

Paper Battery: Journey to the Promising Energy Solution

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Abstract:

Batteries are the most complacent solution of energy storage. Presently, a new battery known as ‘paper battery’ is being prominent towards flexibility, ultra-thin energy storage and disposable in nature. This paper offers an intensive insight on this analogously revolutionizing and fascinate answer of energy storage through paper batteries associated provides an in depth analysis of same. Paper battery is combination of two distinct component such as high energy battery and supercapacitor which are separated in traditional electronics. This paper will give a brief review of how paper battery works. It aimed at understanding and analyzing the properties, advantages, disadvantages and several applications of paper batteries. In this paper I will lighten the recent development in fabrication of paper battery such as ‘Bacteria powered paper battery’ in which microorganism can harvest electrical power from any type of biodegradable source. This paper biobattery will be the future power source for papertronics.

Keywords — Paper battery, carbon nanotubes, papertronics, PEM(Protein Exchange Membrane), E-Waste.

I. INTRODUCTION

Batteries in the modern world have become ubiquitous in the senses that they provide energy in wide range. The 21st century is mainly known as ‘Digital Century’. Due to digitalization, the portable electronics devices like mobile phones, computers, i-pads etc. are becoming popular because of their compact size and light weight property. After briefly studying I reached on conclusion that the heart of all these devices is ‘Battery’.

Traditionally, battery design contain anode (-ve electrode), cathode (+ve electrode) which are separated by electrolyte are in the form of liquid solution. This separator prevents the anode and cathode from touching. LIBs has high energy density and high open circuit voltage. Despite superior performance, there are many problems associated with LIBs. Some of those are listed below:

A. Portability and Size:-

Due to separate anode, cathode and electrolytic solution the traditional batteries are not portable and compact. Therefore, we cannot use it in portable electronic devices and medical gadgets.

B. Confined life time:-

Battery life is depend upon the three key factors-time, temperature and number of charging/discharging cycles. All three parameters are inversely proportional to battery life. The

following graph shows as the number of cycles increases temperature increases and it reduces the capacity of battery.

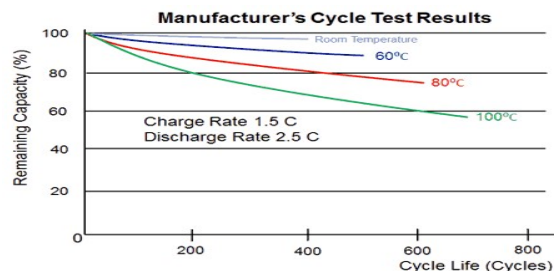


Fig.1 Graph of cycle life of batteries

C. Leakage:-

If battery is deeply discharged the water in battery reacts to form hydrogen gas rather than completing the usual half reaction. The pressure is what burst the battery and leakage happen. The active chemical outflow will damage the instrumentation of batteries.

D. E-Waste:-

E-Waste is an electronic devices which are destined for reuse, resale, recycle and disposal. The traditional batteries also turns into category of e-Waste. Most of the batteries contains cadmium, lead, mercury, copper, zinc etc. Which are all hazardous to the environment and also to human health. These harmful substances permeate into the soil, groundwater and surface water through landfills. It release toxins into the air when they are burnt in municipal waste combustors.

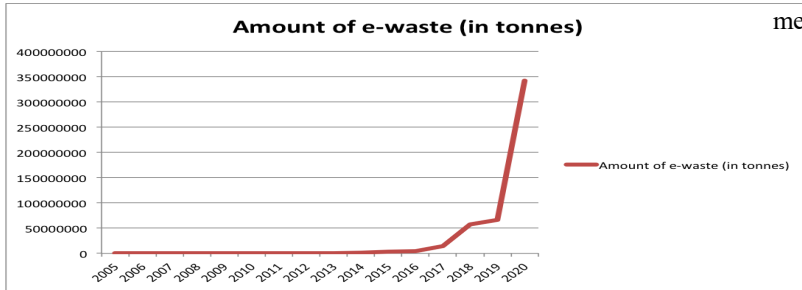


Fig.2 Graph of increasing amount of e-Waste per year

Shockingly, the amount of E-Waste generated within INDIA is literally exponential reaching almost 350 million tons per year.

To remove all these short comes of traditional batteries the term ‘paper battery’ is introduced by engineers.

II. PAPER BATTERY MECHANICS

Paper battery is the innovative solution which find by engineers to pack more power into smaller space. Paper battery is an ultra-thin, biodegradable and super capacity of energy storage made of combination of carbon nanotubes and cellulose paper. A paper battery is act both as charge producing device (battery) and charge storing device (capacitor). A key ingredient of paper battery is carbon nanotubes which is formed from single sheet of carbon atoms rolled into a tiny cylinder. CNTs are stronger than steel and more conducting than the best semiconductors.

