Synthesis and Characterization of Graphene and its oxides

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Abstract

In this paper, we first synthesized Graphene from graphite flakes and then oxidization of Graphene was followed to yield Graphene oxide. The characterization of graphite flakes, Graphene and its oxide was standardized using Scanning Electron Microscope (SEM).

I. Introduction

Graphene has extraordinary properties like thermal conductivity, optical transparency, electrical conductivity, tensile strength etc. But, Graphene polymer nano-composites attract considerable interest due to outstanding mechanical, optical, electrical and thermal properties encountered with only small amount of nano-filler incorporated into polymer matrix. New materials in nano-scale are formed to reinforce polymers almost as soon as they have been developed as nano-fillers in layered silicate clay based nano-composites and carbon nano-tubes based nano-composites and now recently towards Graphene based nano-composites.

Nanotechnology is the ability to manipulate the matter at atomic or molecular level to make something useful at Nanoscale. At Nanoscale, carbon is mostly used which is a metal and exists in many allotropic forms. Of all the allotropic forms, Graphene is in high demand. It is a rapidly rising star on the horizon of material science and condensed matter physics. Graphene is simply anallotrope of carbon, whose structure is one-atom thick planar sheets of sp^2 bonded carbon atoms that are densely packed in a honeycomb crystal lattice. The term Graphene is a combination of *graphite* and the suffix-*ene*. Graphene exists in two main forms: isolated layers formed by exfoliation of graphite, and epitaxial layers residing on suitable lattice matched substrate. The flakes formed by exfoliation method are small in size. So, for large scale fabrication of circuits epitaxial approach is more useful. The crystalline or flake form of graphite consists of many Graphene sheets stacked together. One of the remarkable properties of Graphene is that it has no band gap (A band gap is the amount of energy taken by a free electron to move from valence band to conduction band which allows the current to pass through the material). As, the extra electrons of Graphene are already in conduction band so it does not require any extra energy to transport electron, allowing them to behave ballistically, same as that of mass-less particles. Although, Graphene is a new material, its convenient properties and extensive research have allowed engineers to hypothetically apply it to a wide range of fields. Despite the high dispersive forces of graphite, its applications in gas adsorption processes are limited as it has low porosity because of densely stacked carbon layers. On the other hand, graphite oxide or Graphene oxide (GO), that arrives from the oxidation of Graphene/graphite enhances the gas adsorption property due to increased interlayer space. This increase in the adsorption property could be more visible if composites are built. Metal Organic Frameworks (MOF) are one of the best candidates for the synthesis of nano-composites resulting in improved porosity with Graphene oxides. A lot of studies have been done in the past regarding MOF-Graphite oxide composites [1-5]. For instance, Petit and Bandosz [2] have shown that the amount of Graphene oxide in the composite increases or decreases the porosity of composite. Moreover, the structure of the composite can be changed depending upon the amount of Graphene oxide. From the above study, we conclude that Graphene as well its oxides plays an important role over a wide range of fields such as from electronics to the auto industry. So in this paper, we will synthesize and characterize Graphene as well as its oxides.

II. Methodology

Firstly, the surface modification of Graphene was done whereby we have synthesized Graphene from graphite flakes by modified hummer's method i.e. chemical exfoliation and then graphene oxide was synthesized from it. The following steps were adopted for the surface modifications of Graphene:

1. Graphite flakes (50mg) were taken in a flask and then 37mg of $NaNO_3$ was added to it.
2. Concentrated Sulfuric acid (H_2SO_4) was added to the mixture with constant stirring.
3. Following this, 376mg of potassium dichromate ($K_2Cr_2O_7$) solution was added in the mixture in duration of 2 hours by slowly stirring.
4. Further stirring was done for 2 hours in ice bath
5. The mixture was stirred for 5 days at room temperature which yielded Graphene.

Further, the preparation of Graphene oxide from Graphene was done by following below steps in sequence:

1. 5% of 3.75ml aqueous H_2SO_4 was slowly added to the above synthesis at temperature of 98˚C in one hour. Then, deionized water was added to it to make the final volume of 10ml.
2. This mixture was cooled down at room temperature and centrifuged to collect the solid mass.
3. Before collecting the solid mass, the mixture was washed five times with 3% of HCl using sonication for suspension for 2 minutes and then it was finally centrifuged.
4. The mixture was collected, dried and stored.

The above steps followed the next step which involved the characterization of Graphene (and its oxides) by using Scanning Electron Microscope (SEM), the images of which are shown and discussed in results as given below.

III. Results and Discussions

Figure 1 displays the images of graphite flakes using Scanning Electron Microscope.

