# Graphene-based materials in next generation electrochemical capacitors

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The rapid development of portable electronic devices, such as tablets and cell phones which incorporate complex applications and functionalities, requires new compact energy storage devices with improved energy and power densities.[1]

In this talk I will summarize and discuss some of our most recent research on the integration of graphene in the electrodes used in different electrochemical capacitors.

First, a novel strategy for the preparation of graphene-based self-standing electrodes for EDLC is presented. Wafers obtained by the hydrothermal heating of an aqueous suspension of graphene oxide in the presence of small amounts of either carbon nanotubes, which leads to monolithic hydrogels that can be finally compacted under pressure. These as-obtained highly-packed composite wafers can be directly tested as binder-free electrodes for supercapacitors using 6M KOH aqueous solution as electrolyte. The results show that in the presence of just a 2 wt.% of carbon nanotubes into the graphene-based wafer produces a significant enhancement of the capacitance retention at high current densities when compared to its counterpart without carbon nanotubes. This improvement, was especially relevant in those systems using electrodes with large mass loadings. Thus, volumetric capacitance values of 255 F/cm$^3$ at 1 A/g and very good rate capability (185 F/cm at 10 A/g) were achieved even using electrodes with a mass loading as high as 13 mg/cm$^2$.[2]

The impact of the incorporation of graphene in electrodes for dual carbon lithium-ion hybrid supercapacitors (LICs) will be also discussed. An easy, eco-friendly and cheap synthetic approach for the preparation of carbon composites from the pyrolysis and activation of coffee waste and graphene oxide is presented. [3]

The effect of some important parameters such as particle size, electronic conductivity or mass loading is investigated for the battery-type electrode; whereas the optimum combination of specific surface area and pore size distribution is evaluated for the capacitive-type electrode. Optimization stages carried out in both electrodes leads to a significant improvement mainly in terms of power density of the full cell. Assembled LICs reach values of 100 Wh/kg at 9000 W/kg and retain above 80% of the initial capacitance after 3000 cycles, which can be enhanced to 15,000 cycles by decreasing the voltage window. [3]

## References

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