Construction of a Primary Dry Cell Battery From Cassava Juice Extracts (The Cassava Battery Cell)

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Abstract

The liquid extract from cassava, a tropical root tuber widely consumed in Nigeria, The Gambia and in some other West African countries, is a big environmental hazard and constitute great nuisance as it pollutes the soil and air to a high degree, particularly the soil. Due to its very acidic nature, it becomes toxic to the soil and destroys the plants and nutrients in the soil. If extracts flow or is passed into the soil surroundings, it releases a very unpleasant odor into the air. As a result of this observable pollution hazard caused by this substance, I deemed it appropriate to research into how, this pollutant to soil and air can be controlled and also in the process the liquid extract from cassava, which is wasted and causes environmental damage, can be positively utilized to serve the society and mankind. Since it contains significant amount of acid, the following research hypothesis is drawn: The chemical nature of the liquid extract from cassava containing a mineral acid HCN, can be harnessed and used as an electrolyte for; a Dry cell battery; and The liquid extract from cassava, which is wasted and causes environmental damage, can be positively utilized to serve the society and mankind and thus constitute a means of pollution control. The cassava tubers contain a significant amount of cyanogenic glycosides, which hydrolyses to form hydrocyanic acid (HCN).

Keywords: *Cassava Juice Extracts, Battery Cell*

Introduction

The concentration of hydrocyanic acid (HCN) in cassava tuber varies in different species of cassava. There are two major species of cassava viz: sweet cassava and bitter cassava. The sweet cassava has lower level of hydrocyanic acid, while the bitter cassava has a high level of the acid, about 490mgkg-1. The tuber stores a lot of water, but this could be eliminated by dehydrating the liquid juice which is the store of the acid.

Hydrocyanic acid is poisonous; hence cassava tubers are carefully and elaborately detoxified before being consumed. By its chemical nature, hydrocyanic acid has both cation (H^+) and anion (CN^-). When it undergoes dissociation the products are: $HCN \rightleftarrows H^+ + CN^-$

With these dipolar characteristics, it could undergo electrolytic process involving the exchange of ions and flow of electrons; this can constitute an electric current.

The materials utilised include crushed cassava paste/juice (electrolyte), carbon black, manganese (IV) oxide powder, zinc can, carbon rod, cassava grater, absorbent material. The apparatus needed are voltmeter, ammeter and milliammeter, circuit wires, crocodile clips, electric bulbs.

The following tests were carried out:

i. Test for electromotive force, (e.g.) of the battery cell
ii. Test for current output of the battery cell
iii. Test with a load of 2.5volts electric bulbs.

The battery (cassava battery cell) generated of electromotive force (E.M.F) of 2.0volt and a current (1) of 60MA = 0.06A. And three of this was able to brightly light up a 2.5volts electric bulb; and produced a total electromotive force (E.M.F) OF 3.05volts and total current of 202MA =0.22A. These results led me to the conclusion that the cassava battery cell functioned well like other batteries, which can be improved on.

And that cassava juice (liquid) which is considered and drained away as waste material is a good electrolyte which could serve as a local cheap and economical source of electric power generation.

Chemical Components of Cassava Extract

The cassava tuber contains the following chemical compounds viz; water, carbohydrate, protein, traces of fat, fibre, mineral matter and glycosides, which undergo hydrolysis to form hydrocyanic acid (HCN), the rate of hydrolysis could be accelerated by soaking the cut-tubers in water or by raising the temperature of the soaked tuber to about 75˚C.

Hydrocyanic acid (HCN) has a concentration of about 490mgkg¯' tuber (Onwueme I.C, 1978), in bitter cassava specifically, the store of the acid. The concentration of hydrocyanic acid (HCN) in cassava tuber varies in the different species of cassava. There are two major species of cassava viz: sweet cassava and bitter cassava. The sweet cassava has lower level of hydrocyanic acid, while the bitter cassava has a high level of the acid evenly distributed through the tuber. Other factors like low potassium content; high Nitrogen contents in soils, wet soil region, also contribute to high level of hydrocyanic acid in cassava. NOTE: HYDROCYANIC ACID IS POISONOUS; hence cassava tubers are carefully and elaborately detoxified before being consumed.