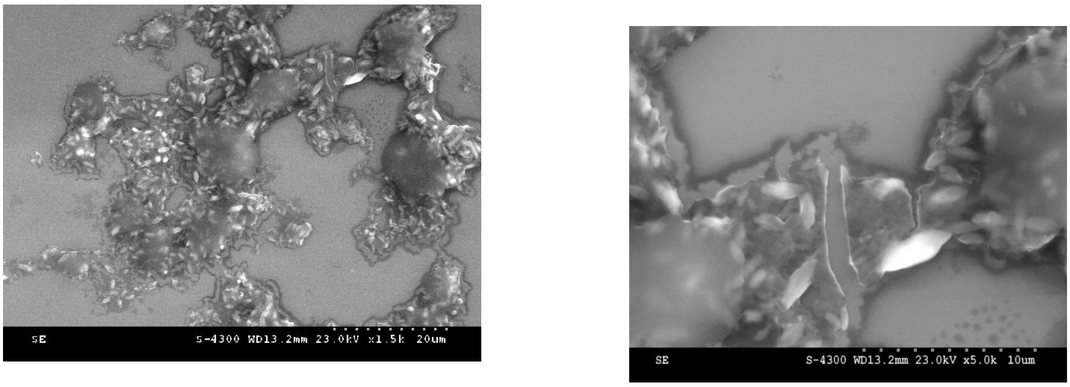

Figure1: Displays the images of graphite flakes.

The images of Graphene and its oxide are shown in Figure 2 and 3, respectively. We noticed that graphite flakes of larger size (few microns) as seen using SEM whereas Graphene and its oxide of nm scale as visualized using SEM.

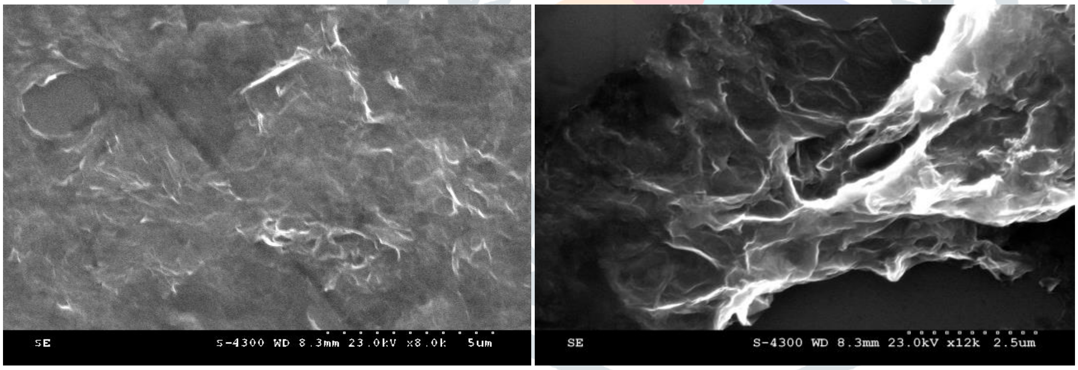

Figure2: Images of Graphene.

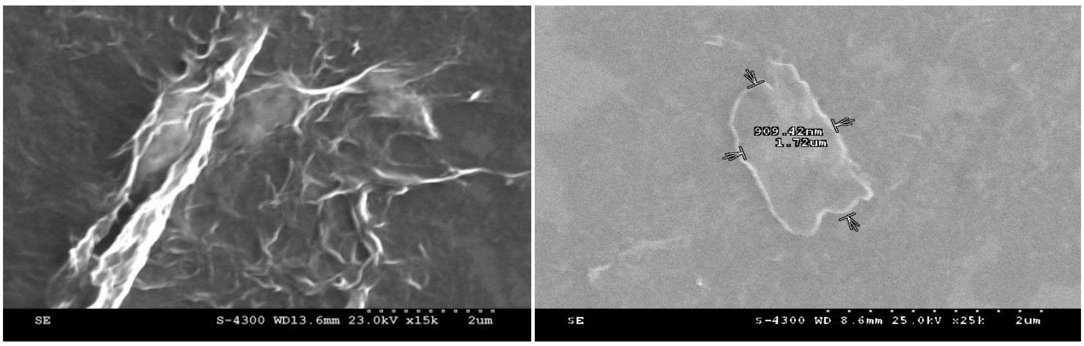

Figure3: Images of Graphene oxide.

IV. Summary

Scanning Electron Microscope micrographs show the surface morphology of graphite flakes, Graphene and its oxide. Larger size graphite flakes in the size range of few microns awhereas Graphene oxide is smaller (of nm scale) as can be visulaized using Scanning Electron Microscope. This shows that graphite flakes can be successfully processed into Graphene oxides for further application.

V. References:

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