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Study on the Adsorption of Nickel (Ⅱ) in Water by Modified Dried Duckweed

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Abstract. The paper uses dry duckweed before modification and dry duckweed modified with formaldehyde and concentrated sulfuric acid as adsorbents to adsorb and remove nickel ions in water. The results show that the removal rate increases with the increase of temperature. When the reaction time is 70 min, the concentration of nickel is 20 mg/L, and the dosage is 0.05 g, the removal rate of nickel ion by the duckweed adsorbent is 35.01%. When the reaction time is 30 min, the concentration of nickel is 20 mg/L, and the dosage of modified duckweed is 0.1 g, the removal rate of nickel ion by the modified duckweed adsorbent is 44.85%. The adsorption effect of the modified adsorbent is obviously improved, which provides a basis for the application of duckweed in the adsorption of nickel - containing wastewater.

1 Introduction

The development of industry and urbanization has brought harm to rivers and lakes, air, soil and urban solid waste, among which heavy metals are extremely harmful [1]. Heavy metals will flow into the network water system on the land through the sewage discharged from enterprises and factories, the solid waste that is too late to be treated, and the leachate generated after solid waste landfill, affecting the survival and life of vegetation, human beings and various animals [1,2]. Once heavy metals exceed the scope of human needs or are not needed by the human body, they will cause inflammation, cancer and other lesions in the human body, which cannot or is difficult to eradicate [3,4].Nickel is one of them. The human body needs a small amount of nickel, which can be absorbed through the small intestine to maintain the normal function and quantity of blood and red blood cells, and avoid the occurrence of anemia symptoms. But once it exceeds the standard, it will cause cancer, inflammation, nervous system disorders, endocrine disorders, fertility disorders and a variety of gene sudden symptoms. There are chemical precipitation method[5], electrolysis method[6], ion exchange resin method[7] and biological adsorption method[8] for nickel containing wastewater treatment. Among them, the biosorption method has attracted more and more attention due to its abundant raw materials, low cost, many varieties, fast adsorption rate and large adsorption capacity.

Duckweed is a multi-species aquatic plant that is widely distributed in water systems around the world and is cheap and readily available. In this paper, modified duckweed was used as adsorbent to remove heavy metal nickel from water. The optimal dosage, initial concentration, pH, temperature and adsorption time of the modified duckweed for adsorption of heavy metal ions in water were explored, which provided the basis for the mechanism research of modified duckweed for adsorption of nickel containing wastewater.

2 Experimental methods

2.1 Preparation of duckweed adsorbent

The duckweed taken from the river is removed from impurities, washed with distilled water and drained, and placed in an oven at 55℃-65℃ for drying. After drying, it was put into a pulverizer to crush into fine powder, and then passed through a 100 mesh sieve to obtain the duckweed adsorbent (DA).

2.2 Preparation of modified duckweed adsorbent

200 ml formaldehyde and 10.00 ml concentrated sulfuric acid were added into a beaker containing about 20.00 g duckweed powder and stirred thoroughly. It was put into a magnetic stirrer, stirred at constant temperature for 8-9 hours, and taken out to get a viscous mixture. the mixture was rinsed to neutral with deionized water. The modified duckweed was transferred to the oven glass dish and dried at 55℃-65℃. After drying and passing through 100 mesh sieve, the modified duckweed adsorbent (MDA) was obtained.

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3 Results and Analysis

3.1 Effect of Dosage on Adsorption.

0.01, 0.02, 0.05, 0.1, 0.2, 0.25, 0.3g adsorbent and 25.00 ml of 160 mg/L Ni(II) solution were added into a conical flask with a stopper. The constant temperature was 30℃, the oscillation speed was 200 r/min. After 150 min of oscillation, and the content of nickel ion in the filtered solution was determined and the removal rate was calculated. The results shown in Fig.1.

