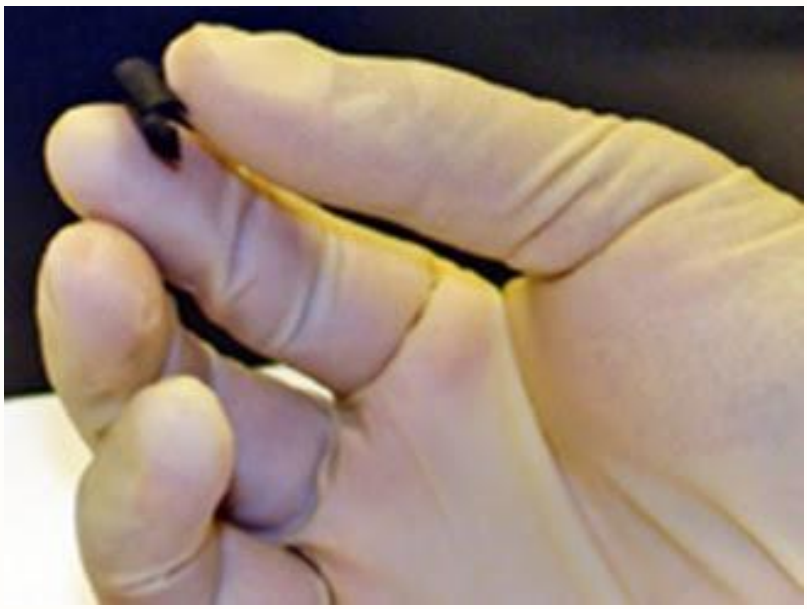
Paper Battery : Seminar Report, PPT,PDF, Free Download

A paper battery is a battery engineered to use a paper-thin sheet of cellulose (which is the major constituent of regular paper, among other things) infused with aligned carbon nanotubes. The nanotubes act as electrodes; allowing the storage devices to conduct electricity. The battery, which functions as both a lithium-ion battery and a supercapacitor, can provide a long, steady power output comparable to a conventional battery, as well as a supercapacitor's quick burst of high energy—and while a conventional battery contains a number of separate components, the paper battery integrates all of the battery components in a single structure, making it more energy efficient. The paper-like quality of the battery combined with the structure of the nanotubes embedded within gives them their light weight and low cost, making them attractive for portable electronics, aircraft, automobiles, and toys (such as model aircraft), while their ability to use electrolytes in blood make them potentially useful for medical devices such as pacemakers. The medical uses are particularly attractive because they do not contain any toxic materials and can be biodegradable; a major drawback of chemical cells.

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.

Specialized paper batteries could act as power sources for any number of devices implanted in humans and animals, including RFID tags, cosmetics, drug-delivery systems and pacemakers. A capacitor introduced into an organism could be implanted fully dry and then be gradually exposed to bodily fluids over time to generate voltage. Paper batteries are also biodegradable, a need only partially addressed by current e-cycling and other electronics disposal methods increasingly advocated for by the green computing movement.



What is a Carbon Nanotube?

Carbon nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. A nanostructure is an object of intermediate size between molecular and microscopic (micrometer-sized) structures. Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1, significantly larger than for any other material. These cylindrical carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. In particular, owing to their extraordinary thermal conductivity and mechanical and electrical properties, carbon nanotubes find applications as additives to various structural materials. For instance, in (primarily carbon fiber) baseball bats, golf clubs, or car parts, where nanotubes form only a tiny portion of the material(s).
Nanotubes are members of the fullerene structural family, which also includes the spherical buckyballs, and the ends of a nanotube may be capped with a hemisphere of the buckyball structure. Their name is derived from their long, hollow structure with the walls formed by one-atom-thick sheets of carbon, called graphene. These sheets are rolled at specific and discrete ("chiral") angles, and the combination of the rolling angle and radius decides the nanotube properties; for example, whether the individual nanotube shell is a metal or semiconductor. Nanotubes are categorized as single-walled nanotubes (SWNTs) and multi-walled nanotubes (MWNTs). Individual nanotubes naturally align themselves into "ropes" held together by van der Waals forces, more specifically, pi-stacking.

