Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(3):906-911

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Adsorption mechanism of low concentration pollutants in water on modified zeolite

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ABSTRACT

Na-Citrate and $FeCl_3$ as active agents were used to modify natural zeolite. The adsorption of ammonia-nitrogen、nitrate nitrogen and COD on modified zeolite improved rapidly. In this paper, adsorption mechanism of ammonia-nitrogen、nitrate nitrogen and COD in water on modified zeolite were studied under static and dynamic absorption experiments. The results suggested that: the adsorption mechanism of ammonia nitrogen and COD on modified zeolite was basically consistent with Langmuir isotherm model, which was chemisorption; The adsorption of nitrate nitrogen were strongly consistent with Freundlich adsorption isotherm, which was multilayer absorption.

Key words: zeolite, ammonia-nitrogen, nitrate nitrogen and COD, adsorption isotherm

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INTRODUCTION

Eutrophication is the main water pollution problem of lake, reservoir and ocean, etc. in many countries [1-3]. To solve the problems of avoiding eutrophication by biological treatment effluent, reuse of wastewater, reducing sewage discharging and alleviating water shortage, Researches of advance sewage treatment in many countries were done, especially researches in nitrogen and COD. Zeolite is a natural mineral, full of holes and channels inside, is large in adsorption ratio surface area [4-7]. In recent years, researchers were focusing on adsorbing materials made by zeolite [8].

Based on the static and dynamic adsorption experiments, This paper studies on the adsorption mechanism of ammonia-nitrogen、nitrate nitrogen and COD by modified zeolite in water.

EXPERIMENT SECTION

2.1 Experiment material

Zeolite from Shenyang was chosen for sample materials. The particle size was 0.074mm. After preparation by modifying zeolite with Na-Citrate and $FeCl_3$, zeolite was drying in 105℃, reserved to change to modified zeolite.

Main experiment apparatuses were HZQ-F160 Full Temperature Oscillation Incubator, DHG-9053A Electrothermal–homoiothermal Air-blast Dry Box, WFZ-UV-2000 Ultraviolet Spectrophotometer, 320 pH Monitor and SX-10-13 Chamber Electric Furnace.

2.2 Experiment method

(1) Removal efficiency experiments. Ammonia nitrogen、nitrate nitrogen and COD water sample of 6, 3, 60 mg/L were prepared. First, water samples were input into several 200mL triangular flasks with 1g zeolite. Second, put the flasks in incubator and stirred for 4 hours in 200rpm.Then filtered by 0.45μ membrane and measured the residual

content.

(2) Adsorption isotherm experiment. In 25℃ condition, ammonia nitrogen、nitrate nitrogen and COD water sample of 5, 10, 20, 40, 50, 70, 100, 150 mg/L were prepared. First, water samples were input into several 300mL triangular flasks. Then the flasks were putted in incubator and were stirred for 24 hours in 200rpm condition to make sure adsorption equilibrium. Last, filtered by 0.45μ membrane and measured the concentration of ammonia nitrogen、nitrate nitrogen and COD in water, drew the adsorption isotherm separately.

RESULTS AND DISCUSSION

3.1 Synchronization removal efficiency of low concentration pollutants in Water

Figs.1 showed synchronization removal efficiency of ammonia-nitrogen、nitrate nitrogen and COD by zeolite and modified zeolite in water by comparison.

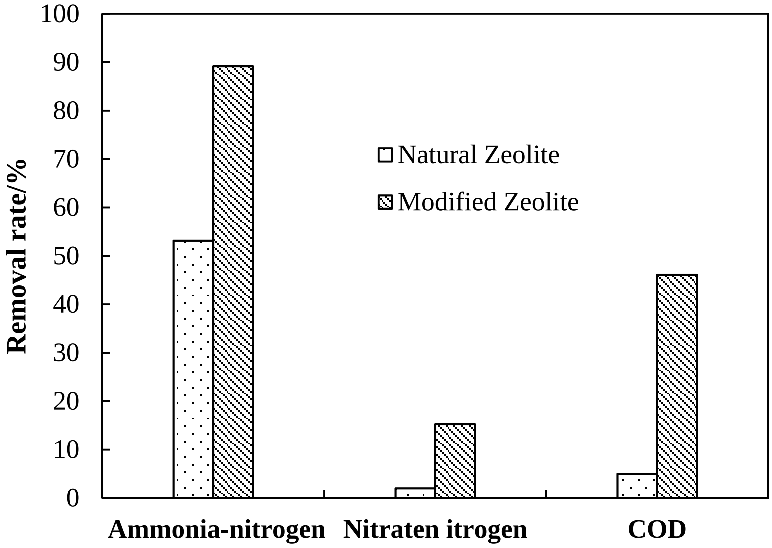

Fig.1 Synchronization removal efficiency of ammonia-nitrogen、nitrate nitrogen and COD by zeolite and modified zeolite in water

