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Preparation of Organic-Inorganic Composite Nanofiber Membranes and Their Use in the Removal of Heavy Metal Ions

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Abstract

With the development of global industry development, environmental pollution has become increasingly prominent, among which heavy metal ions are highly toxic, easily soluble in water and soil, and not easy to deal with. Long-term exposure to Cr (VI), Cu (II), Pb (II) and other heavy metal ions will cause a series of diseases. Therefore, how to remove heavy metal ions from soil has become one of the research hotspots in recent years.

Keywords

Heavy Metal Ions; Soil; Removal.

1. Introduction

In the last century, with the development of global industry, environmental pollution has become increasingly prominent, among which heavy metal ions are highly toxic, easily dissolved in water and soil, and not easy to handle, so how to handle heavy metal ions has become an important international issue.

Heavy metal ions mainly come from four aspects: First, mineral mining. Minerals not only contain a large number of useful minerals, but also are rich in many heavy metal ions. When minerals are processed, these heavy metal ions will be dissolved in aqueous solution, and eventually these mineral processing effluents will cause water pollution. The second is the electroplating industry. In the electroplating process, many heavy metals are also discharged into the environment without treatment. The third is the smelting industry. The smelting process produces a lot of waste heavy metal salts. These heavy metal salts usually accumulate in the soil without being treated. The fourth is the discharge of waste dyeing and finishing liquid. The dyeing and finishing industry mainly uses heavy metal salt for oxidation measures, resulting in a large amount of dyeing and finishing waste liquid [1-2].

Common heavy metal ions mainly include Cr (VI), Cu (II), Pb(II), Hg(II), etc. These heavy metal ions will enter the human body through the food chain or drinking water. After long-term abdominal deposition, they will interact with proteins in the human body, resulting in protein degradation and various diseases. For example, hexavalent chromium can enter the human body through the digestive tract, skin and mucous membranes, accumulate in the liver, kidney, endocrine glands and other organs, enter the human body through the respiratory tract and

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easily accumulate in the lungs. When hexavalent chromium enters human blood, it can rapidly bind to blood proteins, globulin and R-globulin in plasma. Chromium also binds to hemoglobin via red blood cells. Due to the strong oxidation of hexavalent chromium, when it enters the human body through the respiratory tract, it will cause damage to the upper respiratory tract, causing rhinitis, pharyngitis and laryngitis, bronchitis, etc., which can lead to cancer and even death in severe cases.

At present, the industrial treatment methods of heavy metal ion pollution in soil mainly include: chemical precipitation method, ion exchange method, electrochemical method, adsorption method, etc.

2. Adsorption Method

Adsorption method is currently widely used in a method, the principle is through the huge surface area of the adsorbent or adsorption groups on the adsorbent can produce very good adsorption effect on the heavy metal ions in the water, the common adsorbent is activated carbon, titanium dioxide, magnesium hydroxide, silica, hydrotalcite. Among them, hydrotalcite has been widely studied and developed due to its unique material structure and adsorption mechanism. Hydrotalcite is a layered bimetallic compound, usually composed of Mg and Al bimetallic laminates, and a large number of ions are added in the middle. The purpose of adjusting the thickness between the laminates can be achieved by changing the proportion of metals. Heavy metal ions in the water will normally exchange with the ions between the laminates, so as to remove heavy metal ions. In addition, many new nanomaterials have emerged in recent years, which also show good effects on the treatment of heavy metals. However, nano-scale adsorbents also have obvious shortcomings in application, such as: easy to agglomerate phenomenon, not easy to separate in water, solution to water secondary pollution, difficult to reuse.

3. Other Methods

In recent years, there have been some new methods for the treatment of heavy metal ions, such as membrane separation [3], biological treatment [4], etc., but the research is still shallow and cannot be fully exploited, and there are a series of problems in the treatment process, such as difficult separation, high cost, easy to cause secondary pollution, etc., so these methods still remain in the laboratory stage.

4. Organic-Inorganic Composite Nanofiber Membranes

With the gradual rise of nanomaterials, nano fiber membrane with adsorption function has attracted more and more peoples' attention. The nano fiber membrane can effectively make up for the shortcomings of traditional adsorbent and membrane technology in many aspects.

Many high polymers have some special functional groups, such as COOH, NH_2, OH, etc., so they can be complexed or adsorbed with heavy metal ions, so as to have a very good adsorption performance on heavy metals. Polyacrylic acid (PAA) is an important electrospinning material, which can be used as an ion complexing agent because it contains a large amount of COOH.

Xiao [5] prepared PAA/PVA nanofiber membrane by mixing PAA with PVA and used it to adsorb Cu (II). They found that the removal rate could reach 91% in 3 h and could have very good selectivity for Cu (II) in solution.

Wang [6] cross-linked polyvinyleneimine (PEI) nanofiber membrane through a wet electrospinning process and was used as an adsorbent for heavy metal ions, showing very good adsorption properties for Cd (II), Pb (II) and Cu (II).

Haider [7] first prepared pure chitosan nanofibers by electrospinning, the diameter of fiber is about 235 nm, and after the step of freezing treatment, the adsorption amount of Cu (II) and Pb (II) can reach 485.44 mg/g and 263.15 mg/g, compared with the other adsorbents, shows very high adsorption. The main reason is that after the freezing treatment, chitosan nanofibers have an excellent porous structure, physical adsorption inside the fiber and external NH_2 chelate with heavy metal ions, working together, the adsorption amount is greatly improved.

The surface modification of nanofiber membrane has two forms, or it changes the micromorphology of nanofiber membrane to increase its surface area, or increase the number of functional groups on the nanofibers, to achieve the purpose of complexation or adsorption of heavy metals. PEI and PES materials were mixed by electrospinning technology [8], and then the nanofiber membrane was soaked in a mixture of water, acetone and glutaraldehyde. The results showed that the surface of the nanofiber was partially dissolved by water, but at the same time by the crosslinking of glutaraldehyde, the specific surface area increased a lot, and the adsorption of Cu (II) into it. The adsorption capacity and efficiency of the nano-fiber membrane without soaking are improved.

5. Conclusion and Outlook

With the development and maturity of electrostatic spinning technology, functional electrostatic spinning nanofiber membrane as a novel adsorption material is more and more favored by the majority of researchers, so the research and development of functional electrostatic spinning nanofiber affinity membrane is one of the main development directions in adsorption separation field. Although the technology of electrostatic spinning nanofibers is developing rapidly, there are still many challenges in the preparation of electrostatic spinning affinity membranes and the optimization of adsorption properties.

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