ISSN: 2688-8645

Graphene Composites and its Application in Environmental Treatment

Yue Sun*

Environmental engineering, Chongqing University, Chongqing, 400000, China

*664146565@qq.com

Abstract

Graphene, as a new two-dimensional material, is an ideal material for pollutant adsorption because of its large specific surface area and strong adsorption capacity. Moreover, graphene has an ultra-high electron transport capacity and can be used as a carrier of photocatalysis to further treat pollutants, so it has a wide range of applications in the field of environmental governance. However, with the application of graphene in the field of environmental treatment, the shortcomings of graphene are gradually exposed, such as easy aggregation, easy oxidation and biological toxicity. In recent years, in order to better meet the needs of removing pollutants in the environment and solve the shortcomings of graphene, graphene composites came into being. In this paper, three kinds of graphene composites which can solve the problems of easy aggregation, easy oxidation and biological toxicity of graphene are found out from thousands of graphene composites, and the basic properties, preparation methods and applications in environmental treatment are summarized respectively. They are graphene/metal oxide composites, porous foam/graphene oxide composites and graphene oxide/chitosan composites. At the same time, the application of graphene composites in pollutant adsorption and degradation and the problems existing in this process are also introduced in detail.

Keywords

Graphene Composites; Environmental Governance; Pollutant Adsorption; Pollutant Degradation.

1. Introduction

Graphene has many excellent properties, but at the same time, it also has some shortcomings, which limit the application of graphene in environmental treatment to a certain extent. In order to better meet the needs of removing pollutants in the environment and solve the shortcomings of graphene, graphene composites came into being. Graphene composites not only have the excellent properties of graphene itself, but also can combine the excellent properties of doped compounds, making a major breakthrough in environmental governance[2]. In this paper, the basic properties and preparation methods of graphene/metal oxide composites, porous foam/graphene oxide composites and graphene oxide/chitosan composites, as well as the application of graphene composites in pollutant adsorption and degradation and the problems existing in this process are reviewed.

2. Graphene/Metal Oxide Composites

2.1. Basic Property

Because of electrostatic action and van der Waals force, graphene is easy to gather together, and the adsorption capacity of graphene after aggregation is greatly reduced. If graphene is

ISSN: 2688-8645

combined with various metal oxides (such as TiO_2, ZnO, etc.), it can limit the easy aggregation and re-accumulation between graphene, and at the same time increase the surface area of graphene composites to enhance the adsorption capacity of materials. Because graphene is compounded with metal oxide, metal oxide nanoparticles grow in situ on graphene, thus keeping graphene in a dispersed state to reduce the agglomeration between particles.

In addition, the surface of graphene has different functional groups and defect positions, which can be used as the nucleation and growth sites of nanoparticles. The combination of the two can prolong the life of adsorption materials made of graphene/metal oxide composite materials, but also inhibit the leaching of metal oxide particles in treated water, thus avoiding the occurrence of secondary pollution[1].

2.2. Preparation Method

Graphene can be combined with different metal oxides to form composites with different characteristics, and the corresponding preparation methods are also different. For example, Wu et al[5]. prepared graphene/lanthanum TiO_2 fibers by doping graphene with electrostatic spinning solution. Pei et al[4]. compounded flaky graphene with TiO_2/ZnO/Bi_2O_3 (TZB) material, and prepared TZB-Gr quaternary composite nano-fiber by sol-gel electrospinning process. But generally speaking, people will use different types of electrospinning methods to prepare various graphene/metal oxide composites.

3. Porous Foam/Graphene Oxide Composites

3.1. Basic Property

Simple porous foam itself is hydrophilic and oleophobic, but the composite material attached with graphene has excellent oleophilic and hydrophobic properties. At the same time, graphene oxide (GO) has excellent adsorption performance and rich oxygen-containing functional groups, which can provide reaction sites for various chemical reactions and facilitate surface modification and functionalization. Based on the respective characteristics of these two materials, the porous foam/graphene oxide composite material is made by combining GO with porous foam material. Its porous structure and oleophilic and hydrophobic properties can be well applied to the adsorption of pollutants, especially for the adsorption of high-viscosity oil pollutants, such as the oil spill in the sea.

At the same time, the cost of foam material is low, and the preparation method of porous foam/graphene oxide composite material is simple, which can greatly reduce the material cost and reduce the total cost.

3.2. Preparation Method

Xu et al[6]. soaked the melamine foam in GO dispersion, took it out after 5 seconds, and then put it in a vacuum drying oven, keeping it at 60°C for 1 hour. After that, the foam material was put into hydrogen iodide (HI) solution for reduction, and the reduced foam material was washed with deionized water after reduction, and the porous foam/graphene oxide composite material was prepared.

4. Graphene Oxide/Chitosan Composites

4.1. Basic Property

Chitosan (CS) is a deacetylated derivative of chitin, and its surface is rich in active functional groups, so it is prone to various chemical reactions, which gives CS many special functions. At the same time, CS is considered as a green adsorbent because of its wide sources, non-toxicity, biocompatibility, biodegradability and low cost. But at the same time, CS also has some

ISSN: 2688-8645

shortcomings that limit its application, such as poor mechanical properties, poor thermal stability and easy deformation when drying[15].