Hydrocyanic acid (HCN) by its chemical nature has both Cation (H^+) and anion (CN^-) (i.e. +ve and –ve ions) when it undergoes ionic decomposition the products are;

HCN H+ + CN-

With this dipolar characteristic, it could undergo electrolytic processes involving the exchange of ions and flow of electrons. This can constitute an electric current.

Primary Dry Cell Battery (E.G .The Leclanché Cells).

Primary cell with a nominal open circuit voltage of 1.5 Volts produced in very high volumes. Chemistry based on a zinc anode and a cathode/depolariser of manganese dioxide which absorbs the liberated hydrogen bubbles which would otherwise insulate the electrode from the electrolyte. It uses a carbon rod as the cathode current collector with an electrolyte of ammonium chloride. Its variants have been in use for over a century. The performance of Leclanché cells improved by 700% between 1920 and 1990.

Also referred to as Zinc- Carbon Cells or Dry Cells (not to be confused with Solid State Cells) despite having an aqueous electrolyte since in modern cells the electrolyte of ammonium chloride and zinc chloride is produced in gel form or held in porous separators to reduce potential leakage if the cell becomes punctured.

Variants include

- Zinc carbon (Carbon cathode)
- Zinc chloride (Ammonium chloride electrolyte replaced by zinc chloride)
- Alkaline manganese (Ammonium chloride electrode replaced by potassium hydroxide)

Advantages are as follows

Inexpensive materials, Low cost, Available in a wide range of sizes including AAA, AA, C, D and 9Volt sizes.

Suitable for a wide range of consumer applications, Interchangeable with alkaline batteries.

Applications

General purpose, low cost applications such as: Toys, Remote controls, Flashlights, Clocks, Consumer applications etc.

Hypotheses

Since it contains significant amount of acid, the following research hypothesis is drawn:

The chemical nature of the liquid extract from cassava containing a mineral acid HCN, can be harnessed and used as an electrolyte for; a primary Dry cell battery; and

The liquid extract from cassava, which is wasted and causes environmental damage, can be positively utilized as a control of soil and air pollutions.

The Construction

Materials/Apparatus Used

The first step I took in the construction of the cassava battery cell was to gather all the relevant materials needed for the project.

MATERIALS: - Crushed cassava paste/juice (Electrolyte) Carbon black and Manganese (IV) oxide powder (Depolarizer); Zinc Can (Cathode); Carbon rods (Anode); Cassava grater, Absorbent material (Tissue paper).

APPARATUS: - Voltmeter, Ammeter and Milliammeter, Circuit wires, Crocodile clip, Electric bulbs (2.5v).

Procedures

Step 1

The first step followed was to make a grater, which I used to grate the freshly peeled cassava tuber.

This was made by perforating some holes on a rectangular zinc slate of about 9cm2 in area, with a 5cm – sized nail from one side of the slate so that sharp openings are produced at the opposite side. The rectangular zinc slate was then nailed to a stick of 4cm × 2cm× 1cm in dimension to serve as the comfortable handle.

The peeled cassava tuber was soaked in water for about two days before it was grated; (this is to increase the rate of hydrolysis of the cynogenic glycosides to Hydrocyanic acid within the tuber).

After soaking the fresh, peeled cassava tuber for two days, it was grated, after which transferred into a scarf where it was pressed and squeezed to extract the juice from the paste. The extracted juice was bottled and kept for one day to give way for further hydrolysis reaction.

Step 2

The formation of the Cathode mix called Bobbin. This was made in two different ways. The first Cathode mix is a moderately thick paste and the second was a very thick paste. The Cathode mix is a composition of mixture of the extracted cassava juice (acidic); Manganese (IV) oxide powder and Carbon black obtained from Generator plant Exhaust pipe.

The positive electrode (Anode) is the carbon rod, taken from an old U2-Sized dry cell battery.

The negative electrode (Cathode) is a zinc can (milk can and the zinc container of a U2-Sized battery).

