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RESEARCH ARTICLE

FABRICATION AND CHARACTERIZATION OF GRAPHENE OXIDE NANOPARTICLES AS PLATFORM FOR DRUG DELIVERY

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Abstract:
Graphene oxide [GO] nanoparticles have rapidly grown a new type of nanomaterial for drug delivery. A novel approach to fabricate graphene oxide nanoparticles has been reported. The graphene oxide synthesized by oxidation of graphite in H_2SO_4: H_3PO_4 [9:1] with continuous stirring for 12hr. Graphene oxide contribute as biomaterial for biomedical application due to its structural features as two dimensional, planar structures with high surface area, good biocompatibility and it also acts as filler. The synthesized GO characterized by using SEM, DSC, FT-IR, Malvern Zetasizer, and UV-spectroscopy. Due to its multifunctional properties GO acts as nanocarrier and most preferably used as novel nanomaterial for anticancer therapy with high drug loading capacity and for the design of advanced drug delivery system and delivery of a broad range of therapeutics.

Keywords: Graphene oxide, Nanocarrier, Drug delivery, Nanoparticles , Biomedical, Oxidation

Introduction

Nanotechnology broadly defined as the creation, processing, characterization and utilization of material devices and system with dimensions in the nanometer range[1, 2]. Nanoparticles are particles in nanometer range. Particles are classified according to their diameter. Ultrafine particles are the same as nanoparticles and between 1 and 100 nanometers in size. Coarse particles cover a range between 2,500 and 10,000 nanometers. Fine particles are sized between 100 and 2,500 nanometers.

Graphene oxide [GO] , a two dimensional material featured by a variety of reactive oxygen functional groups such as epoxy and hydroxyl groups on the basal plane and carboxylic acid groups at the sheet edges[3-10] which has been widely used for cancer therapy and drug delivery[3, 11-13].

Graphene a monolayer of two dimensional nanomaterial having sp^2 hybridized network of carbon atom [6, 14-18]. Graphene a fundamental building block for other graphite materials through different geometries which can be wrapped into spherical structures [zero-dimensional fullerenes], rolled into one dimensional(1-D) [Carbon nanotubes CNT's] or stacked into three-dimensional [3-D] layered structures [Graphite][14, 15].It has impending application in the different field of material science for developing nanocomposites, sensors, optoelectronics devices, hydrogen storage and supercapacitors [6, 16, 17, 20, 21]. One of the most promising applications of this graphene material is in polymer nanoparticles which incorporate nanoscale filler materials [18].

Polymer nanoparticles shows significant enhancement of property at much lower loading in comparison to polymer particles which having predictable micron-scale filler [for e.g. Carbon fibers or glass] those ultimately results lower component weight and be able to simplification of process[18, 19]. Furthermore creation of new application of polymers due to multifunctional property enhancement made possible with nanoparticles[18].

Materials and Method

Materials

The major materials used in this research were as follows: Graphite powder and per acetic acid were obtained from Research- Lab fine chem. Industries [Mumbai].

Method

The improved method for the synthesis of graphene oxide was used. The method used for synthesis was well optimized. The oxidizing and cyclising agents used were different from reported methods. In reported methods mostly $KMnO_4$ and H_2O_2 are used instead of that in proposed method peracetic acid was used which represents novelty in synthesis method. The equipments required for synthesis were simple in comparison to reported methods. The particle size obtained from GO synthesis 404.2 nm which is identical and in the nano range than reported methods. Oxidation of graphite was carried out by mixing H_2SO_4: H_3PO_4 [90:10] , graphite powder [0.1mole] using a magnetic stirrer with hot plate. The above mixture was stirred at constant stirring for 12 hr. at 70° C to allow oxidation of graphite. After 12 hr. addition of peracetic acid to maintain pH of solution 4-5. The colour of mixture becomes shiny black, indicating high oxidation level of graphite. The decantation of supernatant via a centrifugation technique at high speed of 6000 r.p.m. and temperature 15° C which resulted in solid graphene oxide then dry it.

