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Properties of sodium alginate based nanofibre composites prepared by electrospinning for contaminant removal

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Abstract

Dyes are generally organic compounds that are themselves coloured and are capable of imparting a strong and lasting colour to other substances. Cationic dye is a common dye, also known as alkaline dye. Soluble in water to present cationic state, soluble in water, ionization in aqueous solution, producing dye with positive charge of colored ions. Our country is a large country of dye production and use, dye and dyeing wastewater discharge has increased year by year, has become a major domestic water and soil pollution sources in recent years, so there is an urgent need to develop economic and effective dye and dyeing liquid waste treatment technology and wastewater pollution technology of water-soil system.

Keywords

Dye, liquid waste, soil.

1. Introduction

With the worsening of environmental pollution, people's awareness gradually tends to inherit the idea of "Lucian waters and lush mountains are gold and silver mountains" and find that it plays an important role in the sustainable development of resources. Our country is a major producer of cationic dyes. Cationic dyes are mainly used in synthetic fibres, especially acrylic dyes. In recent years, with the improvement of synthetic fibre production technology, the printing and dyeing industry demand for cationic dyes is gradually increasing, so the production process of cationic dye effluent is also more and more. Therefore, it has become an urgent problem to find efficient cationic dye wastewater treatment methods. Because printing and dyeing wastewater has the characteristics of high chroma, complex composition, poor biodegradability, toxic and harmful substances[1], which makes the treatment of printing and dyeing wastewater become the focus of attention.

There are many printing and dyeing wastewater treatment methods, such as adsorption method, membrane separation method, oxidation method, flocculation precipitation method, electrolysis and electrochemical method. The adsorption method has low cost, wide range of adaptation, good treatment effect, non-toxic, reusable advantages, so adsorption method is one of the most widely studied and used. The treatment of printing and dyeing wastewater by adsorption method has high water pre-treatment requirements, complex operation and high

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operation cost, which makes it more difficult to treat dyeing wastewater by adsorption method. Therefore, the treatment of printing and dyeing wastewater by adsorption method needs to be further investigated.

Sodium alginate (SA) is a natural polysaccharide compound extracted from kelp or seaweed. It is a white or light yellow powder and is a renewable resource. Sodium alginate has good biocompatibility, hydrophilicity, biodegradability and high viscosity of its aqueous solution, so it is widely used in medicine, food, textile, wastewater treatment and other fields. Because sodium alginate itself has the characteristics of low mechanical strength, poor water resistance, poor stability, so sodium alginate is usually the first physical and chemical modification before its application.

As the conductivity of pure sodium alginate aqueous solution is too high to be used for electrostatic spinning, people often mix sodium alginate with other substances or modify sodium alginate before electrostatic spinning. The electrostatic spinning device has become one of the most important methods for the effective preparation of nanofibre materials due to its ease of fabrication, low price, wide variety of spinnable substances and controllable process.

2. Research status of electrospinning sodium alginate composites

Lei[2] prepared SA/PVA nanofibres by using the electrostatic spinning mechanism of nano-spider silk and characterised the nanofibres. The research found that as the sodium alginate content increased, the viscosity and electrical conductivity of the spinning solution also increased, and nanofibres with more uniform diameter distribution were successfully prepared by using different volume ratios of sodium alginate and polyvinyl alcohol.

Sun[3] prepared sodium alginate/polyvinyl alcohol composite nanofibre membrane by electrospinning technology and crosslinking method, and investigated the water resistance of the composite nanofibre membrane. The results showed that the thermal stability of sodium alginate/polyvinyl alcohol composite nanofibre membrane decreased and the water resistance improved after modification by calcium chloride anhydrous ethanol solution.

Dodero[4] added polyethylene oxide and Triton X-100 to the alginate solution and prepared nanofibre membranes using two different electrostatic spinning devices. The results showed that the fibres produced by this method are finer and the fibre membranes have a high porosity, which is suitable for the medical field.

