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# PAPER BATTERY

***Usha C*, Nirmala Devi A C***

Dept. of Electronics and Communication Engineering, SJC Institute of Technology, Chikkaballapur, India

ABSTRACT :

An innovation in energy storage that is truly revolutionary is the paper battery. This innovative design combines aligned carbon nanotubes with a standard cellulose paper sheet to produce an ultra-thin, flexible energy gadget. The paper battery increases efficiency and decreases weight by combining electrodes and other components into a single structure, in contrast to conventional batteries that have separate components. This invention has the ability to provide energy bursts as well as continuous, long-term power generation, akin to a supercapacitor. Paper batteries have the potential to power medical equipment, electrical gadgets, and perhaps hybrid cars in the future because of their distinctive shape and environmentally benign composition. The idea of paper batteries is examined in this essay, along with its benefits, uses, and operational principles. It also covers the continuous research and development initiatives to improve this exciting technology.

Keywords: Paper-based bio batteries, microbial fuel cells, carbon nanotubes, cellulose, paper batteries, backup power, energy, paper, technology, and origami techniques.

## INTRODUCTION:

Many electronic devices and gadgets uses electrical energy, thus a power supply is required. The supply can be given by direct electricity and batteries, the batteries are the devices which are capable of storing and giving electrical energy whenever required. Batteries convert chemical energy into electrical energy, based to charging batteries are divided viz. rechargeable and non- rechargeable. But the batteries are very heavy in Weight and require large floor area.

Thus the advancement in this technology is PAPER BATTERY, it is flexible and thin energy storing device. It is made by merging the carbon nanotubes and Nano composite paper [made by cellulose). The composition is thus inexpensive and the battery is disposable as well as biodegradable. Thus paper battery is high energy storing device and has a property like superconductor. In addition to this paper batteries are flexible and environment-friendly. The paper battery is thin, light in weight and non-corrosive and can be used almost everywhere replacing the conventional large batteries. The paper batteries can be wrapped in any shape so; the set of batteries can be used in electric cars thus the weight of vehicle will reduce to great extent. Paper batteries increase electron flow, which is very essential for high performance.

There has been a growing demand for thinner and smaller electronic devices. To achieve those demands "Paper Battery" offers the best solution. Paper battery is actually a cellulose based „paper" with CNT deposited on either side of paper. A stack of such papers makes a paper battery. Some batteries use Silver Nano Wires instead of CNT. It is extremely thin, flexible, light weight and stores much power in less space. Recently developed paper battery combines the Li-ion based chemicals to make a combination of Li-ion and paper battery.

A paper battery is a flexible, thin, and environmentally friendly electric battery that is made by combining carbon nanotubes with cellulose-based paper. The cellulose spacer in the battery incorporates nanoscale structures to improve conductivity and act as high surface-area electrodes. Paper batteries are non- corrosive, don't need extensive housing, and function similarly to conventional chemical batteries.

Paper batteries are versatile, adaptable, and can be used as a power source for medical devices, electronic gadgets, and hybrid vehicles. They can be folded, cut, or formed into different shapes without losing efficiency or integrity. Paper batteries are also non-toxic, low-cost, and can be easily disposed of. They can produce 1.5 V energy and can be recharged.

A paper battery is a flexible, ultra-thin energy storage and production device formed by combining carbon nano tubes with a conventional sheet of cellulose based paper. A paper battery acts as both a high-energy battery and super capacitor , combining two components that are separate in traditional electronics. This is the Volta battery, which forms the basis for modern chemical batteries. It was discovered by another Italian named Alessandro Volta, whom the battery was named after, in 1800.

## LITERATURE SURVEY

Paper 1

Title : A Survey on Made from Paper Materials Authors : P Richy Rendy Rattery
Published on : March 2023

Description : Carbon nanotubes (CNTs) are large cylindrical molecules that can be used as drug carriers, delivering small molecules, proteins, RNA, DNA, or genes. CNTs can be administered orally or by injection. They can improve the bioavailability of drugs by increasing their solubility and residence time in the blood.

Paper 2

Title : A Survey on Flexible energy storage devices Authors : V. L. Pushparaj, M. M. Shaijumon
Published on : June 2022
Description : Flexible energy storage devices based on nano composites are thin freestanding paper devices that offer mechanical flexibility during operation. These devices can be used to build various types of devices, including super capacitors, batteries, hybrids, and dual-storage battery-in-super capacitors.

Paper 3

Title : A Survey on Paper battery Authors : Nojan Aliahmad, Mangilal Agarwal Published on : May 2021
Description : Paper-based lithium-ion batteries(LIBs) are flexible, rechargeable batteries that produce electricity in the same way as conventional LIBs. They are made by combining cellulose with aligned carbon nano tubes.

