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Synthesis of Aerogel with Graphene and Significance with Aerospace Industry

Cover Page Footnote

Authors would like to thank Sandip university for providing the facility and carry this work.

Synthesis Of Aerogel With Graphene And Significance With Aerospace Industry

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ABSTRACT

The Primarily focus on Graphene Aerogel, its synthesis and structural integrity together with high electrical conduction. Graphene could be a new nanocarbon that has, single-, bi- or few- layers of carbon atoms forming membered rings. Mechanically powerful and electrically semiconductive graphene aerogels will be produced by either essential drying or freeze of gel precursors integration from the reduction of graphene substance with L-ascorbic acid. In distinction to ways in which utilize physical cross-links between GO, this approach provides valency carbon bonding between the graphene sheets. The graphene aerogels put together possess large surface areas and pore volumes, creating those materials to a feasible possibility to be used in energy repository, catalysis, and sensing applications. We've additionally showcased some applications for Graphene Aerogel such as their electrical conductivities, Lithium-ion batteries and electrical phenomenon devices, Supercapacitors and photocatalysis.

Keywords: Aerogel; Composites; Graphene; Aerospace

INTRODUCTION OF GRAPHENE

Graphene is two-dimensional material, made up of layers of carbon atoms forming six membrane rings shown in fig. 1. Graphite has electrical conductivity, mechanical strength, and optical properties Graphene is flat, ripples occur to eliminate the effect of thermal fluctuations. Graphene samples that have two layers known as bi-layer graphene and which have more than two but less than ten layers are known as few-layer graphene.¹

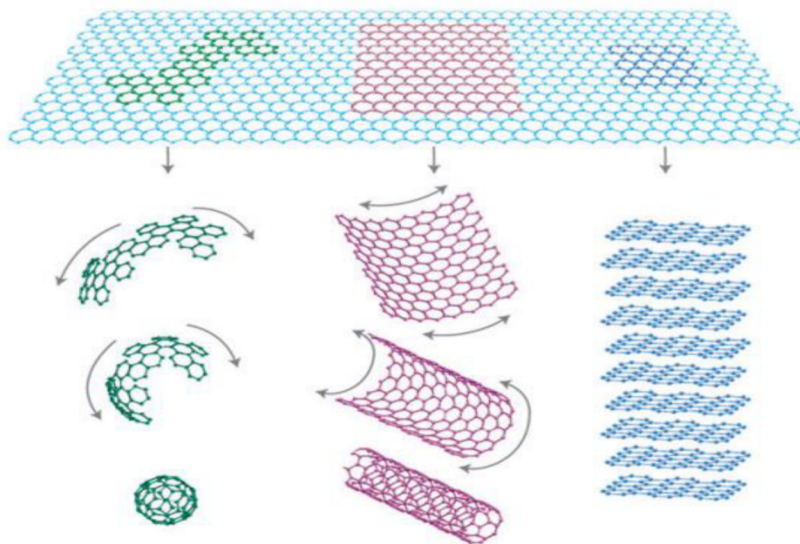


Fig 1: Graphite forms of Graphene¹

Aerogels are generally prepared from molecular precursors by sol-gel Treatment and then by drying the liquids supercritical or by freezing Drying to replace solvents in moist air gels is considered high Solid, porous nanomaterials with unique properties include large pore sizes, high surface areas and adjustable porosity, thus with potential applications in the fields of Cerenkov detectors, Stimulation, electronic devices, etc.^{5,6} Carbon aerogels, one of the most important aerogels, are new porous carbon materials that have received considerable attention as they have great potential in many fields.⁷

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1. GRAPHENE- PREPARATION

1.1 Single/ Bi-layer graphene

Single-layer and Bi-layer graphene is made up of micromechanical cleavage of bulk graphite or highly oriented pyrolytic graphite (HOPG). It is obtained in the gas phase by using a substrate-free atmospheric pressure microwave plasma reactor. Thermal decomposing of SiC has been done for the exfoliation of single and bi-layer graphene. Nano-ribbons (width <10nm) of single-layer and bi-layer graphene get by thermal exfoliation followed by solubilization and configuration of expandable graphite. Single-layer and bi-layer graphene is formed by using sonification in water following the chemical reduction of the graphitic oxide with hydrazine.¹

