

Application of Molybdenum Disulfide Nanomaterials in Wastewater Treatment

Yueyun Fang^{1, a}

¹ Guangdong University of Science and Technology, Dongguan 523000, China

^a 996987541@qq.com

Abstract: The problem of global water pollution is becoming increasingly serious, especially in industrial wastewater from industries such as textiles and printing, which contains a large amount of toxic and harmful organic dyes, causing serious water pollution problems. It is urgent to remove organic dyes from wastewater and improve the quality of water resources. In wastewater treatment, adsorption is considered the most convenient, economical, and efficient method for treating dye wastewater, and can be used in large-scale production. Molybdenum disulfide nanomaterials have attracted the attention of researchers, especially in the field of wastewater treatment, due to their unique physical, chemical, electrical, biological, and mechanical properties.

Keywords: Wastewater treatment; Molybdenum disulfide; Nanomaterials.

1. Introduction

With the development of industrialization and urbanization, people's demand for water resources continues to increase. However, due to the unreasonable discharge of domestic sewage and industrial wastewater, the problem of global water pollution has become increasingly serious. Especially industrial wastewater from industries such as textile, printing, papermaking, electroplating, etc. contains a large amount of toxic and harmful organic dyes, such as Rhodamine B, methylene blue, methyl orange, alizarin red S, Congo red, neutral red, methyl green, etc., causing serious water pollution problems and posing a huge threat to human health and the ecological environment. Therefore, it is urgent to remove organic dyes from wastewater and ensure that the supply of drinking water is not affected.

2. Treatment Methods for Dye Wastewater

At present, the treatment methods for dye wastewater are mainly divided into three categories: physical method, chemical method, and biological method, including adsorption method, membrane separation technology, flocculation sedimentation method, etc. Among them, the adsorption method uses solid materials with porosity and high specific surface area as adsorbents. When dye wastewater comes into contact with the adsorbent, organic dye molecules in the aqueous solution will accumulate at the active sites on the surface of the adsorbent, causing decolorization of the dye wastewater to achieve the purpose of purification. In the current sewage treatment technology, adsorption method is considered to be the easiest, cheapest, and most effective method to operate. It has a wide adsorption range and no intermediate products are generated, and can be widely produced and applied. Therefore, it has received widespread attention.

The ideal adsorption material should have properties such as large adsorption capacity, fast adsorption speed, easy separation and recycling after adsorption, and strong reusability. Researchers have developed many functional

materials and applied them in the field of sewage treatment as adsorbents to remove organic dyes from sewage. Traditional adsorbents include activated carbon, diatomaceous earth, kaolin, cellulose, etc. Among them, activated carbon has an excellent adsorption effect, with a maximum adsorption capacity of 742mg/g for methylene blue dye. However, its adsorption time is longer (more than 50 hours), resulting in lower adsorption efficiency. Some new adsorbents, such as ultra-high cross-linked polymers, graphene oxide ferrite composites, and tungsten oxide nanomaterials, can shorten the adsorption time of dyes to a certain extent and improve efficiency. However, their adsorption capacity for common organic dyes (Rhodamine B) is only 20-80mg/g, and it is difficult to recycle. In addition, the production cost of new functional materials is high, processing difficulty is high, and large-scale production is difficult. Therefore, developing a more environmentally friendly, efficient, and recyclable adsorbent is a topic that needs further in-depth research.

3. Molybdenum Disulfide Nanomaterials

Molybdenum disulfide (MoS₂) is an emerging graphene like two-dimensional nanomaterial that is gradually attracting widespread attention due to its unique physical, chemical, electrical, biological, and mechanical properties. It can be used in fields such as environmental governance, electronics, lubrication, and biomedicine.

3.1. Structure of molybdenum disulfide nanomaterials

Molybdenum disulfide is the main component of molybdenite and a common natural mineral, mainly present in the form of black solid powder. The molecular structure of MoS₂ is composed of multiple MoS₂ monolayers, as shown in Figure 1. Each MoS₂ monolayer is a sandwich like structure formed by two layers of sulfur (S) atoms sandwiched between a layer of molybdenum (Mo) atoms. There are highly polar Mo-S covalent bonds within the molecular layer, while the Mo atoms located at the edge of the layer that can connect to four S atoms are only connected to

two S atoms, resulting in many dangling bonds at the edge of the molecular layer, This increases its energy, increases the active sites of the reaction, and makes it easier for physical and chemical reactions to occur.

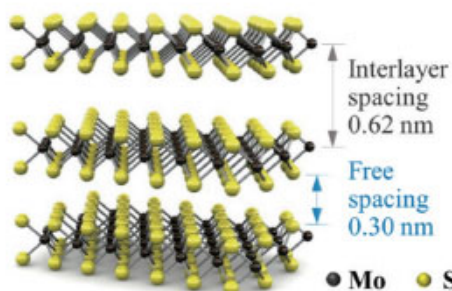


Figure 1. Layered Structure Model of Molybdenum Disulfide

3.2. Preparation of molybdenum disulfide nanomaterials

There are two main methods for preparing molybdenum disulfide nanomaterials: the Top down method and the Bottom up method. The Top down method mainly includes mechanical stripping method, liquid phase ultrasonic stripping method, and chemical stripping method. It overcomes the van der Waals force between molecular layers through mechanical, ultrasonic, or chemical actions, and ultimately obtains MoS₂ nanosheets with single or few molecular layers. Bottom up method includes chemical vapor deposition method and hydrothermal method, mainly obtaining flower shaped or tubular MoS₂ nanomaterials. Among them, flower shaped and layered molybdenum disulfide nanomaterials can be used as adsorbents to adsorb organic dyes in dye wastewater, playing a role in sewage purification.

3.3. Application of molybdenum disulfide nanomaterials in sewage treatment

Researchers prepared molybdenum disulfide nanomaterials with different morphologies through hydrothermal methods and applied them to the treatment of dye wastewater, achieving excellent results. He et al. synthesized layered porous MoS₂ nanosheets and used them to remove Rhodamine B dye from wastewater. They showed the ability to quickly adsorb the dye, with a maximum adsorption capacity of 163mg/g for Rhodamine B within 420 minutes, further revealing the feasibility of molybdenum disulfide nanomaterials as organic dye adsorbents. Han et al. demonstrated through zeta potential testing that the prepared

flower shaped molybdenum disulfide nanostructures have negative charges on the surface, and their adsorption performance for cationic dyes such as Rhodamine B and methylene blue is better than that of anionic dyes such as methyl orange. In addition, this molybdenum disulfide material, which adsorbs Rhodamine B dye, can be easily regenerated by alkaline solution cleaning and can be reused multiple times, thus having good prospects for water treatment applications. In particular, due to the problem of difficult separation and recovery of powder adsorbents, some researchers introduced magnetic substances such as Ni and Fe₃O₄ into MoS₂ nano powders, and successfully prepared magnetic sensitive Ni/MoS₂ and Fe₃O₄/MoS₂ nanocomposites. After adsorption in dye wastewater treatment, they can be easily separated from wastewater by the action of external magnetic field (magnet), Clearly overcomes the shortcomings of non magnetic substances in separation. Through the experimental research of researchers, it can be seen that molybdenum disulfide nanomaterials have enormous application prospects in the field of dye wastewater treatment.

4. Conclusion

The treatment of dye wastewater is an important environmental protection project facing the world today. Developing new environmentally friendly, efficient, and reusable functional adsorption materials is a topic that requires continuous in-depth research. Protecting water resources and the environment is also the responsibility and obligation of everyone.

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