Paper 4

Title : A Survey on Paper battery offers future power Authors :Shaijumon Manikonth S.M, Kumar A Published on : August 2021
Description : The paper discusses how paper batteries can be a promising energy solution for the future, as they can function as both a high-energy battery and super capacitor. Paper batteries have the potential to power the next generation of electronics, medical devices, and hybrid vehicles.

## WORKING PRINCIPLE

### *PRINCIPLE OF OPERATION*

A paper battery works by using a metal-air electrochemical cell that contains a water-based electrolyte, paper as a separator, graphite in the cathode, and zinc in the anode. The battery is inactive until it comes into contact with water, which is then transported and absorbed across the paper membrane, activating the battery. The paper's natural wicking and hygroscopic properties are used in this design, along with its biodegradability, low cost, and sustainability.

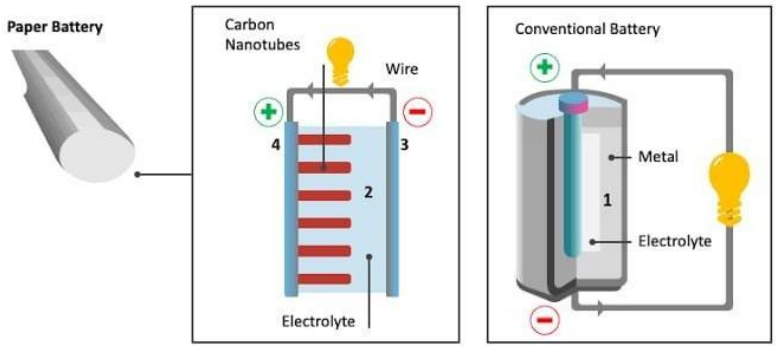


**Fig 3.1 : Working of Paper Battery**

When the paper is dipped in an ion-based liquid solution, a chemical reaction occurs between the electrodes and the liquid. Electrons then move from the cathode to the anode, generating electricity.
Paper batteries can be made with different components, including:

- Anode: Lithium or zinc
- Cathode: Carbon nanotubes or graphite
- Separator: Paper or cellulose

The pores in the paper allow electrons to travel easily while preventing the cathode and anode from touching, which can improve the battery's capacity, cycle stability, and output. Carbon paper can also be used as an interlayer to improve the battery's efficiency and capacity by increasing the contact area between the cathode and electrode, allowing for greater electron flow.

In Paper Batteries, Lithium is used as anode and carbon nanotubes as Cathode, and cellulose is used as the separator. Due to the chemical reaction of electrolytes and carbon, electrons are generated. Similarly, ions are generated due to the chemical reaction between electrolytes and metal.

Paper batteries are flexible and thin due to the use of cellulose paper. They can be environmentally friendly as they avoid some harmful materials used in traditional batteries. The specific components of the electrolyte and electrodes can be adjusted depending on the desired application of the battery. Paper battery technology is still under development. While they hold promise for future applications, researchers are working on improving their energy storage capacity and overall efficiency.

***CONSTRUCTION***

A paper battery construction involves the following components:

Cathode: Carbon Nanotube (CNT) Anode: Lithium Metal (Li+)
Electrolyte: All electrolytes (including bio Electrolytes like sweat, blood and urine). Separator: Paper (Cellulose)

Construction of a paper battery mainly includes these steps:

Step 1: Black carbon ink is applied on a cellulose-based paper.
Step 2: Black Carbon ink is being spread on a paper spread on the paper. Step 3: A thin lithium film is laminated over the exposed cellulose surface.
Step 4: The cellulose paper is heated at 800C for 5 minutes.
Step 5: Next, the film is peeled off from the substrate.
Step 6: The film acts electrodes of the paper battery. One film is connected to the electrolyte LTO (Li4Ti5012) and another film is pasted to the electrolyte LCO (LiCo02).
Step 7: Next, connect a LED on both the ends of the battery and check its functionality.

Paper battery combines cellulose based paper with CNT the paper can act both high energy paper battery and super capacitor depending on the design. Cellulose is complex organic substance found in paper and pulp. CNT"s are main ingredients of paper battery. CNT's where discovered by Japanese scientist name lijima in 1991. They are now considered as top class subject in academic researches and industrial areas CNT's are allotropes is carbon made of graphite and have be constructed in cylindrical. tubes with Nano meter scale in diameter and several millimeters in length. [2.3) Carbon nanotubes (CNTs), consist exclusively of carbon atoms arranged in a series of condensed benzene rings rolled up into a tubular structure. This novel artificial nanomaterial belongs to the family of fullerenes, the third allotropic form of carbon along with graphite and diamond which are both natural sp2 (planar) and sp3 (cubic) forms, respect

## TECHNOLOGIES

Paper battery technology is a developing field with the potential to revolutionize how we store energy.expand_more These batteries are made from cellulose, the main component of paper, and incorporate nano structures to act as electrodes.expand_more This makes them thin, flexible, and eco-friendly.

