

Review and Future Prospects of Properties and Applications of Graphene based Anti corrosion Composite Materials

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ABSTRACT

This article reviews the properties and application prospects of graphene based anti-corrosion composite materials in the field of anti-corrosion. This article mainly introduces the preparation methods and property testing results of composite materials such as graphene/polyaniline, graphene oxide/aluminum tripolyphosphate, and silica graphene oxide. Through hardness, impact resistance, electrochemistry, and salt spray resistance tests, the superiority of graphene based composite materials over individual anti-corrosion coatings has been revealed. The future outlook is on how to change the current situation, improve anti-corrosion effects, and point out the development direction of composite materials. This review aims to provide reference for the research of graphene anti-corrosion composite materials and promote their application in the field of anti-corrosion coatings.

KEYWORDS

Anti-corrosion coating; Graphene composite materials; Anti corrosion effect

1. INTRODUCTION

1.1. Research Background And Significance

Corrosion is a ubiquitous electrochemical/chemical phenomenon that changes the state of metal and alloy structures to the most stable chemical form. Although corrosion is an unavoidable process, it can be prevented or slowed down to some extent through the use of corrosion-resistant materials, reasonable material design, cathodic protection, corrosion inhibitors, and coatings [1]. As a new type of material, graphene has high electrical conductivity, thermal conductivity and mechanical properties, so it has a wide range of application prospects in anti-corrosion composites. In order to better understand the performance advantages and disadvantages of different graphene anti-corrosion composites, we conducted a comparative study on their electrical conductivity, thermal conductivity, mechanical properties and other aspects [2].

1.2. Overview Of Anti-Corrosion Materials

The composite anticorrosive material based on graphene has a wide application prospect in the industrial field. As a new type of carbon nanomaterial, graphene has excellent electrical conductivity, thermal conductivity and mechanical properties, which can effectively improve the hardness and impact resistance of the material. By composite with different matrix materials, such as polyaniline, aluminum tripolyphosphate and silicon dioxide, composites with different properties can be formed to improve the corrosion resistance of the material.

2. GRAPHENE ANTICORROSIVE COMPOSITES

2.1. Graphene Anticorrosive Composites

Graphene has excellent physical, electrical, mechanical and chemical properties, and has broad application prospects in anticorrosive composite coatings. Due to the comprehensive performance advantages of graphene composite coatings, they can better meet the protection requirements in complex and changeable environments, and will gradually replace the traditional single coatings used in industry [3]. At present, common graphene anticorrosive composites include graphene/polyaniline, graphene oxide/aluminum tripolyphosphate, silica-graphene oxide and so on. Among them, the silica-graphene oxide composite has excellent hardness properties, impact resistance properties, electrochemical properties and salt spray resistance properties.

However, at present, there are still some challenges in graphene anticorrosive composites, such as high preparation cost and large-scale preparation technology still need to be improved. In the future, the performance and application range of graphene anti-corrosion composites can be further improved by improving the preparation technology, improving the stability and durability of the composite materials, and exploring more application areas of graphene composites.

2.2. Preparation Of Graphene Oxide/Polyaniline Composites

In order to improve the service life of steel in harsh environment, functional graphene oxide/polyaniline nanocomposites were prepared by in-situ reoxidation-reduction polymerization in phytic acid solution, and their corrosion resistance was enhanced synergically. Polyaniline can improve the protective ability of the coating on steel, which is due to the increased corrosion potential between the polyaniline coating and the steel surface, forming a passive oxide layer. The preparation of polyaniline, usually aniline monomer, is synthesized by oxidation in hydrochloric acid solution [4].

2.3. Preparation Of Graphene Oxide/Aluminum Tripolyphosphate Composites

The graphene oxide/aluminum tripolyphosphate composite is a novel anticorrosive material in which ADTP and GO are ultrasonically dispersed into a DMF solvent respectively and then mixed in a three-neck flask. Heat to 105 °C in oil bath, stir at 1000 r/min, hold for 5 h, centrifuge at 4000 r/min, wash and precipitate with ethanol. The sediment was then dried at 60 °C for 24 hours. The ground powder is used as an ADTP/GO blend [5]. Graphene oxide has excellent electrical conductivity and mechanical properties, while aluminum tripolyphosphate has excellent corrosion resistance and high temperature resistance, and the combination of the two can play a synergistic effect to improve the overall performance of the material.

