

The Ability of Chitin Roasting Carbon Composite Sheet to Absorb and Remove Just Cr (VI) and Rhb from Water

Abstract

There are currently a wide range of pollutants in wastewater, such as dyes and heavy metal ions. The most important adsorbents are those that can simultaneously remove dyes and heavy metal ions. This study used treated coal gasification slag and chitosan to make a renewable composite membrane. With a Cr (VI) maximum adsorption capacity of 50.0 mg/L, the composite membrane outperformed the chitosan membrane by 4.3% to 8.8%. For RhB adsorption, the removal rate of the chitosan membrane was only about 5%; however, the addition of coal gasification slag has the potential to increase this rate to 95.3 percent. The specific surface area of the chitosan membrane could be 16.2 times greater with the addition of coal gasification slag. This is because the chitosan membrane's nanopores, which range in size from 80 to 110 micrometers, could be opened by coal gasification slag. Coordination bonds with the amino groups on the chitosan molecular chains were the primary means by which Cr (VI) was absorbed, as revealed by the analysis of adsorption kinetics and mechanism. In the meantime, when hydrogen bonds were formed with the surface of coal gasification slag, RhB adsorption took place. Additionally, coal gasification slag can increase the mechanical properties of the chitosan membrane by 2.2 times, facilitating the application of the composite membrane. This study examines coal gasification slag's adsorbent design and resource utilization in greater depth.

Keywords: Coal gasification slag • Membrane material • adsorb • Heavy metal • Dyestuff

Introduction

In recent years, the printing, dyeing, and textile industries have expanded rapidly, resulting in a lot of dye-laden wastewater and high productivity. The conventional biochemical treatment, on the other hand, is only able to partially decolorize dyes and get rid of heavy metals. Using an efficient adsorbent, dye wastewater can also be free of heavy metals, which are necessary for the treatment process. As a result of ongoing research into adsorption treatment technology, a number of new adsorbents have been developed. The effective treatment of printing and dyeing wastewater requires these adsorbents more and more [1]. Activated carbon, metal oxides, resins, inorganic substances, and natural polymeric materials are all common adsorbents. These adsorbent materials must contend with high wastewater treatment costs, a single response to pollutants, inability to handle complex pollutants, and limited metal ion removal [2].

We attempted to select a solid waste coal gasification slag with a small particle size, well-developed porosity, and strong hydrophilicity as a dye adsorbent and load it on a polymeric organic membrane that has a strong response to heavy metals in order to effectively treat wastewater containing heavy metal ions used for printing and dyeing while also achieving solid waste resourceification. Slag from coal gasification is a solid waste product made by the process [3]. It has residual carbon, which is necessary for utilizing resources, as well as a lot of SiO₂, Al₂O₃, Fe₂O₃, and other inorganic minerals. The residual carbon in the gasification residue possesses sufficient

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physical properties for adsorption due to its high content, small particle size, large specific surface area, and rich pore structure. This study's powder adsorption material was coal gasification slag as a result. Industrial coal gasification slag with a high heavy metal content was directly transformed into an excellent adsorbent with a theoretical maximum adsorption capacity of 1787 mg/g for the adsorption of malachite green wastewater [4]. Carbon/zeolite composites (C/ZC) were produced from coal gasification slag by inducer-based acid leaching and alkali solubilization. After being modified with iron sulfate, the maximum adsorption capacities of the composites for NH_4^+ and PO_4^{3-} were 7.44 mg/g and 6.94 mg/g, respectively [5]. A coal gasification slag-based ZSM-5 molecular sieve was used. When chitin is deacetylated, the natural polymer chitosan (Cs), which is biodegradable and contains amino groups, is produced. For the purpose of adsorbing Cu^{2+} , porous poly (L-lactic acid) (P-PLLA) nanofiber membranes were produced by grafting chitosan with polydopamine (PDA) as an intermediate layer. To produce glucose and chitosan, Jiang and colleagues used ultrasonic-assisted free radical polymerization to adsorb Cu (II), Co (II), and a variety of other metal ions. We chose chitosan as the carrier to make a gasification residue/chitosan composite membrane with a unique reticulation and reusable structure. This novel composite will address the challenges of powder adsorbent recovery, the response of a single pollutant, the poor adsorption of heavy metals, the high costs of wastewater treatment, and the ineffective removal of dye and heavy metals [6].

In this study, the coal gasification slag was treated at high temperatures to produce a composite membrane made of chitosan and coal gasification slag. Using Rhodamine B (RhB) and Cr (VI) as models of dye and heavy metal in printing and dyeing wastewater, the adsorption effect of the composite membrane on RhB and Cr (VI) was investigated. The composite membrane's swelling rate, mechanical properties, specific surface area, and other parameters were examined with FT-IR and SEM. Also provided was the adsorption mechanism for the composite membrane's adsorption of RhB and Cr (VI). Kinetic simulation was used to investigate the composite membrane's adsorption of RhB and Cr (VI) [7].

