

Making Polypyrrole/Graphene Oxide Composite Nanosheets and Using Them to Remove Cr (VI) From Aqueous Solutions

Xiafenj Li*

Institute of Environmental Engineering, School of Metallurgy and Mining, Central South University, China

Abstract

Using the sacrificial-template polymerization approach, we describe the straightforward, dependable synthesis of polypyrrole (PPy)/graphene oxide (GO) composite nanosheets in this study. Here, PPy, which acted as both the oxidant and the sacrificial template, was deposited onto MnO₂ nanoslices. MnO₂ was continuously consumed during the polymerization of pyrrole on the surface of GO nanosheets. As a result, the PPy that is developing on the surface of GO nanosheets resembles MnO₂ nanoslices in shape [1]. Due to its independence from removing the template, which is typically a difficult and time-consuming experimental operation, this method can allow the manufacture of PPy nanostructures more readily than the standard route. Based on the synergy effect, the as-prepared PPy/GO composite nanosheets showed improved characteristics for removing Cr(VI) ions in aqueous solution. The PPy/GO composite nanosheets have an adsorption capacity that is roughly twice as great as that of regular PPy nanoparticles. We think that our research may provide a fresh, efficient route for enhancing adsorption's capacity to remove heavy metal ions from waste water [2].

Keywords: Polypyrrole/Graphene Oxide; Nanosheets; Cr (VI) ion

Introduction

Growing interest in potential methods to deal with heavy metal ions is a result of growing concern over the problem of worldwide environmental contamination. Among the different types of heavy metal ions, the Cr(VI) ion is one of the most hazardous and has been linked to cancer. The Cr(VI) ion has been widely utilised in a number of polluting sectors, including the production of steel, metal plating, leather tanning, military applications, and refractory materials [3, 4]. The environment and public health are seriously at risk due to the bulk discharge of Cr(VI) ions from sewage and industrial waste. Adsorption, precipitation, ion exchange, membrane process, and chemical coagulation are a few of the technologies that have been developed to date to reduce or remove Cr(VI) ions from aqueous solutions. Adsorption is one of these strategies that is the easiest, most efficient, and most cost-effective. However, due of their inadequately wide surface areas, traditional adsorbents frequently displayed a restricted adsorption ability. Therefore, the need for novel adsorbents with a high Cr(VI) removal capacity remains [5].

Due to their potential use in nanoelectronic devices, energy conversion and storage devices, sensors, catalysis, electrochromic devices, actuators, and biomedicine, intrinsically conducting polymers have received a lot of attention over the past forty years. Because of its simple production, fascinating electrical, and redox properties, polypyrrole (PPy) has received the greatest research attention among conducting polymers. PPy has demonstrated a promising possibility in adsorption application for its positively charged nitrogen atoms in the polymer chains in addition to the researched applications described above, just as other conducting polymers. The usage of PPy materials dealing with the heavy metal ions has been thoroughly researched since Rajehwar et al. initially showed that they may be utilised for decreasing and eliminating Cr(VI) ions from waste water. The surface area or porosity of the adsorption media is, as we are all aware, one of the most significant influencing elements to adsorption efficiency [6]. To increase its adsorption efficacy, it is crucial to create nanostructured PPy with a wide surface area. On the other hand, one of the most often used adsorbents is active carbon. Graphene oxide (GO), a significant member of the carbon family, is thought to be one of the most

intriguing materials of the twenty-first century. GO nanosheets are an excellent choice for supporting other functional nanomaterials because of their distinctive two-dimensional nature and diversity of reactive oxygen functional groups on their surface. Recent research has focused on creating PPy/GO and PPy/graphene nanocomposites for use in transparent electrodes, super capacitors, and environmental fields [7]. In this instance, GO or graphene nanosheets are coated with PPy films or nanoparticles. There are, however, few publications on the creation of hierarchical PPy/GO nanosheets using a combination of GO's 2D and PPy's 3D nanoflowers.

