

The Effect of Single Walled Carbon Nanotubes on Lithium-Ion Batteries and Electric Double Layer Capacitors

C. Moran, S. Umemoto, K. Sato, Y. Abe, T. Yanagiura, M. Endo
Faculty of Engineering, Shinshu University, Nagano, Japan

Since SWNTs have improved the performances of similar devices, we incorporated them into the anode of the Li-ion battery and the electrodes of the EDLC to observe the effects it would have on their respective efficiencies. We will measure the current capacity of the Li-ion battery and the capacitance and resistance of the EDLC. If the use of SWNT also improves these devices, it would be evidence that Li-ion batteries and EDLCs are excellent options for more efficient commercial energy storage. Li-ion batteries are better for applications than other secondary batteries because there is no memory effect and they have a higher energy density. Li-ion batteries are therefore suitable for the lightweight batteries needed in cell phones and laptops, as well as electric cars. Super capacitors have a high power density and a very long life, with a short charge/discharge time and a high charge/discharge efficiency (above 90%), making them suitable for clean energy storage for memory back-up, hybrid and electric cars and bridge power.

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Introduction

We tested the effects of SWNTs on the overall performance of Li-ion batteries and EDLCs.

SWNTs were incorporated into the anode of the Lithium-ion Battery (LIB). A LIB using only graphite in the anode was the control.

SWNTs were mixed with activated carbon in the EDLC to act as conductors. An EDLC containing no SWNT was the control. Activated carbon is used because of its high surface area.

Better than Other Secondary Batteries:

Lithium-ion Batteries

•Higher energy density than other secondary batteries

•High voltage (3.6 V)

•No memory effect

weight

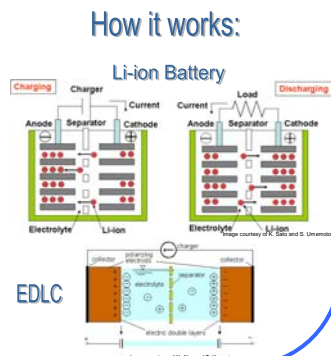
EDLCs

•High power density

•High charge/discharge efficiency (>90%)

•Short charge/ discharge time

•No pollution

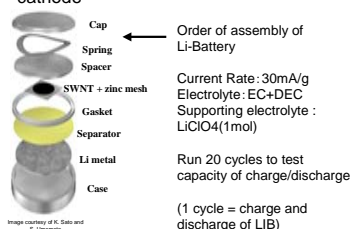


Experiment

Li-ion Battery

ANODE: HiPco SWNT + PVdF binder pressed into zinc mesh

DEVICE: assembled with Lithium metal cathode



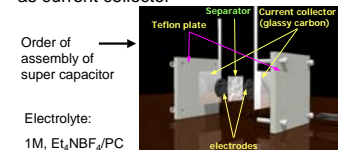
Experiment setup



EDLC

ELECTRODES: HiPco SWNT + PTFE binder + activated carbon

DEVICE: assembled with glassy carbon as current collector



Experiment setup (Ar atmosphere)



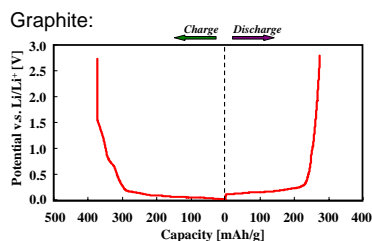
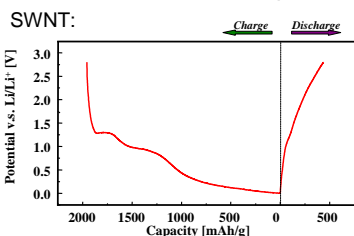
Potential/Galvanostat Method:

For each of three voltages – 2V, 2.5V and 3V – six discharge currents were tested – 1mA, 5mA, 10mA, 20mA, 40mA and 60mA.

$$C = I \times \frac{t_2 - t_1}{V_1 - V_2} \text{ [F]}$$

Capacitance calculated using voltage and time at 60% and 40% of regulation voltage

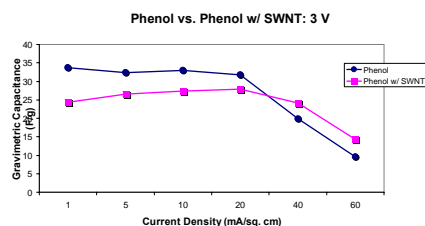
Li-ion Battery



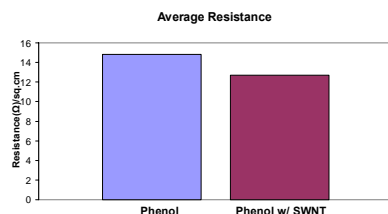
The LIB with SWNT reached a much higher capacity (close to 500 mAh/g) than graphite alone (close to 300 mAh/g).

Results

EDLC



Electrodes with SWNT only perform better at high current density (>30 mA/cm²)



Electrodes with SWNT had a much lower resistance than plain activated carbon.

Conclusions

Li-ion Battery

- Using SWNT increased the capacity of the battery
- However, the battery was unable to hold a constant voltage.
- The graphite anode had a lower capacity, but was able to hold a voltage constant for an extended period of time.

EDLC

- Adding SWNT improved the capacitance at high current densities.
- Resistance decreased with addition of SWNT

Acknowledgements

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