1.2 Few layers graphene

A few layers of graphene are synthesized by the chemical vapour decomposition of camphor. Conversion of nano-diamond (DG) and exfoliation of graphitic oxides. Camphor is pyrolyzed at 770 deg C over nickel nanoparticles with argon. DG is prepared by annealing nano Dimond at 1650 deg C. Also, preparation is done by the exfoliation of graphite oxide. Graphite oxide is prepared by reacting graphite with a mixture of concentrated nitric acid and concentrated sulfuric acid with potassium chlorate at room temperature for 5 days. Exploitation is done by giving thermal shocks to graphite oxide in a quartz tube 1050 deg C under an air atm. HG is prepared by Arc evaporation of graphite in presence of H₂ and He mixtures.¹

2. PROPERTIES:

2.1 Electrochemical properties

For electrochemical properties activated carbon, graphite fibres, and other carbon structures are used. By using redox reaction with potassium ferrocyanide method electrochemical properties were achieved. Different graphene samples have been investigated for electrochemical super-capacitors using Sulfuric Acid and an ionic liquid (N-butyl-N-methyl pyrrolidinium bis (trifluoro-methane-sulfonyl) imide, PYR TFSI) as electrolyte. EG and DG have high specific capacitance in Sulfuric Acid 117 F g⁻¹ and 35 F g⁻¹ respectively which is shown in fig. 2.¹

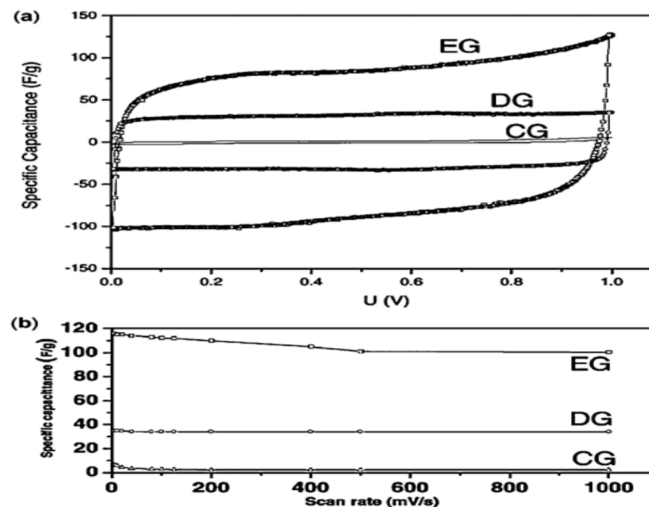


Fig 2: (a) Volumetric characteristics of a capacitance
(b) Specific capacitance as a function of scan rate.¹

TABLE 1: Comparison of typical synthetic methods for graphene–inorganic nanostructure composites, their properties and their related applications.¹³

