Study on Lead Adsorption Performance of Ti Modified Mesoporous Molecular

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Abstract: The prepared MCM-41 mesoporous material was synthesized into the new mesoporous material of Ti-MCM-41 by impregnation method, and the sample was characterized by infrared spectrometer. The adsorption of lead ions in solution was carried out by using Ti-MCM-41 as adsorbent. The effects of adsorbent dosage, initial mass concentration of lead ion, temperature and time on adsorption performance were investigated. The reaction kinetics model of Ti-loaded molecular sieves adsorbing lead ions conforms to the second-order kinetic model, and the reaction thermodynamics process conforms to the Langmuir thermodynamic model.

1. Introduction

At present, traditional treatment methods for lead-containing wastewater include chemical precipitation, membrane separation, ion exchange, and adsorption [1-2].The adsorption method is widely used because of its advantages of simple operation, high efficiency, low consumption, and low cost[3]. Pb (II) treated by adsorption has a good effect [4-7]. MCM-41 mesoporous molecular structural characteristics make it uniquely advantageous in adsorption [8-9]. MCM-41 molecular sieves have made some progress in the adsorption of metal ions [10-12]. After functionalization and optimization of the synthesis conditions of MCM-41 mesoporous materials, the adsorption and stability have been improved [13].In this paper, the new adsorption material was prepared in an acidic environment, and the adsorption properties of lead ions in wastewater was studied.

2. Experimental

Experimental Reagent

Lead ion standard solution (China Institute of Metrology); cetyltrimethylammonium bromide (Tianjin Tianli Chemical Reagent Co., Ltd.); tetraethyl orthosilicate (Tianjin Tianli Chemical Reagent Co., Ltd.).

3. Results

3.1. Infrared Characterization Results and Analysis.

The synthesized MCM-41 and Ti-MCM-41 characterized by IR are shown in Figure 1.

Figure 1 is an IR of MCM-41 and Ti-MCM-41 sample. The absorption peak at 1089 cm-1 is Si-O- on the mesoporous molecular sieve MCM-41 skeleton. The antisymmetric stretching vibration of Si bond and the symmetric stretching vibration[14]; the absorption peak at 472.49 cm-1 is the bending vibration of Si-O-Si bond, and the above two characteristic peaks indicate the skeleton structure of MCM-41 molecular sieve. The absorption peak of the Ti-MCM-41 sample molecular sieve at 950.78 cm-1 is the characteristic absorption peak of Ti entering the molecular sieve skeleton [15], which can indicate the successful loading of Ti.
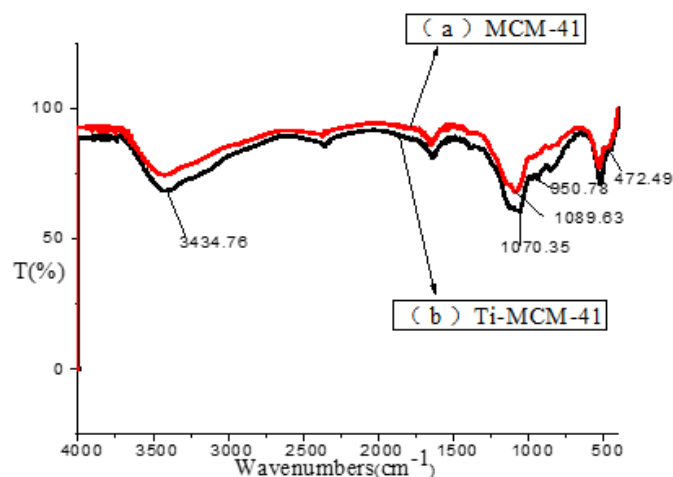
Figure.1 Infrared Spectroscopy

3.2. Effect of Initial Concentration on Adsorption Performance.

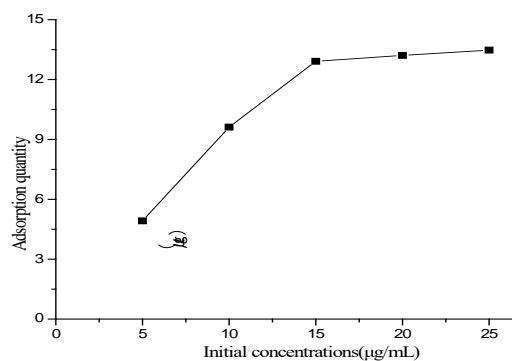The effect of the initial concentration of lead ions on the adsorption is shown in Figure 2.

Figure.2 Adsorption at different initial concentrations

It can be seen from Fig.2, when the initial concentration is less than 15μg/mL, the adsorption amount increases linearly with the increase of the concentration. The initial concentration is greater than 15μg/mL, the adsorption amount increases slowly with the increase of the initial concentration.

