

CHEMICAL BATTERY AS SUBSTITUTE TO CONVENTIONAL FUEL

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Abstract

In this paper we have discussed the possible means to run a car using chemical engineering and various chemical reactions. The main purpose of this paper is to solve the world fuel crisis with a simple household solution. We have highlighted the use of chemical cells for the same by making use of a working model of a small car.

Our experiments demonstrate the use of lemon batteries as a substitute to the traditional alkaline batteries. Lemon juice containing citric acid makes up an excellent electrolyte using Copper and Magnesium as electrodes. The working of a cell is based on simple electrolytic cell which is a combination of redox reactions. The power drawn by the cell is directly proportional to the concentration of lemon juice used. A single lemon cell gives enough voltage to power an LED. During this experiment we found out that the current drawn per cell is very less. Connecting enough cells in series and parallel combinations draws enough power to run a motor of the car.

Because of the small current being drawn the final battery was very bulky. To overcome this difficulty we found out various other solutions which can draw more power than lemon juice. They are

- *Bleach cell*
- *Salt cell*
- *Vinegar cell*

Among the above solutions, bleach cell is the most efficient and long lasting. All the above mentioned cells including the Lemon cell are eco friendly i.e. there isn't any waste or toxic gases evolving. Using chemical cells and improvising them on a larger scale can certainly help reduce the energy crisis all over the world.

Keywords: Alkaline batteries, concentration, electrolyte, series & parallel combinations.

I. INTRODUCTION

Nothing happens in the world without energy. Civilizations would collapse if it ceased to be available. Civilizations advance by deploying energy in ever greater abundance. Petroleum is one of the legacies of the past, being the partially decomposed residue of organic matter, such as plankton and algae, that sank to the bottom of lakes and seas and was later subjected to heat and pressure. It is, of course, an extraordinarily convenient source of energy, as it can be transported easily, even in weight-sensitive aircraft.

Chemical Engineers contribute at all levels and to all aspects of developing both new sources of energy and more efficient applications of current sources. Chemical Engineers have long contributed to the refinement of this raw material, which is squeezed and pumped from the ground. They have developed processes and catalysts that have taken the molecules provided by nature, cut them into more volatile fragments, and reshaped them so that they burn more efficiently. Of course, burning nature's underground bounty might be seen, especially by future generations, as the wanton destruction of an invaluable resource. The supply of petroleum is also finite and, although new sources of petroleum are forever being discovered, for the time being at least, they are proving hazardous and increasingly expensive to access and use. Although an "empty" Earth is decades away, one day non-renewable resources such as petroleum will be depleted. Chemical Engineers are already at work on the development of new sources of energy.

Nature, with its head start of four billion years on laboratory, Chemical Engineers have already developed a highly efficient system based on chlorophyll.

Electrochemistry, the use of chemical reactions to generate electricity and the use of electricity to bring about chemical change, is potentially of huge importance to the world. Chemical Engineers have already helped to produce the mobile sources, the batteries that drive our small portable appliances, such as lamps, music players, laptops, telephones, and monitoring devices of all kinds, as well as, increasingly, our cars.

Finally, there are various other methods to generate energy such as the solar energy and wind energy. But the generation of electricity from these sources requires huge plants to be set up which are very complicated and costly. Also highly skilled labour is required to run and handle such plants. Hence the use of simple household methods to generate electricity comes in handy.

A novel technique which we practised was with the use of a lemon cell i.e. Lemon juice (citric acid) as electrolyte in our electrochemical cell. In our method copper and magnesium strips are used as the two electrodes. In this process redox reaction takes place, which is the main reason for power generation. In this reaction the anode metal oxidises and electrons flow through the electrolyte to the cathode thus completing the circuit. By connecting external wires we can work up several electrical devices.

II. BATTERY DESIGN

Cuvettes are used to hold the lemon juice (100% concentrated). 5 ml of the electrolytic solution was used. Magnesium and copper strips were dipped inside the juice, taking care that the two electrodes do not touch each other in the electrolyte. For this purpose clay can be used as it does not react in the solution and also provides a firm base for the electrodes where they can be mounted on. Connect wires to the free end of the electrodes.