The graphene oxide/chitosan composite made by compounding CS and GO can solve the existing shortcomings of CS, and at the same time, it is biodegradable, which can make the application of graphene composite safer and more environmentally friendly. At the same time, its huge specific surface area and rich oxygen-containing functional groups and amino groups make it an adsorbent with excellent adsorption performance[7].

4.2. Preparation Method

F.Han et al[8]. dissolved chitosan with acetic acid, added graphene oxide aqueous solution, used glycerol as plasticizer, and mixed evenly by ultrasonic wave, and prepared graphene oxide/chitosan composite membrane by solution casting method.

Mithilesh et al[9]. added iron oxide into chitosan acetic acid solution, stirred at 27°C for 5 hours, then added human graphene oxide into the mixed solution, degassed the mixed solution in vacuum for 30min, and poured the mixed solution into a mold to dry into a composite membrane, thus preparing graphene oxide/chitosan composite material.

5. Application of Graphene Composites in Environmental Treatment

5.1. Application in Pollutant Adsorption

Adsorption method uses the pore structure of adsorbent to adsorb pollutants, which can prevent pollution from spreading and is beneficial to the subsequent treatment of pollutants. It is one of the important methods of environmental governance. However, the pretreatment of pollutants by adsorption method has high requirements and high cost. Therefore, it is of great practical significance to find an efficient, cheap and large-scale adsorbent.

A large number of studies show that graphene composites have good adsorption performance for pollutants. This property is widely used in industrial wastewater containing heavy metals and dye wastewater containing complex organic pollutants. At the same time, it can also solve the problems of graphene. For example, GO modified by phenyl isocyanate can solve the problem that graphene is easy to aggregate, compounding graphene with metal oxides can improve its oxidation stability and solve the problem that graphene is easy to oxidize, and compounding graphene with foam materials can reduce the cost of graphene composites.

A large number of scholars have carried out exploratory research on the adsorption of pollutants by graphene composites. Liu Hongjuan and others have studied the adsorption of uranium in uranium-containing wastewater by graphene oxide composites[10]. The research shows that graphene oxide composites can adsorb uranium efficiently because of its rich oxygen-containing functional groups and amino groups. Samuel et al[11]. used the prepared CS-GO nanocomposites to adsorb Cr(Ⅵ). When the pH=2 and the adsorption time was 420min, the adsorption capacity reached 104.16mg/g, and the adsorption effect was good. Najafabadi et al[12]. found that the graphene oxide/chitosan composite had an excellent adsorption capacity of 461.3mg/g for Cu(Ⅱ) in industrial wastewater at 45°C for 30min.

5.2. Application in Pollutant Degradation

Photocatalytic technology has attracted much attention in the environmental field because of its low energy consumption, high catalytic activity and reduction of secondary pollutants[1]. If photocatalytic technology is introduced into graphene composites, it can help us to adsorb pollutants and degrade them at the same time, thus avoiding the subsequent treatment process.

For example, in the aspect of water pollution control, using graphene/semiconductor photocatalytic composite material to degrade organic wastewater can not only save energy, but also have a simple process, and can react with almost any organic pollutants without selection;

ISSN: 2688-8645

In the aspect of air pollution control, when using graphene composite photocatalyst to reduce CO2, it is an ideal way to obtain green energy by using solar energy, which is of great significance to alleviate the greenhouse effect and the shortage of fossil energy. A large number of scholars have made great progress in studying the degradation of pollutants by graphene composites. Yang et al[13]. synthesized nitrogen hybrid graphene by alkali-assisted hydrothermal method in one step, and photocatalytic degraded RhB under visible light irradiation, and the degradation rate reached 96%. Hao Qiang et al[14]. prepared g-C_3N_4/rGO composite photocatalyst, which degraded 2,4-DCP and RhB in visible light.

5.3. Problems Existing in the Application Process

In terms of adsorbing pollutants, graphene composites have good adsorption performance for pollutants, but such methods only transfer pollutants from the environment to graphene composites, and do not completely solve the pollutants, and the pollution still exists. At the same time, due to the extensive use of graphene composites, graphene composites will inevitably be released into the natural environment, which will pollute the adsorption materials and become pollutants. For example, graphene oxide composites have high dispersibility and chemical activity in water, which may have adverse effects on aquatic ecological environment and aquatic organisms. Therefore, how to solve the pollutants adsorbed by graphene composites and ensure the safer and more environmentally friendly application of graphene composites needs further research.

In the aspect of pollutant degradation, the degradation of pollutants by graphene composite solves the problem of pollutant removal, but the degradation of pollutants by graphene composite is combined with photocatalysis, but the photocatalytic mechanism is controversial, and further research is needed to better combine the two. At the same time, most pollutants degraded by graphene composites are organic pollutants, and there are still limitations in large-scale application.

