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Study on the Adsorption Capacity of Chitosan Coated Bentonite for Acid Blue Dye

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Abstract. Chitosan coated bentonite (CCB) was prepared by microwave irridiation, original bentonite as raw materials and chitosan as modifier. The adsorption performance in acid scarlet dye solution was discussed. Firstly the optimum adsorption conditions: concentration of chitosan of 35 g/L, bentonite quality and chitosan solution volume rate of 0.7(g/L), microwave time of 17 min, infilltration time of 50 min, deacetylation degree of chitosan of 85%, soil particle size of 15 mm, pH of 5, dosage of CCB of 20 g/g, stirring speed of 300 r/min, centrifugal time of 15 min, and stirring time of 35 min, were investigated by single factor experiment. And the maximum adsorption rate reached to 96.2%. Subsquently, all the effect tendencies of the physicochemical parameters of the preparation and adsorption were studied on the optium experimental condition, which would provide reference data for the subsequent pilot test. The results suggested that CCB was a promising sorbent to remove organic contaminants and might be utilized to purify water contaminated by organic compounds.

Introduction

Dyestuff industries have produced numerous dyes and pigments and inevitably generate a considerable amount of colored wastewater that were lost in the dye effluent during dyeing processes. Cheap adsorbent and simple and quick application techniques are required due to the strong economic pressure caused by large amount of wastewater.

Bentonite as an important non-metallic minerals, is abundant, cheap, non-toxic, and no chemical contaminated, and has a character of strong adsorption, moisture absorption and ion exchange capacity, expansion, catalysis and lubrication, therefore enjoy the laudatory name of "universal material"[1-2]. Organic cation can exchange ions in bentonite slice layer structure, and organic macromolecular will be introduced into layers of bentonite, and then the natural bentonite can be turned into hydrophobic soil. Ealier, lots of researchers have investigated the organic bentonite to remove the organic pollutants and inorganic metal ions from waste water[3-8]. This experiment was designed to provide the variablity of tendency with respect to the adsportion capacity for subsequent pilot tests, so that it could reduce the pilot test time.

Materials and Methods

Materials and Reagents. Calcium base bentonite was got from Hei mount in Liaoning province. Its chemical composition is aviable in table 1, basic performance is shown in table 2. Chitosan was purchased from Shenyang Xinhua reagent factory (Shenyang, China). All chemicals used in the study were of analytical grade, and all solutions used were prepared with distilled water.

Apparatus. 721-spectrophotometer, LG microwave oven, 79-1 magnetic heating blender, PHs-3C type precision acidity plan, 4A high-speed desktop centrifuge, DHG-9240A digital electrothermal thermostatic drying oven.

Table 1 Chemical composition of original bentonite

Composition	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	MnO	H_2O	LOI
W_B/%	56.40	15.88	4.27	2.22	0.75	2.45	1.60	0.48	0.09	15.49	15.28

Table 2 Basic performance of original bentonite

pH	Colloidindex	CEC	Expansion Ratio	Methylene Blue Absorption
8-9	100mL/15g	144mmol/100g	15	24.58g/100g

Methods. The sodium bentonite was made as follows: the 10% original bentonite content slurry was prepared, and mixxed with 2% alkaline sodium solution under continuous stirring for 3h at 75□, then left for 24h, dryed and grinded. Susquently 5% of acetic acid solution was added into chitosan suspension liqid with some deacelation degree, followed by stirring until it dissolved and got a transparent solution. Finally, a mushy could get after sodium bentonite was added into the transparent solution above, and was continue to stirred at slow speed, then settled down for 90 min to ensure sodium bentonite fully infiltrated. After that, the mushy was modified by microwave, and then dryed, grinded, sieved. The preparation of CCB was finished.

The test examined the influence trends of preparation and adsorption conditions on the dye absorption performance simultaneously. This experiment defined three influence trends: A-type: the rate of adsorption firstly increases then to a plateau with the parameter; B-type: the rate of adsorption firstly increases then relatively slow decreases; C-type: the rate of adsorption firstly increases and then relatively fast decreases. Absorption rate was calculated by the Eq. 1. The absorbance was determined at the maximum absorption wavelength lambda Max = 590 nm by 721-spectrophotometer in acidic scarlet dye solution.

$$\mu=\frac{A_0\text{-}A}{A_0}\times 100\% \quad (1)$$

Where μ is the absorption rate, A_0 is the absorbance before absorption, A is the absorbence after absorption.