Fig1. Materials used

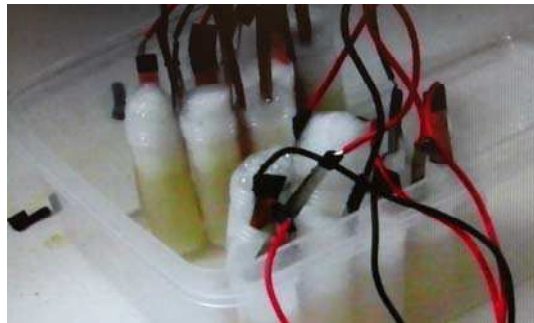


Fig2. Sample lemon Battery

III. EXPERIMENT

A potential difference of about 1.7V was measured across the two terminals of the cell by making the above set up. The motors used in this experiment were standard 9V, 100 rpm motors. To increase the voltage many such single cells were connected in series combination.

| Sr. No. | No. of cells in series connection | Voltage measured (Volts) |
|----------------|--|---------------------------------|
| 1. | 1 | 1.7 |
| 2. | 2 | 3.4 |
| 3. | 4 | 7.0 |
| 4. | 6 | 10.3 |
| 5. | 10 | 15.8 |

This voltage received was much more than the current obtained. It was observed that the current measured from a single cell was comparatively low i.e. 0.1 micro Amps. It was noted that the motors

were working on the principle of maximum power dissipated. Power being a product of potential difference and current ($V \cdot I$) had to be maximised. To overcome this difficulty we connected single cells in parallel so that the current value rises up.

| Sr. No. | No. of cells in parallel connection | Current measured (micro Amps) |
|----------------|--|--------------------------------------|
| 1. | 2 | 0.15 |
| 2. | 6 | 0.4 |
| 3. | 10 | 0.79 |
| 4. | 15 | 1.1 |
| 5. | 20 | 1.4 |

By keeping cells in parallel the voltage was not affected. The goal was to maximize the performance of our car. Increasing the number of cells connected in series will increase the voltage supplied by the battery. Increasing the voltage supplied to a dc electric motor will increase its maximum rotational speed. Increasing the number of cells connected in parallel will increase the current supplied by the battery. Increasing the current supplied to a dc electric motor will increase the maximum applied torque of the motor.

Thus by numerous trial and error methods it was found that 20 cells of such kind when connected in parallel provided enough power to run a motor. Though enough to run the motor, it was not enough to run a car. Hence two batches of twenty cells in parallel each were connected in series which helped to get the required current as well as voltage and in return the power to run the two adjacent motors of the car. This same procedure was repeated for the other two motors.

IV. HOW IS POWER GENERATED?

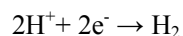
The energy for the battery comes from the chemical change in the Magnesium when it dissolves into the acid. The energy does not come from lemon (electrolyte). Magnesium is oxidized inside the lemon, exchanging some of its electrons with the acid in order to form hydrogen gas in the electrolytic solution which evolves from the copper (cathode). The Magnesium (anode) reaches a lower energy state, and the energy released provides the power. This power generated is enough to light up a LED for three days.

V. MECHANISM

When the cell is providing an electrical current through an external circuit, the metallic Magnesium at the surface of the Magnesium electrode is dissolving into the solution. Magnesium atoms dissolve into the liquid electrolyte as electrically charged ions (Mg^{2+}), leaving 2 negatively charged electrons (e^-) behind in the metal:



This is an oxidation reaction. While Magnesium is entering the electrolyte, two positively charged hydrogen ions (H^+) from the electrolyte combine with two electrons at the copper electrode's surface and form an uncharged hydrogen molecule (H_2):



This is a reduction reaction. The electrons used from the copper to form the molecules of hydrogen are made up by an external wire or circuit that connects it to the Magnesium. The hydrogen molecules formed on the surface of the copper by the reduction reaction ultimately bubble away as hydrogen gas.

