Cycling Characteristics and Electrochemical Impedance Spectroscopy Study of Carbon/Carbon Supercapacitor in Organic Electrolyte

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Supercapacitors, commonly described as power sources, are in fact intermediate systems between electrochemical batteries and dielectric capacitors : as compared to dielectric capacitors, supercapacitors can supply high power during several seconds. These characteristics, associated with a very good cyclability, explain the lot of applications in which supercapacitors are or could be used : automotive, electronic, spatial, military (…).

Three different types of supercapacitors are described in the literature : carbon/carbon [1,2], metal oxide [3], and electronically conducting polymers [4,5] systems.

This communication will present the results obtained in the Laboratoire d'Electrochimie Industrielle of CNAM (France) on carbon/carbon supercapacitors. The active material used in this system is an activated carbon powder [2] with high specific surface area (2300 m^2/g). The electrostatic charge storage processes through the reversible adsorption of ions from the electrolyte, here a non-aqueous one (NEt_4BF_4 in ACN). No faradaic reaction occurs during the charge/discharge cycles. Current collectors are treated-aluminium expanded grids. The treatment consists in an acetylene black-charged conductive paint applied on the courant collectors.

The characteristics of the cells assembled in the laboratory are as follow :

- ESR = 1 Ω.cm²
- Specific capacitance = 100 F/g
- Cyclability over more than 20,000 cycles

All these results are obtained with galvanostatic cycling between 0 and 2.3 V(cf. figure 1).

Electrochemical Impedance Spectroscopy measurements were also carried out on the supercapacitors. It is possible to define C*(ω) as the complex capacity of the system, and to calculate the real part(1) and the imaginary part(2) of the capacity, from the Nyquist experimental plot, by using a simple mathematic transformation. It will be showed that the frequency dependence on the real and imaginary parts of the capacitance can bring information concerning the time constant of the whole system (cf. Figures 2 and 3). The influence of several parameters on this time constant, like the active material amount in the electrode, the nature of the electrolyte or the type of electrode used, will be presented and discussed.

(1) $C' = - Im(C^*) / |Z|^2 \omega$

(2) $C'' = Re(C^*) / |Z|^2 \omega$

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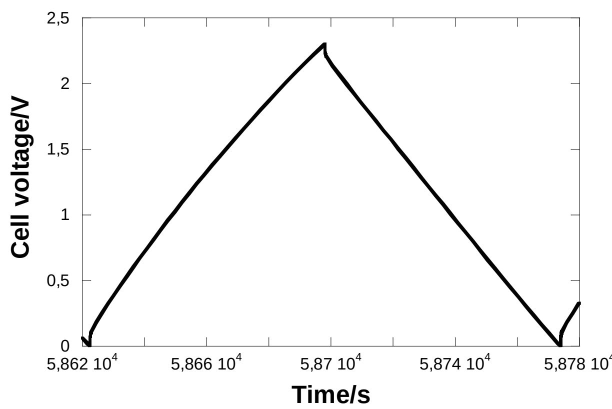

Figure 1 : galvonastatic cycling between 0 and 2.3 V

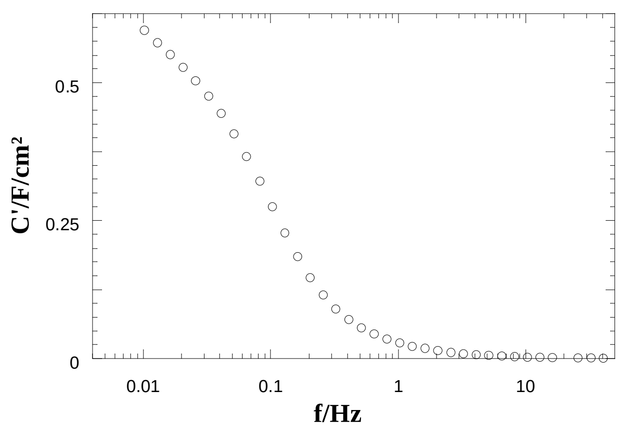

Figure 2 : evolution of the real capacity with the frequency

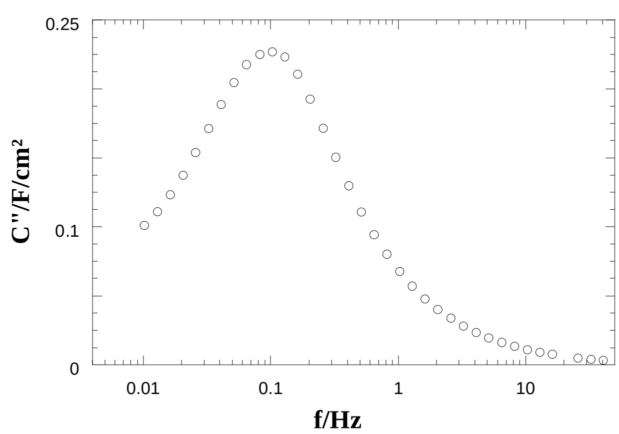

Figure 3 : evolution of the imaginary capacity with the frequency

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