# CARBON NANOTUBES IN SUPECAPACITORS

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## Introduction

Supercapacitors are electrochemical devices that have the ability to store and release charge and deliver high power densities over short periods of time. The voltage of carbon-based supercapacitors depends mainly on three factors:(a) the electrolyte potential stability, (b) the active material potential stability and (c) the current collector potential stability. The electrolyte working potential depends on the type of electrolyte used. With aqueous-based supercapacitors, it is generally limited to 1.224 V, due to water electrolysis. When aprotic electrolytes are used, this potential can be theoretically increased up to 4 or 4.5 V, limited by the redox decomposition reactions of the organic compounds [1].

Carbon nanotubes are unique nanostructures with remarkable electronic and mechanical properties. Interest from the research community first focused on their exotic electronic properties, since nanotubes can be considered as prototypes for a one-dimensional quantum wire. As other useful properties have been discovered, particularly strength, interest has grown in potential applications. Carbon nanotubes could be used, for example, in nanometre-sized electronics or to strengthen polymer materials compounds [2].

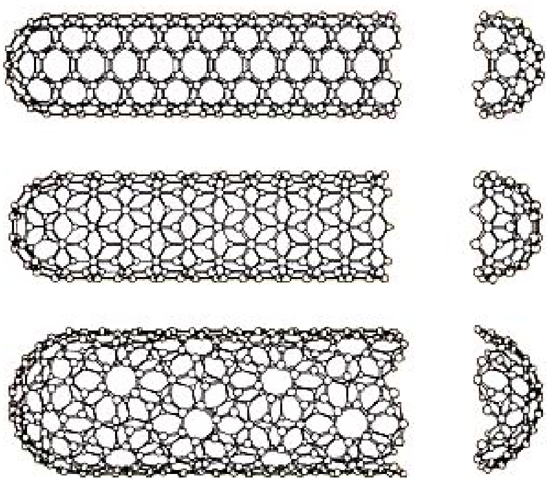

***Fig. 1*** *Models of nanotubes*

## Experimental

Supercapacitor is created from non-corrosive metal screen, carbon nanotubes (four types), binding agent (teflon) and conditioner ($NH_4HCO_3$).