Results and Discussion

Firstly the ranges of parameters were confirmed through single factor experiment, then orthogonal method was conducted to get the following optimal parameters: concentration of chitosan 35 g/L, bentonite quality and chitosan solution volume rate 0.7(g/L), microwave time 17 min, infilltration time 50 min, deacetylation degree of chitosan 85%, soil particle size 15 mm, pH, dosage of CCB 20 g/g, stirring speed 300 r/min, centrifugal time 15 min, stirring time 35 min. Then CCB was preparaed and applied to the absorption experiment with acidic scarlet dye solution of 700 mg/L concentration to detect the influence trend of each of single factor.

The follwing expriment were perfected on the optium experimental condition, which were detected by the single factor experiment. The effects of 11 elements on the adsorption capacity were studied, and the experimental results were shown in from Fig. 1 to Fig. 11 respectively.

Effects of concentration of chitosan. The experimental results of concentration of chitosan were shown in Fig. 1. The adsorption capacity firstly increased with concentration of chitosan, then relatively slow decreased. This is mainly because it was affected by the number of chitosan into bentonite layers. The critical point was the cation exchange capacity of bentonite interlayer. Obviously, the influence trend of concentration of chitosan belonged to B-type trend.

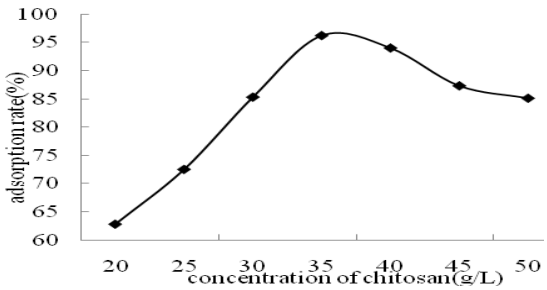

Fig. 1 Effects of concentration of chitosan

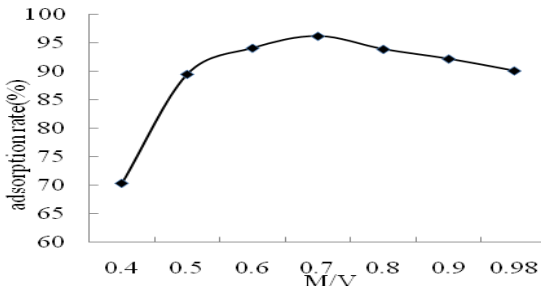

Fig. 2 Effects of M/V

Effects of bentonite quality and chitosan solution volume rate. The experimental results of bentonite quality and chitosan solution volume rate were shown in Fig. 2. When (M/V) < 0.7, the adsorption capacity incread, when M/V 0.6~0.8, it achieved its maximum, when M/V > 0.8, the adsorption capacity declined. Obviously, the influence trend of M/V belonged to B-type trend.

Effects of heating time. The experimental results of heating time were shown in Fig. 3. The function of heating of CCB in the microwave oven are drying and modification. In microwave field, chitosan molecules motion makes the motion of molecules orderly, reduces reaction activation energy, and also accelerates the ion exchange reaction speed. When heating time < 17min, the adsorption capacity increased, at 17min it achieved its maximum, when heating time > 17min, it relatively decreased rapidly. Obviously, the influence trend of heating time belonged to C-type trend.

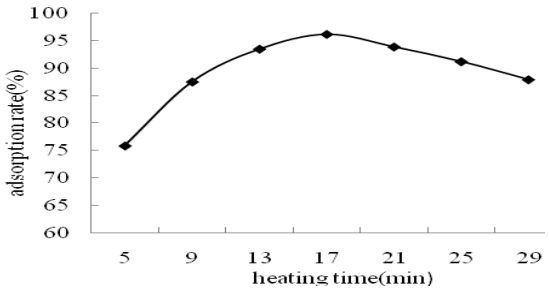

Fig. 3 Effects of heating time

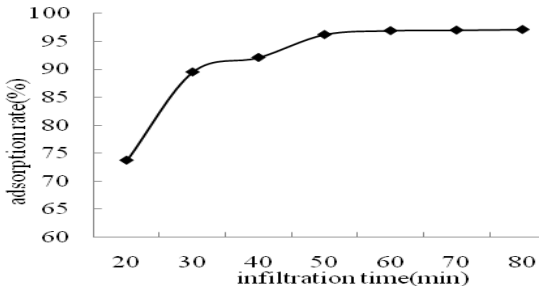

Fig. 4 Effects of infilltration time

Effects of infilltration time. The experimental results of infilltration time were shown in Fig. 4. When the adsorption capacity increased then to a plateau at 50 min. Infilltration made chitosan and bentonite fully react. Obviously, the influence trend of infilltration time belonged to A-type trend.

