First demonstration of hydrophobic membrane contactors for removal of ammonia from condensate wastewater

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Introduction:

Hydrophobic membrane contactors represent a promising solution to the problem of recovering ammoniacal nitrogen from wastewater. The process has been shown to work best with wastewater streams that present high ammonia concentrations, low buffering capacities and low total suspended solids. The removal of ammonia from rendering condensate, produced during heat treatment of waste animal tissue, was assessed in this research using a hydrophobic membrane contactor. The main objective was to test the ammonia stripping technology using two types of hydrophobic membrane materials, polypropylene and polytetrafluoroethylene, at pilot scale and carry out process modification for ammonia removal. The results demonstrate that polypropylene membranes are not compatible with the condensate waste as it caused wetting. The polytetrafluoroethylene membranes showed potential and had a longer lifetime than the polypropylene membranes, removing up to 64% of ammonia from the condensate waste. The product formed contained a 30% concentrated ammonium sulphate salt which has a potential application as a fertilizer. This is the first demonstration of hydrophobic membrane contactors for treatment of condensate wastewater.

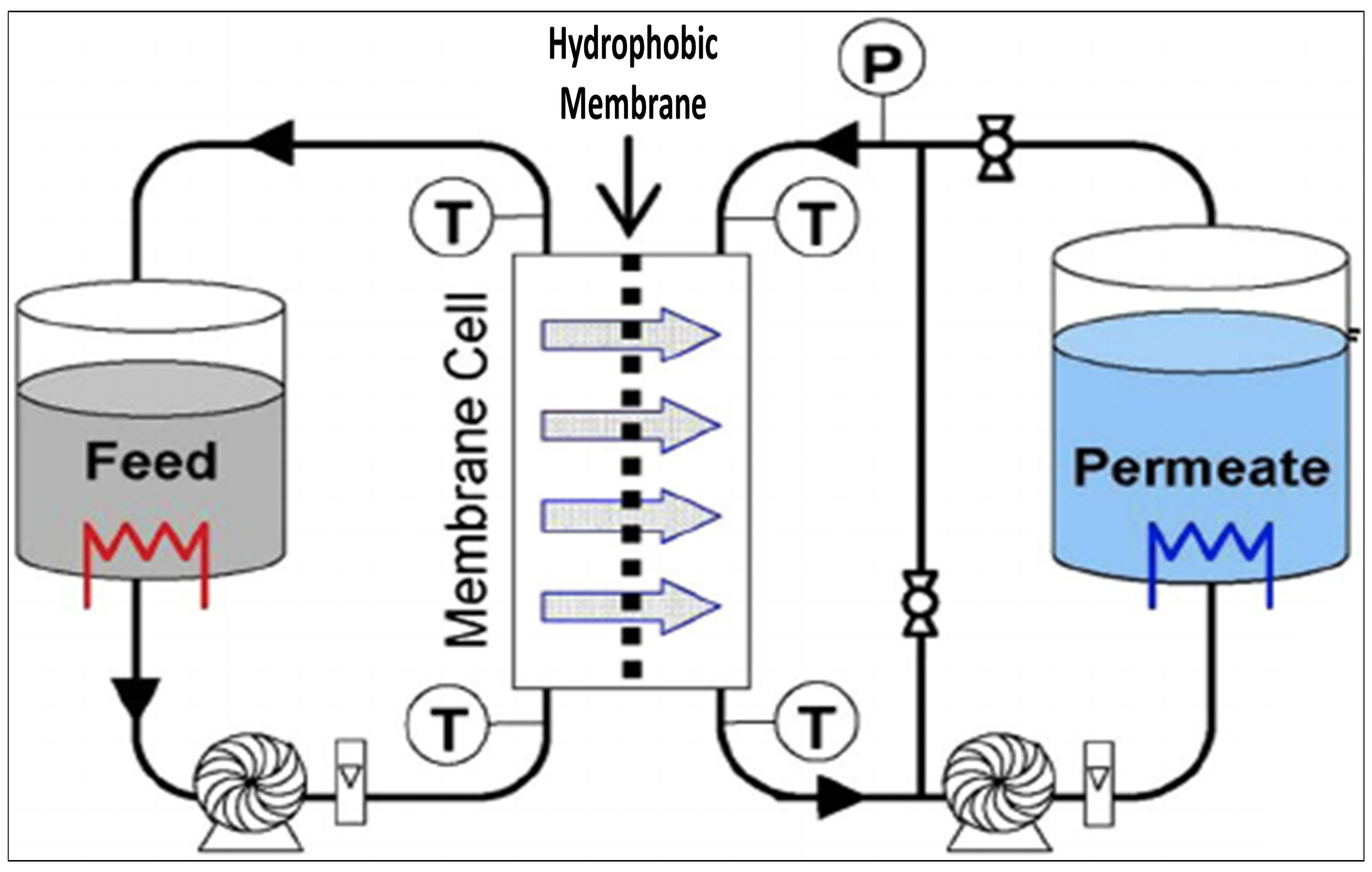


Figure 1: Schematic diagram outlining the process of the membrane system with feed and acid side on left and right, respectively.

Product characterization:

The reaction between N-NH_3 and H_2SO_4 produces ammonium sulphate ($(NH_4)_2SO_4$) which is an inorganic salt consisting of 21% nitrogen (N) and 24% sulphur (S), and is commonly used as a fertilizer. The product formed in this study was found to have a purity of 30%. Liquid fertilizer products on the market were found to have a purity of 40%, indicating that this is potentially a sustainable production route with a viable route to market. However, the pH at 2-2.5 would need to be increased for optimum agricultural application.

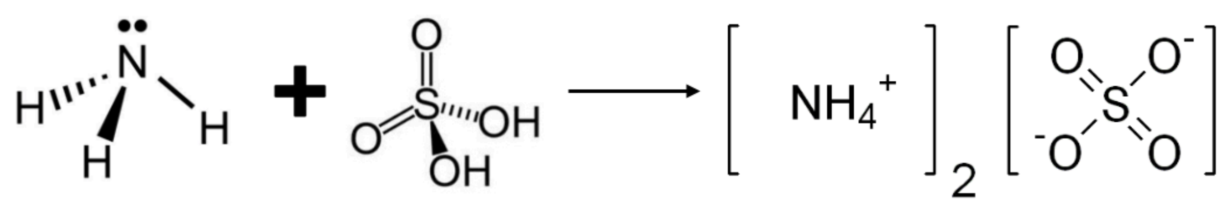


Table 1: Specifications of 2 types of membrane tested

	Membrane module 1	Membrane module 2
Membrane material	PTFE	PP
Configuration (type)	Spiral wound	Spiral wound
Surface area (m^2)	6.7	3.7
Flow feed side (m^3/h)	0.05-0.7	0.05-1
Flow acid side (m^3/h)	0.05-0.7	0.05-0.5
Pressure max (bar)	0.6	0.5
Temp max (°C)	45	50