Figs.1 show that the ammonia-nitrogen、nitrate nitrogen and COD removal efficiencies of modified zeolites exhibited qualitative changes compared with natural zeolites. The ammonia-nitrogen and the nitrate nitrogen removal rates increased from 53.15%、2.01%to 89.19%、15.26%, and the ammonia-nitrogen removal rate increased from 5.02% to 46.11%.

3.2 Adsorption isotherm experiment of ammonia-nitrogen

24hours absorption experiments of modified zeolite were done in 30℃ conditions. When adsorption equilibrium was achieved, the concentrations of ammonia nitrogen in the water sample were measured. After that, adsorption experiment results were analyzed according to Langmuir and Freundlich adsorption isotherm models [9-11].
Here is the Langmuir adsorption isotherm model:

$$\frac{C_e}{q_e} = \frac{1}{K_L} + \frac{a_L C_e}{K_L} \tag{1}$$

Freundlichadsorption isotherm model is showed in the following:

$$\lg q_e = \lg K + \frac{1}{n} \lg C_e \tag{2}$$

Langmuir and Freundlich modified zeolite adsorption isotherms of ammonia nitrogen by were plotted by using experiment results. See Fig. 2 and 3.

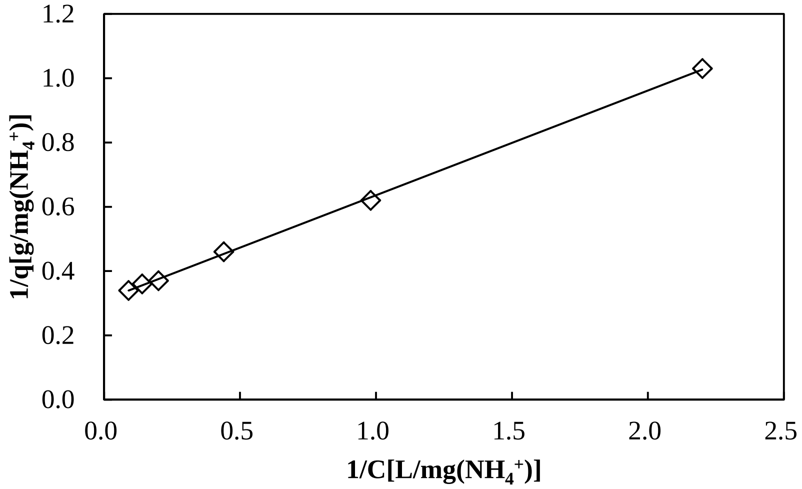

Fig. 2 Ammonia-nitrogen Langmuir adsorption curve of modified zeolite

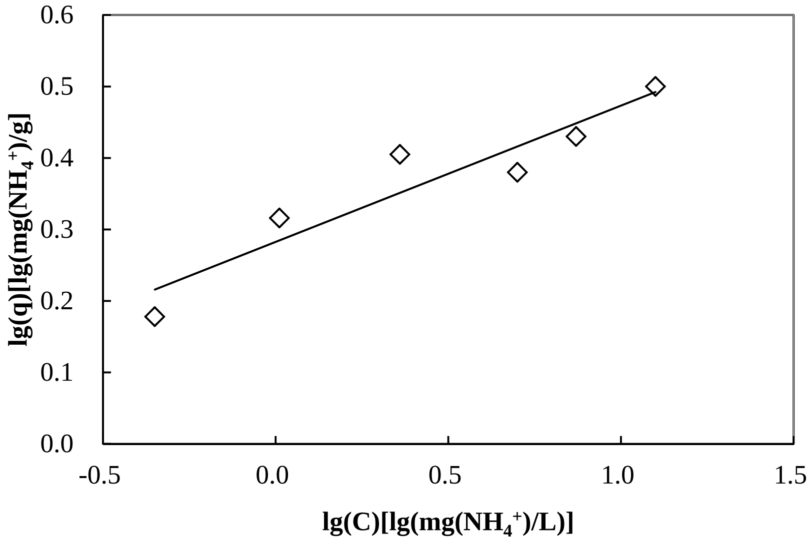

Fig. 3 Ammonia-nitrogen Freundlich adsorption curve of modified zeolite

Langmuir adsorption isotherm of phosphorus is showed in the following:

$1/q = 0.336/C + 0.321 \quad R^2=0.998$ (3)

Freundlich adsorption isotherm of phosphorus is showed in the following:

$\lg q = 0.200 \lg C + 0.272 \quad R^2=0.875$ (4)

The experiment results showed the ammonia nitrogen adsorption isotherms are similar with Langmuir adsorption isotherm model, which means the ammonia nitrogen adsorption type of modified zeolite is chemisorption.