Results and Discussion

The surface morphology of graphene oxide nanoparticles were observed by the FE-SEM as shown in figure 1 (b)(c)(d). The SEM images of graphene oxide have well defined and two dimensional graphene sheets which forms a porous network that resembles a loose, spongy like structure as shown in figure 1 (b)(c)(d). This SEM observation of graphene oxide as porous nature enhanced interfacial adhesion as well as dispersibilityofGO in the polymer matrix. Some nanoparticles shows white bright spot which may be due to insufficient drying hence these areirregular in shape. The higher magnification SEM images clearly demonstrate the dense and heterogeneous distribution of graphene oxide.

Figure 2. Showing particle size distribution of GO nanoparticles. By using Malvern Zetasizer, mean particle size was found to be about 404.2nm based on dynamic light scattering measurement. The particle size distribution graph shows bell shape with polydispersity index 0.927.

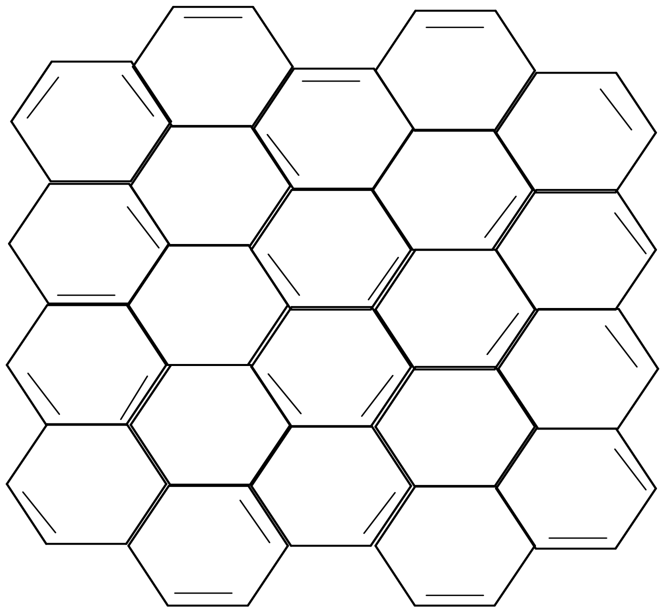
The two step thermal degradation process, first attributed to the loss of water at 100°C and secondly at 221°C for loss of acidic functional groups and residues of graphene oxide [GO]. At 254°C it shows endothermic peak. GO shows little weight loss below 300°C, onset temperature becomes dramatically lower presumably due to pyrolysis of the labile oxygen containing functional groups yielding CO, CO2. Main loss takes place around 100-400° C and is ascribed due to the decomposition of oxygen containing functional group. These results explained as the oxidation product of graphite has a layered morphology with oxygen containing functionality, thereby weakening the Vander Waals forces between layers. This will disrupt structure of GO thus accelerating weight losing.

The GO , a two dimensional material featured by a variety of reactive oxygen functional groups such as epoxy and hydroxyl groups on the basal plane and carboxylic acid groups at the sheet edges. The FT-IR spectrum of GO in figure 4 demonstrates the characteristics oxygen containing groups. The intense characteristic peak at 3440cm attributed to O-H stretching vibration of –COOH functional group, the peak at 1738cm corresponds to the stretching band C=O from carboxylic acid group, the peak at 1625cm (aromatic C=C) could be assigned to the skeletal vibration of unoxidized graphitic domains, the vibration of O=C-O from carboxylate at 1404cm, 1044 C-O-C of epoxy group in the sample. The sample of various oxygen bearing groups [C=O, C-O, -OH] in the GO structure can lead to synthesis of various nanoparticles with varied properties.

Prior to UV measurement, samples were dispersed in water and sonicated for 20 min. In figure 5. GO shows a strong absorption peak at 232nm which indicate the $\prod \rightarrow \prod^*$ conjugated transitions.

