

# Novel graphene-based electrodes for energy storage devices

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**Abstract**— Graphene sheets have exceptional electrical, mechanical and optical properties. Graphene-based nanocomposites can be utilized as an electrode for the fabrication of energy storage devices for practical applications. Graphene nanosheets were produced by an enhanced technique including graphite oxidation, ultrasonic treatment, expansion, and chemical reduction.

**Keywords:** Graphene, electrode, energy storage devices

## Introduction

Recently, graphene has been discovered for its outstanding electronic, thermal, and mechanical properties for different applications like energy storage devices (supercapacitors, batteries, fuel cells, etc.) [1]. Graphene-based nanocomposites can be utilized as an electrode material for the fabrication of energy storage devices. The main drawbacks for the commercial production of energy storage devices are the cost, poor durability and reliability.

The electrode layer is made up of the catalyst and porous electrode or gas diffusion layer in fuel cells. Carbon nanomaterials are extensively used for the metal catalyst support because of high electrical conductivity, chemical stability and low cost production cost. In polymer electrolyte membrane fuel cells, in both cathode and anode compartments, low loading platinum (Pt) and platinum alloys with carbon support having large surface area are extensively used to reduce the cost [2].

The main aims of this work are the reduction of the number of layers in the graphite material and the fabrication of large quantities of graphene nanosheets to be used as an electrode material in energy storage devices.

## Experimental

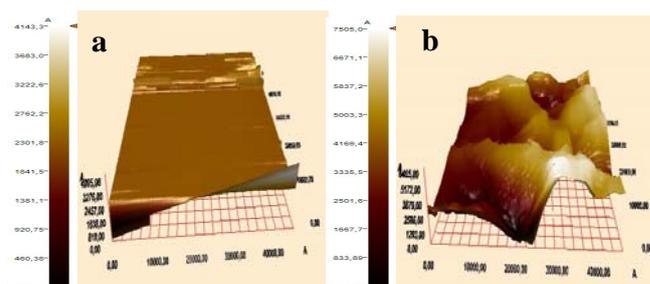
The experiments were performed in two steps:

(1) *Graphene Nanosheets production:* Graphene nanosheets were produced by an improved technique including graphite oxidation, expansion, and chemical reduction. Ultrasonic treatment was performed for the homogenous dispersion after each step.

(2) *Electrode preparation:* Pellet electrodes were prepared under adjusted pressure by mixing graphene nanosheets and conducting polymers (polypyrrole) and several binders. Electrical properties of electrodes were estimated according to their thickness, resistance and conductivity values. Samples were investigated by SEM, XRD, TGA, AFM and Raman Spectroscopy.

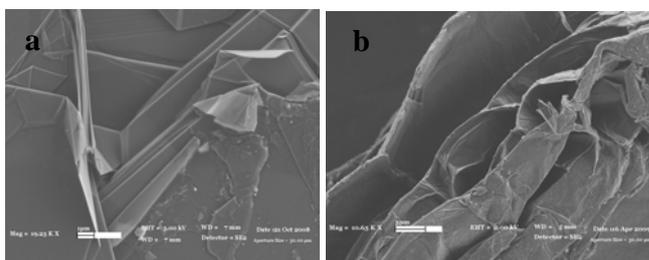
## Results and Discussion

The smooth and sharp surface of pristine graphite flake was observed in 3D surface topography (Figure 1a). After oxidation process, the wavy and swelled structure was noticed due to the diffusion of intercalating agents into the graphene layers in graphite (Figure 1b).



**Figure 1.** 3D AFM images of (a) pristine graphite flake (b) GO sheet obtained after 72 hr oxidation by tapping mode

SEM images were also supported the formation of graphite oxide (GO). Graphite flake has rigid and condensed layers before the oxidation (Figure 2a). The acid and intercalating agents led to the swelling of graphite oxide layers (Figure 2b).



**Figure 2.** SEM images of (a) pristine graphite flake and (b) GO via secondary electron detector.

The electrodes were made of graphene nanosheets by mixing polypyrrole and binders. Improved capacity can be achieved by creating a nanocomposite with conducting polymers [3].

## Conclusions

The utilization of graphene as an electrode material is currently to be examined. Graphene-based electrode materials have been developed to solve the problems coming from the mass and charge transport, electron transfer and variations during processes, and achieve good performance in energy storage device applications.

## References

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