Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 4, No. 1, 2022

Preparation and Application of Graphene

Junxiao Feng[1, *]

[1]Gaoxin Experiment School, Jinan, Shandong, 250161, P.R.China
[*]Corresponding Author's Email: 13256697165@163.com

Abstract: Energy is one of the most serious problems faced by human beings in the twenty-first century. The developments of new energies have become a global consensus. With excellent electrical, mechanical, and optical properties, Graphene has important prospects of application in science, energy, biomedicine, and drug delivery, micro-nano processing. This work introduces the development of graphene and propose several mrthods for preparing graphene. It also suggests several application of graphene. Graphene is regarded as a breakthrough in the future. It is now on the eve of industrial application, and it will have a bright future when combined with new energy.

Keywords: Chemical and physical methods for preparing graphene.

1. Introduction

In 2004, Novoselov and Geim et al. first discovered graphene monolayer and studied its electrical properties. Then graphene and stone ink derivatives have attracted extensive attention from researchers in many fields.[1]It is known that Graphene is a recently discovered coal nanomaterial and it has a two-dimensional plane structure.Its special single-atomic layer structure enables it to have many unparalleled chemical and physical properties. The basic and applied research of graphene has reached the frontier and popular topics. Recently, a number of researchers in chemistry has been interested in graphene due to its brilliant properties and unique structure. Positive progress has been made for the graphene preparation, which furnishes unprocessed material guarantee to basic researches of graphene. In this paper, background, development prospects, properties, and applications as well as preparation processes of graphene are reviewed, and various modification methods of graphene are introduced in detail.

2. Basic Introduction of Graphene

It is acknowledged that graphene is a two-dimensional, hexagonal, honeycombed, only one atomic layer crystal consisted of carbon atoms with SP2 hybrid orbits. Graphene's unique structure gives it extraordinary physical properties. The electronic behaviors of graphene (payloads) reveal very much similar to relativistic neutrinos, travelling at about one 300th of the speed of light, far faster than electrons in ordinary conductors. In theory, graphene has an electron mobility of 2×100000 cm2 /V·s, making it an extraordinary conductivity. Graphene has excellent transparency, and the transmittance of monolayer graphene can reach 97.7% in the visible-infrared.

3. Development History and Background of Graphene

Tracing the development history of graphene, the earliest report appeared in 1840, on graphite oxide and graphite intercalation Compounds. German scientists Schafhaeutl claimed: between the layers of graphite by van der Waals force, this force is weak, so the graphite layer can be inserted into small molecules of acid or alkali metal, graphite interlayer complex. In 1859, Brodie, a English chemist, provided graphite oxide with heavy oxide as well as acid (KCl03) which are based on Schafhaeutl's report: the lammellar structures were more loose, but also the surfaces were charged by functional groups, which means oxidized graphite. After about forty years, Staudenmaier added chlorates to the preparation process of graphite oxide, producing the thinner layers of graphite in 1962 Boehmetal. By heating and the chemical declining splitting of graphite oxide by using the hydrazine hydrate, hydrogen sulfide and divalent become more ferric salt, A thin layer of carbon with A thickness of 4.6A was obtained. Much of that research provided the basis for today's go. In 2004, Andre Konstantin Novoselov and his companions Geimand, who are two physicists at the University of Manchester, ultimately successfully separated graphene from HOPG using micromechanical stripping method, thus proving that graphene can exist on its own. This overturns a long-standing misconception in science that without two-dimensional crystal along with a single atomic layer could present at a limited temperature. Graphene is a crystal that can being(present) at normal temperature and be stable in room conditions at the same time. The 2010 Nobel Prize also were divided by those professors in Physics for the name called"pioneering experiments in two-dimensional graphene materials." Since then, graphene research has passed into a new phase.