Experimental

Material for the Experiment

Glacial acetic acid (AR, Tianjin Fuyu Fine Chemical Co., Ltd., Tianjin, China) and aqueous glutaraldehyde solution (25 percent by weight; The experimental components were provided by Shanghai Lanji Bioreagent Co., Ltd., Shanghai, China. Slag from coal gasification (Shaanxi Geological and Mineral Research Institute Co., Ltd., Xian, China) and AR (Tianjin Comio Chemical Reagent Co., Ltd., Tianjin, China) were used in this study, as were $\text{K}_2\text{Cr}_2\text{O}_7$ (AR, Comio, Tianjin, China), CuSO_4 (AR, Tianjin Tianli Chemical, Tianjin, China), Pb [8].

Preparation of Samples

Methods for making activated carbon using coal slag: After being crushed (multi-functional grinder, HebiXinyun Equipment Co., Ltd., XY-100, Hebi, China), screened to a mesh of 200, and calcined at a specific temperature in a muffle furnace (box muffle furnace, Hefei Kejing Material Technology Co., Ltd., KSL-1200X), the dried coal slag was finally given the name CGS. First, the factory collected the industrial gasifier slag [9].

Chitosan solution (30.0 mL) was first poured into a three-necked flask before the cinder-based activated carbon composite membrane for the synthetic route was prepared. The system was then heated to 50 °C in a water bath. The glutaraldehyde aqueous solution (10.0 mL) and a specific amount of CGS (0.05, 0.10, 0.15, 0.20, 0.30, 0.60, and 1.20 g) were added while the above solution was mechanically stirred. A predetermined amount of the mixture was removed and stored for freeze drying after being stirred for a predetermined amount of time. F-0.05, F-0.10, F-0.15, F-0.20, F-0.30, F-0.60, and F-1.20 were the respective labels applied to the serial samples. F-0 is a film that was made as a comparison and did not have any CGS loading [10].

Morphological Characterization

Analyses of Chemical Structure

The Frontier FT-IR spectrometer from INVENIO, Brook, Germany, was used to ascertain the chemical structure of the films using Fourier transform infrared spectroscopy (FT-IR) [11]. The specific surface area and pore size distribution of the composite membrane were measured with a BET-physical adsorption instrument-specific surface area analyzer (McMeritik (Shanghai) Instrument Co., Ltd.,

ASAP 2460, Shanghai, China). The freeze-dried composite membrane was added to pure water at 25 °C for standing water adsorption and then removed at specific intervals to determine the swelling ratio. The morphological characteristics of various samples were examined using a field emission A high-speed rail AI-7000-NGD servo electronic tensile tester was used to examine the mechanical properties of the composite membrane [12].

Experiment in Adsorption of RhB and Cr (VI)

The diphenylcarbazide chromogenic method was used to measure the concentrations of RhB and Cr (VI) using UV spectrophotometry. 60.0 milliliters of a specific concentration of RhB or Cr (VI) solution were contained in a conical flask. The conical bottle that contained the sample was filled with 0.2 g of the sample [13]. Oscillation adsorption at a constant temperature oscillation box (30 °C, 120 r/min) was also performed on the conical flask. The suspension of approximately 60.0 mL was removed for centrifugation after being absorbed for some time. The supernatant was used as the sample to measure RhB and Cr (VI) concentrations following centrifugation [14].

In contrast to LAT, liquid ammonia can bring dyeing equilibrium to 100 °C in 20 minutes. When compared to Lanazol Red CE and Blue CE, the dyeing rate of Blue CE was found to be higher than that of Red CE. Dyeing equilibrium times for W and LAT were 70 and 50 minutes, respectively, at 85 °C; Dyeing equilibrium times for W and LAT were 80 and 120 minutes, respectively, at 70 °C [15].

Discussion

Analyses of Performance in Adsorption

To determine its adsorption capacity, 0.2 g of coal gasification slag was added to a RhB or Cr (VI) solution containing 60.0 mL (40.0 mg/L). As can be seen, the adsorption of Cr (VI) by coal gasification slag can reach dynamic equilibrium in about ten minutes. In this study, the removal rate of Cr (VI) was found to be 25.0%. As can be seen, blank film F-0 can achieve the adsorption equilibrium in forty minutes and a removal rate of more than 80.5% of Cr (VI) in ten minutes. At equilibrium, the removal rate of Cr (VI) was 95.5%, indicating that F-0 has a favorable effect on Cr (VI) adsorption.

