ARTICLE

Preparation of Graphene Materials and Their Applications in the Field of Electrochemistry

Qing Liao[1]   Tingting Song[2*]

1. Hezhou University, Hezhou, Guangxi, 542899, China
2. China West Normal University, Nanchong, Sichuan, 637002, China

ARTICLE INFO	ABSTRACT
	In the development of modern society, many new materials and technologies have been integrated into the development of various industries. As a new type of two-dimensional carbon nanomaterials, graphene has great advantages in physical and chemical properties and is widely used in various fields of development. Among them, the electrochemical method is one of the important ways to prepare graphene materials, which has the characteristics of quickness and environmental protection, and can effectively produce a large amount of high-quality graphene and its composite materials. Based on this, the paper introduces the preparation method of graphene materials and studies the application of graphene materials in the field of electrochemistry.

1. Introduction

At present, many advanced materials and equipment have emerged and have been applied in various fields. As a new type of material, graphene material has received wide attention from all walks of life. The electrical, thermal and mechanical properties of this material are unique and have become an important research content in the world. Graphene materials have a large surface to volume ratio and high electrical conductivity, and have important application prospects in the development of electrochemical fields.[1] Therefore, in the development of the new era, relevant technicians need to actively study the preparation method of graphene materials, and apply them to the field of electrochemistry, and exert the application effect.

2. Related Content Analysis of Graphene Materials

Graphene is a new type of carbonaceous material, which is mainly composed of a two-layer honeycomb lattice structure composed of a single layer of carbon atoms. This structural unit is a stable benzene six-membered ring with high stability. The relationship between each carbon atom in graphene is relatively tight, and the surface of the carbon atom has a bending deformation problem when an external mechanical force is applied, at this time, the carbon atoms will not be rearranged to be able to adapt to external forces, which largely guarantees the stability of the structure. Moreover, the lattice structure of graphene has the advantages of stability and conductivity. Graphene electrons do not scatter due to lattice defects or foreign

Corresponding Author:
Tingting Song,
China West Normal University, No. 1 Shida Road, Shunqing District, Nanchong, Sichuan, 637002, China;
E-mail: songttphy@gmail.com

electrons when moving. At the same time, each atom has a strong force, the carbon atoms under normal temperature are collided, and the graphene electrons are not easily interfered, therefore, graphene is the most conductive material. Due to the huge surface area ratio and conductivity of graphene, graphene and its composite materials have been widely used in the field of electrochemistry. Many researchers have increased the research on the preparation and electrochemical performance of graphene materials.[2]

In addition, the electrochemical method has great advantages in the process of preparing graphene, which is embodied in the following aspects: first, the electrochemical preparation method does not require the use of strong oxidants, reducing agents, and toxic reagents, which makes the cost of the method relatively low, and is environmentally friendly and clean; second, during the oxidation process, the electrochemical method is stripped by ion insertion, which effectively reduces the damage of the graphene structure by the degree of oxidation, and can be completely reduced in the electrochemical reduction process, which makes the physical properties and chemical properties of graphene relatively strong; third, in the process of non-oxidative stripping of the graphene working electrode as the cathode, the graphite sheet structure will not be destroyed, and high-quality graphene sheets can be obtained. However, under the action of the electrochemical strong electric field, the surface force and the ultrasonic force are larger than the solvent surface, and the glass efficiency is also improved; fourth, in the process of electrochemically preparing graphene, the technician can easily control the current and voltage, and effectively control the performance of the graphene, and the electrochemical process and equipment are relatively simple and convenient to operate.

3. Overview of Graphene Composites

In the development of the new era, relevant researchers are committed to researching graphene composite materials and applying them to related fields, and achieved good application results. The effective fusion of graphene and related materials makes the composites have special mechanical properties and electrical conductivity. For example, supported nanoparticles with graphene as carrier have been applied in catalysis, sensors and supercapacitors.[3] The following is a brief introduction to graphene composites and their applications.

3.1 Graphene/Polymer Composites

The researchers used a solution blending method to effectively fuse graphene and polystyrene to form a graphene/polymer hybrid material. The conductive percolation threshold of this material is very low, only 0.1%, and the conductive percolation threshold of the functionalized graphene poly(ethylene-2,6-naphthalenedicarboxylic acid) complex is 0.3%. Through related research, it is found that the combination of polymethyl methacrylate and graphene greatly enhances its own mildness, modulus, glass transition temperature and thermal decomposition temperature, and has achieved good effects.

