of the graph gives the numerical value for the temperature coefficient of the power cell.

## **CHAPTER FOUR**

### **4.0 RESULTS AND DISCUSSION**

The end-goal of the project study is to develop a prototype alternative liquid-water-based power source utilizing the electrolytic cell battery technology. Electrical energy is produced in many forms such as through combustion, mechanical methods and photosynthesis. Electrical energy generation of batteries is produced by an electrochemical reaction between two metals having different affinities such as zinc and copper. When the metals (the electrodes) are exposed to a type of liquid (usually acid) voltage is developed between them as part of ion transfer. The energy produced in the process comes from the chemical change in dissolving the metal into the acid termed as redox reaction.

#### **4.1 Results**

The project employed the use of copper and zinc as electrodes for the power cell. The electrodes proved to produce reasonable amounts of voltage and current. One major observation we noted is that, higher amounts of voltage can be realized by reducing the distance between the electrodes. For current, there is no significant change due to this effect.

The following is a layout of all information gathered during the course of this project.

Performance testing of a salt water power cell over a period of three days (72hours)

Volume of solvent—600ml

Electrodes— copper (anode) and zinc (cathode)

**Table 4.1.0: Voltage – Current values for day 1**

Mass of solute (NaCl)	Voltage(volt)	Current(Ampere)
15g	0.720	0.001
30g	0.730	0.002
45g	0.740	0.004

**Table 4.1.1: Voltage – Current values for Day 2**

Mass of solute (NaCl)	Voltage(Volt)	Current(Ampere)
15g	0.740	0.010
30g	0.720	0.020
45g	0.707	1.400

**Table 4.1.2: Voltage – Current values for Day 3**

Mass of solute (NaCl)	Voltage(volt)	Current(Ampere)
15g	0.750	1.010
30g	0.730	0.020
45g	0.700	0.030

Performance testing on the salt water power cell with varying temperature

Volume of solvent—600ml

Mass of solute—45g.

**Table 4.1.3: Voltage – Current variations with Temperature**

Temperature(°C)	Voltage(Volt)	Current(Ampere)	Resistance(ohm)
0	0.700	---	220
20	0.710	0.001	200
40	0.720	0.002	198

60	0.730	0.003	192
80	0.735	0.004	124
100	0.740	0.006	62.5

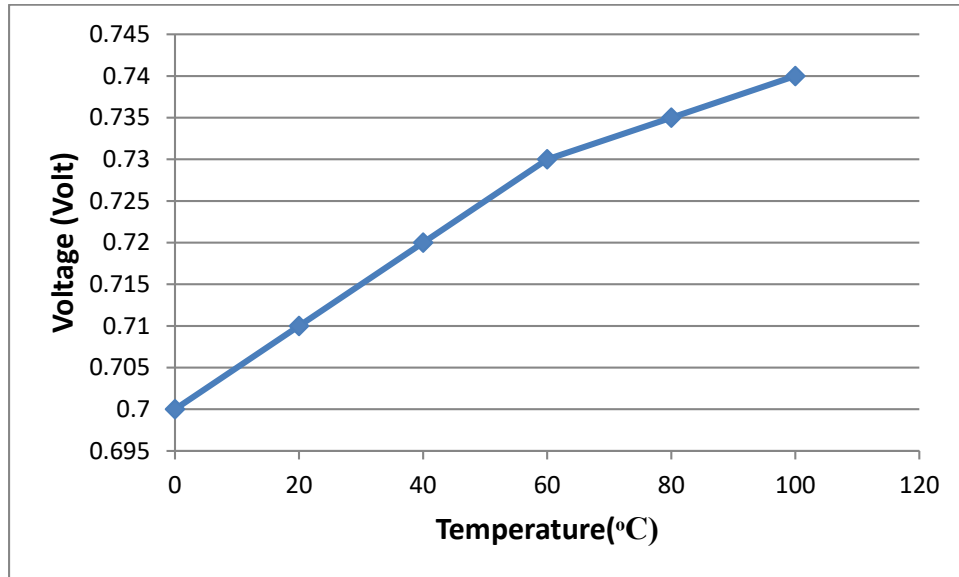
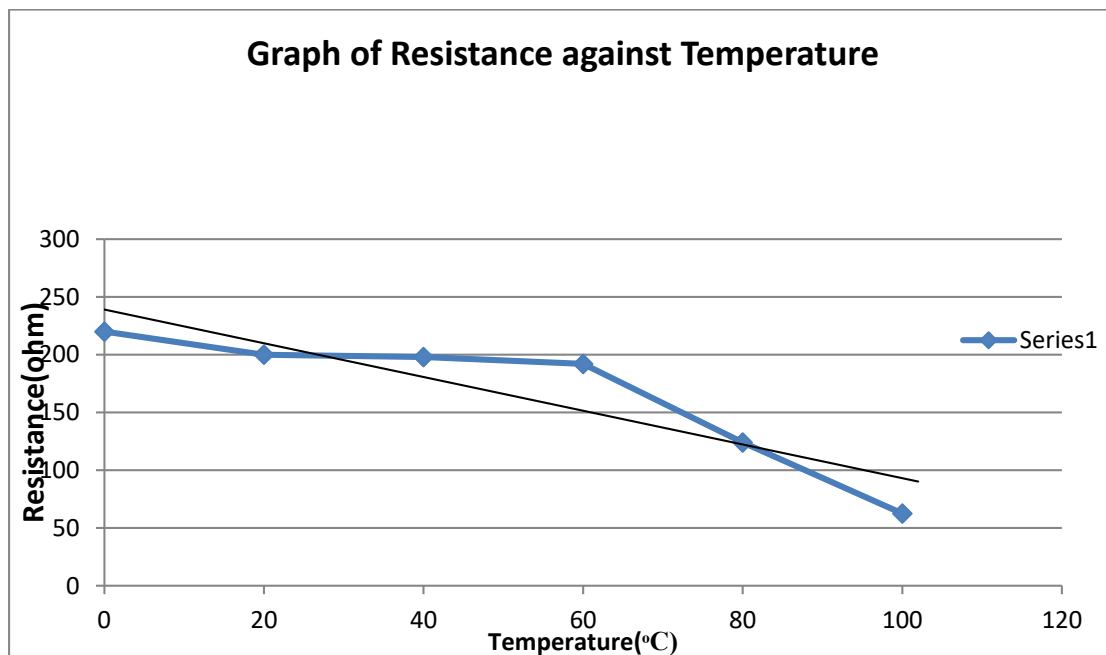