3.3. Effect of Adsorption Time on Adsorption Performance.

The effect of adsorption time on the adsorption is shown in Figure 3.
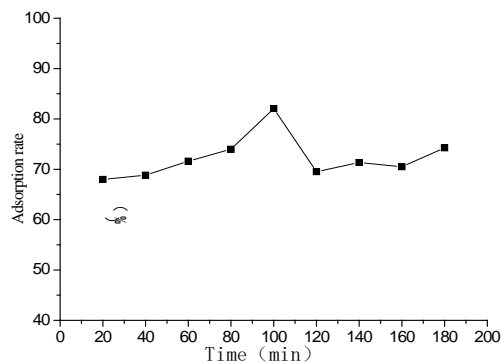

Figure.3 Adsorption rate at different adsorption times

As shown in Fig. 3, the adsorption rate increases slowly from 20 to 80 min. When the adsorption time reaches 100 min, the adsorption rate reaches the maximum value. After 100 min, the adsorption rate decreased, indicating that desorption occurred. The adsorption rate fluctuated up and down from 120 to 180 min, it was in the state of adsorption desorption equilibrium.

3.4. The Effect of the Amount of Adsorbent on the Adsorption Performance.

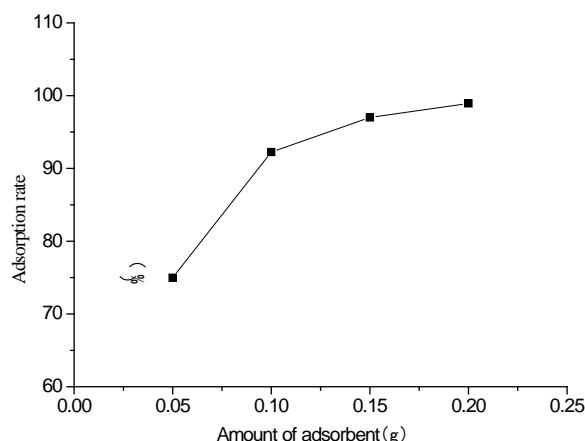The effect of the amount of adsorbent on the adsorption is shown in Figure 4.

Figure.4 Adsorption rate under different adsorbent dosage

From the data analysis of Fig. 4, it is known that as the amount of adsorbent increases, the adsorption rate of the adsorbent to lead ions also increases. When the slope is 0.05 g-0.10 g, the slope is larger, and the adsorption rate is obviously improved. When the amount of adsorbent is higher than 0.10 g, the slope becomes smaller.

3.5. Effect of Temperature on Adsorption Performance.

The effect of temperature on the adsorption is shown in Figure 5.
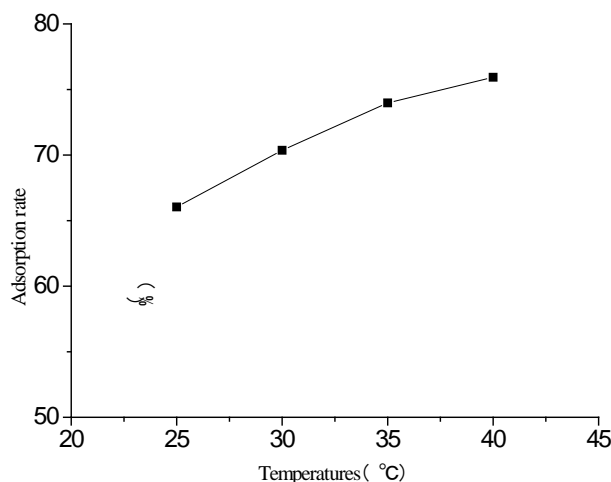

Figure.5 Adsorption rate at different temperatures

It can be seen from the analysis of Fig. 5 that under different conditions, the adsorption rates of the temperature are different. Between 25°C and 40°C, the adsorption rate increases with the increase of temperature, increasing from 66% to 75%, but the increasing trend is gradually slowing down and gradually reaching a balance.

3.6. Ti-MCM-41 Adsorption Kinetics Analysis

Based on the data of the influence of adsorption time on the adsorption effect, Ti-MCM-41 adsorption kinetics analysis was performed.