The composite material not only has good corrosion resistance and high temperature resistance, but also has high electrical conductivity and mechanical properties, and can be widely used in aerospace, chemical industry, Marine and other fields. Graphene oxide/aluminum tripolyphosphate composites also show excellent thermal insulation and antioxidant properties, which makes it have broad application prospects in the field of corrosion protection.

In the future, the formulation and preparation process of composite materials can be further optimized to improve their performance stability and reliability. At the same time, the combination of new nanomaterials and traditional anticorrosive materials has developed a more competitive graphene composite anticorrosive material, and increased its research and application promotion efforts to inject new impetus into the development of the field of anticorrosive.

2.4. Preparation Of Silica-Graphene Oxide Composites

Nano-sio₂ and graphene oxide effectively enhance the surface hydrophobicity of graphene oxide, improve the dispersion of graphene oxide, avoid the formation of micropores in epoxy resin, and greatly improve the anti-corrosion efficiency [6]. The preparation methods of silica-graphene oxide composites usually include mechanical mixing, solution blending and chemical vapor deposition. The mechanical mixing method is to mix the graphene oxide and silicon dioxide particles evenly in the process of high-speed stirring or ball milling, and then form a composite material by hot pressing or heat treatment. The solution blending method is to disperse graphene oxide in a solvent and mix it with silica solution to prepare a composite material by solvent evaporation or chemical reduction. Chemical vapor deposition (CVAPOR) is a method of synthesizing silica-GO composites on a carrier base by pyrolyzing graphene precursor gas and silicon source gas.

Silica-graphene oxide composites have excellent hardness properties, and their hardness is often higher than that of traditional anti-corrosion coating materials [7]. In terms of impact resistance, this composite material also performs well and has good resistance to various external shocks. In terms of electrochemical properties, it can be seen from the Nyquist diagram and the Bode diagram tests that the SIO₂-graphene oxide composite material has better anti-corrosion properties and electrochemical activity, and its protection is better than that of the monomer anti-corrosion coating.

2.5. Influence The Properties Of Silica And Graphene Oxide

2.5.1. Hardness property test.

Hardness properties test plays an important role in evaluating the properties of silica-graphene oxide composites. Through hardness testing, you can understand the compressive resistance and wear resistance of the material, and then evaluate its performance in practical applications. Hardness testing of SiO₂-graphene oxide composites can reveal the stability and durability of its structure, and provide an important reference for its anti-corrosion properties. In the hardness property test, the commonly used methods include Rockwell hardness test and Brinell hardness test. Through these tests, the hardness value of the material can be obtained under different conditions, so as to compare the performance differences between different materials. Hardness testing can also help researchers optimize the structural design of materials to improve their anti-corrosion properties and durability.

2.5.2. Impact resistance test.

The impact resistance test is one of the important indexes to evaluate the protection ability of composite materials. For SIO₂-graphene oxide composites, impact resistance testing can effectively assess their stability and durability when subjected to impact. Through the impact test of the material, it is possible to observe whether the surface is cracked or damaged, and the changes inside the material. According to the test results, the resistance of the material to external impact can be judged, and provide an important reference for design and application. Different methods and equipment can be used to test the impact resistance properties of silica-graphene oxide composites, such as impact testing machines or falling ball impact tests. By changing the magnitude and direction of the impact force, the protective properties of the material can be fully evaluated. It can also be combined with a microscope and other equipment to observe the changes in the microstructure of the material, so as to deeply understand the principle and mechanism of its impact resistance.

2.5.3. Salt spray resistance test.

Application reliability in harsh environments is of great importance for graphene anti-corrosion composites. Salt spray resistance testing is one of the important test items, because salt spray corrosion is one of the common forms of environmental corrosion, especially in the Marine environment. The test results of the silica-graphene oxide composite show that it has better corrosion resistance under salt spray environment, which is obviously better than the traditional anticorrosive

coatings. By evaluating its performance in salt spray environment, it can better guide the application of the composite in Marine engineering and other fields. In addition to salt spray properties testing, other properties of graphene composites need to be considered, such as hardness, impact resistance and electrochemical properties. Through comprehensive testing, the performance of materials in actual engineering can be comprehensively evaluated, and the path to optimize material properties can be found. In the future, the preparation methods of graphene composites can be further studied to improve their properties and expand their application fields [8].