Materials	Synthetic routes	Applications
Au/GO or rGO	<i>Ex situ</i> : π - π stacking via 2-mercaptopyridine <i>Ex situ</i> : π - π stacking via bovine serum albumin <i>In situ</i> : photochemical reduction <i>In situ</i> : reduction by hydroxyl-amine	Catalysis, SERS Raman enhancement
Au/rGO	<i>In situ</i> : sonolytic reduction in poly(ethylene glycol) at 211 kHz <i>In situ</i> : reduction by NaBH ₄ <i>In situ</i> : reduction by amino terminated ionic liquid; perylene-modified rGO <i>In situ</i> : reduction by sodium citrate <i>In situ</i> : reduction by ascorbic acid in the presence of CTAB <i>In situ</i> : microwave assisted reduction	Plasmonics Electrocatalysis SERS Raman enhancement
Au/pristine graphene	<i>In situ</i> : thermal evaporation	Identification of layer number of pristine graphene
Ag/GO or rGO	<i>Ex situ</i> : π - π stacking via bovine serum albumin <i>In situ</i> : reduction by NaBH ₄ <i>In situ</i> : electroless deposition	SERS
Ag/TiO ₂ /rGO Ag/rGO	<i>In situ</i> : Ag is reduced by the photo-generated electrons from TiO ₂ /rGO <i>In situ</i> : microwave assisted reduction	
Pt or Pd/GO or rGO Pd/rGO	<i>Ex situ</i> : π - π stacking via bovine serum albumin <i>In situ</i> : microwave assisted reduction	
Pt-on-Pd/rGO	<i>In situ</i> : sequential reduction of H ₂ PdCl ₄ with HCOOH, and K ₂ PtCl ₄ with ascorbic acid	Electrocatalysis
Cu/rGO Ru/rGO Rh/rGO	<i>In situ</i> : microwave assisted reduction <i>In situ</i> : microwave assisted reduction <i>In situ</i> : microwave assisted reduction	Catalysis Catalysis
CdS/rGO TiO ₂ /GO	<i>Ex situ</i> : π - π stacking via benzyl mercaptan <i>Ex situ</i> : non-covalent adhesion via solution mixing of P-25 TiO ₂ and GO <i>Ex situ</i> : non-covalent adhesion via solution mixing with the GO film	Optoelectronics DSSC Photocatalysis
TiO ₂ /rGO	<i>Ex situ</i> : noncovalent adhesion via Nafion <i>Ex situ</i> : self-assembly of TiO ₂ nanorods and rGO at two-phase interface <i>In situ</i> : templated hydrolysis starting with TiCl ₃ and titanium isopropoxide <i>In situ</i> : hydrolysis starting with TiCl ₃ <i>In situ</i> : hydrolysis starting with titanium butoxide <i>In situ</i> : hydrothermal starting with P25 and GO	DSSC Photocatalysis Photocatalysis Li ion battery DSSC Photocatalysis
ZnO/rGO Cu ₂ O/rGO	<i>In situ</i> : electrochemical deposition <i>In situ</i> : electrochemical deposition	Photovoltaics Photovoltaics
Cl-doped Cu ₂ O/rGO Co ₃ O ₄ /GO or rGO	<i>In situ</i> : electrochemical deposition <i>Ex situ</i> : electrostatic via aminopropyltrimethoxysilane <i>In situ</i> : reduction of Co(OH) ₂ /GO at 450 °C	Optoelectronics Li ion battery Li ion battery
Co ₃ O ₄ /rGO MnO ₂ /GO	<i>In situ</i> : microwave assisted reaction between urea and Co(NO ₃) ₂ <i>In situ</i> : redox reaction between MnCl ₂ and KMnO ₄ <i>In situ</i> : microwave assisted reaction between C and KMnO ₄	Supercapacitor Supercapacitor
MnO ₂ /FGS SiO ₂ /GO or rGO SiO ₂ /FGS	<i>In situ</i> : redox reaction between Na ₂ SO ₄ and KMnO ₄ <i>Ex situ</i> : electrostatic via aminopropyltrimethoxysilane <i>In situ</i> : hydrolysis starting with TEOS	Li ion battery
SnO ₂ /FGS Fe ₃ O ₄ /rGO Fe ₃ O ₄ /GO	<i>In situ</i> : redox reaction starting with SnCl ₂ and H ₂ O ₂ <i>In situ</i> : hydrolysis starting with FeCl ₃ <i>In situ</i> : redox reaction starting with FeCl ₂ , FeCl ₃ and NaOH <i>In situ</i> : reaction of ferric triacetylacetonate with GO in 1-methyl-2-pyrrolidone	Li ion battery Li ion battery Magnetic drug carrier Magnetic composite
NiO/graphene RuO ₂ /rGO CdS/rGO	<i>In situ</i> : sputtering <i>In situ</i> : redox reaction starting with RuCl ₃ and GO <i>In situ</i> : chemical bath deposition	Nanocapacitor Supercapacitor Solar cell
CdS/rGO CdSe/CVD-graphene	<i>In situ</i> : hydrothermal starting with dimethylsulfoxide, GO and Cd(CH ₃ COO) ₂ <i>In situ</i> : electrochemical deposition templated by a porous silica film	Optoelectronics Optoelectronics