Effects of deacetylation degree of chitosan. The experimental results of deacetylation degree of chitosan were shown in Fig. 5. The increasing of deacetylation degree increases the amount of free amino and positive charge, thus the adsorption capacity increases consequently. The nature of bentonite may be changed by chitosan, which enhance the adsorption capacity of bentonite. It is to a plateau finally. The influence trend of deacetylation degree of chitosan belonged to A-type trend.

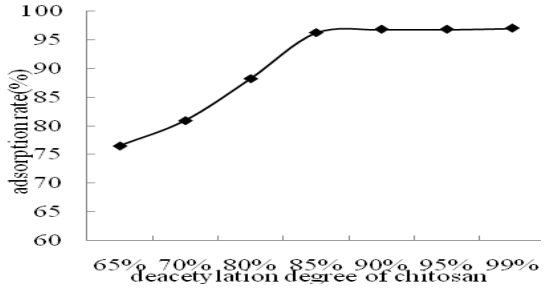

Fig. 5 Effects of deacetylation degree of chitosan

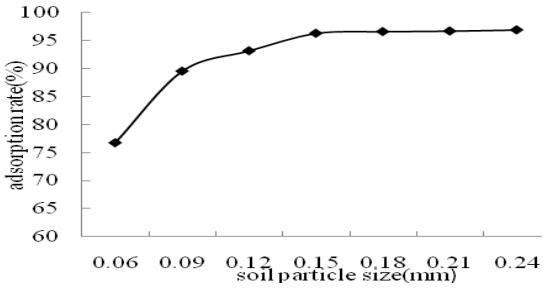

Fig. 6 Effects of soil particle size

Effects of soil particle size. The experimental results of soil particle size were shown in Fig. 6. The adsorption capacity increased with the increase of soil particle size. When soil particle size > 0.150 mm, adsorption capacity was to a plateau. The influence trend of soil particle size belonged to A-type trend.

Effects of pH value. The experimental results of pH value were shown in Fig. 7. PH value influences properties and numbers of surface charge of organic polymer adsorbent and similarly to suspended particles, which affects the adsorption capacity. At acidic condition of pH = 5, chitosan molecule are less likely to hydrolysis to produce polysaccharide, so it can change natural bentonite decentralized state in solution, and improve its activity and specific surface area. Thereby that can enhance the capacity of organic adsorption and ion exchange. As shown in Fig. 7, pH = 5 was critical point. The influence trend of pH value belonged to C-type trend.

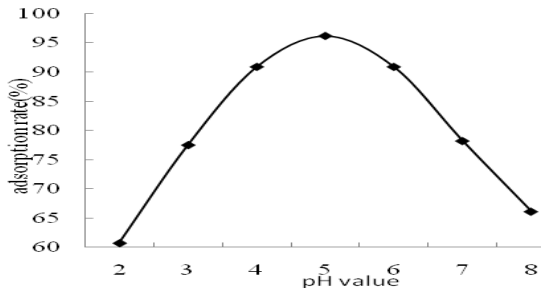

Fig. 7 Effects of pH value

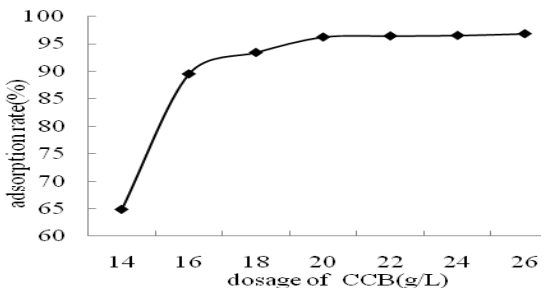

Fig. 8 Effects of dosage of CCB

Effects of dosage of CCB. The experimental results of dosage of CCB were shown in Fig. 8. CCB can counteracted negative surface charge of pollutants while reduce ζ potential , then pollutants can be settld down by the action of adsorption bridging. As shown in Fig. 8, the optimum point of dosage of CCB was 20g/L. The influence trend of dosage of CCB belonged to A-type trend.

Effects of stirring speed. The experimental results of stirring speed were shown in Fig. 9. When stirring speed < 300 r/min, adsorption capacity increacsed, when stirring speed > 300 r/min, it decreased with stirring speed. The influence trend of stirring speed belonged to A-type trend.

