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Removing aqueous ammonia by membrane contactor process

Cheng-Lee Lai*, Shih-hsiung Chen, Rey-May Liou

Department of Environmental Engineering and Science, Chia-Nan University of Pharmacy and Science, Tainan 717, Taiwan
Email: clai23@mail.chna.edu.tw

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ABSTRACT

High-tech industries have been rapidly developing for the last two decades in Taiwan, which also result in high concentrations of various nitrogenous compounds in the wastewater, such as eutrophication. Polyvinylidene fluoride (PVDF) membranes with asymmetric structures and good hydrophobicity have been prepared by a phase-inversion method and applied for removal of ammonia from water by membrane contactor. Aqueous solution containing sulfuric acid was used as stripping solution to accelerate the removal of ammonia. It was found that the investigation of membrane contactor revealed that the flux of PTFE and PVDF (12 wt%) was 193.1 and 97.4 g NH_4^+/m^2 h, respectively. Therefore, membrane contact system has great potential for future applications in wastewater treatment with high strength of ammonium.

Keywords: Ammonia removal; PVDF; Membrane conductor

1. Introduction

Ammonia (NH_3) has been recognized as a major pollutant in both municipal and industrial wastewater. From the environmental point of view, a complete removal of ammonia from wastewater is desirable. The concentration of ammonia in industrial wastewater varies from 5 to 1,000 mg/L [1]. High concentrations of ammonia are commonly present in industrial wastewaters such as coke plant, tannery, textile, landfill leachate, and fertilizer wastewater [2]. Removal of ammonia from industrial effluent is an important and dynamic area of research as well as being an important challenge, because environmental laws and regulations governing safe discharge levels are becoming increasingly stringent. Traditional methods for the removal of ammonia include biological treatments, chemical precipitation, advanced oxidation processes, air stripping, ion exchange, adsorption, membrane processes, and so on [3–6].

There are few studies on ammonia removal from wastewater. Hasanŏglu et al. [7] experimentally and theoretically studied the performance of the hydrophobic hollow-fiber and flat-sheet membrane contactors under various operational configurations, temperature, and hydrodynamic conditions for the ammonia removal from wastewater streams.

*Corresponding author.

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2. Experimental

2.1. Membrane preparation

The PVDF solutions were dissolved in NMP at room temperature for 24 h. The polymer solution was casted onto a glass plate to a predetermined thickness of 350 μm using a Gardner Knife. The membrane was dried at room temperature for 30 min, then peeled off, and immersed in distilled water for 12 h. Then the PVDF membrane was dried in vacuum oven for 24 h before the sorption and membrane contact measurements.

2.2. Membrane contact operation

The experimental setup implemented in this study using flat-sheet module is described in outline as shown in Fig. 1.

3. Result and discussion

Fig. 2 describes the exit concentration of NH_4^+ experimentally obtained of feed tank. In Fig. 3, concentration change of ammonia with different concentration of receiving solutions is compared as a function of time. The experiments were carried out using 0.1, 0.2, 0.3, and 0.4 M H_2SO_4 and H_3PO_4 solutions at 1,350 mL/min. H_2SO_4 as receiving solution was more efficient than H_3PO_4. After 120 min treatment, ammonia was received by 0.4 M H_2SO_4.

The effect of pH values of the feed solution on the ammonia stripping at 25°C is shown in Fig 4, where the volume of the simulated water was 100 mL. As can be seen, the total ammonia concentration in the reservoir solution is lowered more quickly at higher pH values than that at lower pH values. This can be expected that mass transfer efficient for NH_4^+ removal decreases with increasing pH value.