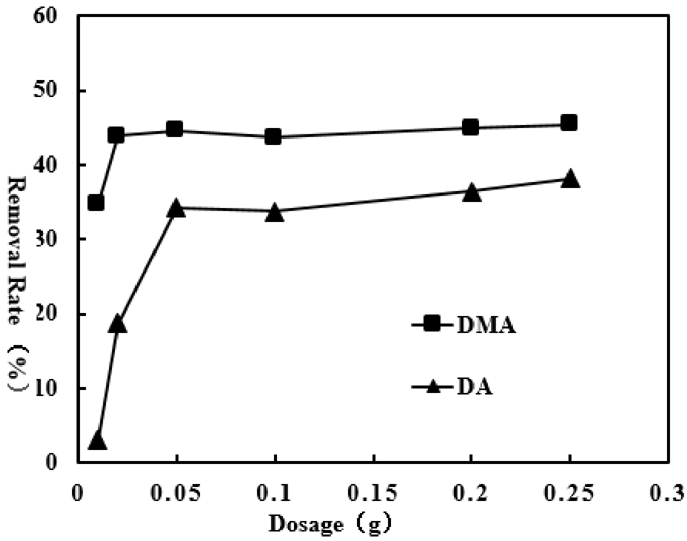

Fig 1 Effect of dosage on adsorption performance

It can be seen from Figure 1that the removal rates of nickel ions in solution by DA and MDA both increased with the increase of dosage, which was due to the increase of adsorption sites with the increase of dosage. Then, due to the constant excess nickel concentration of adsorbent and excess adsorption sites, the removal rate did not change significantly after reaching saturation. Before modification, the removal rate of dry duckweed was from 2.65% to 40.45%, the removal rate of DA was about 0.05 g, the removal rate was 35.01%; after modification, the removal rate of dry duckweed was from 34.72% to 47.91%, and after modification, the dosage of 0.05-0.1 g tended to be gentle, and the removal rate reached 44.85%. Contrasting with DA the removal efficiency of MDA is better than that of DA, because the internal structure of acid modified duckweed will produce larger pore size and larger specific surface area, so more particles can be adsorbed and the removal rate is higher. The adsorption capacity of the two adsorbents decreases with the increase of adsorbent quality[9]. Therefore, from the economic point of view, on the premise of ensuring a higher removal rate, the adsorption capacity of the two adsorbents decreases. The mass of adsorbent should be reduced as much as possible. DA 0.05 g and MDA 0.1 g should be selected as the best dosage for the follow-up experiment.

3.2 Effect of Adsorption time on Adsorption.

Add adsorbent and 25ml Ni (II) solution with a concentration of 160 mg/L into the conical flask with stopper, and vibrate at constant temperature for 3, 6, 12, 20, 30, 50, 70, 90, 110 min, respectively. Determine the content of nickel ion in the filtered solution and calculate the removal rate. The results are shown in Fig. 2.

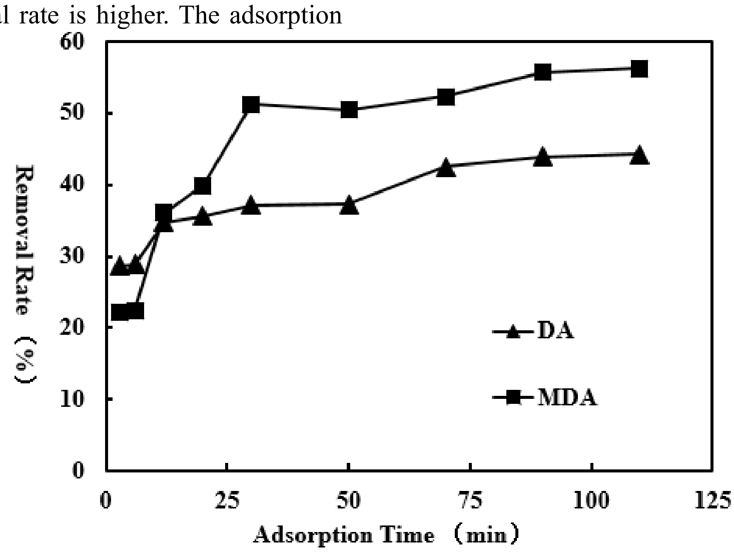

Fig. 2 Effect of adsorption time on adsorption performance

It can be seen from Fig. 2 that with the increase of the oscillation time of the adsorbents DA and MDA, the removal first increases and then tends to be gentle. Generally, the increase of oscillation time will increase the contact probability between the adsorbent and the adsorbate, which can make full use of the adsorption sites on the adsorbent surface. However, due to the limitation of the adsorption capacity of the adsorbent itself, the adsorption capacity will not change significantly when the adsorption process reaches saturation[10]. In addition, the removal rates of DA and MDA were 27.88% to 46.34% and 22.68% to 56 .80%, respectively. The reason is that due to the influence of acid modification, the active site of MDA is higher than that before modification, so the removal rate is higher than that before modification. The removal efficiency of MDA is 51.26%, which is 42.34% higher than that of DA, which is about 9% higher than that of DA. the removal rate of DA tends to be flat after 70 min of oscillation, while the adsorption equilibrium of MDA is about 30 min. Therefore, the best oscillation time of DA is 70 min and that of MDA is 30 min, which are the follow-up study conditions.

3.3 Effect of Initial Ni (II) concentration.

Add 25 ml Ni (II) solutions with concentrations of 20, 40, 80, 120 and 160 mg/L into a conical flask with a stopper, mix them evenly with adsorbent, and vibrate at constant temperature for 150 min, determine the content of nickel ion in the filtered solution and calculate the removal rate. The results are shown in Fig. 3.