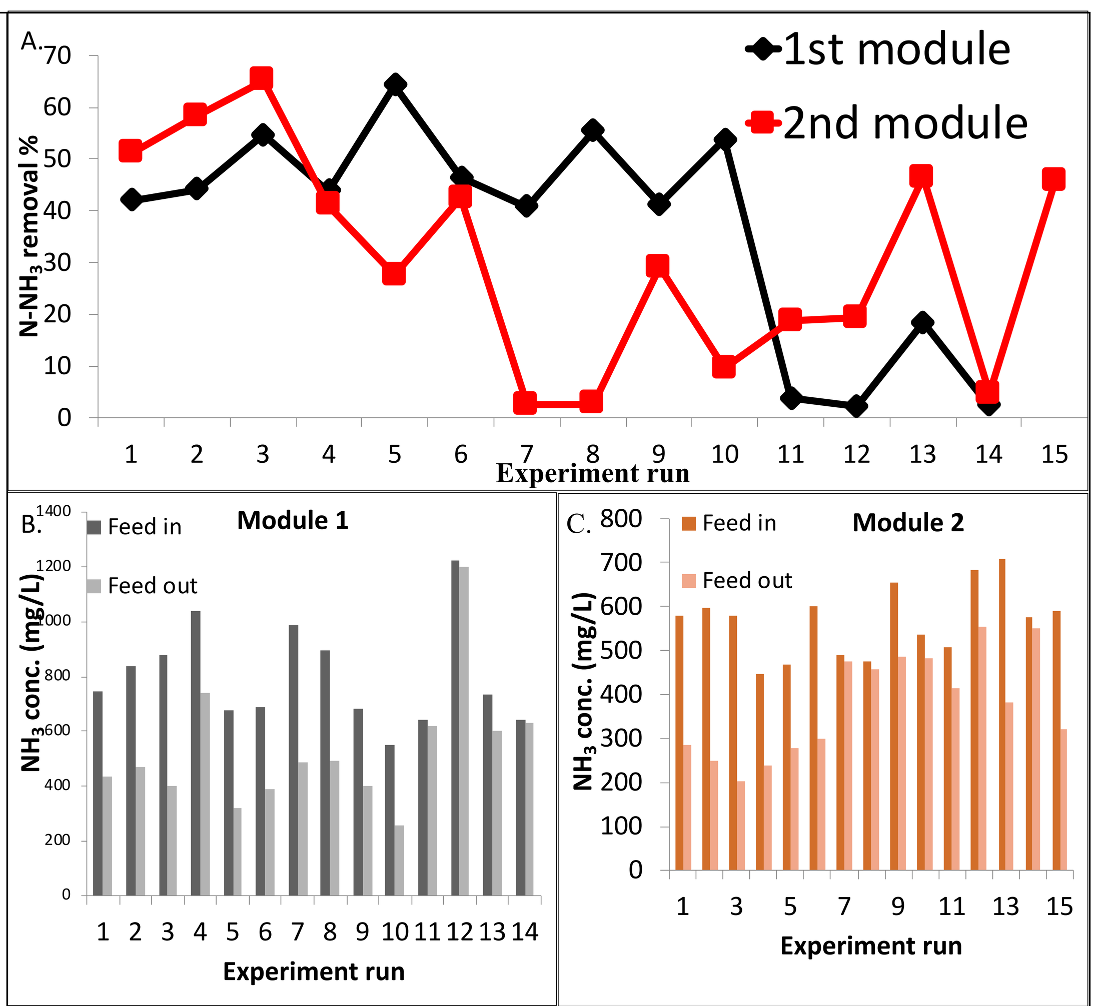