Here's a breakdown of the technology behind paper batteries:

Materials: Paper batteries are made from cellulose paper infused with carbon nanotubes.expand_more Cellulose is a natural polymer that is abundant, renewable, and biodegradable.expand_more Carbon nanotubes are microscopic tubes of carbon that are excellent conductors of electricity.

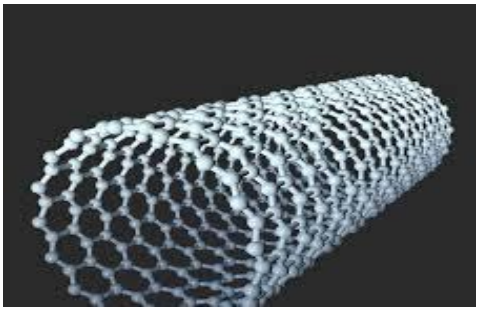

**Fig 3.1 : Carbon nanotubes**

Carbon nanotubes: Carbon nanotubes are used to improve the conductivity of paper batteries. Cellulose: Cellulose is the main component of paper and is used to create a spacer in paper batteries. Ionic liquid: Ionic liquid is used as an electrolyte in paper batteries.
Nanotechnology: Nanotechnology is used to create the nanoscopic scale structures that act as high surface-area electrodes in paper batteries.

Photolithography: Photolithography is used to create hydrophobic and hydrophilic sections on the paper to direct the capillary action of the fluids used in batteries. Wax printing: Wax printing is used to create hydrophobic and hydrophilic sections on the paper to direct the capillary action of the fluids used in batteries.
Laser micro machining: Laser micro machining is used to create hydrophobic and hydrophilic sections on the paper to direct the capillary action of the fluids used in batteries.

***ADVANTAGES***

1. Flexible and Lightweight: Paper batteries are flexible and can be bent or folded without damaging the battery. This makes them ideal for use in wearable electronics and other applications where a rigid battery would not be practical.
2. Biodegradable and Safe: Paper batteries are made from environmentally friendly materials and are biodegradable. This means that they can be disposed of safely without harming the environment. Additionally, paper batteries do not contain any toxic materials, so they are safe to handle.
3. Durable and Wide Operating Temperature Range: Paper batteries are surprisingly durable and can operate in a wide range of temperatures. This makes them suitable for use in a variety of environments.
4. Leak-proof and No Overheating: Paper batteries do not leak or overheat, even under extreme conditions. This makes them a safer option than traditional batteries, which can leak harmful chemicals or overheat and cause fires.
5. Potential for Dual Functionality: Some paper battery designs show promise for functioning as both a battery and a capacitor. This could allow for even more flexibility and wider applications.

***APPLICATINS***

1. Wearable electronics: Paper batteries are thin, flexible, and lightweight, making them ideal for powering wearable devices like smart watches, fitness trackers, and medical sensors. Their conformability allows them to mold comfortably to the body.
2. Low-power electronics: Paper batteries are well-suited for powering low-power devices such as calculators, remote controls, and disposable electronics. Their disposability eliminates the need for complex recycling processes.
3. Medical devices: The biocompatible nature of paper batteries makes them attractive for powering medical implants like pacemakers and drug delivery devices. Their flexibility reduces the risk of irritation or rejection by the body.
4. RFID tags and smart cards: Paper batteries can be used to power RFID tags and smart cards, enabling them to be smaller and more flexible. This could have applications in supply chain management, contactless payments, and identification systems.
5. Sustainable electronics: Paper batteries are made from organic materials and are biodegradable, making them a more environmentally friendly alternative to traditional batteries. This aligns well with the growing demand for sustainable technologies.

## CONCLUSION

The range of possible applications for paper batteries derives from their important advantages as compared to conventional battery technologies. They can be made in virtually any shape and assize to meet the requirements of each application. The batteries are rechargable, and have reduced cost and weight which in itself may give birth to new applications. Paper battery could solve all the problems associated with electrical energy storage. However the reality is still very far away, though the researches are promising.
After analysis of paper battery, we a conclude that the major component of paper battery is CNT. The CNT manufacturing techniques are nefficient which obviously increases the cost, making the paper battery expensive. If the cost is kept economical the batteries will revolationize the electronics industry, The shear strength of paper battery can be increased by adding glass fibre, resins, plastics etc. Further research is needed in Nano toxicology to make CNT's non-hazardous for our health. The use of lithium as an electrode in paper battery can solve most of the safety issues of Li-ion batteries. With paper batteries which will one day change our daily lives.

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