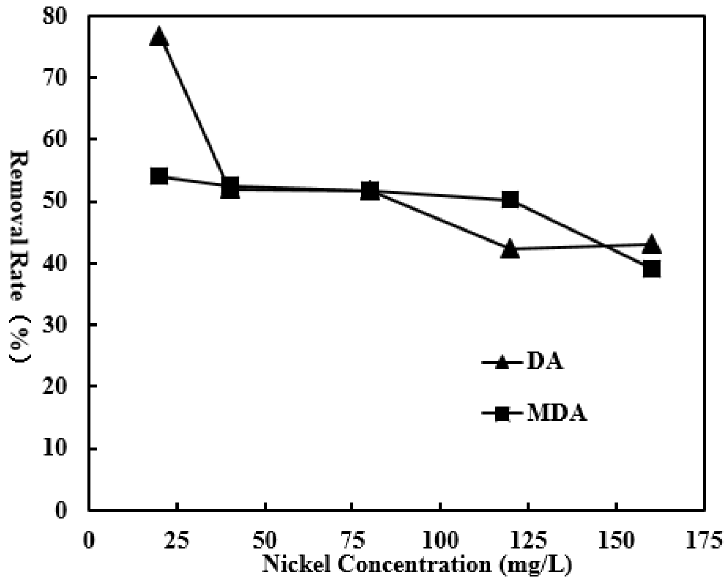

Fig. 3 Effect of nickel concentration on Adsorption Properties

In Figure 3, it can be concluded that the removal rates of nickel ions in solution by DA and MDA decrease with the increase of nickel concentration. If the concentration is too high, the adsorption of dried duckweed is inhibited, but the effect is not good. The removal efficiency of nickel (II) by DA is in the range of 75.32% to 42.68%. The removal efficiency of MDA ranged from 53.70% to 39.66%. If the concentration of nickel compounds is too high, the relative quantitative adsorption sites will be close to saturation, which will inhibit the adsorption efficiency of dried duckweed before and after modification. When the concentration of nickel is high, the adsorption sites of dried duckweed before and after modification are saturated with high content of nickel (II), and the adsorption efficiency is reduced; when the nickel concentration is low, the adsorption of dry duckweed and nickel (II) ions before and after modification can be very full, the remaining adsorption sites are large, the removal rate increases rapidly, and the removal efficiency is effectively improved[11]. Therefore, 20 mg/L nickel solution with the best adsorption effect was selected as the best adsorption concentration for subsequent experiments.

3.4 Effect of Temperature on Adsorption.

The adsorbent and 25.00 ml Ni (II) solution with a concentration of 160 mg/L were added into a conical flask with a stopper, and the solution was vibrated at 20, 30, 40, 50, 60 and 70 ℃ for 150 min, respectively. The content of nickel ion in the filtered solution was determined and the removal rate was calculated. The results are shown in Fig. 4.

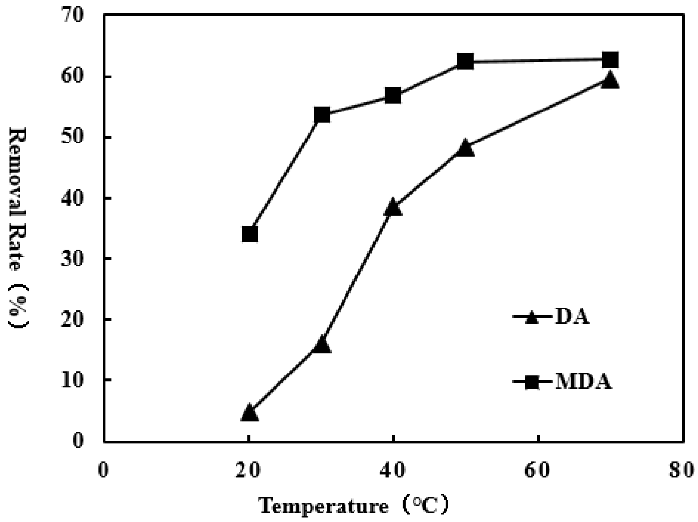

Fig. 4 Effect of temperature on adsorption properties

It can be seen from Fig. 4 that the removal efficiency of DA and MDA increases with the increase of temperature. The higher the removal rate is, the higher the temperature is, the better the nickel adsorption process is. The diffusion rate of nickel ion increased with the increase of temperature, which accelerated the contact reaction efficiency of dry duckweed before and after modification, which proved that the removal rate of dry duckweed before and after modification was greatly affected by temperature, which was conducive to the adsorption of nickel ions by dry duckweed before and after modification[12]. The removal rate of DA is from 5.50% to 60.05%, and the removal rate of MDA is from 30.60% to 63.87%. The removal rate of DA reaches the highest at 70℃, while that of MDA reaches the best at 50℃.

4. Summary

When the oscillating reaction time was 70 min, the nickel concentration was 20 mg/L, and the dosage was 0.05 g, the nickel removal rate of DA adsorbent was 35.01%. When the oscillating reaction time was 30 min, the nickel concentration was 20 mg/L, and the dosage of mL was 0.1 g, the nickel removal rate of mL adsorbent was 44.85%. Under the optimum reaction conditions, DA and MDA reacted with the nickel (Ⅱ) ions in the water reaction results show that the dry duckweed after modification of nickel (Ⅱ) ion in water adsorption effect is better than before modification.

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