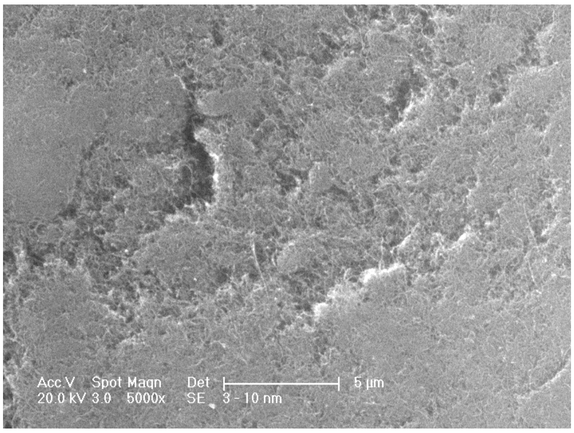


***Fig. 2*** *Nanotubes - size 3-10 nm*

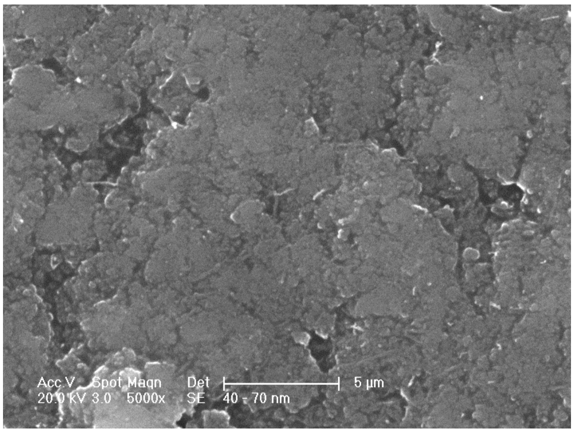


***Fig. 3*** *Nanotubes - size 40-70 nm*

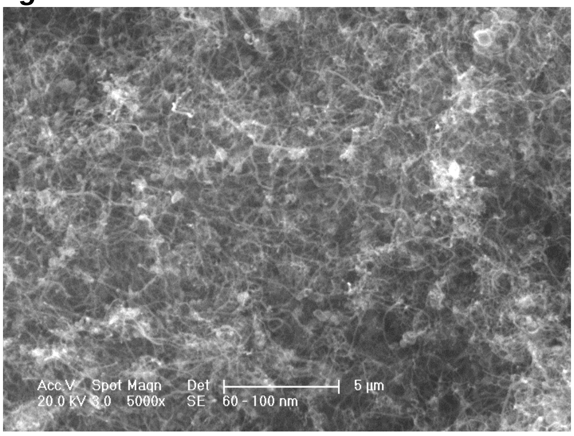


***Fig. 4*** *Nanotubes - size 60-100 nm*

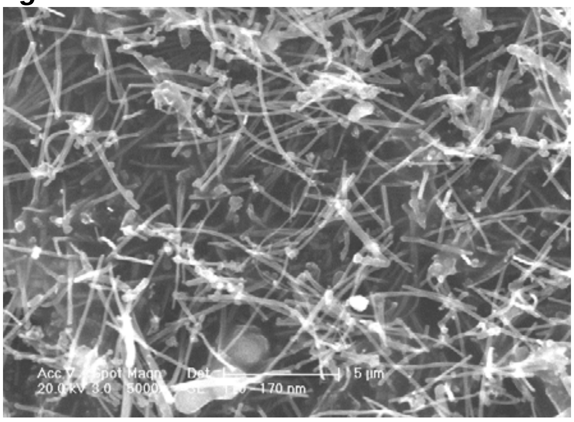

***Fig. 5*** *Nanotubes - size 110-170 nm*

Old method of preparation: Mixture of these three substances (carbon nanotubes, binding agent and conditioner) are suitable in the ratio (1:1:2). Subsatnces are thoroughly mixtured in porcelain basin. Then the mixture is put on the non-corrosive metal screen. The electrode is put into an oven at 140 °C for 30 minutes.

New method of preparation: The carbon nanotubes are boiled in water about one hour then teflon is added in minimum quantity. The mixture is filtrated and dried in the oven and then is added conditioner. The mixture is put on metal screen and pressed in the hand press and then the electrodes are dried in the oven at 140 °C for 30 minutes.

The electrodes are measured in liqiud electrolyte. Liqiud electrolyte is lithium perchlorate with propylene carbonate:

$$0.5 \text{ mol.l}^{-1} \rightarrow \quad 2.66 \text{ g } LiClO_4 + 50 \text{ ml propylenecarbonate}$$

All measurements were measured in the glass container for liquid electrolytes.

Potentiogalvanostat PGSTAT 12 (Eco Chemie, The Netherlands) was used for electrochemical measurements (the method of cyclic voltammetry).

## Results and Discussion

The capacity is calculated from the formula:

$$C = \frac{1}{2} . \frac{\Delta I}{\alpha} \tag{1}$$

where C [F] is capacity, $\Delta$i [A] is difference of currents at anodic and cathodic branches and $\alpha$ [V/s] is the scan rate (for this measurement 0.01 [V/s]).