Because of its excellent electrochemical properties, graphene is not only used in lithium-ion batteries and supercapacitors, but also used in other fields. Graphene has extremely important application value in all fields in the future, with broad development prospects and huge market potential. In the future, the regional development of graphene industry will show three trends: first, the strong will become stronger in the eastern coastal region, and the resource elements will continue to converge to the advantageous regions; Second, hot cities continue to emerge, and industrial parks are blossoming everywhere. Local governments are building various graphene research institutes and industrial parks, taking graphene industry as the focus of development. Third, it will present "characteristic and differentiation" development and make the regional division of labor clearer. The future of the graphene industry will be significant in three areas. One is graphene, a material similar to carbon fiber, which will be widely used in aerospace and other high-end equipment manufacturing. Second, graphene materials similar to plastic will be widely used in People's Daily life, and may even become as common as plastic in the future. Third, graphene materials similar to silicon materials will be widely used in the field of integrated circuits, which is expected to greatly accelerate the development of the integrated circuit industry and further promote the industrial revolution of the whole information industry.

4. Preparation of Graphene

At present, there are many literature reviews about the preparation methods of graphene at aboard as well as home. Graphene is prepared mainly by .Physical method is usually after expansion of graphite and cheap graphite as raw material, through direct stripping of liquid phase or gas phase and micro mechanical stripping method to prepare single layer or multilayer graphene, the advantage of the method is: rich raw materials, relatively simple, and high purity, but there are many fatal shortcomings, such as graphene synthesis defects, time, low yield, cut is not suitable for mass production. At present, graphene in the laboratory preparation mainly using chemical method, because of its various advantages in this method, benzene ring first used as the core, and six benzene ring or large aromatic ring reaction, and later with the study of graphene, replaced the early method is a multi-step forward or backward cycle, with the expanded aromatic system, people obtained a certain size of graphene and plane structure (chemical synthesis method).

Liquid or gas phase direct stripping method: graphite or expanded graphite (EG)(generally obtained by removing the groups consist of a large amount of oxygen on the surface by heating quickly up to 1000℃) is usually directly added to some organic solvent or water, and some concentration of single or graphene that have many layers(more than two layers) solution are prepared by means of ultrasound, heating or air flow. For improving the yield of graphene. recently developed a new method called solvothermal-Asssisted exfoliation to prepare graphene (Figure 1). This method uses EG as raw material, The total yield of graphene was increased to 10%-12% by dipoleinduced dipole interaction between acetonitrile and graphene sheet. Coincidentally, for the sake of improving the immobility of graphene solution, some stabilizers are usually added in the course of liquid stage stripping graphene sheets to prevent graphene from reassembling owing to vander Waals forces between the sheets. Coleman's researchful team treated graphite in water/sodium dodecylbenzene sulfonate (SDBS) for 30min by ultrasound.

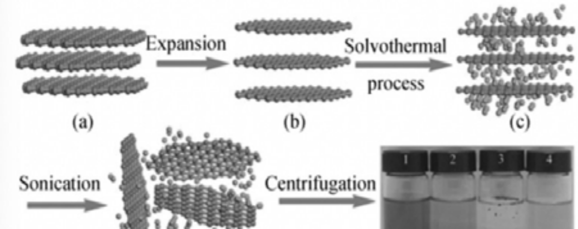

Figure 1. Liquid or gas phase direct stripping method

Crystal epitaxy growth (SiC high temperature) : In this method, single crystal 6H-SiC is used as raw material and etched by hydrogen. After treatment, oxygen is removed by heating under high vacuum by electron bombardment Compound. Auger electron spectroscopy was used to determine the oxidation of the sample surface. After complete removal, the samples were removed under ultra-low vacuum (1.333×10^{-8} Pa) and high temperature (1200 ~ 1450℃) under the condition of constant temperature for 1 ~ 20 min, thermal decomposition. In addition to the Si, the thickness of the single crystal (0001) surface is decomposed by temperature Controlled graphene sheets.[2] There are two kinds of graphene obtained by this method, both of which are greatly influenced by the SiC substrate: one is the graphene grown on the Si layer, which has a great impact on the electrical conductivity due to contact with the Si layer, and the other is the graphene grown on the C layer, which has an excellent electrical conductivity. This process is demanding and produces graphene that is not easily separated from the substrate, making it difficult to manufacture graphene in large quantities.The downside is the efficiency of graphene production. The rate is extremely low and limited to basic laboratory research.

Redox method: The method of chemical synthesis followed by dissection is the most popular.