3.2 Graphene/Nanoparticle Composites

Both metal nanoparticles and oxide nanoparticles can be fused with graphene to form nanocomposites, which have achieved good results in catalysis, biosensors and spectroscopy applications. For example, the application of grapheme-Pt nanocomposite in methanol fuel cell plays a role in catalysis, anti-toxicity, etc. The decomposition rate of TiO2/graphene composite photocatalytic material itself is much higher than that of P25 under the same conditions. The surface carboxyl modified Fe3O4 nanoparticles and polyethyleneimine modified graphene oxide were fused to obtain a composite material, which has been applied to magnetic targeting drug loading, biological separation, magnetic resonance imaging and sewage treatment. Therefore, graphene is a good electron acceptor and transfer medium, which greatly enhances the migration rate of photogenerated electrons, enhances the photoelectric properties of composite materials, and photocatalyticly decomposes hydrogen production activity.[4]

4. Preparation Methods of Graphene Materials

4.1 The Method of Graphene Oxide by Electrochemical Reduction

There are many methods for preparing graphene by reduction of graphene oxide. In the development of the new era, the electrochemical reduction of graphene oxide is widely used in the process of preparing graphene materials. This method has many advantages, such as simple operation, environmental protection, and mass production. In the process of applying the conventional electrochemical redox method, the relevant technicians often need to invest a large amount of buffer solution, and a reduction reaction is generated under the action of high voltage. At this stage, the researchers invented a low-power electrochemical reduction method that can complete the graphene oxidation reaction in a single solution and achieve a current-voltage curve monitoring method.

4.2 The Method of Mechanical Exfoliation

The method of mechanically stripping the preparation of

graphene has been developed for a long time, mainly by applying mechanical force to peel off the graphene sheet from the surface of fresh graphite crystal. Several sheets of graphite flakes were prepared by mechanical stripping method. The prepared graphene has strong stability in the external environment, and the crystal quality is better, but the size is small. Therefore, the mechanical peeling method has been widely used in the optical and electrical properties of graphene. Although the mechanical exfoliation method has the characteristics of simple operation, the prepared graphene sheets are difficult to control, and the single-layer graphene cannot be produced on a large scale.

4.3 The Method of Electrophoretic Deposition

The electrophoretic deposition method is widely used, and it has certain economy. This method mainly applies a voltage to the electrode in the colloidal solution, and the charged colloidal particles move and discharge to the surface of the electrode to form a deposited layer.[5] Therefore, electrophoretic deposition has great advantages: first, the electrochemical redox reaction occurs on the surface of the motor, which is beneficial to the preparation of nano-film materials; second, the nanomaterial structure will grow in the direction of the electric field, so that the structurally ordered nanomaterial can be formed; third, the electrode modified by the deposit can be applied to an electrochemical device, which not only has the characteristics of electrochemical reduction, but also avoids the use of harmful reducing agent, so that the graphene can be firmly adhered to the conductive substrate, this method is more convenient to operate. In addition, the electrode-position method has strong controllability, and the total mass of graphene can be controlled by the number of deposition weeks and time. The electrochemical reduction of graphene oxide can be used to deposit three-dimensional network graphene on the surface of the electrode; at this time, the oxygen-containing functional group of the graphene oxide is removed to be reduced to graphene. The hydrophobicity of graphene will increase, the weak electrostatic repulsion and strong internal π-π stack will be assembled into a three-dimensional network under the action of electric field, which makes graphene exhibit high porosity, large surface area and low mass density.

5. The Applications of Graphene Materials in the Field of Electrochemistry

5.1 The Application of Graphene Materials in Super Capacitors

With the development of society, after the relevant techni-cians prepared the graphene material, the people began to study the carbonaceous material of the sp2 structure and tried to apply it to the supercapacitor. Related scholars synthesized electrochemical graphene, which has a thickness of 1 C atom, and tested the performance of graphene in a supercapacitor battery. Research results show that the specific capacities of the materials in the inorganic electrolyte and the organic electrolyte are 135F/g and 99F/g, respectively.

5.2 The Application of Graphene Materials in Lithium Ion Batteries

Graphene is a new type of carbonaceous material prepared on the basis of graphite. For example, single-layer graphene, thin-layer graphene, multi-layer graphene, and 2 to 10 layers of graphene have been widely used in the field of electrochemistry. The atomic structure and electronic structure of graphene have certain peculiarities, which makes graphene exhibit strong structural advantages and performance advantages in composite materials, especially in the lithium ion battery as a negative electrode material, in the lithium ion deintercalation process, it can effectively buffer the expansion and contraction of the material volume, prolong the service life of the material, and further improve the overall performance of the material.[6] Therefore, graphene-based composite materials are still in the research stage, and lithium-ion battery anode materials will be widely used.

