

Graphene Manufacture and Utilization

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Graphene which is the basal building block in all graphitic materials is a flat sheet of pure carbon atoms tightly packed into 2D honeycomb shaped lattice. It has attracted great interest due to its unique electronic, thermal, and mechanical properties arising from its strictly 2D structure, and to its potential technical applications. Novoselov et al. produced a one-atom-thick graphene sheet stable at ambient conditions by extracting monolayer sheets from graphite using micromechanical exfoliation technique in 2004 [1]. With the proper surface modifications, single graphene sheets can be separated from the graphite material and the layer-to-layer distance can be extended [2]. However, graphene of sufficient quality has only been produced in the form of small flakes of tiny fractions of a millimeter upto now.

Polymer electrolyte membrane fuel cells (PEMFCs) still cannot compete commercially in several utilizations owing to the high cost, the poor durability and reliability. Advanced materials are desirable for use in energy technologies to overcome these obstacles. Conducting polymers (e.g. polypyrrole-PPy) are extensively utilized for fuel cell operations because of good electronic and proton conductivity properties, dispensability and special nanometer structure [3]. PPy-modification can enlarge the electrochemical surface area and improve the electrocatalysis ability of Pt/carbon catalyst [4].

In the present work, we present an enhanced and safer method for the exfoliation of graphene like sheets from graphite. The main goal in this work is to decrease the number of layers in the graphite material and to fabricate large quantities of graphene bundles to be used as fuel cell electrode material. Samples were investigated by SEM, XRD, TGA, AFM and Raman Spectroscopy.

Graphene nanosheets were separated from pristine graphite flake by an enhanced chemical route including three major steps: graphite oxidation, thermal expansion of graphite oxide (GO) and chemical reduction. After each process, ultrasonic treatment was performed for the homogenous dispersion of layers. The oxidation process carried out in chromic acid using acetic anhydride as an intercalating agent leading to expanded and leafy structures of graphite oxide layers, Fig. 1a and 1b.

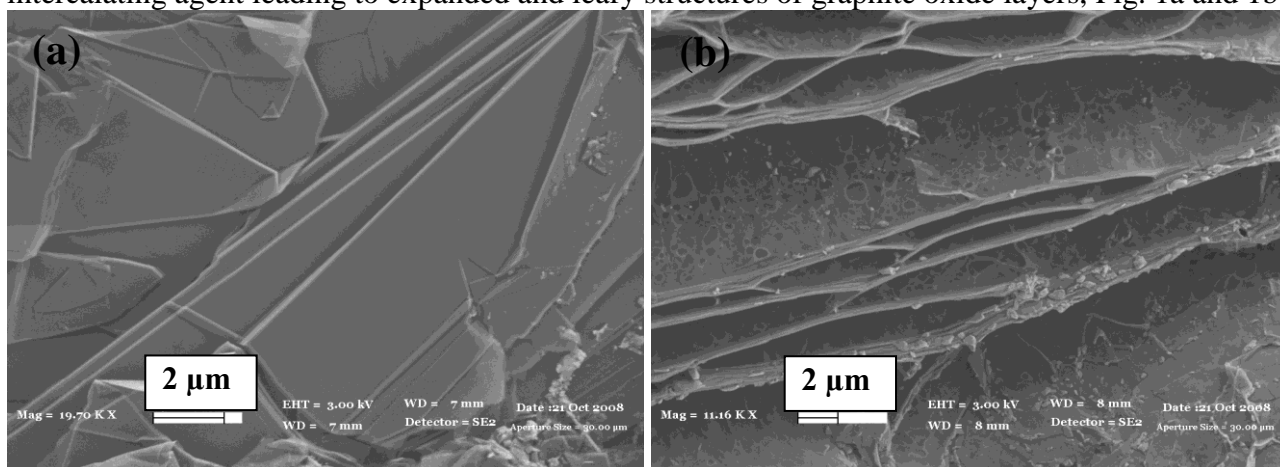


Fig. 1.(a) pristine graphite flake and (b) GO.

In oxidation step, several experimental conditions were adjusted to tune the oxidation level of GO via the alteration of reaction time and reactant ratios.

GO sheets were thermally exfoliated under an argon atmosphere at different expanding temperatures and different expanding times in a tube furnace. The intercalating agent between the layers decomposed into CO₂ and H₂O at high temperatures and this caused the expansion of graphitic crystal lattice and the formation of “worm-like” or accordion structure, Fig. 2.a. GO and thermally exfoliated sheets were chemically reduced through refluxing with hydroquinone in water to produce graphene nanosheets, Fig. 2.b.

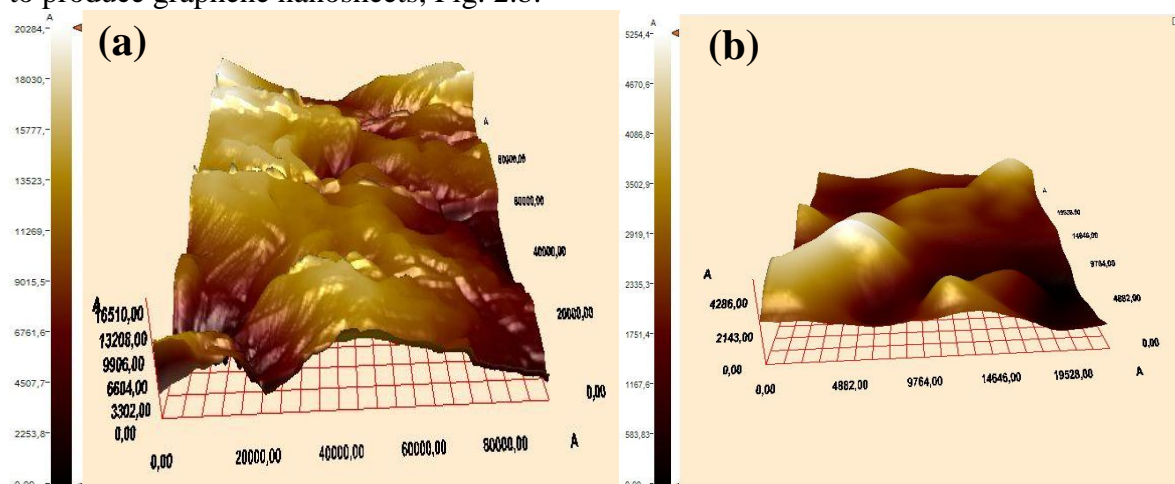


Fig. 2. 3D AFM images of (a) thermally exfoliated GO and (b) reduced graphene nanosheets

The average number of layers for pristine graphite flake, GO, expanded GO, reduced expanded GO and reduced GO were calculated as 86, 79, 30, 37 and 9 via XRD characterization, and 89, 17, 25, 17 and 11 via AFM characterization, respectively.

For carbon electrodes, the electrocatalytic properties strongly depend on their microstructure and surface chemistry but also on their organization and aggregation. Pellet electrodes were prepared under adjusted pressure by mixing graphene nanosheets and PPy and several binders. Electrical properties of electrodes were estimated according to their thickness, resistance and conductivity values.

As a result, graphene nanosheets were obtained in moderate quantities by improved, safer and mild chemical route applied in the present work. We suggested the new fuel cell electrode, which is composed of PPy/graphene based nanocomposites, can function almost as well as a conventional electrode.

References

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