Figure 4.1: Graph of Voltage against temperature





## **Figure 4.2: Graphical representation of the temperature coefficient.**

The temperature coefficient of the cell is given by the slope of the above graph.

Where;

Slope = Change in resistance / change in temperature.

This implies that slope =  $200 - 124 / 80 - 20 = 1.267 \approx 1.3$

Thus the temperature coefficient of our saline electrolyte based power cell is 1.3.

## **4.2 DISCUSSIONS**

### **4.2.0 Performance evaluation of the power cell with varying salinity**

It was observed that the output voltage and current increased with increasing salinity. This implies that to obtain higher output voltage and current, the salinity of the solution is to be increased.

### **4.2.1 Performance evaluation of the power cell with varying time**

A good power cell is one that has the capability to store charge over a long period of time. Loss of charge due to physical or chemical reactions is therefore a shortcoming for any 21<sup>st</sup> century battery. However, in this experiment it was observed over a period of 3 days (72 hours) that the output voltage and current was relatively unchanged. This implies that the electrolytic composition of our power cell is capable of hoarding charges over long periods without causing any loss in charge.

#### **4.2.2 Performance evaluation of the cell with varying Temperature**

Most devices (laptops, smart phones, etc.) and even automobiles in need of the technology of power cells expend an amount of heat due to their functioning. For a near 100% efficient battery, the risks associated with its functioning must be properly checkmated. In most batteries (lithium ion or lead acid), exposure to high temperature can lead to explosion altering both the electrolytic composition of the cell and its electrodes and causing a negative effect in the output voltage and current of the cell. However, in our cell, after subjecting the electrolyte to various high temperatures, it was observed that there was increase (though marginal) in the output voltage and current of the cell.

#### **4.3 Temperature coefficient**

The temperature coefficient of the power cell was calculated to be approximately equal to 1.3. This means that the change in the magnitude of the resistance occurs with a change, 1.3 times the value of the temperature.

### **CHAPTER FIVE**

#### **5.0 CONCLUSION**

Based on the experiment done, observations made and results obtained, it can be concluded that the performance of a salt water power cell in terms of temperature change, durability and toxicity is of high standard and its working principle, favorable to the ecological buildup of our planet.

The storage of energy through the utilization of this saline based electrolytic power cell is a step in the right direction and a move for a better energized earth.

## REFERENCES

AboutBatteries.UniversityofMissouriRolla.<https://web.mst.edu/~gbert/BATTERY/battery>

AbSuo, Liumin; Borodin, Oleg; Gao, Tao; Olguin, Marco; Ho, Janet; Fan, Xiulin; Luo, Chao; Wang, Chunsheng; Xu, Kang (2015). "Water-in-salt" electrolyte enables high-voltage aqueous lithium-ion chemistries"

Andreev N.,Ronteltap M., Wernli B., Zubcov E., Bagrin N., Borodin N., and Lens L.(2017). Lactic Acid Fermentation of Human Urine to improve it's Fertilizing Value and Reduce Odor Emissions. *Journal of environmental management*. p.198

Bacongo C., Acelar A., Alayon B., Baldonado V., and Miral C. Determining the Acidity Between Native and Commercialized Vinegar by Obtaining Percent Composition of Acetic Acid through Titration . *WVSU*

Bates M (2012). How Battery Work?