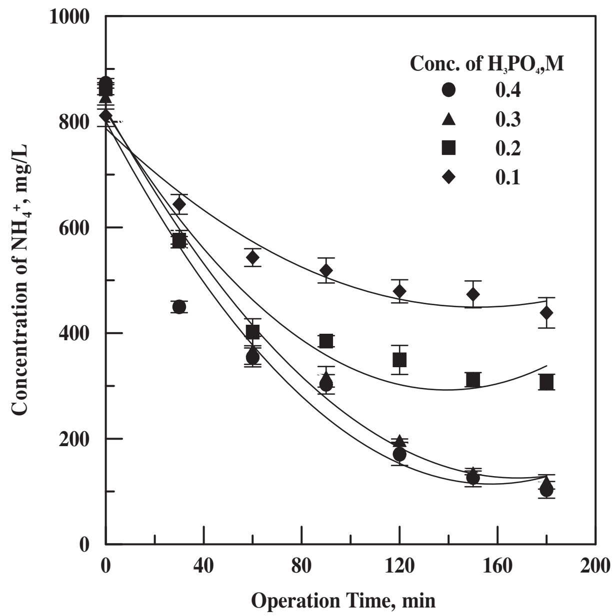

Fig. 2. Concentration of ammonia as a function of operation time at different concentrations of H$_3$PO4.

Fig. 5 illustrates the change of ammonia concentration in the reservoir with NH_4^+ permeate rate. Feed pH value at 11 and operation temperature at 25°C. It can be seen that permeate rate was much higher when ammonia concentration was 800 mg/L.

Fig. 6 shows the effect of feed velocity on ammonia removal, where the feed concentration was at

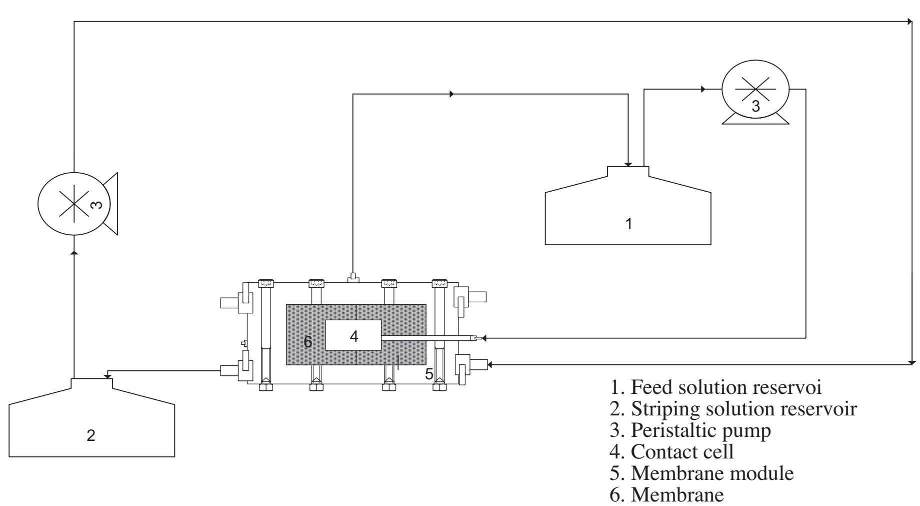

Fig. 1. Experimental setup used for this work.

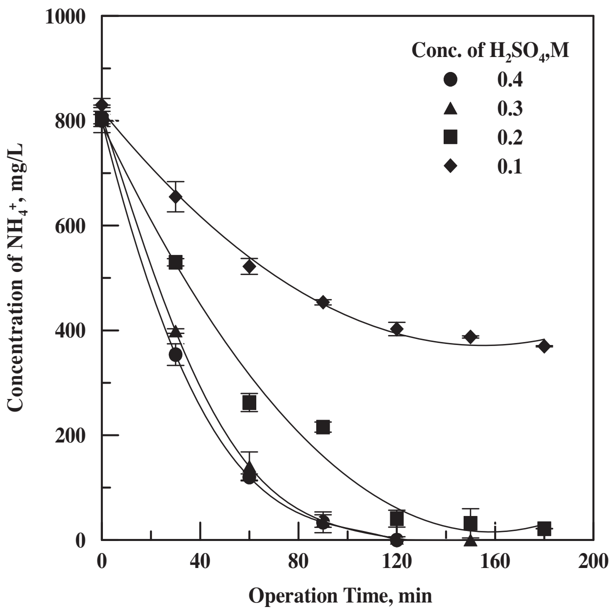

Fig. 3. Concentration of ammonia as a function of operation time at different concentrations of H_2SO_4.

