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TO STUDIES & DEVELOPMENT OF ULTRATHIN ENERGY STORAGE

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Abstract: Paper battery is developing ultrathin super capacitors to enable revolutionary, system-level power and energy solutions. Ultrathin energy storage and production device shaped by combining carbon nano-tubes with a standard sheet of cellulose-based paper. A paper battery will perform each as a high-energy battery and super capacitor for charge storage. This combination permits the battery to produce each long-run steady power production in addition as bursts of energy. Being perishable, Light-weight and Non-toxic, versatile paper batteries have potential ability to power following generation of future electronics, medical devices and hybrid vehicles, permitting radical new styles and medical technologies. The paper is aimed toward understanding & analyzing the properties and characteristics of paper batteries; to review its advantages, potential applications, limitations and drawbacks. This paper additionally aims at light the development and various ways of production ultrathin energy storage.

Keywords: Super capacitor, Carbon Nanotubes, Cellulose, Paper Battery, Polysaccharide

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INTRODUCTION

A paper battery is a flexible, ultra-thin energy storage and production device formed by combining carbon nanotubes with a conventional sheet of cellulose-based paper. A paper battery acts as both a high-energy battery and supercapacitor, 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 centimetre thick. The carbon is what gives the batteries their black color. 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.

A paper battery is an electric battery engineered to use a spacer formed largely of cellulose (the major constituent of paper). It incorporates nano-scale 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.

Paper Battery Construction:

The first and foremost method of constructing paper batteries was proposed and initiated by Robert Linhardt, a chemist at Rensselaer Polytechnic Institute in Troy, New York. Cellulose (paper) was layered upon conductive carbon nanotubes. Though the combination would be a sturdy material to construct batteries,

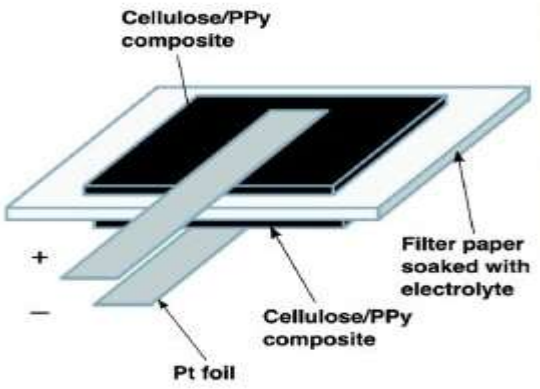

Fig 1: Paper Battery Parts

Given below are three ways to create paper batteries:

1. The first method involves fabricating zinc and manganese dioxide based cathode and anode. The batteries are printed onto paper using standard silkscreen printing press.

This paper is infused with aligned carbon nanotubes which are used as electrode. This paper is dipped in a solution of ionic liquid which acts as the electrolyte.

2. The second method is a bit complex and involves growing nanotubes on a silicon substrate. The gaps in the matrix are then filled with cellulose and once the matrix is dried, the combination of cellulose and nanotubes is peeled off. Thus sheets of paper consisting of layers of carbon nanotubes are created. Two such sheets are combined together to form a super capacitor with a ionic liquid like human blood, sweat or urine being used an electrolyte.

3. The third is a simple method and can be constructed in a laboratory. It involves spreading a specially formulated ink of carbon nanutubes over a rectangular sheet of paper coated with an ionic solution. A thin film of lithium is then laminated on the other side of the paper. Aluminium rods are then connected to carry current between the two electrodes.

4. The fourth method involves coating substrate of stainless steel with carbon nanotubes. The coated substrate is the dried at 80 degree Celsius for five minutes, after which the material is peeled off. A pair of films are used for each paper battery with each film being pasted to different electrolytes like LTO and LCO. A paper is then sandwiched between the two films using glue.

Paper Batteries working Process:

Internal operation of paper batteries is similar to that of conventional batteries with each battery generating about 1.5V.

If one can recall traditional batteries work in the manner where positive charged particles called ions and negative charged particles called electrons move between positive electrodes called anode and negative electrode called cathode. Current flows as electrons flow from anode to the cathode through the conductor, since the electrolyte is an insulator and doesn't provide a free path for electrons to travel.

Similarly in some paper batteries, carbon nanotubes act as cathode, the metal is the anode and paper is the separator. Chemical reaction between metal and electrolyte results in production of ions whereas chemical reaction between carbon and electrolyte results in production of electrons. These electrons flow from the cathode to the anode through the external circuit.