Islam[5] prepared the SA/PVA nanofibre membrane and investigated the water resistance of $CaCl_2$ crosslinking on SA/PVA nanofibre membrane. The study showed that after crosslinking the composite nanofibre membrane with $CaCl_2$, the nanofibre membrane showed good water resistance and could be used as a wound dressing in the medical field. At present, the technology of producing sodium alginate composites by electrostatic spinning has gradually matured, but the mass production technology is not perfect. Therefore, at present, sodium alginate composite materials prepared by electrostatic spinning are mainly used in the medical field, and the application in dye waste liquid treatment needs to be further investigated.

3. Application in adsorption of heavy metal ions

Yang[6] prepared three kinds of sodium alginate composite nanofibre membranes by the method of electrostatic spinning, and investigated the adsorption properties of these three membranes on Cu^{2+}, Pb^{2+} and Cr^{6+}.

Meng[7] found that magnetic sodium alginate flocculant had good flocculation effect on Pb^{2+}, Cu^{2+}, Hg^{2+}, Cd^{2+} and Ni^{2+}. Morphology, structure and drying method of calcium alginate dry gel and its effect on adsorption of lead and copper ions; Wet spinning method was used to modify

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sodium alginate with epichlorohydrin. It was found that the adsorption capacity of cadmium ion on sodium alginate fibre increased significantly after modification.

Raza[8] found that mixed matrix membrane (MMM) can be used for seawater desalination by using PVA cross-linked with zinc oxide nanoparticles (ZnO-NPs) and sodium alginate.

Lv[9] embedded Fe0-Fe_3O_4 into PVA/SA beads and investigated its adsorption of Cr (VI). It was found that the adsorption efficiency of the SA/PVA beads on Cr (VI) was 69.8% and could be reused.

Roh[10] prepared the corresponding sodium alginate composite material to adsorb Cd(II) and Cs(I). The study showed that the maximum adsorption capacity of Cd(II) was 9.73mg/g, and the removal rate of Cs(I) was 70%.

4. Application in dye adsorption

Experts and scholars found that sodium alginate composite material in the adsorption method of wastewater treatment, not only has a certain adsorption effect on heavy metal ions, but also has a certain adsorption effect on dyes.

Lu[11] mixed sodium alginate with nano-Fe_3O_4 to prepare sodium alginate gel beads, and adsorbed methyl orange dye with the gel beads. The research showed that: The adsorption of methyl orange by magnetic sodium alginate gel microspheres was in accordance with the quasi-second-order kinetic equation. The adsorption was mainly chemical adsorption and single molecular layer adsorption. The adsorption rate of methyl orange by magnetic sodium alginate gel microspheres was over 90% and could be reused.

Sun[12] prepared alginate fibre by wet spinning method and used alginate fibre to adsorb weak acid blue dye, methylene blue dye and cationic blue dye. The results showed that the adsorption effect of methylene blue dye and cationic blue dye was very significant and the adsorption process was in accordance with Freundlich model and Temkin model.

Jeon[13] first protonated the polyaspartic calcium alginate gel prepared by HNO_3, and then adsorbed methylene blue, malachite green and methyl orange on the protonated polyaspartic calcium alginate gel. The adsorption capacities of methylene blue, malachite green and methyl orange were 4.47mg/g, 4.45mg/g and 0.28mg/g, respectively.

A number of studies have shown that sodium alginate composites can be used to remove dyes from printing and dyeing effluents. A literature review shows that sodium alginate composites, with their unique properties, have achieved certain results in dye adsorption.

5. Conclusion and outlook

Although there are many researches on the treatment of heavy metal ions and dyes in wastewater, the research on the treatment of dye wastewater by electrostatic spinning composite nanofiber membrane is still not perfect. Studies have shown that sodium alginate composites have certain adsorption effect on cationic dyes. Nanofiber membrane is an ideal adsorption material with large surface area, high porosity and strong adsorption. Sodium alginate has the advantages of good adsorption performance, good water solubility and strong renewability. Therefore, the study on the adsorption of cationic dyes by sodium alginate composite nanofiber membrane has certain research value and application prospect for the treatment of cationic dye waste liquid.

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