2.5.4. Electrochemical property test.

The anticorrosive properties of silica-graphene oxide composites can be evaluated more comprehensively through electrochemical properties testing. The electrochemical properties test is an important characterization method. Nyquist diagram and Bode diagram can be used to analyze the electron transport performance, charge transfer speed and interaction with corrosive media. These test results can reveal the corrosion resistance of the material, thus providing guidance data support. Some scholars have proposed the following formula for calculating the conductivity of composite materials:

$$\sigma = \frac{nq^2\tau}{m} \quad (1)$$

Where, σ is the conductivity of the composite material, n is the carrier concentration, q is the amount of electron charge, τ is the carrier migration time, and m is the mass of the carrier. Through this formula, the electrical conductivity of composites can be better understood.

3. THE MAIN PROBLEMS AND SOLUTIONS OF GRAPHENE ANTICORROSIVE MATERIALS

3.1. Problems Existing In Graphene Anticorrosive Materials

The problem of graphene anti-corrosion materials is that their preparation costs are high and the production process is complex, resulting in high market prices. At present, in the process of large-scale application of graphene anticorrosive materials, its stability and durability still have some challenges. The long-term nature of the anti-corrosion effect, weather resistance and adaptability to different environments also need to be further discussed and improved. The large-scale production and commercialization of graphene anticorrosive materials also need to be solved in order to promote its wide application in engineering practice [9]. In the future, researchers can focus on solving these problems, so as to improve the performance and reliability of graphene anti-corrosion materials, and further expand its application prospects in the field of anti-corrosion. In this regard, research on preparation process, cost-effectiveness and stability can be increased to improve the commercialization level and market competitiveness of graphene anticorrosive materials [10]. Continuous innovation in preparation methods will also be the focus of future research to break the current technical bottleneck of graphene anticorrosive materials and promote their widespread application in engineering practice [11].

3.2. Innovative Ideas And Solutions

As a new type of material, graphene anticorrosive composite has many unique properties and application advantages [12]. Graphene has a very high specific surface area and electrical conductivity, which can effectively improve the mass transfer performance and corrosion resistance of the material. Graphene has excellent mechanical properties, which can enhance the strength and stiffness of the base material and improve the wear resistance and impact resistance of the material.

Graphene also has good chemical and thermal stability, which can maintain the stability and durability of the material in a variety of harsh environments. In order to fully exploit the properties and application advantages of graphene anticorrosive composites, a series of key issues and challenges need to be addressed. It is necessary to realize the effective dispersion and interface combination of graphene and matrix materials, and improve the compatibility and strength of composite materials. It is necessary to optimize the preparation method of the composite material and improve the molding accuracy and performance stability of the material. It is necessary to strengthen the performance testing and application research of graphene anti-corrosion composites, and explore its wide application and future development direction in the field of anti-corrosion. Through continuous innovation and optimization, graphene anticorrosive composites will become one of the important materials in the future anticorrosive field. Abbreviations and Acronyms Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

Table 1. Properties of graphene anticorrosive composite

property	Nature
specific surface area	Wonderful
conductivity	Excellent
mechanical property	Excellent
chemical stability	good
heat stability	Good

4. SUMMARY AND PROSPECT

In summary, the anticorrosive composites based on graphene have excellent properties and broad application prospects. Through the research and comparison of different kinds of graphene composites in terms of electrical conductivity, thermal conductivity and mechanical properties, it can be found that their significant advantages in the field of corrosion protection. Silica-graphene oxide composites perform well in terms of hardness, impact resistance and electrochemical properties, with better corrosion resistance and long service life. However, at present, there are still some challenges in the complex preparation process and high cost of graphene anticorrosive composites. Future research directions can include improving the preparation process, reducing production costs, further improving the performance and stability of graphene composites, and achieving a wider range of applications. Through continuous technological innovation and process improvement, graphene-based composite anticorrosive materials are expected to play a more important role in the industrial field in the future. It is also possible to study and explore new composite composition and structural design, and expand the application range of graphene anti-corrosion composites in the field of anti-corrosion. Through continuous efforts and exploration, graphene-based composite anticorrosive materials will provide more options and solutions for the development and progress of the anticorrosive field.

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