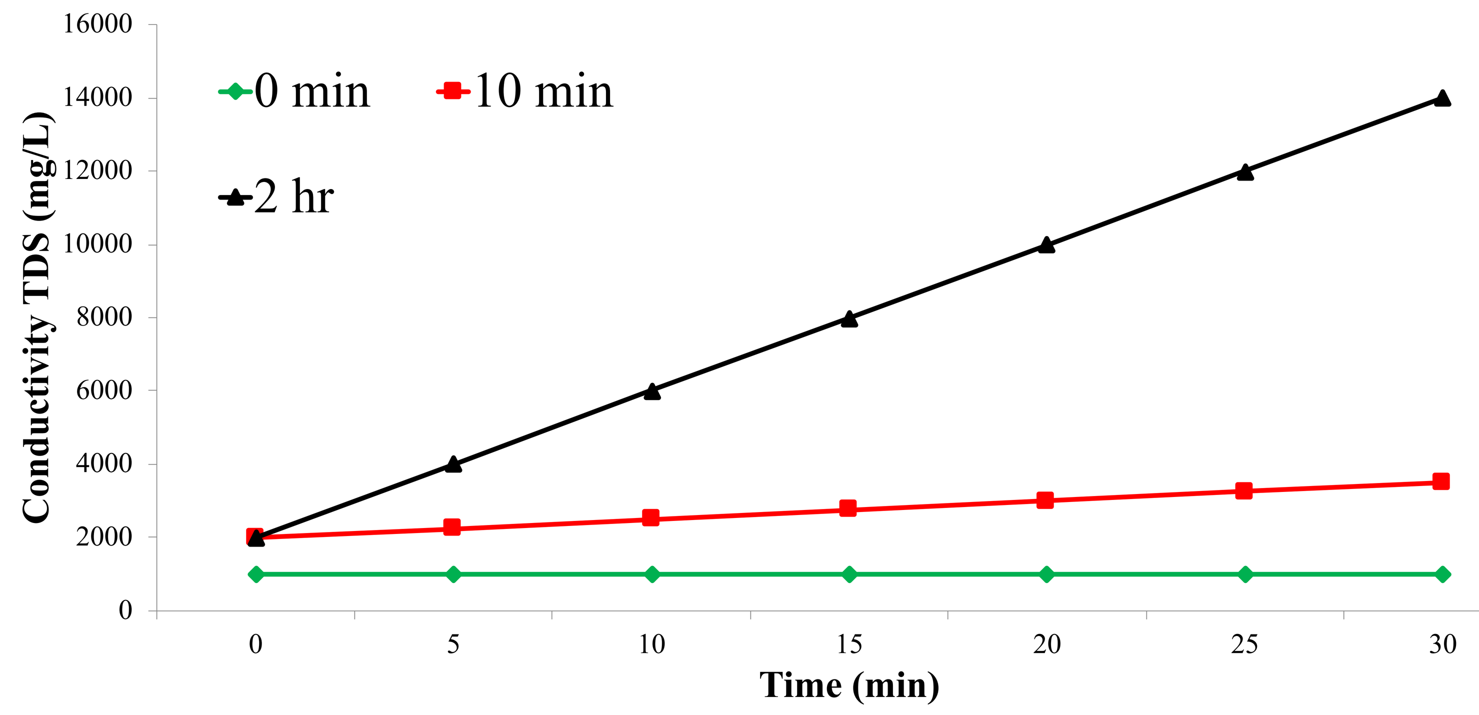


