Electrochemical characterization of Graphene-Mo-based electrodes for energy storage in supercapacitors

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In recent years an increasing demand for energy availability and power consumption has been raised worldwide in many areas of the everyday life, with an acceleration of the global primary energy consumption despite a stagnant economic growth [1]. In order to engage this growing demand, the necessity of finding new and alternative resources and improving the performance of the devices, is becoming increasingly urgent. Together with the development of innovative renewable energy harvesting devices, the need of storage systems is crucial towards a clever energy management. Supercapacitors are electrochemical power storage devices that can find many practical applications with the goal of replacing or going alongside with the already existing battery technology.

The main advantages of supercapacitors towards batteries are their higher power density values (up to 10 kW kg^{-1}), their much longer cycle life (10^5 versus 500-1000), and a fast charge/discharge rate. The fabrication of nanostructured electrodes is expected to improve the performances of the supercapacitors, in particular with the aim of increasing their energy density without losing the high power density [2].

In this work, the electrochemical performance of different nanostructured graphene-based materials, used as supercapacitors electrodes, will be presented and discussed. A comparison between the results obtained using different water based electrolytes will also be discussed alongside the nanostructuration differences. Finally, a feasibility proof for the integration of the devices in a harvesting/storage system (DSSC, silicon solar cells) will be presented.

Graphene-MoS_2 decorated aerogels (dispersion of commercially available flakes and *in-situ* generation), graphene-MoO_2 decorated (*in-situ* generated) aerogels and pure graphene aerogels were our main focus of study. Ball milled graphite powder was employed as reference. The supercapacitor electrodes were prepared by mixing the nanostructured materials with a binder to form uniform pastes and by depositing them on metal-coated substrates.

Supercapacitors were fabricated in symmetric electrodes configuration, with an aqueous electrolyte, a glass fiber paper as separator and the devices were sealed with a thermoplastic polymer. Complete electrochemical characterization was carried out using Cyclic Voltammetry (CV), charge/discharge galvanostatic measurements and Electrochemical Impedance Spectroscopy (EIS).

The analyzed parameters are, in particular, the specific capacitance, the equivalent series resistance and the cycle life. The whole of them will be presented by comparing the different materials.

References

[1] BP Statistical Review of World Energy, (2014) www.bp.com/statisticalreview.
[2] Guihua Yu , Xing Xie , Lijia Pan , Zhenan Bao , Yi Cui, Nano Energy 2 (2013)213

We will show that our graphene-based aerogels decorated with MoS_2 nanostructures improve the specific capacitance values and the relative energy density of the devices. This enhancement can be attributed to the high surface area of the aerogel structure, the low agglomeration between graphene nanosheets, the large number of micro- and meso-pores, and, especially for the pseudocapacitance effect, the addition of metal dichalcogenides nanostructures.

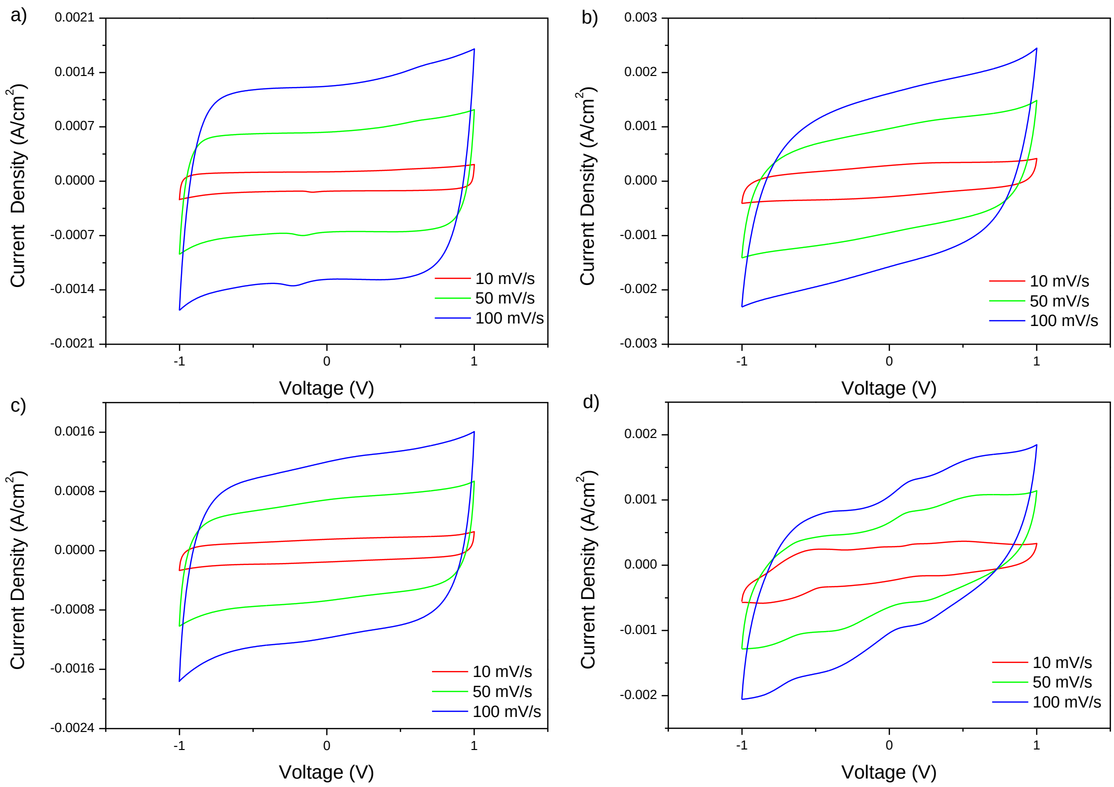

Figure 1: CV measurements: a) Graphite, b) Graphene, c) MoS_2 decorated graphene and d) MoO_2 decorated graphene. All samples are prepared with an active material/ PVDF (binder) ratio of 15:1.

Scan Rate (V/s)	0.0005	0.01	0.05	0.1
Graphite	n.d.	4	3	3
Graphene	n.d.	14	10	8
Graphene+MoO_2	237	154	82	68
Graphene+MoS_2	n.d.	50	41	34

Table 1: Measured specific capacitance (F/g) from Cyclic Voltammetry curves. All samples are prepared with an active material/ PVDF (binder) ratio of 15:1.

Figure 2: Symmetric electrochemical cells