In this study, we have described a straightforward and dependable sacrificial-template polymerization approach for producing PPy/GO composite nanosheets. The GO nanosheets were first covered with MnO₂ nanoslices, which served as both a template and an oxidant source for the PPy nanostructure [8]. MnO₂ was continuously consumed during the polymerization of pyrrole on the surface of GO nanosheets. As a result, the PPy developing on the GO nanosheet surface has the same nanoslice morphology as the MnO₂ nanoslices. Based on the synergy effect, the as-prepared PPy/GO composite nanosheets showed improved characteristics for removing Cr(VI) ions in aqueous solution. The PPy/GO composite nanosheets have an adsorption capacity that is roughly twice as great as that of regular PPy nanoparticles. We think that our research may provide a fresh, efficient route for enhancing adsorption's capacity to remove heavy metal ions from waste water solution [9].

*Corresponding author: Xiafenj Li, Institute of Environmental Engineering, School of Metallurgy and Mining, Central South University, China, Email- XiaLi@csu.edu.cn

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Description

Electrodeposition

Using an Autolab PGSTAT30 and a three-electrode configuration in chronopotentiometry mode, the electrodeposition was carried out at 27°C in ambient conditions. As the working, reference, and counter electrodes, respectively, stainless steel (SS), Ag/AgCl, and carbon rod were utilised. The working electrode's surface area in contact with the solution was set at 4 cm² [10]. Manganese hydroxide particles electrodeposited from a 0.01M Mn(CH₃COO)₂·4H₂O aqueous solution for 300s made up the initial layer [20]. The collected sample was further heated at 150°C for 6 hours when the current density was set to 2 mA cm⁻². After the sample was cooled to 27°C, the second layer was electrodeposited on top of the first layer. The various deposition solutions described in Table 1 were used with a fixed deposition current density of 2 mA cm⁻² for 300s.

Before further characterization, all of the produced electrodes were heated at 300°C for 6 hours and rinsed with distilled water. Measurements and sample preparation are repeatable [11].

Characterization

The morphology of the deposition film was examined by transmission electron spectroscopy (TEM), Joel JEM-2100F, and field emission scanning electron microscopy (FeSEM), Joel JSM-7600F. By utilising CuK monochromatized radiation at 40 kV and 40 mA at room temperature, an X-ray diffraction (XRD) D8 Advance X-Ray diffractometer-Bruker AXS was used to analyse the crystal structure of the deposited metal oxide and powder from the chosen sample scraped off the SS. Electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV), and charge-discharge (CD) experiments were used to analyse the electrochemical performance. All electrochemical measurements were set up with three electrode systems: an Ag/AgCl reference electrode, a platinum counter electrode, and a working electrode that had been constructed. At frequencies ranging from 0.1 Hz to 100 Hz, electrochemical impedance spectroscopy (EIS) measurements were conducted [12,13].

Conclusion

Coaxial electrospinning with a brand-new, PVC-coated concentric spinneret was effectively used to create new, quickly dissolving core-shell composite microparticles containing quercetin. The product shells were made of PVP/SDS/sucralose, and the product cores were made of PVP/quercetin. Coaxial spraying was successful because the shell fluids could be processed even if the quercetin-loaded solutions that made up the particle cores couldn't be processed using single fluid electrospinning. The flow rate of the core solutions (within a suitable range) or the drug concentrations therein can be adjusted to alter the amount of drugs present in the products. Three distinct drug loadings of 7.64, 10.71, and 16.67% w/w were used to create the particles. Each of these had an average diameter of 1.69 by 1.13, 1.74 by 1.02, and 1.85

by 0.83 μm. The core/shell structure is readily visible in SEM and TEM pictures. According to XRD, DSC, and ATR-FTIR results, the physical forms of the constituents in the core and shell are both amorphous as a result of their positive interactions. The microparticles accelerated quercetin's penetration and dissolution rates. These substances therefore have the potential to improve the performance of weakly water-soluble medicines' dissolution and penetration, and to be further developed as novel oral or sublingual drug delivery methods.

Acknowledgement

None

Conflict of Interest

None

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