3.3 Adsorption isotherm experiment of nitrate nitrogen

24hours absorption experiments of modified zeolite were done in 30℃ conditions. When adsorption equilibrium was achieved, the concentrations of nitrate nitrogen in the water sample were measured. Fig. 4 and 5 showed that Langmuir and Freundlich adsorption isotherms of nitrate nitrogen by modified zeolite.

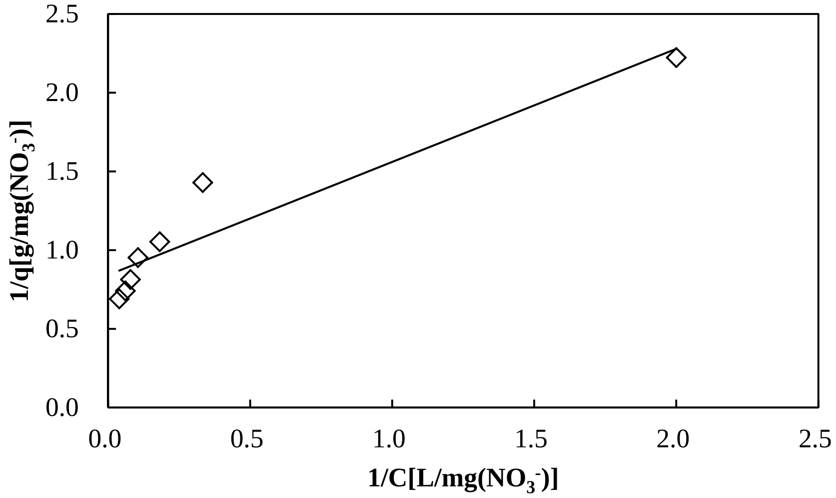

Fig. 4 Nitrate nitrogen Langmuir adsorption curve of modified zeolite

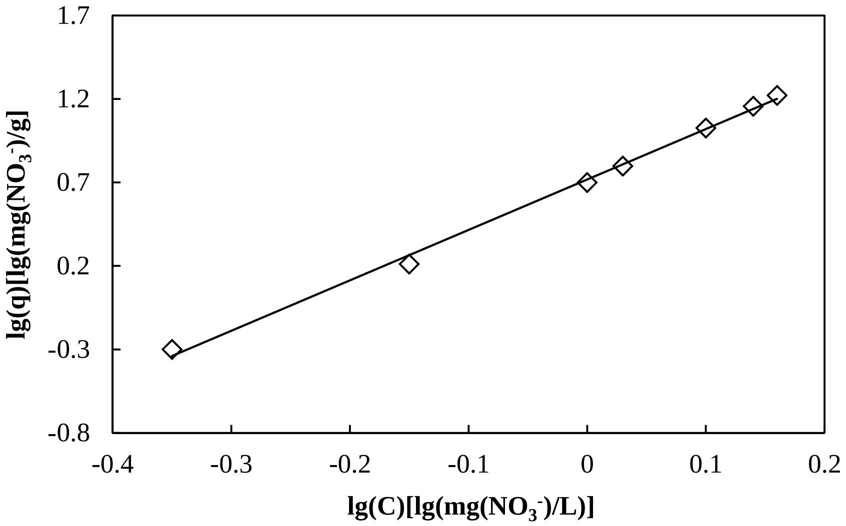

Fig. 5 Nitrate nitrogen Freundlich adsorption curve of modified zeolite

Langmuir adsorption isotherm of nitrate nitrogen is showed in the following:

$1/q = 0.701/C + 0.651 \quad R^2=0.87$ (5)

Freundlich adsorption isotherm of nitrate nitrogen is showed in the following:

$\lg q = 3.021 \lg C + 0.718 \quad R^2=0.997$ (6)

The experiment results showed the nitrate nitrogen adsorption isotherms are similar with Freundlich adsorption isotherm model, which means the ammonia nitrogen adsorption type of modified zeolite is multilayer absorption.

3.4 Adsorption isotherm experiment of COD

24hours absorption experiments of modified zeolite were done in 30℃ conditions. When adsorption equilibrium was achieved, the concentrations of COD in the water sample were measured. Fig. 6 and 7 showed that Langmuir and Freundlich adsorption isotherms of nitrate nitrogen by modified zeolite.