AskanEngineer.MITSchoolofEngineering.<https://engineering.mit.edu/engage/askanengineer/howdoesabatterywork>

Bewick S., Parsons R., Forsythe T., Robinson S., and Dupon,J. (2019). Batteries:UsingChemistrytoGenerateElectricity.ChemistryLibreTexts.[https://chem.libretexts.org/Courses/Eastern\\_Wyoming\\_College/EWC%3A\\_Introductory\\_Chemistry\\_Oxidation\\_and\\_Reduction\\_Batteries\\_Using\\_Chemistry\\_to\\_Generate\\_Electricity](https://chem.libretexts.org/Courses/Eastern_Wyoming_College/EWC%3A_Introductory_Chemistry_Oxidation_and_Reduction_Batteries_Using_Chemistry_to_Generate_Electricity)

Borgino and Dario (2015). ""Water-in-salt" battery bodes well for greener, safer grid storage".[www.gizmag.com](http://www.gizmag.com)

Cotton S. (2011). BP Energy Outlook 2019 Edition.

Energy Access Outlook 2017. From Poverty to Prosperity. International Energy Agency. IPCC (2012).

Georgi D. (2006); Metal Air Batteries ; Half Fuel Cell? 42<sup>nd</sup> Power Sources Conference

GettingtoKnowtheBattery.[https://batteryuniversity.com/learn/article/getting\\_to\\_know\\_the\\_battery](https://batteryuniversity.com/learn/article/getting_to_know_the_battery).

Global Energy Demand Rose by 2.3% in 2018, Its Fastest Pace in the Last Decade. International Energy Agency (IEA). <https://www.iea.org/newsroom/news/2019/march/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-lastdecade.html>

Helmenstine M. (2019). What Is the Chemical Composition of Vinegar? Thought.com

HowdoesElectrolyteWork?[https://batteryuniversity.com/learn/article/bu\\_307\\_electrolyte](https://batteryuniversity.com/learn/article/bu_307_electrolyte)Bertrand

<http://bfp.gov.ph/bfp-warnsthe-public-of-criminal-raps-due-tonegligence>

<Http://www.psa.gov.ph/products-andservices/publications/philippine-statisticalyearbook>

<Https://web.archive.org/web/20101227101957/http://www.batteriesdigest.com/metal>

<Https://www.greenmatch.co.uk/blog/2014/08/5-advantages-and-5-disadvantages-of-solar-energy>

<Https://www.renewableresourcescoalition.org/solar-energy-disadvantages>

<Https://www.thoughtco.com/chemicalcomposition-of-vinegar-604002>

<Https://www.worldenergy.org/data/resources/resource/solar>

Kirchmann H. and Pettersson S. (1994). Human Urine – Chemical Composition and Fertilizer Use Efficiency. Fertilizer Research

Papiewskie J. (2018). What Factors Influence the Rate of a Chemical Reaction? Sciencing.

<https://sciencing.com/whatfactors-influence-the-rate-of-a-chemicalreaction>

Peshin A. (2018). How Does A Galvanic Cell Work? Science ABC – Technology.

<https://www.scienceabc.com/innovation/galvanic-cell-work.html>

Philippines Energy Sector Assessment Strategy and Road Map. AsianDevelopmentBank

Renewable Energy Sources and Climate Change Mitigation. Special Report of the Intergovernmental

Rose C., Parker A., Efferson B., and Cartmell E. (2015). The Characterization of Feces and Urine: A Review of the Literature to Inform Advanced Treatment Technology. Critical Reviews in Environmental Science and Technology

RoyalSocietyofChemistry.<https://eic.rsc.org/soundbite/cocacola/2021233.article>.

Salt f. (2018).

Spector and Julian (2017).

Susanto A., Baskoro S., Wisudo H., Riyanto M., and Purwanka, F. (2017). Performance of Zn-Cu and Al-Cu Electrodes in Seawater Battery at Different Distance and Surface Area. *International Journal of Renewable Energy Research*(2012)

Tj S. and Tsupova S. (2017).

Wang ,Chunsheng ; Xu, Kang; Ren, Yang; Borodin, Oleg; Wang, Yingqi; Qing, Tingting; Hou, Singyuk;Liu, Cunming; Liu, Qi (May 2019)."Aqueous Li-ion battery enabled by halogen conversion intercalation chemistry in graphite  
"Armydiscoveryopenspathtosaferbatteries|U.S.ArmyResearchLaboratory".www.arl.army.mil. (2018).

Xu, Kang; Wang, Chunsheng; Eidson, Nico; Schroeder, Marshall A.; Vatamanu, Jenel; Borodin, Oleg; Ding, Michael S.; Cresce, Arthur von;Sun, Wei (2017)."4.0 V Aqueous Li-Ion Batteries"

© GSJ