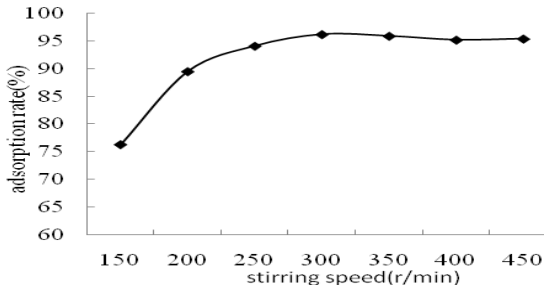

Fig. 9 Effects of stirring speed

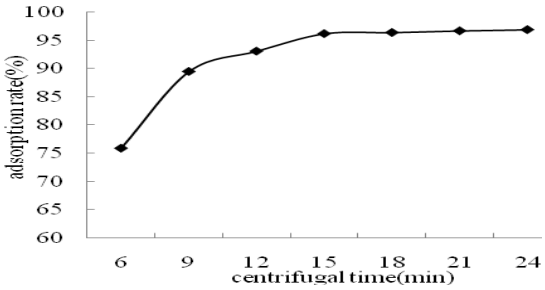

Fig. 10 Effects of centrifugal time

Effects of centrifugal time. The experimental results of centrifugal time were shown in Fig. 10. Adsorption capacity increased with the increase of centrifugal time. when centrifugal time > 15min, it was to a plateau. The influence trend of centrifugal time belonged to A-type trend.

Effects of stirring time. The experimental results of stirring time were shown in Fig. 11. When stirring time < 35min, adsorption capacity increased with stirring time, when stirring tme > 35min, it decreased.Mixing of the CCB and the colloid dye particles can form a different charge reaction system in the solution. The function of electrostatic attraction and electrical neutralization make colloidal particles to settle down. But excessive shearing may break condensed and flocculated sediment to reduce it. The influence trend of stirring time belonged to B-type trend.

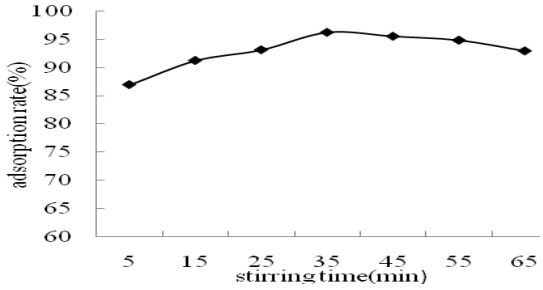

Fig. 11 Effects of stirring time

Conclution

CCB was prepared with calcium bentonite as raw materials, chitosan as modifier and had a efficientive perfomance on the adorption of acid scarlet dye from aqueous solutions. The adsorption of CCB experiment showed that on the optium experimental conditions: concentration of chitosan of 35 g/L, bentonite quality and chitosan solution volume rate of 0.7(g/L), microwave time of 17 min, infilltration time of 50 min, deacetylation degree of chitosan of 85%, soil particle size of 15 mm, pH of 5, dosage of CCB of 20 g/g, stirring speed of 300 r/min, centrifugal time of 15 min,

stirring time of 35 min, the adsorption efficiency fully reach to 96.2% with a concentration of 700 mg/L to acidic scarlet solution. Among all the factors, the influence trend of infilltration time, deacetylation degree of chitosan, soil particle size, dosage of CCB and centrifugal time belong to A-type, and concentration of chitosan, bentonite quality and chitosan solution volume rate, stirring speed and stirring time belong to B-type, moreover, heating time and pH value belong to C-type. This will provide a reference for the subsequent pilot test.

References

[1] Lizhong Zhu, Baoliang Chen: Advances in Environmental Science Vol. 6(1998), p 53-61,in Chinese.

[2] Yang Liu, Yongqing Wang, Hu Chen et al.: China Ceramic Industry Vol. 82001), p. 39-42,in Chinese.

[3] K.R.Srinivasan, H.S.Fogler: Clays and Clay Minerals Vol. 38(1990), p. 277-286.

[4] Hong Shao, Hui Cheng, Jialin Li: Chinese Journal of Environmental Engineering Vol. 6(1998), p. 53-61,in Chinese.

[5] Bingtao Liu, Ruitao Li, Anxi Jiang: Journal of Natural Science of Hei Long Jiang University Vol. 23(2006), p. 345-348,in Chinese.

[6] Yong Ma, Ende Wang, Hong Shao: Chinese Journal of Applied Chemistry Vol. 21(2004), p. 597-600,in Chinese.

[7] Juanjuan Ma, Lin Liu, Xinlong Wang et al.: Chemical Research and Application Vol. 21(2009), p. 562-565,in Chinese.

[8] Lu Zeng, Chunjie Yan, Gang Zhen et al.: Non-Metallic Mines Vol. 33(2010), p. 562-565,in Chinese.