2.2 Magnetic properties

The electronic properties of graphene are conditional on the nature of the edges. For example, zig-zag edges of graphene have non-bonding electrons causes a rise to edge states. This causes unconventional magnetism including ferromagnetism, spin glass behaviour, and magnetic switching phenomena. The addition of hydrogen leads to magnetic properties. Curie -Weiss type behaviour by magnetic susceptibility shows heating of pristine activated carbon fibres (Fig 3a). which indicates the presence of localized magnetic moments at the edges of graphene. The presence of a small cusp at 7 K (Fig 3b). The large field-cooling effect is caused by the growth of quenched disordered magnetic structures in a sample heated at 11000 deg C.

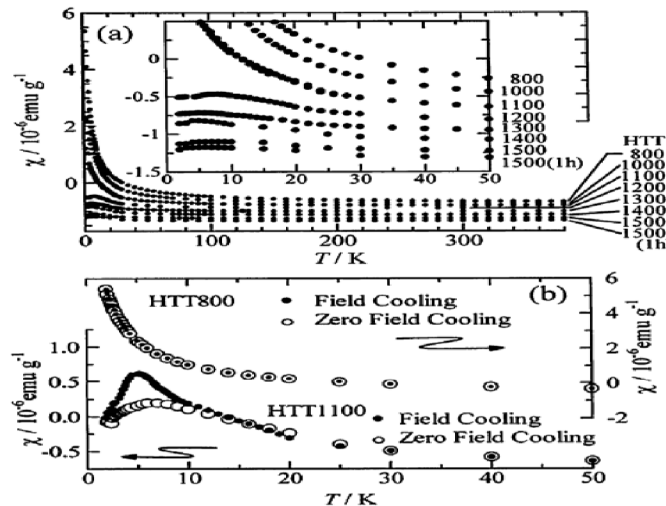


Fig 3: (a) Magnetic susceptibility vs. temperature¹
(b) Field cooling effects¹

2.3 Optical properties:

The white light absorbance of suspended single-layer graphene is 2.3%. it has negligible reflectance of 0.01%. This increases linearly with 1-5-layer numbers. The dynamic conductivity of graphene for visible range $G = 2 / 2h$, The transparency of graphene, $\alpha = 2 / hc$, where, α is a fine-structure constant which describes the coupling between the light and relativistic electrons. The absorbance of n-layer graphene is expressed in NPA. Deviation from this behaviour is with the incident photons with energy which is less than 0.5 eV (or wavelength larger than 2480 nm).¹

3. GRAPHENE AEROGEL SYNTHESIS

By altering the size and form of the main nanoparticles, the porosity properties of carbon aerogels can be controlled. Because they are the building blocks of the three-dimensional network structure, one-dimensional carbon nanotubes with excellent mechanical, thermal, and electrical properties have recently been developed. Because of its many great physical features, two-dimensional graphene with one atom thickness and one layer of plumbago has received a lot of interest in recent years. Unfortunately, they must use a kill R-F gel template and destructive distillation energy throughout the synthesis process. Liquid gel precursors are dried in critical carbonic acid gas or lyophilized to produce graphene aerogels. Scanning microscopy and chemical element sorption investigations revealed they have large Brunauer–Emmett–Teller (BET) surface areas and a wide pore size distribution. According to mechanical property testing, they can sustain more than 14,000 times their weight, which is approximately double the amount supported by the previous generation.