Development of Paper Batteries

The creation of this unique nano-composite paper drew from a diverse pool of disciplines, requiring expertise in materials science, energy storage, and chemistry. In August 2007, a research team at Rensselaer Polytechnic Institute (led by Dr. Robert Linhardt, the Ann and John H. Broadbent Senior Constellation Professor of Biocatalysis and Metabolic Engineering at Rensselaer; Pulickel M. Ajayan, professor of materials science and engineering; and Omkaram Nalamasu, professor of chemistry with a joint appointment in materials science and engineering) developed the paper battery. Senior research specialist Victor Pushparaj, along with postdoctoral research associates Shaijumon M. Manikoth, Ashavani Kumar, and Saravanababu Murugesan, were co-authors and lead researchers of the project. Other co-authors include research associate Lijie Ci and Rensselaer Nanotechnology Center Laboratory Manager Robert Vajtai.

One method of manufacture, developed by scientists at Rensselaer Polytechnic Institute and MIT, begins with growing the nanotubes on a silicon substrate and then impregnating the gaps in the matrix with cellulose. Once the matrix has dried, the material can be peeled off of the substrate, exposing one end of the carbon nanotubes to act as an electrode . When two sheets are combined, with the cellulose sides facing inwards, a supercapacitor is formed that can be activated by the addition of the ionic liquid. This liquid acts as an electrolyte and may include salt-laden solutions like human blood, sweat or urine. The high cellulose content (over 90%) and lack of toxic chemicals in paper batteries makes the device both biocompatible and environmentally friendly, especially when compared to the traditional lithium ion battery used in many present-day electronic devices and laptops.

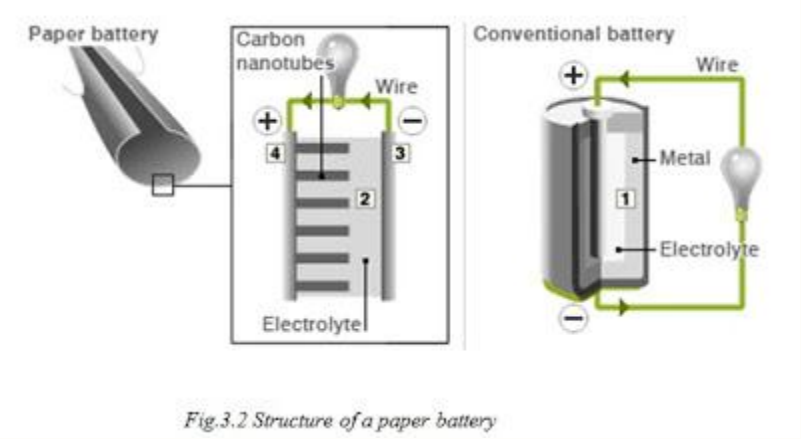


Fig.3.2 Structure of a paper battery

Widespread commercial deployment of paper batteries will rely on the development of more inexpensive manufacturing techniques for carbon nanotubes. As a result of the potentially transformative applications in electronics, aerospace, hybrid vehicles and medical science, however, numerous companies and organizations are pursuing the development of paper batteries. In addition to the developments announced in 2007 at RPI and MIT, researchers in Singapore announced that they had developed a paper battery powered by ionic solutions in 2005. NEC has also invested in R & D into paper batteries for potential applications in its electronic devices.

Construction

A very brief explanation has been provided.

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

The process of construction can be understood in the following steps:

• Firstly, a common Xerox paper of desired shape and size is taken.

• Next, by conformal coating using a simple Mayer rod method, the specially formulated ink with suitable substrates (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 our paper battery. This paper battery is then connected to the aluminum current collectors which connect it to the external load.

• The working of a paper battery is similar to an electrochemical battery except with the constructional differences.