REVIEW

Preparation and Properties of Graphene-based Inorganic Nanocomposites

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ARTICLE INFO	ABSTRACT
	Graphene is a two-dimensional hexagonal monoatomic layer crystal composed of carbon atoms, which exhibits the shape of a honeycomb and plays an important role in the fields of optics and mechanics. It also has the advantages of high specific surface area, strong chemical stability and special planar structure. It is an ideal carrier for carrying various inorganic compounds and is suitable for the development of high performance graphene-based inorganic nanocomposites.[1] Based on this, the paper introduces the characteristics of graphene, expounds the related content of graphene-based inorganic nanocomposites, and studies the preparation methods and properties of graphene-based inorganic nanocomposites.

1. Introduction

At this stage, graphene has been applied to the development of various fields such as chemistry, physics, and materials science. It mainly uses a single layer of atomic thick graphene nanosheets as a support surface to anchor functional nanomaterials. Graphene and functional nanomaterials together constitute a new type of nanocomposites, which have been applied in the fields of catalysis and optoelectronics. Through related research, it has been found that graphene and various inorganic nanomaterials are fused into a composite material, which not only ensures the characteristics of graphene and inorganic nanomaterials, but also has new characteristics, and has been applied in various devices.

2. The Properties of Graphene

2.1 Mechanical Property

The structure of graphene material has certain special characteristics, and it has many special properties. In general, the carbon atoms constituting the graphene are arranged according to a regular hexagon to form a honeycomb structure. In the case where an external force is applied to the graphene, the surface of the carbon atom is deformed, and it is possible to adapt to the external force without rearranging it, thereby ensuring the stability of the graphene structure, so that the graphene exhibits strong mechanical properties. At this stage, the graphene material is the strongest in the known materials, its tensile strength is 125GPa, the elastic modulus is 1.1TPa, and the graphene strength is about 100 times that of the con-

ventional one.[2] In addition, graphene film has both tough properties and strong flexibility. The main performance is that graphene can be bent and folded in any direction to ensure that the crystal structure does not change.

2.2 Electrical Property

Graphene materials have a strong charge transport capability, and their transport process satisfies the description of mass-free relativistic particles. Graphene is a zero-gap two-dimensional semi-metal material with a valence band and partial overlapping of electronic bands. At room temperature, the charge transport process in graphene exhibits an unconstrained parabolic electronic splitting relationship. In addition, graphene also has a strong bipolar electric field effect. In the case of a high carrier concentration, it is necessary to apply a normal voltage, and the electron mobility in the room temperature will reach $10000cm^2V^{-1}s^{-1}$, and the graphene suspension has a low-temperature electron mobility close to $20000cm^2V^{-1}s^{-1}$ at a carrier concentration of $5\times10^9cm^{-2}$, which is a very rare type of semiconductor material.

2.3 Optical Property

The optical properties of graphene have certain uniqueness. The light transmittance of the single-layer graphene is 97.7% or more, but the light transmittance has no relationship with the incident light wavelength, and exhibits a linear relationship with the number of layers of graphene. At the same time, graphene itself has nonlinear saturable absorption characteristics, which has been applied in the field of laser mode-locking technology. It mainly outputs laser light by laser pulse width under the action of graphene compression, which makes the saturable absorber prepared by graphene favorable for full-band mode-locking, and the optical properties of graphene itself have been applied in the field of ultrafast photonics.[3]

2.4 Thermal Property

At room temperature, the thermal conductivity of the single-layer graphene dispersion is relatively high, about $5000Wm^{-1}K^{-1}$, and the thermal conductivity of the single-layer graphene in the silicon base is lower than that of the graphene dispersion, which is about $600Wm^{-1}K^{-1}$. However, the thermal conductivity of graphene in the silicon base is continuously reduced, mainly because the interface diffusibility of the silicon-based graphene is relatively strong, resulting in the loss of phonons. Therefore, the thermal conductivity of graphene is 2 times and 50 times higher than that of copper and silicon.

3. Related Content Analysis of Graphene-based Inorganic Nanocomposites

Graphene nanocomposites are materials formed by dispersing metal nanoparticles in graphene sheets. At this stage, the focus of researchers on the study of graphene nanocomposites is the application of functional nanoparticles of silicon metal to modify graphene. In this way, composite materials with better properties than metals can be obtained, the application value is relatively high, the consumption of silicon metal can be reduced, and the economic value is relatively high. At the same time, graphene is a two-dimensional carbon nanomaterial, which provides more space for modifying various materials, making graphene fully contact with related materials.[4] In addition, Graphene has high chemical stability, optical and mechanical properties, and relatively low production cost. It is suitable for the development of high-performance composite materials. The effective integration of graphene and inorganic nanomaterials will become an important development trend in the future. In the development of modern society, many inorganic nanoparticles, such as metal materials, semiconductor materials, topological insulator materials and graphene, are effectively integrated, which constitutes a graphene-based inorganic nanocomposite material, which has special electrical properties, optical properties and catalytic properties, and has been widely used in the fields of biosensing, catalysis, optoelectronics, electrochemistry, and sewage treatment.

4. The Preparation of Graphene-based Inorganic Nanocomposites

4.1 Chemical Reduction Method

The chemical reduction method is a common method for preparing graphene-based inorganic nanocomposites, which mainly comprises graphene and metal into a graphene oxide solution and a metal salt solution, on the basis of the fusion of the two, a reducing agent is added, and a graphene-based inorganic nanocomposite is prepared by a redox method. There are many types of metal oxides, and many different metals are effectively reduced on the basis of the chemical reduction method. For example, related scholars have applied a two-step chemical reduction method to prepare graphene/Ag nanocomposites.

