KINETICS AND MECHANISM OF AMMONIUM ION ADSORPTION BY NATURAL ZEOLITE-MODERNITE

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Introduction

The total nitrogen concentration in typical municipal wastewater ranges from 15 to 50 mg/L and the major forms of nitrogen in municipal wastewater present are approximately 60% of total nitrogen. Ammonia pollutes the water streams; it is toxic to aquatic organisms especially at alkaline conditions where nitrification of ammonia to nitrate depletes the amount of dissolved oxygen level. High amounts of ammonia in water supply also increases the chlorine dosage required to achieve a free chlorine residual in disinfecting. Thus, an effective method for the removal of ammonia from wastewater is needed. Several methods have been proposed for the removal of ammonia from waste water and these include nitrification, denitrification, stripping, break-point chlorination, ion exchange, membrane processes and precipitation (Sorensen and Jorgensen, 1993). Due to problems such as cost and availability of the materials to conduct the processes, alternative method should be studied. Natural zeolite is a hydrated aluminosilicate with a framework structure enclosing cavities occupied by large ions and water molecules, both of which have considerable freedom of movement permitting ion exchange and reversible dehydration (Deer et al. 1996). Based on its characteristics, zeolites have high ability to adsorp many materials from gas and solution, hence it may be used to adsorp ammonium ions from wastewater. The objective of this study was to determine the feasibility of using zeolites for ammonia removal from municipal wastewater.

Materials and Methods

Natural zeolite, modernite, was purchased from Harta Semarak Sdn Bhd, Batu Pahat, Johor. This type of zeolite was obtained from Java Island, Indonesia. Municipal wastewater was collected directly from the discharged point at a lake in Seri Serdang, Selangor. Sorption isotherm equilibrium experiments were carried out to obtain data for kinetics study. The experiments were carried out in 250 ml flask containing 100 m standard solution of ammonium or waste water. Zeolite particles were added to the flask and shaken at 200 rpm (30°C) for 24 h. Samples were taken at time intervals and centrifuged to separate zeolite particle from the solution. Ammonium concentration in the supernatant was determined using Indophenol blue method. The experimental variable investigated included particle size, amount of zeolite and initial pH. The sorption isotherm equilibrium data were analyzed using several kinetic models such as Langmuir and Freundlich equations.

Results and Discussion

The composition of municipal waste water collected from the lake at Seri Serdang consisted of 250.71 ± 28.72 mg/L COD; 163.57 ± 22.34 mg/L BOD; 37.37 ± 2.29 mg/L ammonium; 38.52 ± 7.38 NTU turbidity; 0.0065 ± 0.0013 g/L total suspended solid and pH 7.37 ± 0.13. The rate of ammonium adsorption by zeolite was very rapid during the initial stages of the reaction and reached equilibrium after about 120 min. The optimum pH, particle size and zeolite concentration for maximal ammonium uptake capacity was 7, 0.075 mm and 0.9 g/100 mL, respectively. In most cases, the experimental sorption isotherm equilibrium data fitted well to Langmuir model, suggesting that the adsorption is similar to ion exchange mechanism. However, the data did not fit well to the Scatchard plot, indicating that the cooperative activity occurred among the multiple binding sites of zeolite in ammonium sorption isotherm uptake at equilibrium. Ammonium ions were adsorp into the pores (uniform size between 3 Å to 10 Å) on the surface of zeolite particles. Due to this characteristic, zeolites are often known as "molecular sieve". Using the optimised conditions for ammonium ion biosorption by zeolite, about 97.5% of ammonium ion in municipal wastewater containing about 40 mg/L ammonium. The advantages of using zeolites as compared to ion-exchange resins are (i) more stable at elevated temperatures; (ii) not susceptible to ionizing radiation; (iii) considerably more selective in some separations; and (iv) reduce operating cost as the sorbent can be regenerated and use for many cycles.

Conclusions

The maximum ammonium uptake capacity for zeolite is 0.065 mg ammonium/g zeolite. From the kinetic analysis, it was found that the sorption isotherm data for ammonium adsorption by zeolite followed Langmuir model, suggesting that the adsorption kinetic is similar to ion exchange system. The use of zeolite enables the removal of 97.5% of ammonium from municipal wastewater containing 38 mg/L ammonium.

References

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