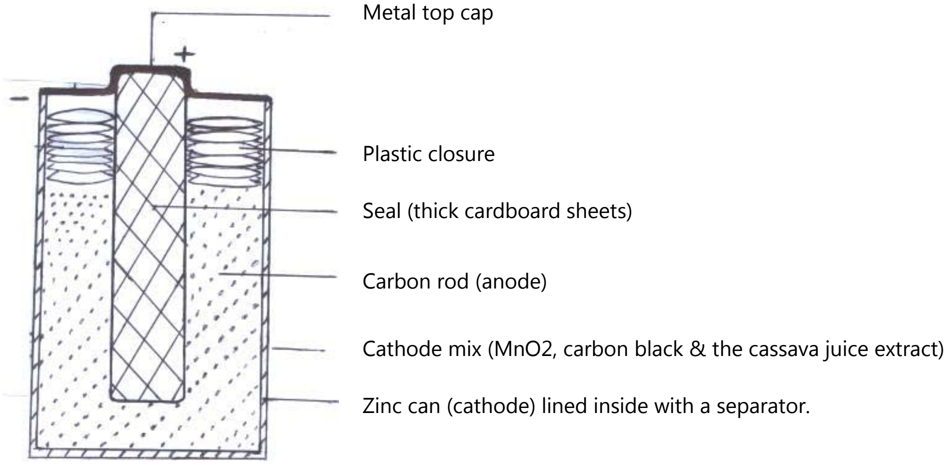
Step 3

Making The Cassava Battery Cell

The Cathode mix was put into the zinc can, which inside base was placed a sizeable round cardboard paper, and the inside was walled with an absorbent material (tissue paper) to act as a separator.

The Cathode mix filled (¾) three –quarter part of the zinc can. This was done with the two different Cathode mix respectively.

The carbon rod (Anode) was impregnated into the middle part of the cathode mix. So the battery cell was now made and ready for testing. Below is the diagram of the cassava primary battery cell.



The following tests were carried out:

i. Test for the electromotive force (E.M.F)
ii. Current output
iii. Test with a 2.5 volts electric bulb.

Step 4

Tests

i. Test for electromotive force (E.M.F) of my battery cell: A voltmeter was connected across the terminals of the battery cell(s).

ii. Test for current output from my battery cell: This was carried out with a milliameter and an Ammeter. The battery was connected to a milliameter and ammeter respectively in series.

iii. Test with a 2.5 volts electric bulb: The bulb was connected to the battery cells in this manner; first to one cell; then to two cells together and lastly to three cells connected together.

Results

Electromotive Force (E.M.F) Readings From Voltmeter. (Error in voltmeter = ± 0.1volt)

No of cells	E.m.f in volts (V) ± 0.1
1	1.0 volts
2	2.0 0 volts
3	3.0 5 volts

Flash Current Readings From Ammeter.

No of cells	Current (i) in MA & A
1	60 MA = 0.06A
2	130 MA = 0.13A
3	202 MA = 0.22A

Error in Ammeter (I) = ± O.5MA AND ± 0.005A

Test With 2.5 Volts Electric Bulb.

No of cells connected	Observations
1	NOT LIT
2	FAINTLY LIT(bulb light but glows dimly)
3	BRIGHTLY LIT(bulb lights up brightly)

Conclusion

The battery (cassava battery cell) generated of electromotive force (E.M.F) of 2.0volt and a current (1) of 60MA = 0.06A. And three of this was able to brightly light up a 2.5volts electric bulb; and produced a total electromotive force (E.M.F) OF 3.05volts and total current of 202MA =0.22A. These results led me to the conclusion that the cassava battery cell functioned well like other batteries, which can be improved on.

And that cassava juice (liquid) which is considered and drained away as waste material is a good electrolyte which could serve as a local cheap and economical source of electric power generation.

Recommendations

I. Manganese (IV) oxide (MnO_2). The possible local source within our environment from which Manganese (IV) oxide could be obtained or extracted should be research on so that every material used in the construction of the battery would be those that can be obtained cheaply and locally from our environment without the foreign dependence.

II. If possible, the actual and accurate, life span of the battery should be carefully measured on continuation with this project.

References

Onwueme I.C. (1978), The tropical tuber crops (yams, cassava, sweet potato, cocoyam) John Wiley & Sons New York.

Hill J.W, Baum S.J, Feigl D.M, (1997): Chemistry and life: an introduction to general,organic,and biological chemistry – 5th ed.,Prentice Hall,Inc.New Jersey,USA.

Muzanila, Y.C; Brennan, J.G & King, R.D.: Residual cyanogens, chemical composition and aflatoxins in cassava flour from Tanzanian villages, Food Chemistry (July 2000), 70 (1), pg. 45-49.