Quasi-first-order dynamic model:
$$lg(q_e - q_t) = lgq_e - k_1 t \qquad (3)$$

Quasi-secondary dynamics model:
$$\frac{t}{q_t} = \frac{t}{q_e} + \frac{1}{k_2 q_e^2} \qquad (4)$$

Particle diffusion dynamics model: $q_t = k_3 t^{0.5} + C$ (5)
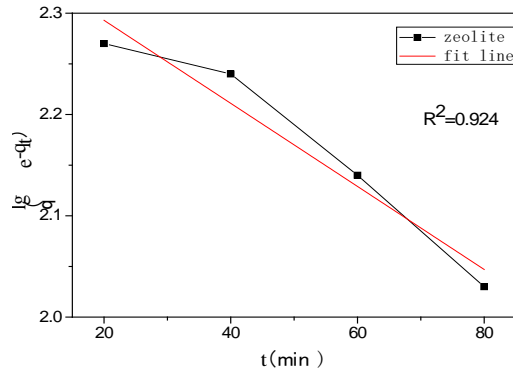
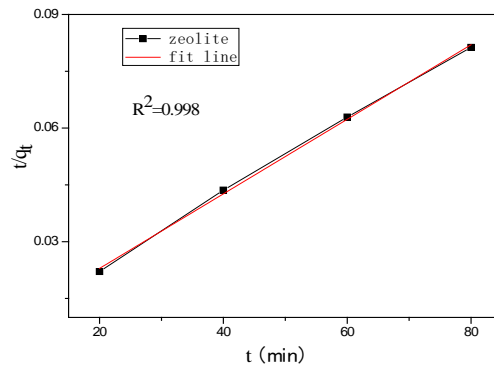

Figure.6 Quasi-first order kinetic equation

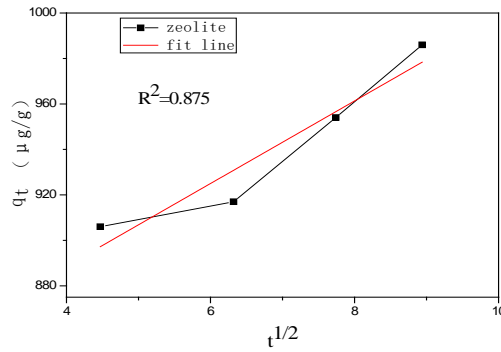

Figure.7 Quasi-second order kinetics equation

Figure.8 Particle diffusion kinetics equation

According to the data and Figures 6-8, it can be seen that the adsorption process conforms to the second-order kinetic equation, $R^2 = 0.998$. The second-order kinetic equation is a kinetic model in which the adsorption rate is controlled by the chemisorption mechanism.

3.7. Thermodynamic Analysis of Ti-MCM-41 Adsorption.

The Langmuir type adsorption isotherm is: $\dfrac{1}{q_e} = \dfrac{1}{bq_0c_e} + \dfrac{1}{q_0}$ (6)

The Freudlich type adsorption isotherm is: $lgq_e = lgK + \dfrac{1}{n}lgc_e$ (7)

Use the Ce/qe as the ordinate to make the Langmuir isotherm with Ce as the abscissa.
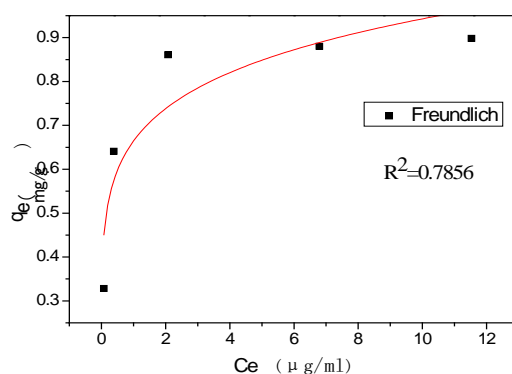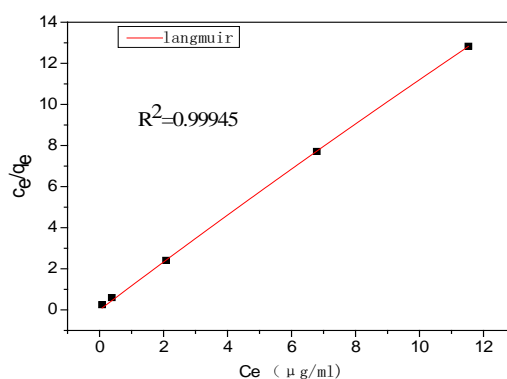
Figure.9 Freundlich isotherms

Figure.10 Langmuir isotherm

According to the data analysis of Fig. 9 and Fig. 10, the Langmuir isotherm fits to a higher degree, $R^2 = 0.99945$, thus conforming to the Langmuir adsorption model[16], which is monolayer adsorption and chemisorption.

4. Conclusion

The prepared MCM-41 mesoporous material was introduced into Ti by impregnation method to synthesize the modified mesoporous material Ti-MCM-41The new Ti-MCM-41 material has a good adsorption effect on lead.

Acknowledgements

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