VI. PROBLEMS FACED

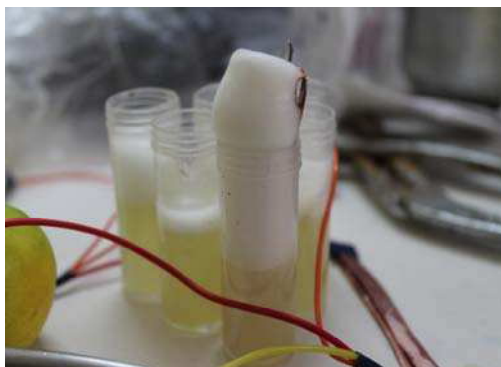


Fig 3. A single cell in reaction phase

As seen in the above figure the hydrogen gas evolved was towering the cuvettes in its reaction phase. Hydrogen gas being combustible was seen as a hazard and had to be taken care of. Changing the ion concentration was one of the ideas. This could have been done by:

- Changing electrolyte concentration
- Changing ion concentration

The electrolyte concentration was changed to 10%, 25%, 50% & 75% and then readings were taken for voltage. The following data was noted.

| Sr. no. | Concentration (%) | Voltage (V) |
|---------|-------------------|-------------|
| 1. | 10 | 0.2 |
| 2. | 25 | 0.5 |
| 3. | 50 | 0.8 |
| 4. | 75 | 1.2 |
| 5. | 100 | 1.7 |

Thus it was concluded to use 100% concentration of lemon juice.

It was then decided to add salt to the electrolyte to check whether the ion concentration changes. It was observed that the addition of salt actually decreased the voltage from 1.7V to 1.53V making it unsuitable to use.

VII. CONCLUSION

It was seen that the batteries had enough power to run the motor but at a very slow speed. The motors when connected to the wheels weren't able to withstand the weight of the car for too long and would abruptly stop. It was observed that after a certain span of time the potential difference between the two electrodes dropped. When the weight of the car was reduced, the car covered a greater distance than the previous case but stopped after sometime because of the weight again and also the magnesium electrode started to dissolve in the electrolyte and the copper strip changed colour. The major problem that occurred during the experiment was that these lemon cells were like "one time use" or use and throw kind of batteries. They cannot be reused or recycled. The container had to be emptied and then refilled again after sometime as the efficiency of the battery decreased, this was because the lemon juice was not a very strong electrolyte and would dissociate fast.

To overcome these difficulties we found an efficient option i.e. using **bleach cell**.

Bleach cell

The main aim for us to study about bleach cell was to get a very efficient substitute to lemon juice. Substituting the lemon juice in the cuvettes by pure bleach one can overcome the above mentioned difficulties. Make the use of the same electrodes i.e. copper and magnesium taking care that the two electrodes do not touch. An unloaded bleach cell records a potential difference of 1.87V across the two terminals while the current was 0.1 micro Amps. Suitable resistances ranging from 100 to 10k ohms can be used in the circuit. This will help to increase the current compromising the voltage which is of greater efficiency. One such cell connected to a 2.5k ohms resistor records a potential difference of 0.606V while the current shoots up to 0.25 mA. Connecting such cells in suitable series and parallel combinations helps increase the current and voltage and in return the power, helping the motor to run better. Though bleach cells took a little time to start up but once started it would give a

constant which lasted for a very long time. A single unloaded bleach cell can easily light up a LED for a week's time.

VIII. FUTURE PROSPECTS AND ADVANCEMENTS

The major advantage of a chemical battery is that there are no hazardous pollutants given out in the environment. Though the project carried out by us was on a small scale and to power a small car this idea can be implemented on a greater scale by improvising techniques used. Not only for cars or automobiles such technique can be used but also to power any small or large electronic gadget by improvising it. This can be done by increasing the number of cells used in series and parallel combination. This reduces the use of conventional sources of energy such as petroleum with simple material which can we can get in abundance cutting down the cost to a great extent.



Fig 4. Cuvettes holding the electrolyte

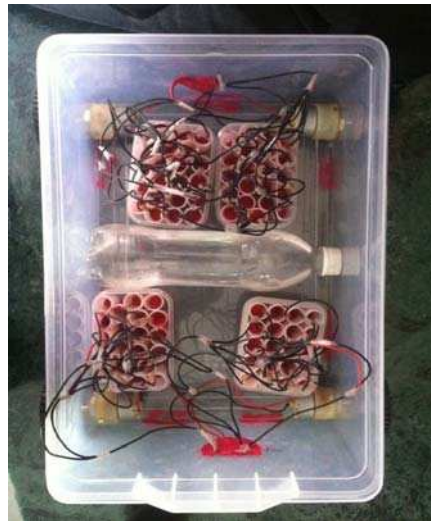


Fig 5. Arrangement of cells in the car



Fig 6. Sample car

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