4.2 Thermal Evaporation Method

The thermal evaporation method is also a commonly used method for preparing graphene-based inorganic nanocomposites. The main feature of this method is that it is

easy to operate, efficient, and does not require a lot of cost. It is mainly based on the heating material, so that the evaporation vaporization is deposited into the substrate. For example, a person skilled in the art can apply a thermal evaporation method to deposit Au nanoparticles on a graphene surface. In the case where Au deposited in the n-layer graphene acts on the base, the surface properties of the graphene may be different, resulting in Au in the thickness-dependent state of the n-layer grapheme, which effectively identifies high-throughput, high spatial resolution graphene.

4.3 Electrochemical Deposition Method

The electrochemical deposition method has high preparation efficiency. This method can directly deposit metal nanomaterials in the graphene matrix, which is environmentally friendly and highly efficient. Relevant personnel can use the electrochemical deposition method to dissolve the graphene sheet into the plating solution, and add a surfactant to form a Ni/graphene composite after stirring. When the amount of graphene material added is 0.05g/L, the elastic modulus of the Ni/graphene composite material reaches 240GPa and the hardness reaches 4.6GPa, which greatly enhances the strength of the material.[5]

5. The Applications of Graphene and Its Composites

5.1 The Application in Photoelectric Field

Graphene has the characteristics of large specific surface area and high electrical conductivity. Graphene-based nanocomposites will become ideal materials for supercapacitors. Graphene's large π-electron system is suitable for the fabrication of nonlinear optical materials with excellent performance, and will be widely used in image processing, optical switching, optical storage and other fields. At the same time, graphene materials also have great application advantages in solar cells. They mainly apply graphene oxide on the surface of quartz. After thermal reduction treatment, the transmittance in the range of 400 to 1800 nm is about 80%, therefore, graphene-based nanocomposites will replace traditional silicon conductive materials and exert great advantages.[6]

5.2 The Application in Biomedical Field

Graphene material has the characteristics of large specific surface area and good biocompatibility. It is an ideal drug carrier and will be widely used in the field of biomedicine. For example, using soluble graphene as a drug carrier, the application of hydrogen bonding is beneficial to ensure the efficient loading of the antitumor drug doxorubicin in graphene; nanographene has strong antibacterial properties, and its inhibition rate against Escherichia coli is over 90%, which will not cause toxicity to mammalian cells.

5.3 The Application in Catalytic and Energy Storage Materials

In the development of modern society, many carbon materials, such as graphite, activated carbon, carbon nanotubes, etc., are the main carriers of the catalyst. Related studies have shown that the structure of the carbon support is directly related to the basic properties of the supported catalyst. Graphene has a regular two-dimensional surface structure and is an ideal template-supporting catalyst. The composite obtained by the combination of Pd nanoparticles and graphene oxide has high catalytic activity. Moreover, the related art has designed a novel 3D carbon material with adjustable pore size, which is called a graphene column, which is fused with lithium atoms and has a hydrogen storage capacity of 611wt%. Therefore, graphene hydrogen storage materials will be widely used in the field of energy storage.

5.4 The Application in DNA Detection

DNA is the basic unit that constitutes the biological function of the organism and maintains the normal functioning of various functions of the organism. The structural changes, deletions and errors will change the genetic information and trigger a series of diseases. In the development of modern society, researchers are committed to the research of DNA separation and detection technology, which will become the focus of medical diagnosis, drug development and bioengineering. Especially in the process of disease prevention, diagnosis and treatment, relevant personnel are paying more and more attention to DNA base sequence analysis and base mutation detection. Related studies have found that DNA detection methods are mainly electrochemical methods, electrochemiluminescence and fluorescence methods. Due to the relatively strong photoelectric properties of graphene, researchers have begun to study the application of graphene in the field of DNA analysis. Related technical personnel fuse DNA strands and composites, and follow the principle of base-complementary matching and complementary DNA strands to form a double-helical structure. The quenching principle of graphene fluorescence by DNA strands is used to measure the change of graphene fluorescence performance before and after binding to complementary strands, which measures complementary DNA strands, opening the application of graphene in the field of DNA detection.[7]

6. The Prospects for the Development of Graphene Materials

In the development of modern society, researchers are paying more and more attention to the study of graphene and its composite materials. By using different methods to prepare high-quality, large-area graphene materials, on the basis of optimizing and perfecting the graphene preparation process, the preparation of graphene materials is reduced, and it is applied to the development of various fields. Graphene materials have certain uniqueness. From the production point of view, graphite is the raw material for the production of graphene, which has many raw materials and low prices. Therefore, many countries have established graphene technology research and development centers, and tried to apply them to the development of industry, technology, electronics and other fields. For example, the European Commission has set up a special research and development program for graphene as a "New Future Flagship Technology Project".

In addition, in the future development, graphene materials will be used in more fields, which require researchers to increase the research of graphene preparation process. At this stage, more and more methods for the preparation of graphene will be widely applied to the development of various fields. However, graphene industrialization research is still in the initial stage of development, and the application of many fields cannot reflect the performance of graphene. Many researchers in the world are exploring the application of "killer level". In the future, there are too many challenges in testing and certification. It is necessary to continuously innovate in means and methods to give full play to the function of graphene materials.[8]

7. Conclusion

In summary, graphene material structure has certain peculiarity, its electrical properties, physical properties, thermal properties are relatively good, and the preparation of graphene is rich in raw materials, low cost, suitable for optoelectronics, multi-phase reminder, biomedicine and other fields. In the development of the new era, the society has paid more and more attention to the research of graphene composite materials, but there are still a series of problems. Relevant personnel need to actively solve the problem of large-scale preparation of graphene and development of graphene composites to ensure the application of graphene is more extensive.

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