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# A Study On Water Activated Disposable Paper Battery

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***Abstract* – This study is about water activated disposable paper battery which is eco-friendly, and easily disposable. This battery contains zinc as a metal anode and graphite as a cathode material. The batter remains inactive until the water is absorbed. The paper is used as a substrate for the battery. Once the water is absorbed by the paper substrate, a single cell provides a circuit potential of 1.2V. This battery is flexible, ultra-thin energy storage and production device by combining carbon nanotubes with a conventional sheet of paper. This acts as a high energy battery as well as a supercapacitor. This battery contains all the battery components in a single element, and also making it as energy efficient.**

## 1. INTRODUCTION

Over the past few decades, enormous quantities of industrial pollutants have been released into the environment. Solid waste management, which is already a massive task in India, is becoming more complicated by the invasion of e-waste, particularly computer waste. Electronic-waste (e-waste) represents electronic products including computers, printers, photocopy machines, television sets, mobile phones, and toys, which are made of sophisticated blends of plastics, metals, and other materials. It is an emerging problem because of the volumes of e-waste being generated and the content of both toxic and valuable materials in them. (Sharma Pramila, 2012)

The use of batteries in the electronics, automobile, and chemical industries is growing rapidly worldwide. The portability, high energy density, and low maintenance needs of batteries eliminates the need for transportation or reticulation of power. However, battery technologies suffer from a limited life span, which results in a need for frequent replacement. The generation of large quantities of battery waste has created a need for an effective management strategy to safely treat and recover valuable resources used in battery manufacturing. This review covers current issues in battery waste management, including a description of the advantages, limitations, challenges, and economical feasibility of various treatment technologies.[1] Future perspectives are also discussed to encourage research on imminent environmental issues associated with batteries. (Giovani Pavoski, 2020)

## 2. EXISTING SYSTEM

Generally, battery is of two types primary batteries and secondary batteries. The primary batteries are used one and discarded as the electrode materials are irreversibly changed during discharge; a common example is alkaline battery. Secondary batteries can be discharged and recharged multiple times during an applied electric current; the original composition of the electrodes can be restored by reverse current examples are lead – acid batteries and lithium- ion batteries. These batteries have advantages as well as disadvantages. A major disadvantage is battery explosion which is generally caused by misuse or malfunction such as attempting a damaged battery to charge. Many battery chemicals are corrosive, poisonous and if leakage occurs, either spontaneously or through accidents the chemicals released may be dangerous.

Batteries are one form of electronic waste. E-waste recycling services recover toxic substances which can be used for new batteries. Batteries may be fatal or harmful if swallowed which may lead to many health problems like tissue damage. These batteries are also economically unfriendly and has no establishment for recycling. Thermal runaway can occur with improper charging. As batteries corrode, their chemicals soakinto soil and contaminate ground water and surface water. Our ecosystems, which contain thousands of aquatic plants and animals are compromised when filled with battery chemicals. These means that when we drink from tap water faucets, we ingesting dangerous metals.

Fig 2.1 Existing System

## 3. FABRICATION

The fabrication process of the paper battery starts with a paper substrate cut to a larger size than the desired battery. One end of the paper substrate is immersed in melted wax to create a hydrophobic region to locate the battery terminals. The paper substrate is immersed in a 3M aq. NaCl and dried. The cathode is printed with stencil and dried for 10min. The same printing technique and drying conditions