Six Important reasons How Paper Batteries are Better than their Conventional Counterparts:

1. Paper batteries have long lasting time.
2. They are non toxic as they do not involve harmful chemical reactions.
3. They are flexible and can be folded or cut without any effect on their efficiencies. This is because of the fact that they are made up of materials like cellulose and carbon nanotubes which have high tensile strength.

4. They are disposable as they are made up of cellulose which is bio degradable and non toxic.

5. They can be used in harsh climate conditions like heat and cold. This is because the electrolyte does not involve water which makes the battery operate in the range of -73 to 149 degree Celsius.

6. They utilize carbon nanotubes, which are one of the most highly efficient conductors of electricity.

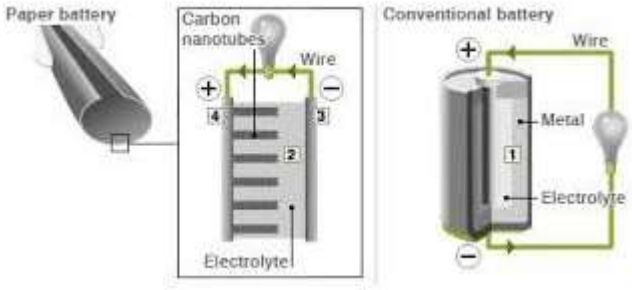

Fig 2 : Working of Paper Batteries

Paper battery can actually prove beneficial for applications where portability and size is the main requirement. Modern day electronic equipments like smart cards, digital watches facilitate the requirement of thin batteries which are long lasting and non toxic.

Wearable Computers – One of the latest real time examples of wearable computers is Google Glass. It actually is a normal spectacle with an optical head mounted display and Glass is a computer in the form of a pair of eyeglasses and includes an optical head-mounted display which allows the user to use a smart phone.

It can also be used for low power devices like calculators, wrist watches and wireless communication devices like mouse, Bluetooth headphones, keypads etc.

Advantages:

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.

Electrolytes:

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.

Potential Application:

The paper-like quality of the battery combined with the structure of the nanotubes embedded within gives them light weight and low cost, offering potential for portable electronics, aircraft, automobiles and toys (such as model aircraft). The batteries employ nanotubes, potentially slowing commercial adoption due to excessive cost. Commercial adoption also requires larger devices. E.g., a newspaper-sized device could be powerful enough to power a car. Paper can be integrated into several different forms of batteries, such as electrochemical batteries, biofuel cells, lithium-ion batteries, supercapacitors, and nanogenerators.

i. Electrochemical batteries can be modified to integrate the use of paper. An electrochemical battery typically uses two metals, separated into two chambers and connected by a bridge or a membrane which permits the exchange of electrons between the two metals, thereby producing energy. Paper can be integrated into electrochemical batteries by depositing the electrode onto the paper and by using paper to contain the fluid used to activate the battery. Paper that has been patterned can also be used in electrochemical batteries. This is done to make the battery more compatible with paper electronics. These batteries tend to produce low voltage and operate for short periods of time, but they can be connected in series to increase their output and capacity.

Paper batteries of this type can be activated with bodily fluids which makes them very useful in the healthcare field such as single-use medical devices or tests for specific diseases. A battery of this type has been developed with a longer life to power point of care devices for the healthcare industry. The device used a paper battery made using a magnesium foil anode and a silver cathode has been used to detect diseases in patients such as kidney cancer, liver cancer, and osteoblastic bone cancer. The paper was patterned using wax printing and is able to be easily disposed of. Furthermore, this battery was developed at a low cost and has other practical application.

Conclusion:

Chemical reaction in the paper battery is between electrolyte and carbon nanotubes. Electrons collect on the negative terminal of the battery and flow along a connected wire to the positive terminal. Electrons must flow from the negative to the positive terminal for the chemical reaction to continue. A paper battery is having a number of advantages over other energy producing devices and has found its vast scope in future also. Being Biodegradable, Light-weight and Nontoxic, flexible paper batteries have potential adaptability to power the next generation of electronics.

Limitations of ultrathin energy storage

1. Since cellulose has low shear strength, these batteries have low strength and can be torn easily.

2. Construction of carbon nanotubes is expensive.

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