***Table 1*** *Results of the old preparation method*

| **Sample** | “3-10“ | “40-70“ | “60-100“ | “110-170“ |
|---|---|---|---|---|
| **Ratio** | 1:1:2 | 1:1:2 | 1:1:2 | 1:1:2 |
| **Nanotubes [g]** | 0.0310 | 0.0450 | 0.0760 | 0.0280 |
| **Binding agent [g]** | 0.0310 | 0.0470 | 0.0770 | 0.0270 |
| **Conditioner [g]** | 0.0610 | 0.0890 | 0.1540 | 0.0550 |
| **Weight [g]** | 0.0077 | 0.0153 | 0.0120 | 0.0048 |
| **$\Delta$I [mA]** | 0.9961 | 1.1470 | 0.7287 | 0.1639 |
| **C [F]** | 0.0498 | 0.0574 | 0.0364 | 0.0082 |
| **C [F/g]** | **6.4682** | **3.7484** | **3.0363** | **1.7073** |

***Table 2*** *Results of the New preparation method*

| **Sample** | “3-10“ |
|---|---|
| **Nanotubes [g]** | 0.2030 |
| **Teflon [ml]** | 0.0175 |
| **Weight [g]** | 0.0205 |
| **$\Delta$I [mA]** | 4.7560 |
| **C [F]** | 0.2378 |
| **C [F/g]** | **11.6000** |

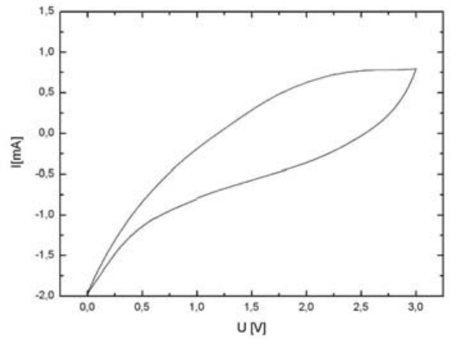


***Fig. 6*** *Scan of cyclic voltammetry for nanotubes - size 3-10 nm*

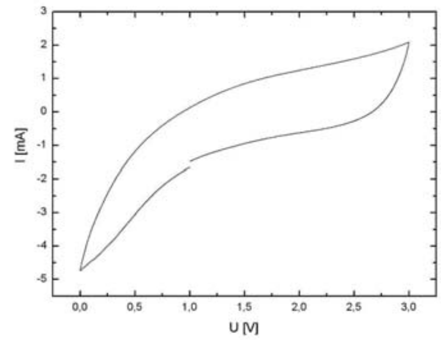


***Fig. 7*** *Scan of cyclic voltammetry for nanotubes - size 40-70 nm*

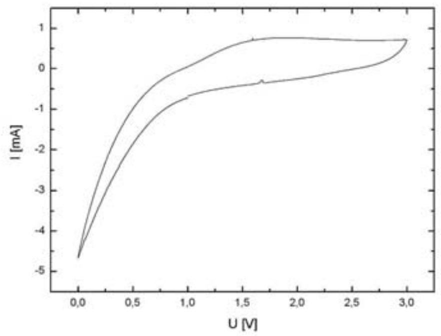


***Fig. 8*** *Scan of cyclic voltammetry for nanotubes - size 60-100 nm*

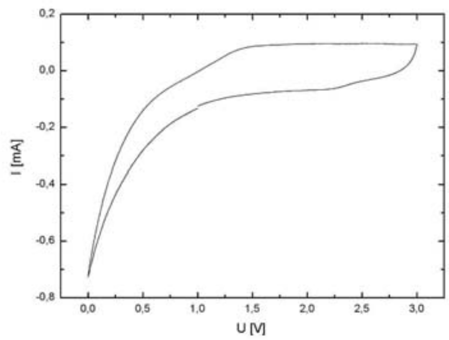


***Fig. 9*** *Scan of cyclic voltammetry for nanotubes - size 110-170 nm*

## Conclusions

The best capacity (6.46 F/g) was measured for “3-10 nm” carbon nanotubes in the old method. Therefore “3-10 nm” carbon was chosen to proceed further measurements using the new preparation method.
The new method of preparation guarantees homogenous distribution of the binding agent hence the capacity of the electrodes is bigger (11.60 F/g).
The carbon nanotubes seem to be good choice for supercapacitors.

## Acknowledgements

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## References

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2. M. and G. Dresselhaus, P. Eklund, R. Saito, Physics World – PhysicsWeb – Carbon nanotubes, 1998.