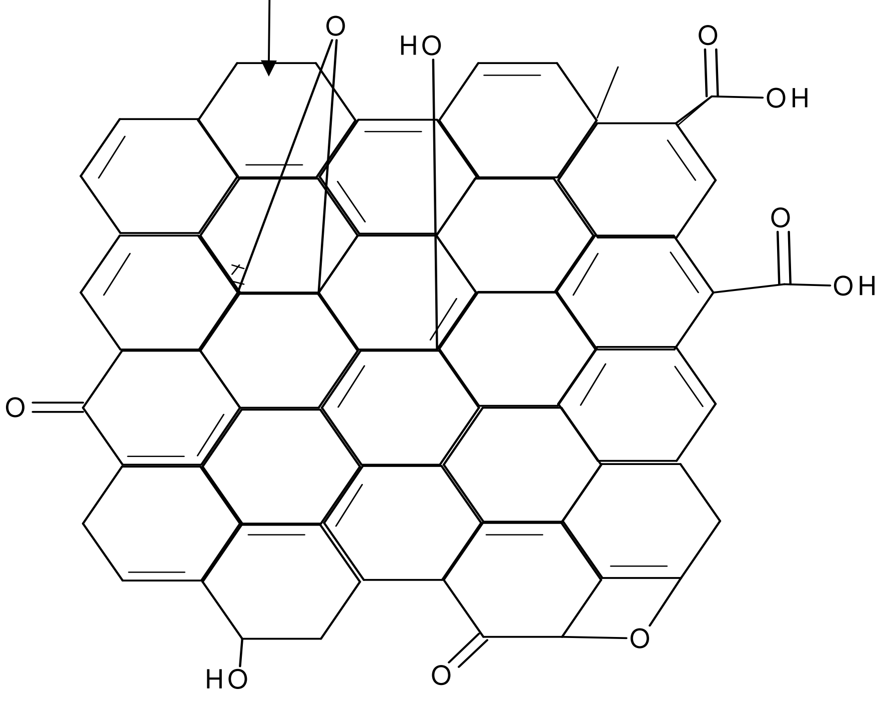
Conclusion

The graphene oxide[GO] based nanoparticles are emerging as a new class of materials which hold promise for many applications. The GO prepared by oxidation of graphite and strong acids. The use of strong acids oxidized GO without emission of toxic gas. It posses planar aromatic macromolecule hence generated great interest in nano medicine and biomedical application. The suitably modified GO may serves as an effective drug delivery platform for anticancer delivery, antibacterial applications, cell culture, tissue engineering. Mainly its usefulness is in anticancer therapy because major portion of cancer therapy till date based on parenteral route of



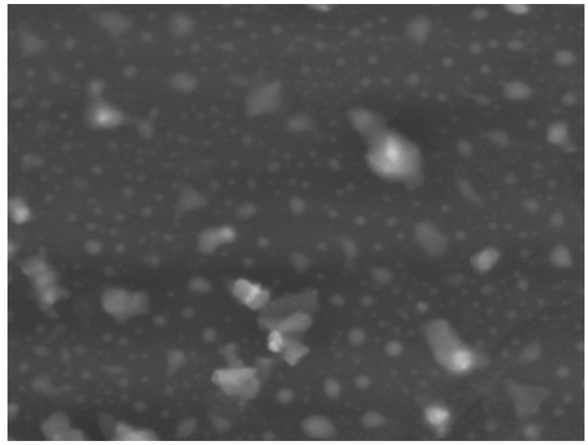
Graphene

H_2SO_4: H_3PO_4 Stirring,
[9:1]Per acetic acid



Graphene Oxide

Scanning Electron Microscopy



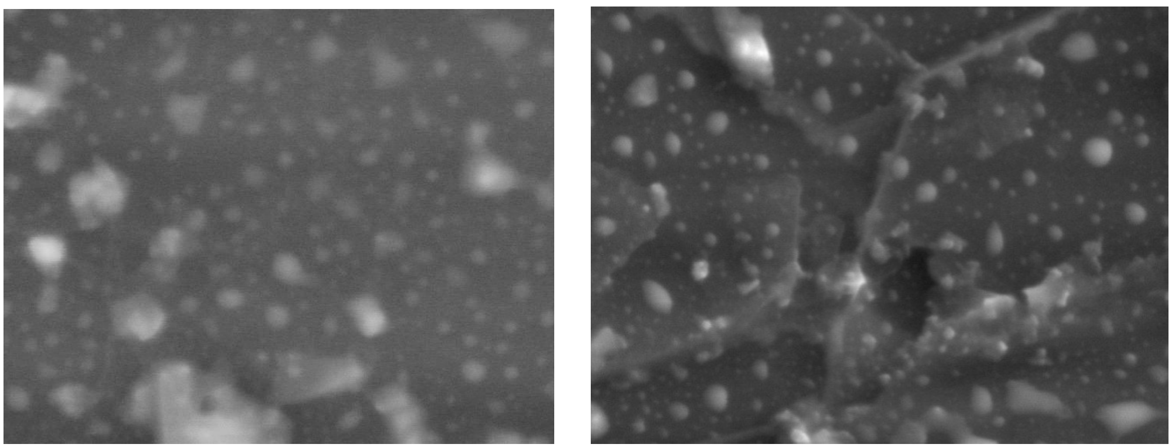


Figure 1.(a)Synthesized Graphene oxide, (b) (c) (d) SEM images of graphene oxide nanoparticles