Commonly used methods for preparing graphene oxide.[3]The main preparation methods of GO include Brodie method, Staudenmaier method and Hummers method, all of which are through strong oxidants. Graphene oxide was prepared by oxidizing graphite in concentrated acid medium. This is the most commonly used method when preparing graphene, and scientists spend a lot of time and energy, both at home and abroad.Graphite itself is a readily hydrophobic substance, with more epoxy groups and hydroxyl groups on its surfaces and edges, and it has special hydrophilic properties. These functional groups make GO prone to react when it reacts with others, while the GO layer spacing (0.7-1.2 nm) is generally wider than the original graphite layer spacing (0.335nm), which facilitates the insertion of other substances.There are generally three methods of preparation.

GO: Standenmaier, Brodie, and Hummers method.When prepared, its basic mechanism is to filter graphite with strong acid, then compounds form between graphene, and finally add graphene, a strong oxidant.Because these methods all use substances that are highly corrosive and oxidizing to chemical equipment, there are many improved synthesis methods of GO at present. The structure of GO is relatively complex, and there is no recognized structural formula at present. A commonly used one is shown in the figure.

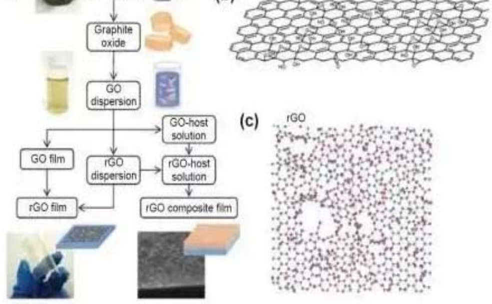

Figure 2. Graphene production process by REDOX

5. Application of Graphene

Graphene oxide has excellent mechanical, optical, electrical and thermal properties. And other properties, have been applied in many scientific and technological fields, such as catalytic inverse. Application, nanocomposites, electrochemistry, adsorption separation, supercapacitor. And hydrogen storage device, etc.[4]Becerril et al. coated GO on the quartz surface. After thermal reduction treatment, its conductivity is 100S · cm-1 and 80% in the wavelength range of 400-1800 nm, indicating that the material can be used as an electrode for solar cells.The graphene obtained by thermal reduction treatment can be made into a transparent conductive film with a thickness of about 10nm, with a conductivity of 550 S · cm-1 and a light transmittance of 70% from 1000 to 3000 nm. Thermo-expanded graphite oxide achieves good results in dye-sensitized solar cells. Functionalized graphene was first used as an electron acceptor material for optoelectronic devices by Liu et al.When poly (3-ocyl thiophene) (P3OT) and poly (3-hexyl thiophene) (P3HT) are used as donor materials, the interaction between graphene and P3OT / P3HT makes the complex a good solar cell electrode active layer (Figure 7).The organic solar cells have an open circuit current density of 4.0mA · cm-2, an open circuit voltage of 0.72 V, and a photoconversion rate of 1.1%.