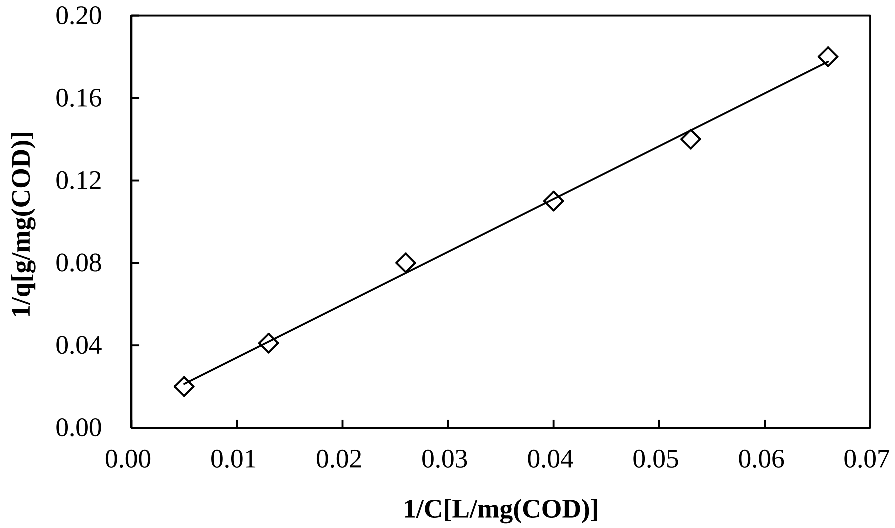

Fig. 6 COD Langmuir adsorption curve of modified zeolite

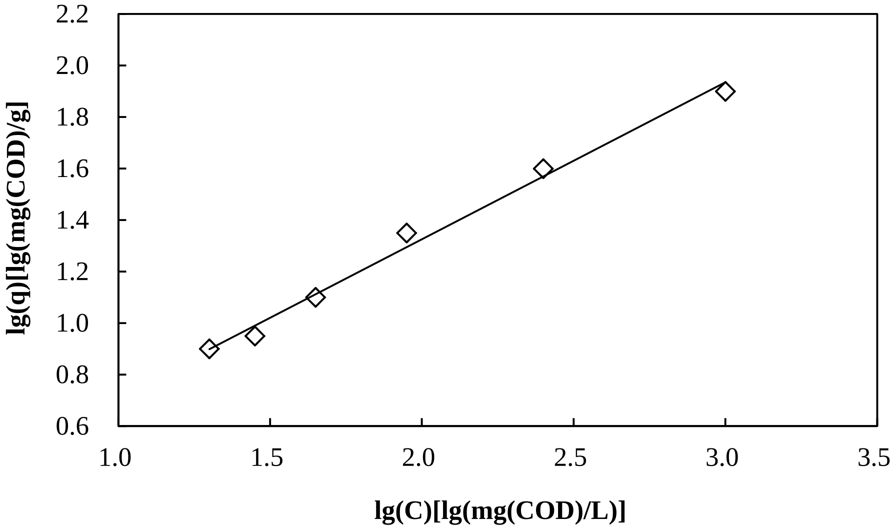

Fig. 7 COD Freundlich adsorption curve of modified zeolite

Langmuir adsorption isotherm of COD is showed in the following:

$$1/q=2.673/C+0.010 \quad R^2=0.998 \tag{7}$$

Freundlich adsorption isotherm of COD is showed in the following:

$$\lg q=0.611\lg C+0.110 \quad R^2=0.981 \tag{8}$$

The experiment results showed the COD adsorption isotherms are similar with Langmuir adsorption isotherm model, which means the COD adsorption main type of modified zeolite is chemisorption.

CONCLUSION

(1) After modified by Na-Citrate and $FeCl_3$, the removal efficiencies of modified zeolites had improved obviously. The ammonia nitrogen and the nitrate nitrogen removal rates increased from 53.15%、2.01%to 89.19%、15.26%, and the ammonia-nitrogen removal rate increased from 5.02% to 46.11%.
(2) The modified zeolite adsorption isotherm shows, to nitrate nitrogen and COD adsorption, modified zeolite was fit with Langmuir isotherm model, and the main type of modified zeolite is chemisorption; to ammonia nitrogen adsorption, modified zeolite was fit with Freundlich isotherm model, and the main type of modified zeolite is multilayer absorption;

Acknowledgments
This work was supported by the National Natural Science Foundation of China (51174017).

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