That the composite film's RhB adsorbing capacity gradually increased with the amount

of coal gasification slag, whereas the blank film F-0 had a RhB adsorbing capacity of less than 0.60 mg/g. When the additional amount of coal gasification slag was 0.60 and 1.20 g, respectively, the adsorption capacity of RhB by F-0.60 and F-1.20 was 11.20 mg/g, reaching equilibrium at 120 min and 90% at 60 min, respectively. With an adsorbing capacity of 11.44 mg/g, F-0.30 was the composite membrane with the highest adsorption effect after 180 minutes. According to the preceding findings, loading coal gasification slag can not only give F-0 the ability to adsorb the organic dye RhB but also change how F-0 adsorbs Cr (VI), realizing the composite film's ability to adsorb both organic dyes and heavy metal ions at the same time. At 2 minutes, F-0.30 had a significantly higher capacity to adsorb Cr (VI) than F-0, indicating that the addition of CGS can accelerate the adsorption of Cr (VI) by the composite membrane. These results indicate that loading coal gasification slag can provide chitosan film with the ability to adsorb the organic dye RhB. This conclusion was also reflected in the equilibrium time of various samples' Cr (VI) adsorbed concentrations.

Cr (VI) Adsorption in Mixed Metal Ions

The adsorption of mixed metal ions by the composite membrane. The reaction between Pb (II) and SO₄²⁻ in the mixed solution to form PbSO₄ precipitate resulted in a lower initial concentration of Pb (II), lowering the concentration of Pb (II). The fact that the concentrations of Cd (II) and Cu (II) in the mixed solution did not change when the adsorbent was added indicates that the composite membrane adsorbs Cd (II). The composite membrane adsorbs Cr (VI) better than other metal ions in the mixed solution. The composite membrane selectively adsorbs Cr (VI), as evidenced by the fact that the concentration of Cr (VI) in the mixed solution decreased to almost nothing from 1.6 mg/L.

Other Influencing Factors

Temperature, pH, and adsorbent concentration were examined in relation to Cr (VI) adsorption. The adsorption amount of F-0.30 on Cr (VI) remained stable at close to 12.0 mg/g regardless of whether the pH was acidic or alkaline, and the adsorption effect of F-0 on Cr (VI) was comparable to that of F-0.30 when the pH was neutral (6–7). The fact that the adsorption of Cr (VI) by F-0 and F-0.30 showed a trend toward decreasing as the ambient temperature increased indicates that the adsorption of Cr (VI) by F-0

and F-0.30 is an exothermic reaction. This was because the presence of CGS buffered F-0.30 against changes in the pH caused by external factors. The adsorption capacity of the adsorbent decreased with each additional addition, but the removal rate increased. This is because more adsorbent is added to the solution when the concentration of pollutants is fixed, but less adsorption occurs per unit mass. The various initial RhB concentrations also have an impact on the adsorption of RhB on the composite membrane. The overall trend of the RhB removal rate of F-0 and F-0.30 gradually decreased as the initial RhB concentration increased. This is due to the fact that when the initial concentration of RhB is low, the composite membrane does not reach the adsorption saturation state, which is necessary for successfully adsorbing RhB. When the initial concentration of RhB rises even higher, the surface adsorption site is full. RhB will continue to move inside the material. However, RhB is unable to transfer any further within F-0.30 because the surface is blocked, which results in a decrease in the amount of adsorption. This article does not go into detail about RhB adsorption because relevant research indicates that the material for RhB was in the neutral pH range (6-8) and that the coal gasification slag played the primary role in this work.

Analysis of the Relationship between Structure and Adsorption Property

The infrared spectra of F-0.30, blank film F-0, coal gasification slag (CGS), chitosan (Cs), and the preparation process's infrared spectrum. The spectrum contained fewer groups because the sample CGS must be calcined at 800 °C. The peak at 1090 cm⁻¹ belonged to the CH-CH₂ shear vibration peak on the Si-CH-CH₂ group. The Schiff base was identified by stretching vibration peaks of C=N at 1538 and 1635 cm⁻¹ in the F-0 during the reaction between chitosan and glutaraldehyde. The C-O-C stretching vibration peak was found at 1040 cm⁻¹, and the primary amine C-NH₂ stretching vibration peak was found at 1395 cm⁻¹. The C-H stretching vibration peak was linked to the wide peak at 3120 cm⁻¹. CGS loading had no effect on the infrared peak of the composite film, indicating that CGS has no destructive effect on the composite film's structure. The primary modes of CGS and composite film binding appear to be physical embedding and hydrogen bond cross-linking. The characterization analysis that followed this one provided additional support for this conclusion.

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