Bio-Batteries

Energy storage based on flexible nanocomposite paper

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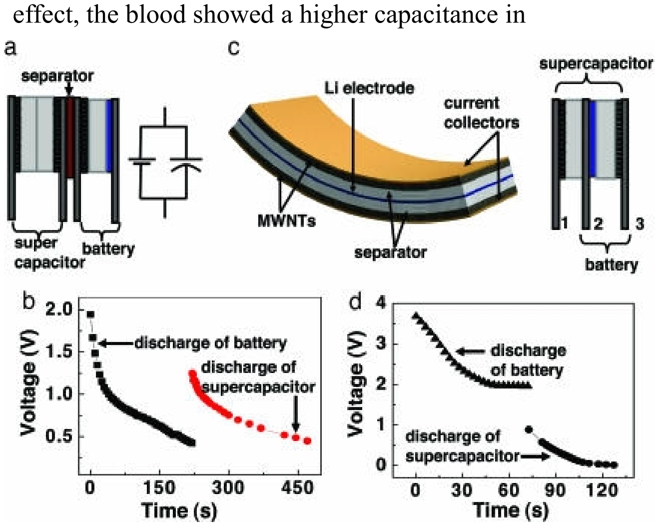
Electronics have influenced many characteristics of the late 20th and 21st century. A portion of this influence involves the battery, which has become well known as an energy source for mobile devices and electrical units requiring autonomy. When a charge is required, the positive and negative leads of a battery are connected through a load, i.e an electrical circuit, which causes an electrochemical reaction to release electrons. This method requires three things; electrodes, a spacer, and electrolytes. A new investigation into multi-walled nanotubes (MWNT) at Rensselaer Polytechnic Institute has developed a system comprised mostly of plant cellulose found in paper. The nanocomposite paper contains carbon nanotubes created using Chemical Vapor Deposition (CVD) on a silicon substrate.

The nanoporous paper can be constructed to form supercapacitors or Li-ion batteries depending on the layering methods, but may be most useful when doubled as a hybrid capacitor/battery. The appearance of this nanoporous paper resembles normal paper, but in this case would be black on one side containing carbon nanotubes and gray on the side of cellulose. The carbon nanotubes give the paper conductivity and will serve a vital role in the battery when utilizing one of many possible electrolytic fluids, an Aluminum current collector, and Lithium anode. These electrolytic fluids range from room temperature ionic fluids ((RTIL),1-butyl,3-methylimidazolium chloride ([bmIm][Cl])) to biofluids such as sweat, urine, or blood. In particular, blood (tested as human whole blood in K_2 EDTA) may prove to become the most resourceful of these biofluids as it worked efficiently as an electrolyte and "measured at a scan rate of 50 mV/s at room temperature." [1] As an end effect, the blood showed a higher capacitance in comparison with sweat at 18F/g to 12F/g with an operating voltage of ≈2.4V, respectively.



The battery is 90% plant cellulose, retaining all the flexible properties of paper and it can withstand a broad range of thermal fluctuation (195-423 K). This MWNT cellulose construction is hailed as environmentally friendly and can form a free standing organic supercapacitor when in combination with RTIL. To create a battery, superconductor, or hybrid, the nanocomposite paper must be layered with a current collector using Ti/Au or Aluminum foil and a Lithium anode plate. Connecting the capacitor(s) in parallel with the battery will create a dynamic hybrid capable of cyclical charge-discharge behavior. This has been shown to retain good performance of over 100 cycles with electrolytic RTIL. There is a large disparity between the first irreversible capacity of (≈430 mAh/g) and a capacity of 110 mAh/g in subsequent reversible cycles. The experiment was produced by powering a red LED with between 3.6 to 0.1V at a constant 10mA/g current.

The fabrication possibilities for supercapacitors and miniature Li-ion batteries are robust with the emergence of the flexible nanocomposite paper. This technology could be applied to a wide range of disciplines with a temperature variance ranging far below and above normal organic conditions and with many aqueous or non-aqueous fluids acting as electrolyte sources. Application could range from aeronautics to biomedical services powering pacemakers, biosensors, and future prosthetics. Nanocomposite paper can adapt to practically any spacial requirements and can be stacked for a desired system voltage source. The production method is still in development, but this technology is expected to be streamlined for future demand.

References

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