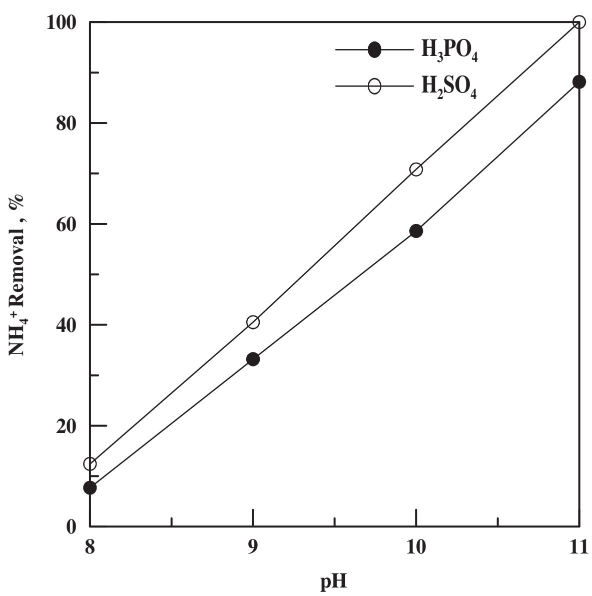

Fig. 4. Ammonia removal as a function of pH of feed solution.

800 mg/L, and pH = 11. The removal rate of ammonia increased as feed velocity increased.

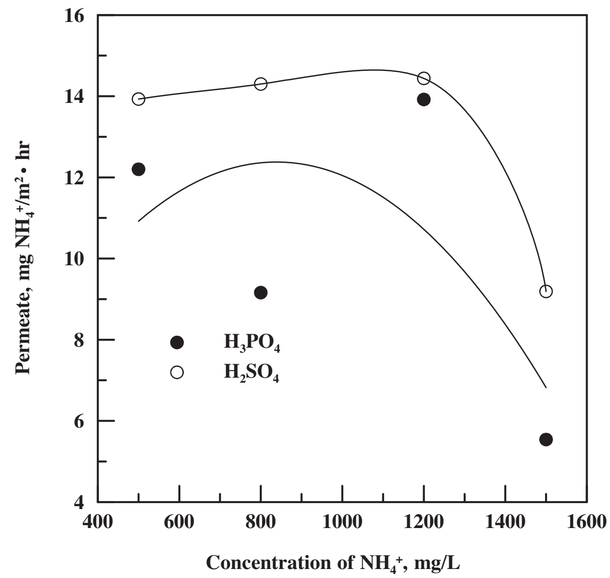

Fig. 5. Ammonia permeates as a function of concentration of ammonia.

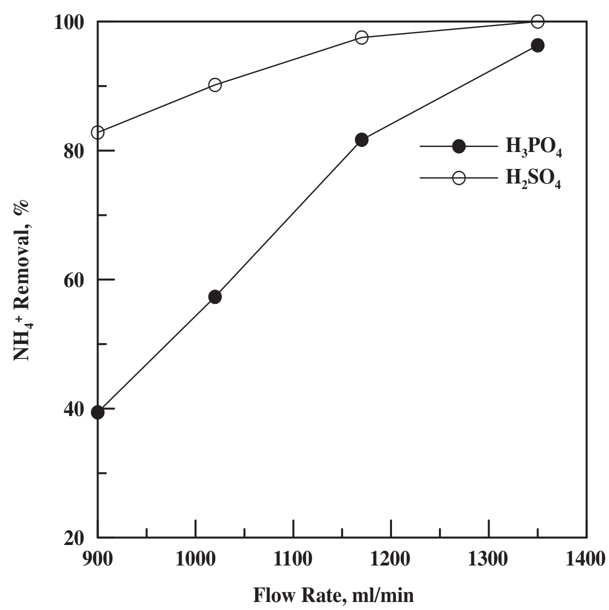

Fig. 6. Ammonia removal as a function of feed-in flow rate.

4. Conclusions

PVDF flat membrane have been prepared and applied for NH_4^+ removal from simulated wastewater. During the expiration, operate condition has been optimized. The ammonia removal rate increases with increasing concentration of reservoir solution, feed velocity, and pH of feed solution. Membrane contactor is suitable for ammonia wastewater treatment.

Acknowledgment

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