Investigation of the Ion-Exchange Behavior of Zeolite Y in the Presence of Resin

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Highlights

- A new ion-exchange method for zeolite Y by using the ammonium-form resin as the exchange reagent was successfully developed.
- The amount of ammonium salts consumed in this process is approximately equivalent to the theoretical consumption value.
- The Na_2O content of the samples exchanged by the resin is significantly lower than the sample exchanged by traditional exchange method.

1. Introduction

Zeolite Y is one kind of zeolites which are the most widely used in catalytic reaction areas. The acidic active sites of zeolite Y are usually created by the substitution of Na^+ ions with other cations such as H^+ ions during the preparation process. But HY can't be obtained by direct exchange with acid solution due to the hydrolysis of Al-O-Si bond in the presence of an excessive acid. Therefore, HY is usually prepared by exchange with ammonium salt followed by the further thermal decomposition of ammonium cations[1]. As the national standards for pollutants discharge are becoming increasingly stringent, the wastewater containing large amount of ammonium salt turns to be a bottleneck for the development of catalyst production enterprises in China[2], and many studies have been proceeded to reduce the emission of the wastewater by developing new exchange methods for zeolite.

A new ion-exchange method for zeolites by using the ammonium-form resin as the exchange reagent was successfully developed in our lab. The amount of ammonium salts consumed in this process is approximately equivalent to the theoretical consumption value. Combined with the electrodialysis technology[3], the water used for regeneration and rinse of resin could be recycled for several months. This will bring about great economic value to the catalyst manufacturing enterprises along with great significance for environmental protection.

2. Methods

In this work, the ammonium-type resin was employed in the ion exchange of NaY zeolite in the fixed bed. The HY zeolites were prepared through ion exchange with the NH_4-form resin, followed by calcination, and then the second exchange with the NH_4-form resin was carried out. The exchange column consists of a glass tube, 1 cm in inside diameter and 100 cm in length, and is filled with 33 mL of resin. It is equipped with a heating jacket to maintain a stable temperature.

3. Results and discussion

The first exchange section: The breakthrough curves of zeolite slurry with different initial Na^+ ion concentrations (6.4─700 mg/L) are shown in Figure 1, which were obtained at a space velocity of 0.61 h^{-1} and a temperature of 70 ℃.The mass-transfer zone (MTZ) decreased dramatically with the increase of Na^+ ion concentration, and the smallest MTZ was 5.5 cm at a Na^+ ion concentration of 423 mg/L. The effective utilization ratio of resin bed rose quickly with the increase of Na^+ ion concentration and it could reach more than 82% when the Na^+ ion concentration was higher than 423 mg/L.

The second exchange section: The sample of qualified zeolite obtained from the first exchange section was calcined at 500 ℃, and then it was subjected to ion exchange in a resin bed which was 1 meter long. The result shows that the whole resin bed (1 m) is the mass-transfer zone at this exchange section which indicates that the exchange of Na^+ ions is more difficult at the second exchange section.

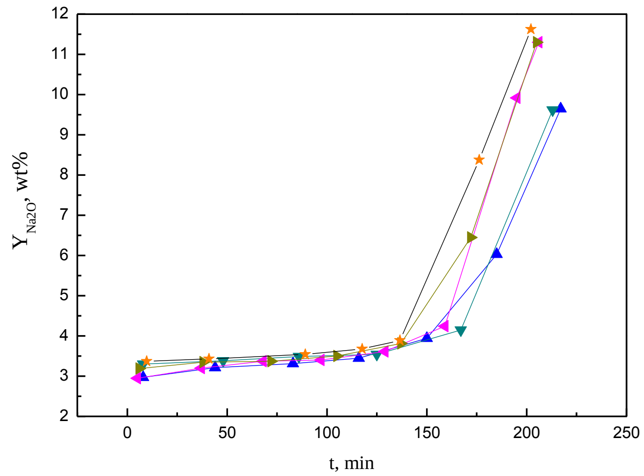

Figure 1. The breakthrough curves at different Na^+ ion concentrations.

■−6.4 mg/L;●−66.3 mg/L;▲−138 mg/L;▼−197 mg/L; ▲−423 mg/L; ▼−621mg/L; ★−700mg/L

Table 1 shows the physical properties of samples treated by resin exchange or by traditional method. The samples treated by resin exchange were obtained at a space velocity of 1 h^{-1}, a Na^+ ion concentration of 700 mg/L and a temperature of 70 ℃. The traditional sample was treated by NH_4Cl aqueous solution at a mass ratio of 1:0.4:10 (zeolite/NH_4Cl/H_2O) at 85℃. In the first exchange section, the samples which were subjected to ion exchange with resin had a lower Na_2O content (3.61%) and a highest crystallinity (88%). In the second exchange section, the samples which were subjected to ion exchange by resin had the lowest Na_2O content (0.12%), which is much lower than that achieved by the traditional exchange method (1.28%).

Table 1. Physical properties of exchanged zeolite samples.

	Original NaY	Exchanged by resin		Exchange by conventional method	
		First exchange	Second exchange	First exchange	Second exchange
Content of Na_2O, %	11.40	3.61	0.12	4.68	1.28
Unit cell, nm	2.465	2.468	2.456	2.470	2.460
Relative crystallinity, %	87.1	88.0	79.4	86.0	80.1

4. Conclusions

The technological conditions for exchange of Na^+ ions of zeolite Y by the NH_4-form resin were investigated in a fixed-bed column. At the first exchange section, the smallest MTZ of 5.5 cm could be achieved at a space velocity of 0.61 h^{-1}, a Na^+ ion concentration of 423 mg/L and a temperature of 70 ℃. At the second exchange section, the whole resin bed is the mass-transfer zone and the exchange of Na^+ ions in zeolite Y is more difficult even after the calcination treatment. The Na_2O content of the samples exchanged by the resin is significantly lower than the sample exchanged by traditional exchange method in both the first and the second exchange sections. Based upon the experimental data, the method for ion-exchange of Na^+ ions from zeolite Y by the NH_4-form resin is completely feasible..

References

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Keywords
zeolite Y, resin, ion-exchange