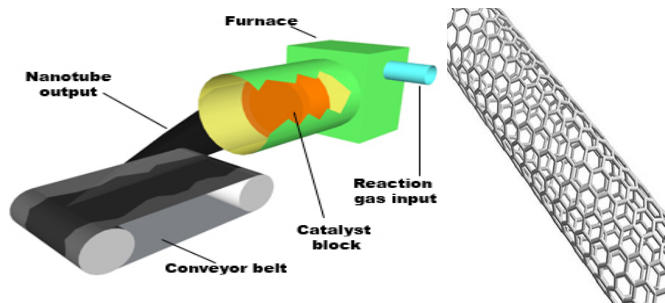


Fig.3 a manufacturing technique of carbon nanotube

In paper batteries paper has intrinsic porous structure which is not only act as separator with low impedance than commercial separator but it also has good cyclability. This separator also function as the mechanical support for battery making it more flexible, cheaper and easier to manufacture.

A. Fabrication:-

A paper battery construction involves following components:

- Cathode:-Carbon Nanotube(CNT)
- Anode:-Lithium metal(Li+)
- Electrolyte:-All type of electrolytes like blood, sweat, urine etc.
- Separator:-cellulose paper

The steps followed in construction of paper battery is mentioned below:

- Take a cellulose based paper and apply black carbon ink on it.
- Spread this ink applied on the paper .
- After spreading ink, laminate a thin film over the cellulose surface.
- Heat the cellulose paper for 5 min. at 80 degree C
- Then, peel of the film from the substrate.
- The electrodes of paper battery is formed by film. The electrolytes LTO(Lithium Titaned Oxide) and LCO(Lithium Cobalt Oxide) are connected to different films.
- The functioning of paper battery can be checked by connecting battery terminals to LED.

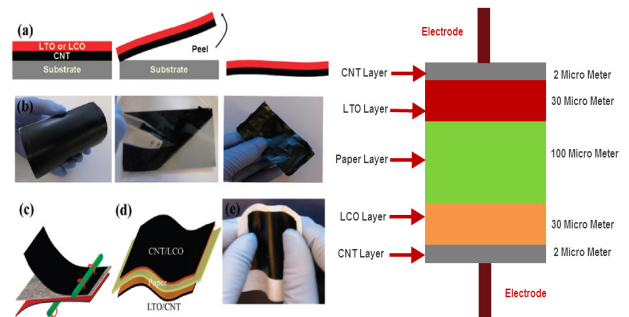


Fig.4 Left side figure shows paper battery construction and right side figure shows the structure of paper battery

B. Functioning:-

The conventional rechargeable batteries which we use in our day-to-day life consist of various separating components which are used for producing electrons with the chemical reaction of a metal and electrolyte. Once the paper of the battery is dipped in ion-based liquid, then the battery start working,i.e. electricity is generated by the movement of electrons from cathode to anode. This is due to chemical reaction between electrodes of paper battery and liquid. Due to quick flow of ions, within few seconds energy will be storage in paper-electrode during recharging. If the anode and cathode comes in contact’ then there will be no flow of current in external circuit. So, to avoid short circuit paper separator is provided.

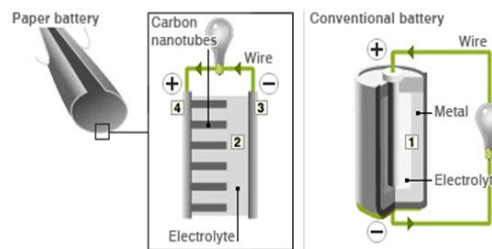


Fig.5 working of paper battery

C. Comparative analysis of paper battery:-

TABLE 1:
Comparison of Advantages, Disadvantages and properties of paper battery

Sr. No	Advantages	Sr. No	Disadvantages	Sr. No.	Properties
1.	Biodegradable and non-toxic.	1.	Having low shearing strength so can torn easily.	1.	Excellent porosity and absorption capacity.
2.	Biocompatible, light weight, flexible and ultra-thin energy storage.	2.	Expansive construction of CNT.	2.	Low mass density and high packing density.
3.	Easily reusable and recyclable.			3.	Good electrical conductivity.
4.	Durable..			4.	Has low resistance($\approx 33\Omega$ PSI)
5.	Rechargeable.			5.	Having low thickness(0.5-0.7 mm)
6.	Operated over large temp.range (-75°C to 150°C)			6.	Shelf life of 3 years.
7.	High tensile strength.				
8.	Adjustable voltage by stacking and slicing.				
9.	No leakage and overheating.				
10.	Cheap in cost.				