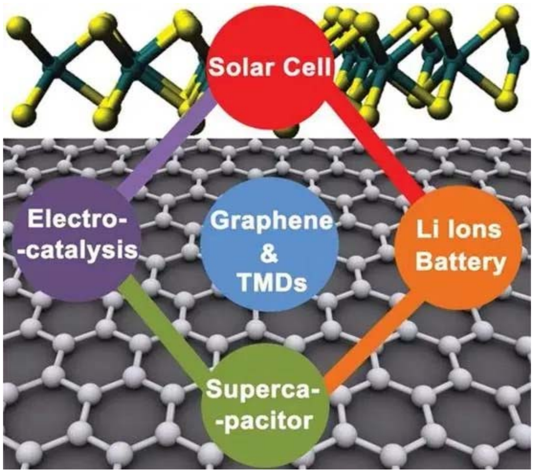

Figure 3. Application of graphene

Gas sensor, some significant of natures of graphene can make it in the production and application of sensor also has good prospects for development, such as graphene specific two-dimensional layered structure could make it have a large specific surface area, which is necessary for high sensitive sensors, in fact this is also other nanostructure materials used as a sensor made of important reason; Graphene is used as the sensor of another important reason is that its unique electronic structure, some of the gas molecules can be induced by the adsorption of the electronic structure of graphene changes, thus makes a great difference to the conductive performance quickly, such as when NH3 molecule after physical adsorption in the surface of graphene, NH3 molecule can provide electronic to graphene, N-type doped graphene was formed; In absorbing molecules such as H2O and NO2, they can absorb electrons in graphene to form a special graphene with p.First time, sensors with graphene gas were successfully prepared by Geim et al.When an electron donor is composed of gas molecules, there are some changes about the graphene conductivity, if the receptor is adsorbed on the graphene surface.The results show that when NO2 and H2O suck tightly on the surface of graphene, they can more effectively improve the conductivity as the electron acceptor, while the NH3 and CO molecular donors adsoras the electron acceptor on the surface.When the graphene adsorbed with the gas is annealed in a vacuum at 150 ℃, the conductivity is restored, which enables the detection of gaseous monomers (NO2, NH3, H2O, CO, etc.).

Superbattery: The new battery can charge and discharge up to 1,000 times in temperatures as low as minus 30 degrees Celsius. It can achieve 45,000 stable cycles at 100 degrees Celsius. A smartphone with this battery can be used for nearly 70 years and can be recharged 10 times a day. It can charge in five seconds and talk for two hours, which is a revolutionary evolution in battery. Of course, commercial use is still some way off.

Graphene engine oil：Shenzhen company using nanometer graphene super lubrication, the strength of super steel one hundred times, ultrathin, super fritter diameter, high thermal conductivity and other excellent performance, using the research synthesis of special dispersant, form a long effect of graphene in oil nanoparticles dispersion system, reunion, precipitation, make graphene protectant and graphene lubricating oil, applied in the field of the engine lubrication. At present, the company production of ink embellish graphene protectant in through the national automobile engine bench test of supervision and inspection center, and other authorities in the driving test, test results show that the energy conservation and emissions reduction, low friction resistance to abrasion, shock absorption, noise reduction, extend the oil change period has a significant effect, oil-saving rate can be up to 5-15%, reducing emissions of 20-40%.

6. Conclusion

In just a few years, graphene has been rapidly explored and developed with its excellent properties and various potential application prospects. At the same time, there is a need for large quantities of high-quality, structurally complete graphene materials. But for now, however, what humans need to do is to improve or further improve the methods and means of preparing graphene, and we still need to explore new ways to prepare graphene.Obviously, micromechanics is difficult, or unable to meet the future standards of gradual and rapid industrialization.Although directly soluble graphene can produce high-quality graphene, the efficiency is too low, and the yield is also low, which takes too long.Although chemical vapor deposition (CVD) can prepare graphene films with excellent performance and relatively large area, the current process is not mature enough, and the cost is high, which greatly limits its large-scale application, which is very needed in the future, so further improvement and exploration are definitely needed.Finally, redox can produce a lot of graphene at a relatively low cost, but there are still many problems: even with strong reductive agents to reduce graphene (especially this covalently modified graphene), it is still difficult and almost impossible to completely restore the initial structural layer of graphene.Because the electronic structure and crystal integrity of graphene has also been severely damaged, it reflects the extent that graphene is limited to certain fields and cannot be used in other applications (such as precision microelectronics).Therefore, how to produce a high quality and large quantity of graphene at a relatively low cost and in a short time is still one of the most important priorities of future research.In addition, because the surface modification of graphene can improve or even enrich its various mechanisms and properties, such fields should also get more and better attention, especially non-covalent modification, to further improve the various properties of graphene and promote its devicalization, industrialization and commercialization process.

References

[1] Zhang,X. , Wei,Q.& Ren,X. (2022). Progress in preparation, structure, properties and application of graphene oxide. Application chemical (7), 2106-2112.

[2] He,D., Wu,J., Liu,Z, Shen,L., Wang,H.& Jin,N.(2015). Research progress of application oriented graphene preparation. Chemical Engineering Journal (08),2888-2894.

[3] Liang,J. (2021). Research progress in preparation and adsorption of graphene oxide/chitosan composites. Leather Science and Engineering (03),30-35.

[4] Zhai,Q.& Feng,S.(2020). Preparation, structure control and application of graphene oxide. Chemical Engineering Progress (10),4061-4072.