The production of physical cross-links between graphene sheets was achieved using sol-gel chemistry to create graphene aerogels. Graphene chemical compound was synthesised similarly to the procedure described elsewhere, and a liquid suspension containing 4.0 mg mL⁻¹ graphene chemical compound was prepared by ultrasonication (as shown in Fig 4a). The gel precursor was made by heating the mixture for a few hours without stirring it. Because no vaporific products were formed during the synthesis of the gel precursor, L-ascorbic acid was chosen as the reductant. The feature of the hydro-gelation will be discussed in detail in a future article, but in summary, the main cause for

such gelation is a little by bit reconditioned robust p-p contact among these decreased graphene compound sheets. Single-layer sheets of each graphene compound and graphene were discovered severally from suspension and gel by atomic force research, transmission microscopy and O 1s XPS (see Supporting Information: Fig. S11) (Fig. 4c). shows the digital photos of the ensuing monolithic graphene aerogels from its pure gel precursors treated by critical dioxide drying or by dehydration.²

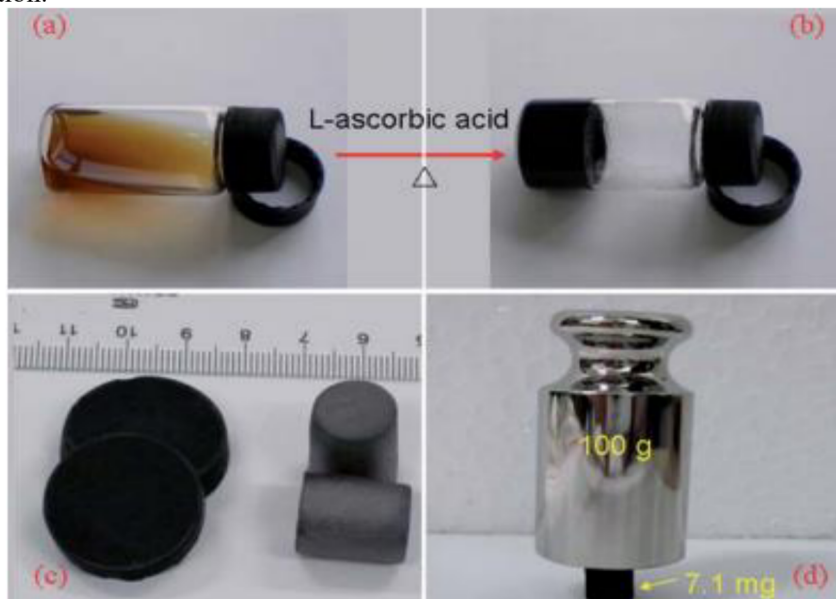


Fig 4. Digital photos of the aqueous suspension of graphene oxide (a), the graphene hydrogel (b) in a vial prepared by heating the mixture of graphene oxide and L-ascorbic acid without stirring, the supercritical CO₂ dried (left) and freeze-dried (right) graphene aerogel (c), and a 7.1 mg graphene aerogel pillar with the diameter of 0.62 cm and the height of 0.83 cm supporting a 100 g counterpoise, more than 14000 times its own weight (d).²

Graphene aerogels with critical dioxide drying might support a minimum of 14,000 times their weight, as compared to those with dehydration, which has the opposite effect. It had previously been rumoured that nothing polyvinyl alcohol increased fullerene aerogeled, and that they were simply 8000 times heavier. Graphene aerogels were characterized by scanning research and N process tests. They exhibit a three-dimensional network of willy-nilly homeward sheet-like structures with wrinkled texture. Macropores (pore size of quite fifty nm) with the size of the many micrometres square measure closely stacked, and solid walls of these macropores are self-assembled.^{9,10}