6. Conclusion and Prospect

Graphene composites not only have the excellent properties of graphene itself, but also can combine the excellent properties of doped compounds, so they are widely used in the field of environmental governance. Based on this, this paper introduces the basic properties and preparation methods of three kinds of graphene composites in detail, and they all have their own unique advantages to make up for the shortcomings of graphene. At the same time, it summarizes the applications of graphene composites in pollutant adsorption and degradation. However, even though graphene composites are widely used in the field of environmental treatment, there are still some problems in this process, such as how to ensure the safe and environmentally friendly application of graphene composites and how to break through the limitations of its large-scale application. There is still a long way to go in the future.

References

[1] Li Heng, Luo Qiuyan, Wang Guanghui, et al. Research progress in the application of graphene composite photocatalytic materials in environmental treatment [J]. Applied Chemical Engineering, 2021,50, (4): 1113-1117. DOI: 10.16581/j. cnki. ISSN 1671-3206.2006.100000000016.

[2] Guo Zixing. The King of New Materials: Graphene Composites and Its Research in Environmental Governance [J]. Contemporary Chemical Research, 2017, (7): 35-38. DOI: 10.3969/j.ISSN.1672-8114.2017.07.020.

[3] Hu Zhongliang, Li Jingying, Xi Liujiang, et al. Characteristics, adsorption principle, modification and compounding of graphene-based adsorbents and research methods [J]. Journal of Packaging, 2021,13, (1): 48-58. DOI: 10.3969/j.ISSN.1674-7100.

[4] Pei, Carina Chun, Lo, Kenneth Kin Shing,Leung, Wallace Woon-Fong.Titanium-zinc-bismuth oxides-graphene composite nanofibers as high-performance photocatalyst for gas purification[J]. SEPARATION AND PURIFICATION TECHNOLOGY,2017,184,205-212.DOI: 10.1016/ j.seppur. 2017. 04.016.

[5] Wang, Wenguang, Yu, Jiaguo, Xiang, Quanjun, et al. Enhanced photocatalytic activity of hierarchical macro/mesoporous TiO2-graphene composites for photodegradation of acetone in air[J]. APPLIED CATALYSIS B-ENVIRONMENTAL,2012,119,109-116.DOI:10.1016/j.apcatb.2012.02.035.

[6] Xu Guangqiao. Basic research on the application of graphene-based materials in the field of environmental governance [D]. shanghai second polytechnic university, 2020.10. 27916/d. cnki. ghdeg. 20010.100000000606.

[7] Liang Jiao-li. Progress in preparation and adsorption application of graphene oxide/chitosan composites [J]. Leather Science and Engineering, 2021, 31, (3): 30-35. DOI: 10.19677/j.ISSN.1004-7964.2021.03.000.

[8] Lyn, F. Han, Peng, T. Chin, Ruzniza, M. Z.et al. Effect of oxidation degrees of graphene oxide (GO) on the structure and physical properties of chitosan/GO composite films[J].FOOD PACKAGING AND SHELF LIFE,2019,21,DOI:10.1016/j.fpsl.2019.100373.

[9] Yadav, Mithilesh, Rhee, Kyong Yop, Park, Soo Jin et al. Mechanical properties of Fe3O4/GO/chitosan composites [J]. COMPOSITES PART B-ENGINEERING,2014,66,89-96.DOI:10.1016/j. compositesb. 2014. 04.034.

[10] Liu Hongjuan, Xie Shuibo, Zhang Xichen, et al. Research progress of uranium adsorption by graphene oxide composites [J]. Materials Engineering, 2018,46, (5): 11-21.doi: 10.11868/ j.issn. 1001-4381.2017.00.

[11] Samuel, Melvin S. Bhattacharya, Jayanta,Raj, Sankalp et al. Efficient removal of Chromium(VI) from aqueous solution using chitosan grafted graphene oxide (CS-GO) nanocomposite [J]. INTERNATIONAL JOURNAL OF BIOLOGICAL MACROMOLECULES,2019,121,285-292.DOI: 10. 1016/ j. ijbiomac.2018.09.170.

[12] Wijeyawardana, Pamodithya, Nanayakkara, Nadeeshani, Law, David et al. Performance of biochar mixed cement paste for removal of Cu, Pb and Zn from stormwater[J].ENVIRONMENTAL RESEARCH, 2023, 232,(1):116331.DOI:10.1016/j.envres.2023.116331.

[13] Yang, Mei-Ling, Zhang, Nan,Lu, Kang-Qiang et al.Insight into the Role of Size Modulation on Tuning the Band Gap and Photocatalytic Performance of Semiconducting Nitrogen-Doped Graphene [J]. LANGMUIR,2017,33,(13):3161-3169.DOI:10.1021/acs.langmuir.6b03317.

[14] Hao Qiang, Hao Siming, Niu Xiuxiu, et al. Improving the photochemical oxidation ability of carbon nitride through π-π stacking between rGO and g-C_3N_4 [J]. Chinese Journal of catalysis, 2017,38, (2): 278-286. DOI: 10.10.

[15] Takeshita, S. Yoda, S. Translucent, hydrophobic, and mechanically tough aerogels constructed from trimethylsilylated chitosan nanofibers[J].NANOSCALE,2017,9,(34):12311-12315. DOI:10. 1039/ c7nr04051b.