Carbon Nanotubes used in Electrochemical Capacitors

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Electrochemical capacitors (ECs) are formed by pure electrostatic attractions of ions in an electrical double layer. They have the advantages of fast release of the stored energy and no pollution to the surrounding environment. ECs can be used as an energy device between traditional capacitor and battery. The application of different types of carbon nanotubes (CNTs) for building capacitors proved the high ability of this material for the accumulation of charges, and progress on ECs using CNTs has been achieved [1,2].

The multi-walled carbon nanotubes (MWNTs) we used were synthesized by catalytic decomposition of benzene or methane. Basically, carbon source, vapor-phase catalyst precursor of ferrocene, growth promoter and hydrogen gas were passed into a horizontal reactor to grow MWNTs at about 1423K[3]. The single-walled carbon nanotubes (SWNTs) we used were prepared by a hydrogen arc discharge method [4].

The microstructure of the CNTs employed were characterized by transmission electron microscopy (TEM) and the pore sizes and their distribution of these nanotubes were measured with nitrogen adsorption at 77K by a micropore adsorption analyzer. The electrodes were prepared by pressing CNTs between two pieces of Ni foam and the electrolyte was 6M KOH solution. The capacitor performance was investigated by a galvanostatic charge/discharge technique using a battery testing system.

In the case of carbon, the double layer capacitance is associated with the electrode/electrolyte solution interface area which varies with the type of carbon and its conditions of preparation. Normally, a value of 15-50μF/cm^2 was estimated [1]. The CNTs has a hollow core structure and entangled network, it may be suitable for electric double layer and the electric double layer capacitance may reach a high value around 50μF/cm^2. The experimental results are summarized in Table 1. MWB1 and MWB2 were synthesized by catalytic decomposition of benzene, the mean diameter was 40nm and 20nm respectively. MWM was synthesized by catalytic decomposition of methane. The capacitance of the as-prepared MWNTs synthesized by catalytic decomposition of benzene showed only several farad per gram, but after purification of ultrasonic, boiling in water, heat treated and acid washing [5], its capacitance was improved to 20F/g, 60F/g respectively. Fig.1 and Fig. 2 are the TEM images of the as-prepared and purified sample MWB1. The impurities such as amorphous carbon, catalyst particles were effectively removed after purification. The as-prepared sample MWM had little impurities and showed good capacitance performance without any treatment. The as-prepared SWNTs (SW), whose specific surface area ranges from 100-170 m^2/g, showed a high capacitance near to 50F/g. It is believed that the capacitance of suitably pretreated SWNTs can be higher.

The capacitance of different types of CNTs is different. Although CNTs have a relatively low specific surface area compared to activated carbon and carbon fibers, they show higher utilization effectiveness of surface area than the commonly used activated carbon electrode materials.

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Reference:
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[5] Hou P X, et al. Carbon, 2002, 40, 81.

Table 1. The comparison of several types of CNTs using as EC electrode

	MWB1	MWB2	MWM	SW
Diameter(nm)	40	20	10	2
BET (m^2/g)	88	176	116	168
Treatment	Purified	Purified	As-prepared	As-prepared
C (F/g)	20	60	55	50

Note:
MWB1: Sample from decomposition of benzene
MWB2: Sample from decomposition of benzene
MWM: Sample from decomposition of methane
SW: Sample from hydrogen arc discharge method

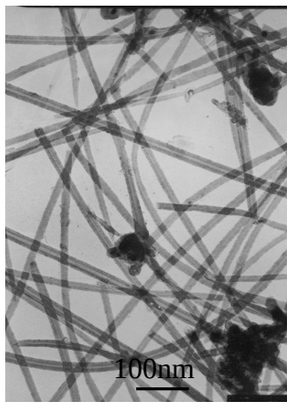

Fig.1. TEM image of the as-prepared MWNTs(MWB1)

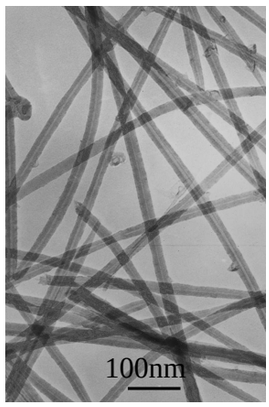

Fig.2. TEM image of the purified MWNTs(MWB1)