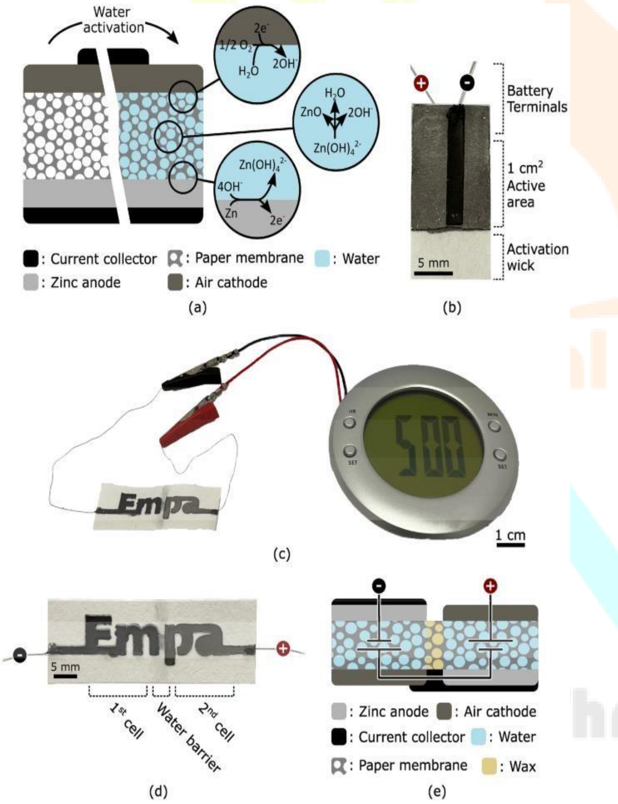


Fig. 3.1 Fabrication of paper battery

are used to subsequently pattern the top current collector, anode and bottom current collector. The sample is cut to its desired shape and the lead wires are connected to create the terminals.

## 4. METHODS

Battery Design:

The single cell battery is composed of paper substrate sandwiched between the air cathode and a current collector on one side and the zinc anode and a current collector on the opposite side. The battery is manufactured without electrolyte, effectively maintaining the anode and cathode isolated from one another. When water is provided to the system, it readily absorbs and diffuses through the paper substrate thus dissolving NaCl dispersed in the paper and activating the electrochemical cell. Because the cathode uses the oxygen from the ambient air, the airtight current collector located on this side of the device is limited in size. This design maximizes oxygen flow while maintaining the contact resistance as low as possible. Contrarily, the substrate is made hydrophobic on the terminals end to avoid undesired electrochemical reactions with the connecting wires. The single cell battery provided a 1.2 V open circuit battery.

Multiple electrochemical cells can be printed on the same substrate and connected in series to achieve higher open circuit potentials.

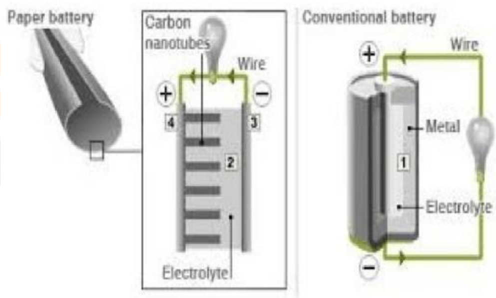


Fig. 4.1 Comparison between conventional and paper battery

## INK PREPARATION AND CHARACTERIZATION

The cathode ink is composed of 15wt% shellac, 30wt% ethanol, 47wt% graphite flakes. Shellac is dissolved with ethanol, after which graphite and PEG are added. The resulting blend is mixed in a planetary mixer for 1 min and 2300 rpm. The anode ink is composed of 2.5wt% shellac, 5.5wt% ethanol, 89.5wt% zinc powder and PEG are added. The resulting blend is mixed in a planetary mixer for q=1 min at 2300 rpm.

The current collector ink is composed of 21.5wt% shellac, 41.5wt% ethanol, 6.5wt% carbon black and 4wt% polyethylene glycol. Shellac is dissolved in ethanol, after which carbon black, graphite and PEG are added. The resulting blend is mixed a planetary mixer for 1min at 2300 rpm, and ball milled for 10 min at 800 rpm. The wax oleogel is composed of 50%wt carnauba wax and 50wt% rapeseed oil. The oil and wax are combined in a metal dish which is then placed on a hotplate, heated above he melting temperature of carnauba wax and thoroughly stirred. The resulting blend is removed from heat and cooled down from room temperature. The rheology of the anode, cathode and current collector was characterized on a rotational and oscillatory rheometer using a plate-plate geometry with a 1mm gap. The measurements were made using a Petier hood to ensure uniform temperature across the sample and minimized solvent evaporation.