5.3 The Application of Graphene Materials in Solar Cells and Fuel Cells

Graphene is widely used not only in supercapacitors and lithium ion batteries, but also in solar cells and fuel cells. Two-dimensional graphene has strong light transmission and electrical conductivity and can replace ITO (Indium Tin Oxide) materials. Numerous studies have shown that graphene materials have excellent performance and feasibility for solar electromagnetically transparent conducting electrodes, working electrodes and acceptor materials.

5.4 The Application of Graphene in Inorganic Ion Analysis

Cadmium and lead are very toxic. Once they enter the human body, they will pose a great threat to the health of the people. In order to effectively solve this problem, relevant technicians need to actively study sensitive, fast and accurate heavy metal detection sensor.[7] In the development of the new era, the stripping voltammetry has been widely used in the determination of heavy metal particles. The traditional working electrode is mainly the

application of mercury membrane electrode, but mercury is a toxic substance, which is relatively volatile and easily causes mercury pollution. Later, technicians began to use low-toxic helium instead of mercury to measure heavy metal particles. Moreover, the relevant technicians measured trace amounts of heavy metal cadmium and lead in water in a graphene-modified platinum electrode sensor. This method has great advantages, such as strong adsorption, fast transfer rate, anti-oxidation corrosion, etc., and the operation is relatively simple and safe.

Nitrite content is an important safety indicator. When the nitrite content is too large, it may cause allergic reactions such as headache, nausea, dizziness and asthma. SO_3^{2-} and NO_2^- in the atmosphere and water will cause serious environmental pollution problems. The determination of the content is an important part of the water quality identification and video analysis process, which requires the relevant technicians to establish a simple, sensitive and accurate detection and analysis method to reduce the problem of ecological pollution. At the same time, the overpotentials of the oxidized SO_3^{2-} and NO_2^- in the conventional electrode are high, and the oxidation potentials of the two in the conventional electrode are relatively close, which makes the corresponding electrode pollution effect in the measurement process, which seriously affects its selectivity and importance. The skilled artisan determined the content of sulfite and nitrite by means of graphene chitosan/gold nanoparticle modified electrode. This method can perform the measurement quickly and accurately without the excessive cost, and has the characteristics of simple operation, high sensitivity and high stability.

6. Conclusion

In summary, with the rapid development of modern society, many advanced technologies have been integrated into the development of various industries and have made great achievements. For example, the electrochemical method can effectively reduce graphene oxide and prepare a single layer or a few layers of graphene material. Graphene materials have excellent properties and can be applied in various fields.[8] The research of graphene materials is still in its infancy, and the continuous improvement of the preparation process and the systematic research of the application still require the unremitting efforts of researchers.

References

[1] Zhao Wang, Hongyan Yue, Zemin Yu, Xin Gao, Bao Wang, Wanqiu Wang. Preparation of three-dimensional graphene and its research status in electrochemical biosensors[J]. Chemical Research and Application, 2018,30(04):472-477. (in Chinese)

[2] Yong Xiao, Weidong Ma, Zhiyong Sun, Guohua Sun, Bin Li, Hui Li, Huatai Du, Qianqian Wang. Research progress in preparation and application of graphene[J]. Journal of Functional Materials and Devices, 2017, 23(05):125-131. (in Chinese)

[3] Yunjie Ping, Youning Gong, Chunxu Pan. Research progress in the preparation of graphene by electrochemical stripping and its photoelectric properties[J]. Chinese Journal of Lasers, 2017, 44(07):104-119. (in Chinese)

[4] Zhangyi Chen. Preparation of Graphene and Its Application in Electrochemistry[J]. Chemical Enterprise Management, 2016(31):119. (in Chinese)

[5] Yuchen Cao, Mingming Guo. Graphene materials and their applications[J]. Petrochemical Technology, 2016, 45(10):1149-1159. (in Chinese)

[6] Liang Cao, An'an Wang, Lihua Ai, Ming Jia, Yexiang Liu. The Application of Graphene in Material Properties Optimization of Lithium Ion Batteries[J]. The Chinese Journal of Nonferrous Metals, 2016, 26(04):807-820. (in Chinese)

[7] Bo Zhao, Li Jiang, Minghui Yuan, Xianzhu Fu, Rong Sun, Zhengping Wang. Preparation of Graphene and Its composites by Electrochemical Method[J]. Journal of Electrochemistry, 2016, 22(01):1-19. (in Chinese)

[8] Huifa Shi, Zhengjie Li, Wei Lv. Assembly and electrochemical energy storage of graphene-based materials[J]. Chemical Industry and Engineering, 2015, 32(05):62-70. (in Chinese)