From above table we can conclude paper batteries will be more preferable than conventional batteries.

III. ADVANCEMENT IN PAPER BATTERY

A. Bacteria powered paper battery:-

Bacteria is generally considered something to avoid or least treated with caution. But our researchers has created bacteria powered battery on single sheet of paper. This is a fine example of disposable electronics. This design could revolutionize the use of bio-batteries as a power source in remote, dangerous and resource-limited areas.

This bio-battery is the forefront of papertronics. The papertronics have recently emerged as a simple and low cost way to power disposable point of care diagnostic sensors.

i. Construction and working:-

- On one half of a standard A4 chromatography paper, a ribbon of silver nitrate was placed beneath as light layer of wax. This made up the cathode of battery.
- The other half of the battery is made into reservoir using conductive polymer. This is act as anode.
- Besides the anode and cathode there is Protein Exchanger Membrane(PEM) which is designed to conduct protons while acting as an electronic insulator and reactant barrier.
- Then pour the few drops of bacteria-laced water carefully. This activates the microbes cellular respiration, which in turn powers the battery.
- Different folding and stacking methods can alter power and current outputs.

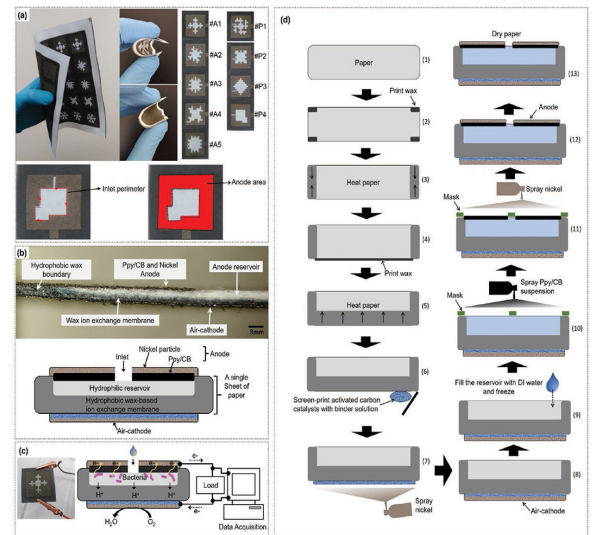


Fig.6 construction of bacteria powered paper battery

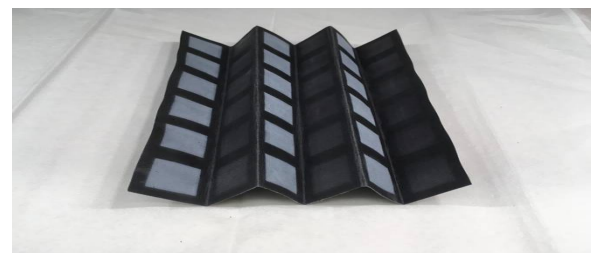


Fig.7 foldable bacteria powered paper battery

ii. Outcomes:-

Scientists were able to generate 31.51 microwatts at 125.53 microamps with six batteries in three parallel series and 44.85 microwatts at 105.89 microamps in a 6×6 configuration. That is enough power to run biosensors that monitor glucose level I diabetes patients, detect pathogens in a body.

III. APPLICATIONS OF PAPER BATTERY

A. In automobiles:-

- For light weight guided missile.
- For powering electronic devices in satellite program.
- In hybrid car batteries.

B. In medical science:-

- Pacemakers for the heart.
- In artificial tissues.
- In cosmetic, drug delivery system.

C. In electronics:-

- In portable devices like laptop, mobile phone, digital camera etc.
- In low drain devices like calculators, wrist watch.

D. Media and advertising:-

The light weight and compactness of paper battery would allow the device to be easily fit into the cereal board design of a cereal box, display videos and play music.

E. Radio frequency identification device.

IV. CONCLUSION

Energy crisis is one of the main issue bugging the planet now. Because for digitalization each nation wants energy and power. This problem which disturbs the developed countries perturbs the developing countries like INDIA to a greater extent. If the day will come without power then paper batteries can be the path breaking solution to the same. The paper batteries have potential adaptability to power next generation electronics due to their shining

properties like non-toxicity, flexibility and bio-degradable in nature. paper batteries can fulfill the energy shortage without concerning about environmental and health issues. So' the paper battery as a energy device has found vast scope in future. A lot of research work is ongoing for emerging technology in paper battery.

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