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A Study Paper on Carbon Nanotube Based Paper Battery

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ABSTRACT: This paper gives a satisfying solution of energy storage through Paper Batteries. 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 can function both as a high-energy battery and super capacitor, combining two components that are separate in traditional electronics. This combination allows the battery to provide both long-term steady power production as well as bursts of energy. Being Biodegradable, light-weight and non-toxic, 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.

KEYWORDS: Paper Batteries, Carbon Nano Tubes, Electrolyte.

I.INTRODUCTION

A paper battery is an electric battery engineered to use a spacer formed largely of cellulose (the major constituent of paper). It incorporates nanoscale structures to act as high surface-area electrodes to improve conductivity.In addition to being unusually thin, paper batteries are flexible and environmentally-friendly, allowing integration into a wide range of products. Their functioning is similar to conventional chemical batteries with the important difference that they are non-corrosive and do not require extensive housing.

The composition of these batteries is what sets them apart from traditional batteries. Paper is abundant and self-sustaining, which makes paper cheap. Disposing of paper is also inexpensive since paper is combustible as well as biodegradable. Using paper gives the battery a great degree of flexibility. The battery can be bent or wrapped around objects instead of requiring a fixed casing. Also, being a thin, flat sheet, the paper battery can easily fit into tight places, reducing the size and weight of the device it powers. The use of paper increases the electron flow which is well suited for high performance applications. Paper allows for capillary action so fluids in batteries, such as electrolytes, can be moved without the use of an external pump. Using paper in batteries increases the surface area that can be used integrate reagents. The paper used in paper batteries can be supplemented to improve its performance characteristics. Patterning techniques such as photolithography, wax printing, and laser micromachining are used to create hydrophobic and hydrophilic sections on the paper to create a pathway to direct the capillary action of the fluids used in batteries. Similar techniques can be used to create electrical pathways on paper to create paper electrical devices and can integrate paper energy storage.

Paper batteries = Paper + Carbon nano tubes (CNT)

Carbon nanotube is an allotrope of carbon. Allotropy is nothing but different structural modifications of an element. For example the following image shows the different allotropes of carbon. As you can see from the figure all the allotropes have different arrangement of atoms. For example, in case of diamond, the hardest element found on the earth, every single carbon atom is linked or bonded (covalent bond) with every other 4 atoms of carbon. Likewise, carbon nano tubes are a one of the allotropes of carbon where every carbon atom is linked with every other three carbon

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atoms and also form a cylindrical structure. Carbon nano tubes are manmade. The graphite and diamond are alone the naturally occurring allotropes of carbon.

The carbon nanotube is customary to categorize into two groups – single-walled and multi-walled. A carbon nanotube that consists of only one layer of graphene is usually called a single-walled carbon nanotube or SWCNT (Single-Walled Carbon nanotube). The multi-walled nanotubes consist of several layers of grapheme shaped into concentric cylinders, which are bound together by van der Waals forces.

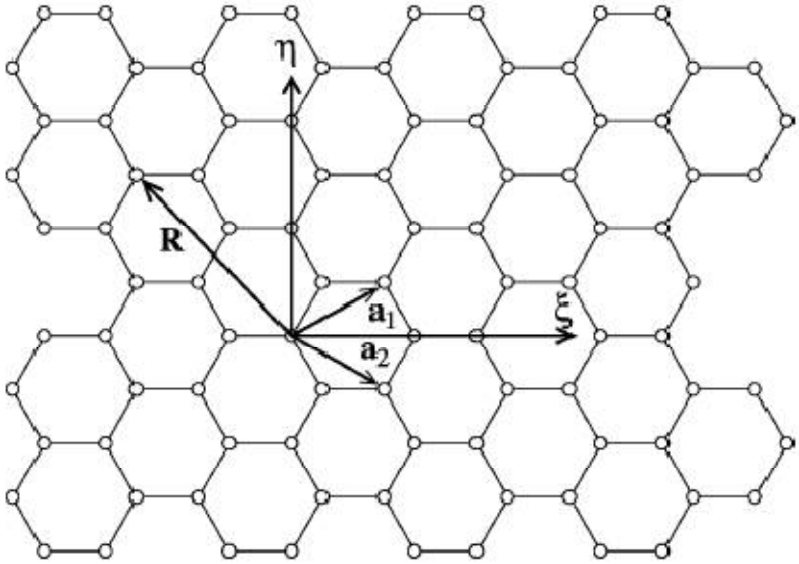

Fig. 1 Graphene sheet showing coordinate system, lattice basis vectors and position vector circle denotes the positions of carbon atoms

Paper, or enhanced paper can be used to develop thin, flexible super capacitors that are lightweight less expensive. Paper that has been enhanced with carbon nanotubes is generally preferred over regular paper because it has increased strength and allows for easier transfer of electrons between the two metals.

A paper battery is a flexible, ultra-thin energy storage and production device formed by combining carbon nanotube s 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 combination allows the battery to provide both long-term, steady power production and bursts of energy. Non-toxic, flexible paper batteries have the potential to power the next generation of electronics, medical devices and hybrid vehicles, allowing for radical new designs and medical technologies.