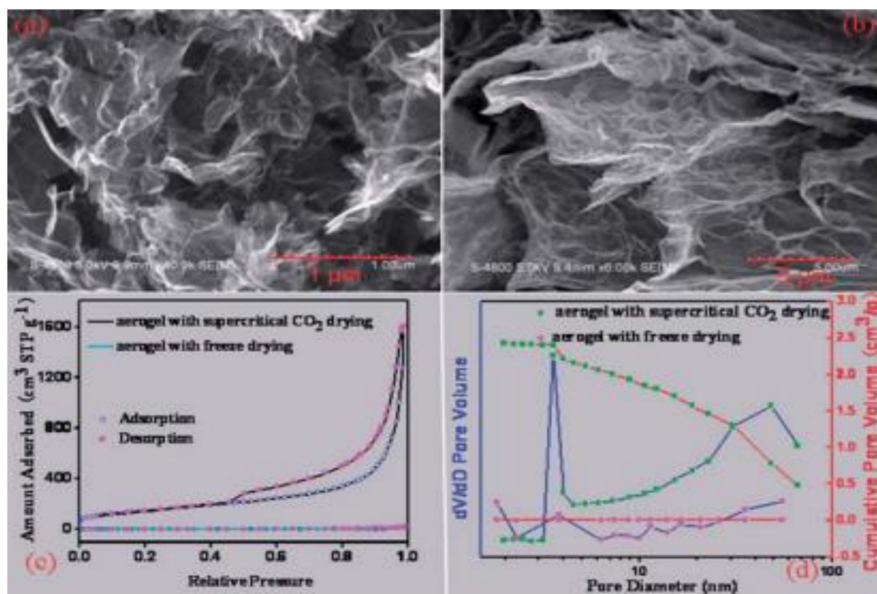


Fig. 5; SEM images of supercritical CO₂ dried (a) and freeze-dried (b) graphene aerogels, and typical nitrogen sorption isotherms (c), BJH (Barret–Joyner–Halenda) desorption pore size distribution (d) of these graphene aerogels.²

The BET surface morphology and porous attribute of the following graphene aerogels were characterized by scanning research and N process tests. The pore size distribution as determined by the Barret-Joyner-Halenda technique shows that heaps of the pore volume ($2.48 \text{ cm}^3 \text{ g}^{-1}$) lie among the 2–100 nm vary, with a double-peak pore diameter of 3.5 and cardinal nm, severally (Fig 5d). For the sample dried by crucial oxide, a typical kind IV line characteristic with degree action natural phenomenon, indicates that their square measure loads of mesopores existing within the aerogels.^{11,12}

The porous properties of the following graphene aerogels were to boot confirmed by the part action tests. The pore size distribution as determined by the Barret-Joyner-Halenda technique shows that heaps of the pore volume ($2.48 \text{ cm}^3 \text{ g}^{-1}$) lie among the 2–100 nm vary, with a double-peak pore diameter of 3.5 and cardinal nm, severally. This all told likelihood is also ascribed to the fact that at intervals the gel precursors were amalgamated on to make macropores actuated by gradual growth of ice crystals throughout evaporation.

Most of the oxygen-containing useful teams in graphene compound, particularly for the epoxy and alkoxy teams, were removed by L ascorbic acid and most of the conjugated bonds were restored. The removal of the thermally labile O useful teams by chemical reduction ends up in abundant exaggerated thermal stability for the graphene aerogels. The large BET surface areas and pore volumes, at the side of their excellent mechanical properties and high physical phenomenon [Fig 6], will create these graphene aerogels viable candidates to be used in several fields. These fields include energy storage, catalysis, sensors, actuators, chemical compound composites, etc. These results indicate an honest rate of performance, that most likely is ascribed to its robust physical cross-links and porous structure.⁸