## 5. ADVANTAGES OVER EXISTING BATTERIES

1. Biodegradable & Non-Toxic: Since its major ingredients are of organic origin, it is a biodegradable and non-toxic product.
2. Biocompatible: They are not easily rejected by our body's immune system if implanted into human body. 3. Easily Reusable & Recyclable: Being cellulose based product it is easily recyclable and reusable, even with the existing paper recycling techniques
4. Durable: It has a shelf life of three years (at room temperature). Under extreme conditions it can operate within -75° to +150°C
5. Rechargeable: It can be recharged upto 300 times using almost all electrolytes, including bio-salts such as sweat, urine and blood.
6. No Leakage & Overheating: Owing to low resistance, it does not get overheated even under extreme conditions. Since there are no leaky fluids, so even under spontaneous or accidental damage, there is no leakage problem.
7. Very Light Weight & Flexible.
8. Easily Moldable Into Desired Shapes & Sizes.
9. Customizable Output Voltage:
• By varying CNT concentration.
• By stacking & slicing.[33]

## 7. APPLICATIONS

1. In Electronics:
•in laptop batteries, mobile phones, handheld digital cameras: The weight of these devices can be significantly reduced by replacing the alkaline batteries with light- weight Paper Batteries, without compromising with the power requirement.
Moreover, the electrical hazards related to recharging will be greatly reduced.
• in calculators, wrist watch and other low drain devices.
•in wireless communication devices like speakers, mouse, keyboard, Bluetooth headsets etc.
• in Enhanced Printed Circuit Board (PCB) wherein both the sides of the PCB can be used: one for the circuit and the other side (containing the components would contain a layer of customized Paper Battery. This would eliminate heavy step-down transformers and the need of separate power supply unit for most electronic circuits.

2. In Medical Sciences:
• in Pacemakers for the heart
• in Artificial tissues (using Carbon nanotubes)
• in Cosmetics, Drug-delivery systems
• in Biosensors, such as Glucose meters, Sugar meters, etc.
3. In Automobiles and Aircrafts:
• in Hybrid Car batteries
• in Long Air Flights reducing Refueling
• for Light weight guided missiles
• for powering electronic devices in Satellite programs

## 6. LIMTATIONS & DISADVANTAGES OF PAPER BATTERIES:

It would not be logical only to ponder over the miraculous properties and applications of Paper Batteries.
Things need to be discussed at the flip side as well. Following are some of them:

a. Have Low Shear strength:

b. They can be ‘torn’ easily. The Techniques and the Set-ups used in the production of Carbon Nanotubes are very Expensive and very less Efficient. They are electrolysis, CVD etc.

c. When inhaled, their interaction with the Microphages present in the lungs is similar to that with Asbestos fibers, hence may be seriously hazardous to human health

## 8. RESULTS AND CONCLUSION:

One of the major problems bugging the world now is Energy crisis. Every nation needs energy and everyone needs power. And this problem which disturbs the developed countries perturbs the developing countries like India to a much greater extent. Standing at a point in the present where there can’t be a day without power, Paper Batteries can provide an altogether path-breaking solution to the same. Being Biodegradable, Light-weight and Nontoxic, flexible paper batteries have potential adaptability to power the next generation of electronics, medical devices and hybrid vehicles, allowing for radical new designs and medical technologies. But India still has got a long way to go if it has to be self-dependent for its energy solution. Literature reflects that Indian researchers have got the scientific astuteness needed for such revolutionary work. But what hinders their path is the lack of facilities and funding. Of course, the horizon of inquisitiveness is indefinitely vast and this paper is just a single step towards this direction.[33],[20]

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