Paper batteries may be folded, cut or otherwise shaped for different applications without any loss of integrity or efficiency . Cutting one in half halves its energy production. Stacking them multiplies power output. Early prototypes of the device are able to produce 2.5 volt s of electricity from a sample the size of a postage stamp.The devices are formed by combining cellulose with an infusion of aligned carbon nanotubes that are each approximately one millionth of a centimetres thick. The carbon is what gives the batteries their black colour. These tiny filaments act like the electrode s found in a traditional battery, conducting electricity when the paper comes into contact with an ionic liquid solution. Ionic liquids contain no water, which means that there is nothing to freeze or evaporate in extreme environmental conditions. As a result, paper batteries can function between -75 and 150 degrees Celsius.

Electrical Properties of CNT

Carbon nanotubes are electrically conductive and semiconductors. The chiral angle determined characteristics of the tubes are primarily, but for tubes with a small diameter also by their surface curvature. Theoretically, metallic carbon nanotubes can conduct electricity with a density that is 1,000 times greater than metals such as copper. The electrical

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resistance of the tubes is determined by quantum mechanical phenomena and is independent of the tubes' length. There are many applications for the use of carbon nanotubes as electrical components. For example, diodes could be produced by merging SWCNT that have different electrical properties. It has also been shown that the electricalproperties of the tubes change during deformation and stretching. This further increases the potential for the use of carbon nanotubes in electromechanical components such as sensors. Due to its electrical property it is widely use in paper battery and use as anode in lithium ion battery anode.

II. CONSTRUCTION AND WORKING OF PAPER BATTERIES

For the construction of Paper Battery following components are required.

- Carbon Nanotube (CNT) is used as Cathode.
- Lithium metal (Li+) is used as a Anode.
- All electrolytes including bio-electrolytes like blood, sweat and urine etc. are used.
- Paper i.e. Cellulose is used as a separator.

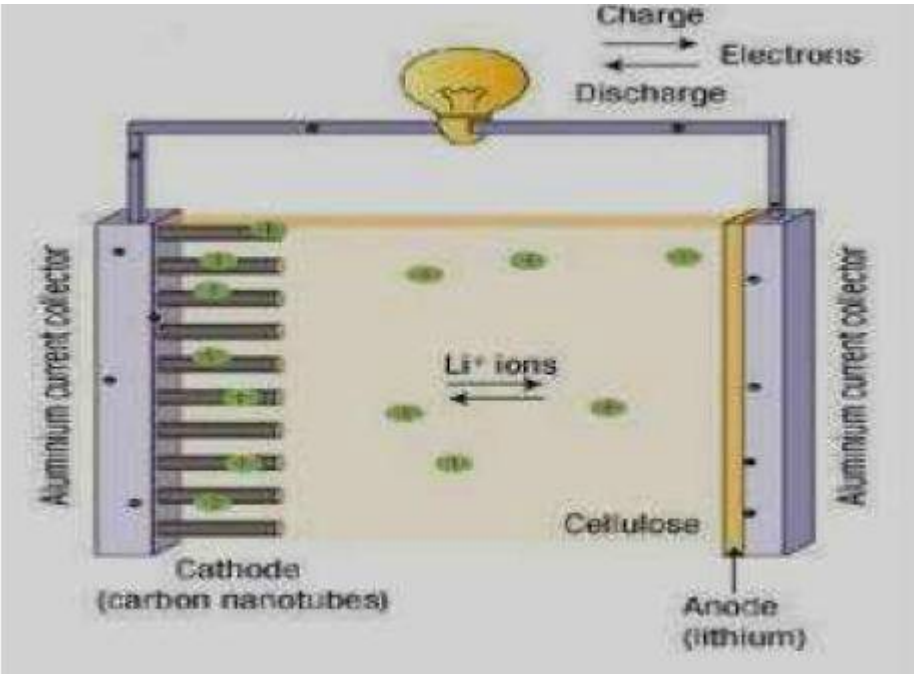

Fig. 2 Schematic of Paper Battery

Anode and cathode are the metal electrodes in the battery. The electrodes are placed in the battery in such a way that, they are in contact with the electrolyte. When an external load connected to the battery circuit is closed, current begins to flow because of the electro chemical reactions occurring inside the battery. Oxidation and reduction are the two main electro chemical reactions happening in any batteries. Oxidation takes place at anode and reduction takes place at cathode. Anode loses electrons to the ions from the electrolyte to form a compound and hence is said to be positively charged. Cathode gains electron from the electrolyte to form a compound and hence is negatively charged.
Firstly, a common Xerox paper of desired shape and size is taken. Then, conformal coating a simple Mayer rod method is used. The specially formulated ink with suitable substrates which is known as CNT ink is spread over the paper sample. The strong capillary force in paper enables high contacting surface area between the paper and nanotubes after the solvent is absorbed and dried out in an oven. A thin lithium film is laminated over the exposed cellulose surface which completes paper battery. This paper battery is then connected to the aluminum current collectors which connect it to the load.