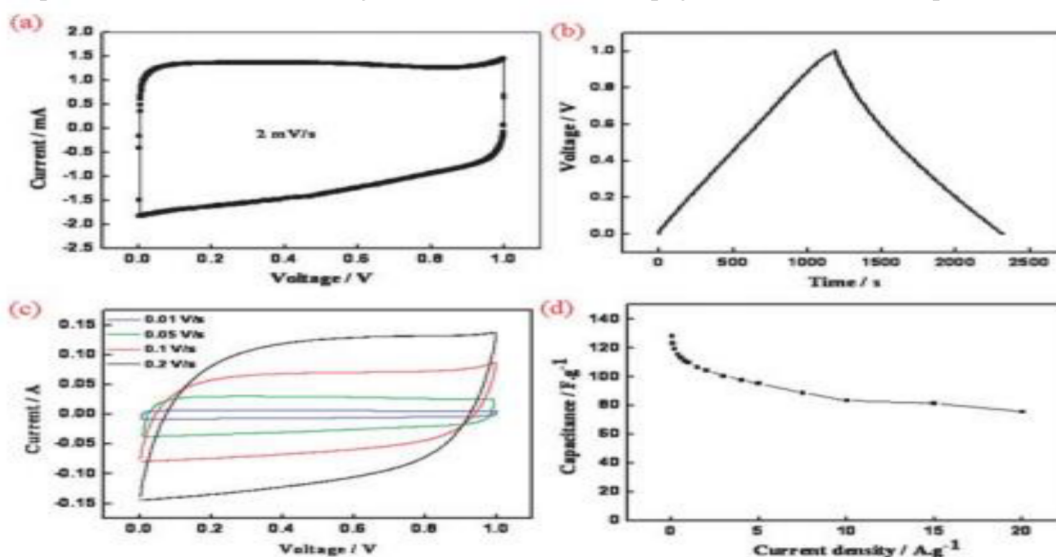


Fig.6 Electrochemical characterization of graphene aerogel electrodes: (a) cyclic voltammetry at a scan rate of 2 mV s^{-1} , (b) charge-discharge curves in $6 \text{ mol L}^{-1} \text{ KOH}$ at a current load of 50 mA g^{-1} , (c) cyclic voltammetry at enhanced scan rate, and (d) the dependence of specific capacitance of the electrode on the current density.²

4. Significance and Future Approach in the Field of Aerospace Industry

4.1. Reduction of aircraft engine noise-

The graphene oxide-polyvinyl alcohol aerogel is the thinnest noise material yet created, weighing only 2.1 kg per cubic metre. It could be utilised as noise insulation in aviation engines, lowering the 105-decibel scream of a jet engine lifting off to a sound similar to a hair drier. The composition of the aerogel is extremely light, so it might be used as an insulator within aircraft engine nacelles with no weight gain. The material is now being refined by the research group in an attempt to improve thermal dissipation, which will enhance fuel efficiency and safety.³

4.2. Lithium-ion batteries

The battery systems with high efficiency, low cost, and green solutions for energy conversion and storage devices are

very popular in the market. Thus, making them one of the many priorities for mass production especially in rechargeable batteries. The storage systems with high absolute potential against the standard hydrogen cell (3.04 V) and its low atomic weight ($M = 6.94 \text{ g mol}^{-1}$) leads them to a large energy density with a theoretical value of up to $\sim 400 \text{ Wh kg}^{-1}$. These storage systems are Li-ion batteries (LIB) which are the best and most promising systems in the market. Instead of the conventional insertion-type (e.g. TiS_2 and LiCoO_2) and alloying-type (e.g. Sn) of electrode systems for insertion/extraction of Li. The redox reactions (reaction 1) between the ionic and metallic states of the metal provide high capacities for the conversion type LIB which employs transition metal compounds such as (MaXb , $M = \text{Co, Ni, Fe, Cu, etc.}; X = \text{O, S, P, N, etc.}$) making it easier for the Li insertion/extraction.⁴



CONCLUSION

In conclusion from the research study made it is clear that graphene research is more exciting in the last few years. Graphene has reliable procedures become available to prepare samples with the desired number of layers. Graphene has many properties like magnetic, electrochemical, and optical. Preparation of graphene-based composites by using various fabrication methods. The graphene aerogels may be ready by either supercritical carbonic acid gas drying or freeze of graphene gel precursors obtained from heating the liquid mixture of graphene oxide with L-ascorbic acid while not stirring. The ensuing graphene aerogels show light-weight ($12\text{--}96 \text{ mg cm}^{-3}$), high physical phenomenon (approaching 102 Sm^{-1}), giant BET extent ($512 \text{ M}^2 \text{ g}^{-1}$), and ample volume ($2.48 \text{ cm}^3 \text{ g}^{-1}$) with a hierarchically porous structure. The chemical science investigation shows that the ensuing graphene aerogels with a particular capacitance of 128 F g^{-1} (at a relentless current the density of fifty mA g^{-1}) may be used as electrodes with a superior rate performance for chemical science power sources. The mechanical study shows that the graphene aerogel will support over 14000 times their own weight, nearly double the quantity supported by the carbon nanotube counterpart. The light-weight and enormous surface area, along with their glorious electrical and mechanical properties, would enable these graphene aerogels to be applied in several fields with Associate in Nursing surprising performance.

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