# Development of a prototype of supercapacitor based on activated carbon and a neutral aqueous electrolyte

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Supercapacitors are energy storage devices with interesting characteristics such as fast charge storage, high power density and exceptional cycling stability (> 500.000) and exhibiting much higher capacity than traditional capacitors. However, supercapacitors show energy density much lower than secondary rechargeable batteries, and for this reason many researchers around the world work to improve this aspect. Starting from the equation $E=1/2\ CV^2$, in which the energy varies with the square of voltage, our activity was addressed to increase the capacity by increasing the working voltage of the supercapacitor that could be obtained by using stable material electrodes under this condition. This activity started with a study of the characteristics of the carbon material and the subsequent analysis of the electrochemical properties of positive and negative electrodes. A prototype of supercapacitor was designed and fabricated in asymmetric configuration.

A commercial activated carbon, Norit A Supra Eur ( BET S.A. 1500 $m^2/g$), was used for the preparation of electrodes. The electrodes were composed with different carbon loadings to compensate the different charge capacity between the positive and negative electrodes. A neutral aqueous solution of 1M $Na_2SO_4$ was employed as the electrolyte in the prototype.

First of all, a series of stability tests were performed separately on the positive and negative electrodes in a three-electrode cell system. The results of former studies evidenced that in 1M Na2SO4 electrolyte, the material of the positive electrode was stable in the range from 0 to 0.9V, while that of the negative cycled in a manner reversible in the range from 0 to -1V. These preliminary results indicated that potentially the supercapacitor can be stable in a voltage window of 1.9 V. However, because the positive electrode is more polarisable than the negative one, we have increased the carbon loading on the former to lower its polarization. Moreover, the equilibrium potentials of the two electrodes when the supercapacitor is completely discharged is not zero but is about +0.2 V (versus NHE) and this was a further problem to be solved because positive electrode reaches its limit of stability faster than negative electrode. As a consequence the positive has a potential window of only 0.7V (i.e. from + 0.2 to +0.9V) while the negative electrode had a potential range of 1.2V. The use of a higher load of carbon in the positive electrode produces an increase of the surface area available for the double layer formation with consequent decrease of its polarization during the charging process. For this reason the load of carbon on the positive electrode was settled as the twice than negative one. Practically, we have designed and realized a prototype of supercapacitor, in which the carbon of the positive is 2 times than the negative electrode. The so obtained supercapacitor was capable to work in the voltage range from 0 to 1.6V. A cycling test performed for many thousands cycles indicate a stable performance (see Figure 1). The results of electrochemical tests obtained from the single electrodes and on the prototype of supercapacitor were promising for the development of cheap and eco-friendly asymmetric aqueous supercapacitors.

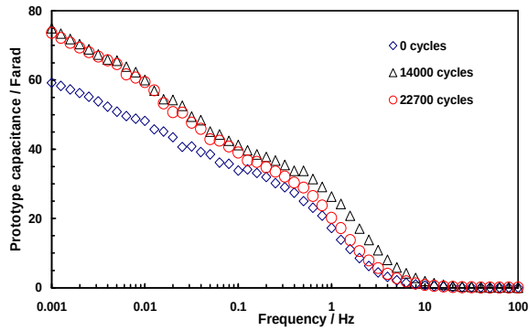


Figure 1. Specific capacitance (F) as a function of the frequency (Hz) for the prototype of supercapacitor during a cycling stability test carried out for 22700 cycles.

A prototype of supercapacitor based on a high-surface area activated carbon material and an aqueous electrolyte was successfully fabricated. The prototype was realized with electrodes of different mass ratio between the positive and negative. The supercapacitor was electrochemically stable in the voltage range from 0 to 1.6 V. The prototype shows an average capacitance of 70 F at 1.6 V. The successful of fabrication of the supercapacitor was demonstrated by a stable performance for more than 20.000 cycles.

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