Ni Decorated Graphene-based Electrodes for Asymmetric Supercapacitors

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Supercapacitors (SCs) are innovative energy storage devices that bridge the gap between conventional capacitors and batteries. Thanks to their higher reversibility and lower environmental impact, as compared to batteries, SCs are attracting the attention of the scientific community.Graphene is an outstanding material for applications in electrochemical double layer capacitors (EDLCs); thanks to its high surface area, hierarchical porosity and high electronic conductivity, graphene-based electrodes show enhanced capacitance and high power densities [1] However, the specific energy is still at least one order of magnitude lower than batteries, thus limiting the applications for such devices. Nevertheless, the specific energy can be increased by coupling the SC physical capacitance with a "pseudo-capacitance" [2], and/or by extending the electrochemical working window of the devices, for example building asymmetric SCs [3].
Here we present a novel asymmetric SC made with graphene as the negative electrode, and graphene decorated with nickel nanoparticles (Ni-NPs) as the positive one, operating with an aqueous electrolyte (KOH 3.5M). Our peculiar graphene, obtained by thermal exfoliation of graphite oxide (TEGO), is particularly suitable for anchoring metal nanoparticles, due to the large amount of active defects produced during the synthesis process [4].
The electrodes were characterized by means of powder X-Ray diffraction, transmission electron microscopy, X-ray photoemission spectroscopy and three-electrode cyclic voltammetry. We proved that, during the charge/discharge process, Ni-NPs transform into $Ni(OH)_2$ and participate in battery-like redox reactions, hence increasing the specific capacitance of the electrode.
The final asymmetric device, characterized by two-electrode cyclic voltammetry, galvanostatic charge/discharge cycles and impedance spectroscopy, displayed also an extended electrochemical working window up to 1.7 V (Figure 1), which further allowed increasing its energy density.

References

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