Particle Size Analysis

			Size (r.nm):	% Intensity	Width (r.nm):
Z-Average (r.nm):	404.2	Peak 1:	266.9	82.5	46.91
PdI:	0.927	Peak 2:	73.85	17.5	9.733
Intercept:	0.983	Peak 3:	0.000	0.0	0.000

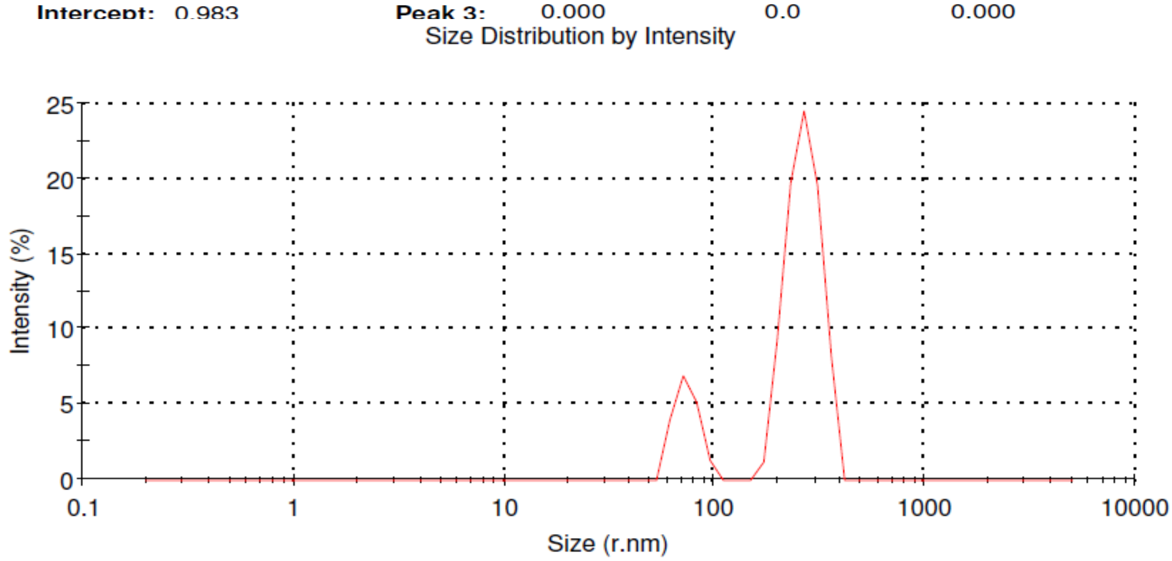


Figure 2. Particle size distribution of graphene oxide

DSC

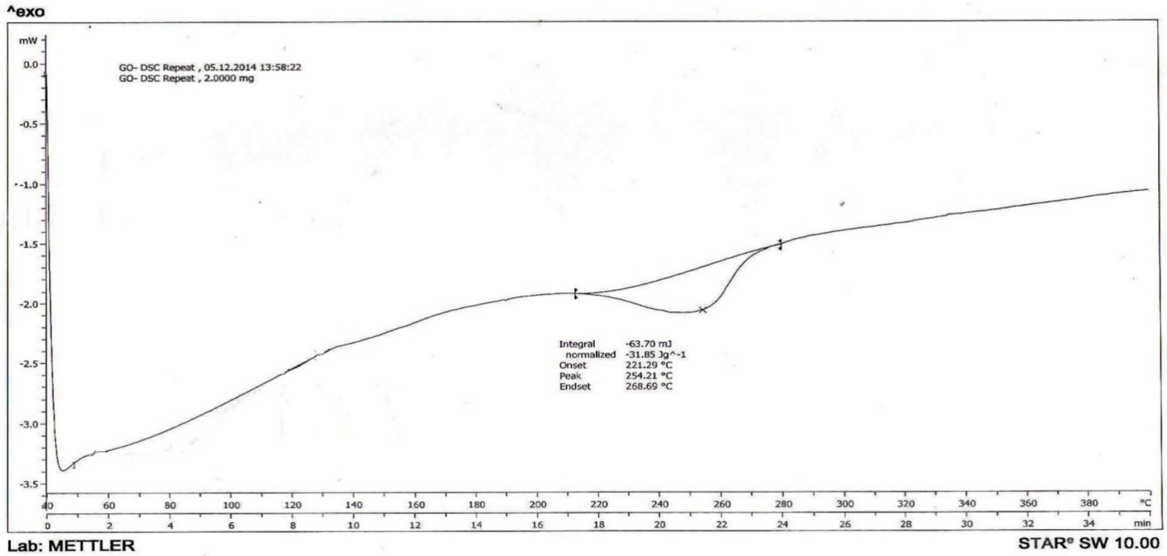


Figure 3. DSC of Graphene oxide

FT-IR

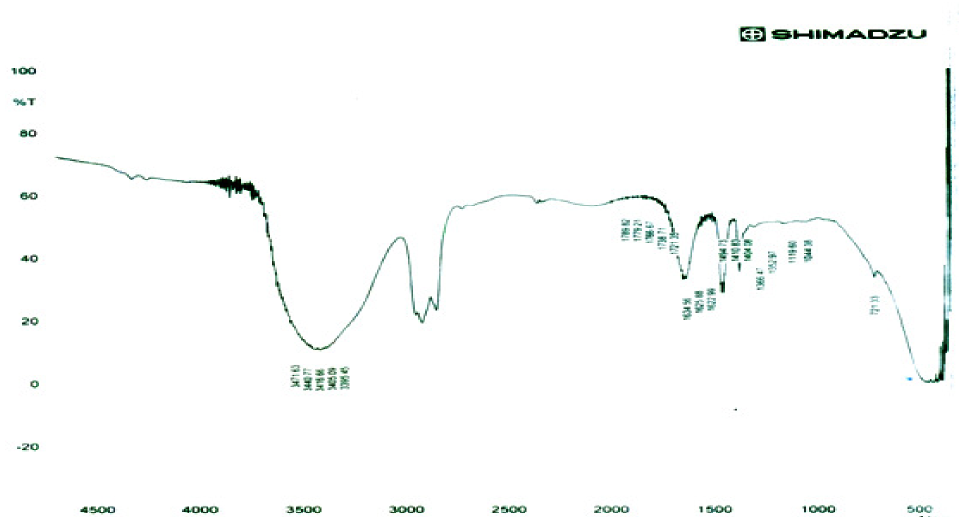


Figure 4. FT-IR Spectra of graphene oxide

UV Spectroscopy

