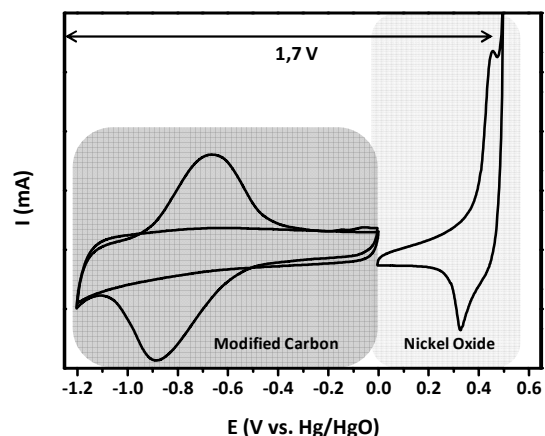


**ASYMMETRICAL AQUEOUS-BASED
ELECTROCHEMICAL CAPACITORS USING
MODIFIED-CARBON AS NEGATIVE
ELECTRODE MATERIAL**

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Electrochemical capacitors (ECs) are energy storage devices, which are currently subject to great interest. Due to their unique properties they can fill a gap in the Ragone plot by storing more energy than conventional capacitors and delivering higher power density than batteries. Nowadays the majority of commercial ECs consist of two porous carbon electrodes and an organic electrolyte but their performance can be improved by developing asymmetrical systems which combine a capacitive carbon-based negative electrode and a Faradaic battery-type positive electrode¹. This configuration presents many advantages: first the capacity is enhanced via the Faradaic charge-storage mechanisms of the positive electrode and the capacitive negative electrode maintains fast charge/discharge kinetics. Then, aqueous electrolytes are economically and environmentally friendly and have better electronic conductivity than organic electrolyte or ionic liquids (178 mS/cm for KOH with 5 wt. % concentration), but their thermodynamic maximum operating voltage of 1.2 V limits their performance. Asymmetrical systems allow to circumvent this issue and extend the stability voltage window, which will lead to higher power density¹.



Scheme 1. Schematic representation of cyclic voltammograms of a EC based on a modified-carbon negative electrode and a nickel oxide positive electrode.

Nickel oxide is a good candidate for positive electrode material since its redox potential in KOH (1M) is 0.4 V vs. Hg/HgO and its maximum theoretical capacity is 292 mAh/g. The interface surface area between the active material and the electrolyte can be

increased via the synthesis of nanoparticles².

Because of its high specific surface area, its good chemical and thermal stability and its low resistivity, activated Black Pearls carbon was chosen as negative electrode material. We successfully modified carbon powder with quinone groups using spontaneous reduction of *in-situ* generated diazonium salt^{3,4}. Thus, redox reactions occurring at the carbon surface can add a Faradaic contribution and then can double the total specific capacitance compared to an unmodified carbon electrode.

Thermogravimetric analysis (TGA) measurements revealed that grafted groups are stable up to at least 300°C. A significant mass loss appears at high temperature (500 °C) and is attributed to the departure of grafted species. The amount of grafted molecules estimated by TGA is in good agreement with that obtained by electrochemical characterization. The evolution of the carbon porous structure with the quantity of precursors has been studied using nitrogen gas adsorption. The stability of the grafted electrodes in alkaline media has been studied: for a loading of 4 wt.%, the loss of faradaic capacity is about 7% after 1000 cycles at 2 A/g.

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