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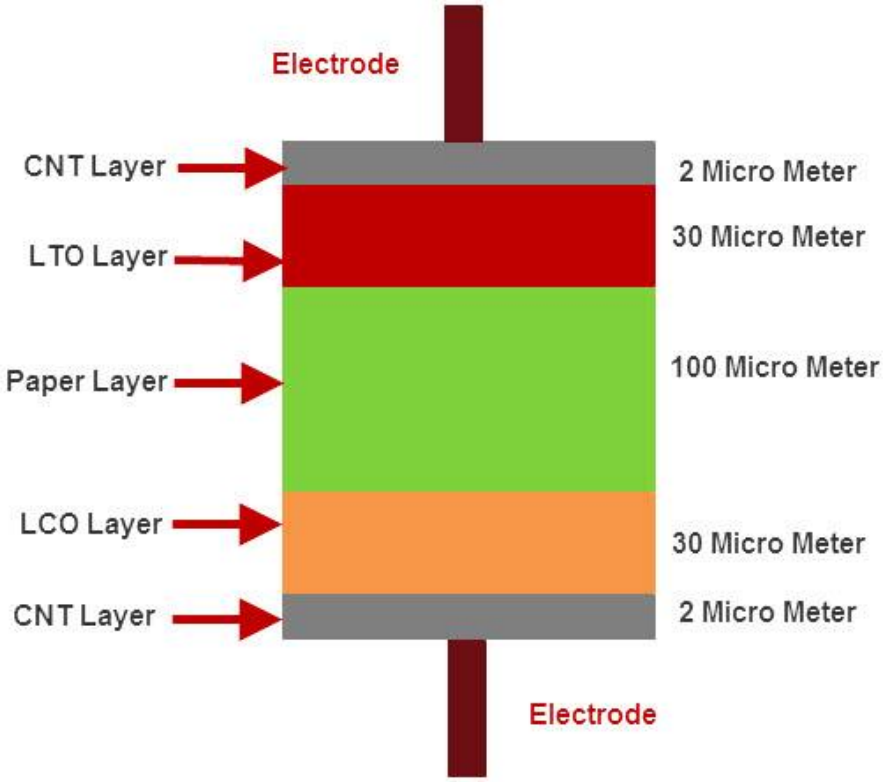

Fig. 3 Constructional Layers

The separator separates the anode and cathode. The batteries have to be very compact in size for the ease of use and hence the cathode and anode are closely packed. The separator acts as a barrier preventing the anode and cathode from touching each other. When they come in contact there will be no flow of current in external circuit. This cellulose based spacer is compatible with many possible electrolytes. Researchers used ionic liquid, essentially a liquid salt, as the battery's electrolyte, as well as naturally occurring electrolytes such as human sweat, blood and urine. Use of an ionic liquid, containing no water, would mean that the batteries would not freeze or evaporate, potentially allowing operation in extreme temperatures.

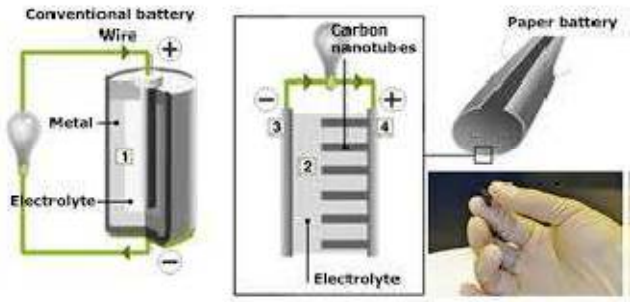

Fig. 4 Operation of Paper Battery

The working of Paper Batteries is similar to that of conventional batteries. Anode and cathode are the metal electrodes within the battery. The electrodes are placed within the battery in such the simplest way that, they're put within the

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III.ADVANTAGES

The Paper Batteries has got several advantages over other types of batteries:-

- It is very light weight, ultrathin, cheap and flexible source of energy storage and production.
- It can operate over large range of temperature (from -75 degree C to 150 degree C).
- It has a shelf life of 3 years.
- These are rechargeable batteries and can be recharged up to 300 times.
- It can work as a super capacitor, having a capacitance up to 200f/g.
- They are ecofriendly device made up of non-toxic material.
- They are biodegradable and bio compatible batteries.
- These are having high tensile strength and the voltages can be adjusted through stacking and slicing.
- They can be easily recycled and reused.

IV.APPLICATIONS

- Paper batteries are portable and used in toys, calculator, wrist watch that requires low energy.
- They can be used in laptops, keyboards, Bluetooth headset and smart card to reduce their weight.
- It found its use in cosmetics, drug delivery and pace makers used for heart treatment.
- They are used in the field of automobiles and aircrafts.

V.CONCLUSION

The energy requirement of the world is increasing day by day that increases the demand of ecofriendly and low costbatteries like paper battery. A paper battery is having a number of advantages over other energy producing devicesand has found its vast scope in future also. A lot of research work is still on the way for this emerging technology. 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 potentialadaptability 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.

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