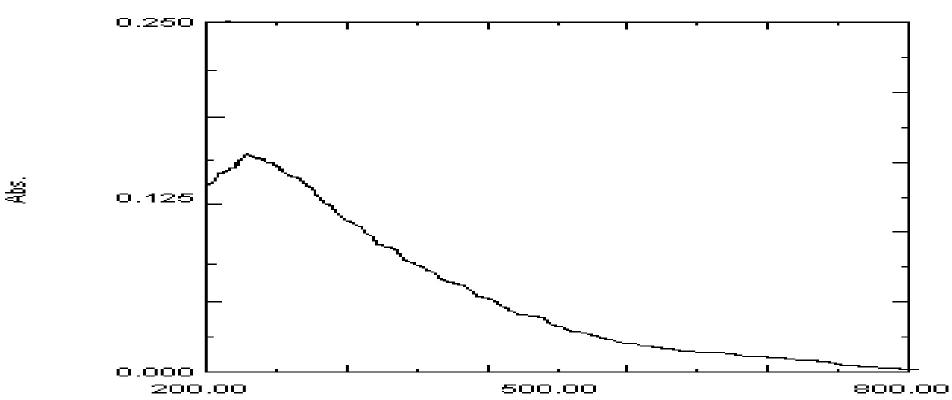


Figure 5. UV-Visible spectra of graphene oxide

administration but above 80% patients preferred oral route for cancer treatment. Due to this for targeted chemotherapy functionalized graphene oxide may acts as the efficient nanocarrier, this graphene oxide afford high drug loading and pH dependant release of drug in-vitro and its application in biomedicine to improve quality of life of patients suffering from cancer.

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