Figure 2: A) NH_4 removal % from 15 different condensate samples for the 2 modules; Ammonia concentration pre- and post-membrane for Module 1 (B) and Module 2 (C)

Conclusion:

This study describes the first pilot application of HMC for the removal of ammonia from rendering condensate from abattoirs. Up to 65% removal of ammonia from condensate wastewater was achieved using PTFE membranes while PP membranes were shown to be unsuitable for application with this type of feed stream due to membrane wetting. Installation of membranes in series could reduce ammonia levels further, while installation of membranes in parallel could allow treatment of larger volumes of condensate while allowing for redundancy to ensure continuous operation. Future research will focus on the relationship between condensate composition and membrane wetting and fouling, along with identification of more compatible polymer membrane materials.



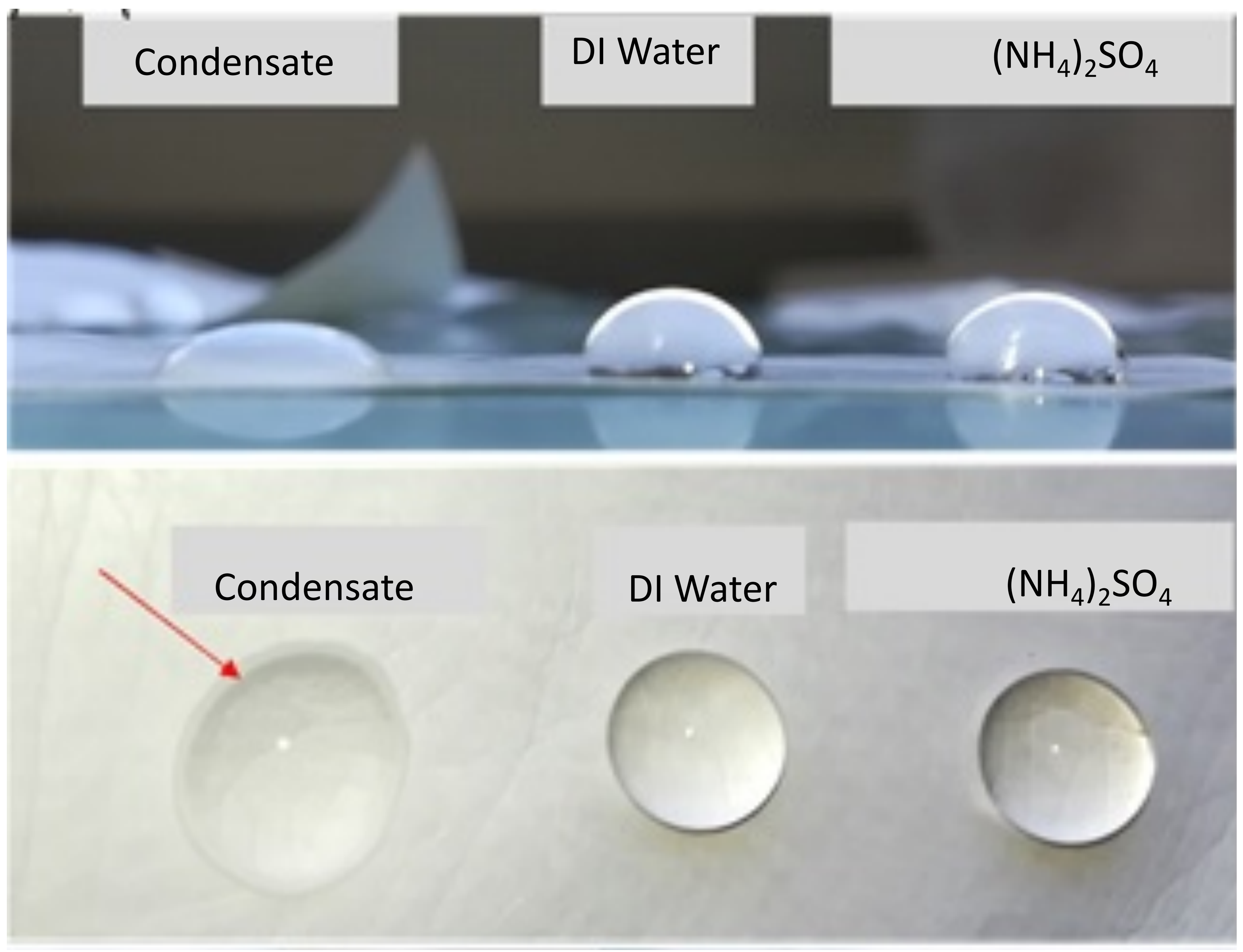


Figure 3: (upper graph) conductivity increase in the feed tank with condensate exposure times on PP module; (Lower image) membrane wetting characteristics (DI Water = deionised water)

Results and discussion

Membrane material comparison

Two PTFE membrane modules were assessed. Maximum ammonia removal for PTFE membranes was 65%, with decrease in ammonia removal efficiency after 10 and 6 days of operation at 5 hours per day. The polypropylene membrane investigated failed immediately upon contact with condensate, indicating that PP was not compatible with condensate.

Membrane wetting

A high conductivity gradient is presented between the feed and permeate side of the membrane (1 vs 30 g/L). The PP membrane was exposed to condensate for varying time periods and then conductivity on the feed side with pure water was monitored. The results suggest that the much higher conductivity rate after 2 h of exposure as opposed to 10 min exposure is wetting the membrane surface which allows back permeation of acid across the membrane. The wetting characteristics of the PP membranes were investigated using DI water, condensate and $(NH_4)_2SO_4$ (30%). Condensate has a much lower contact angle with the surface than DI water or $(NH_4)_2SO_4$. Liquids with lower surface tension have greater tendency to wet the surface, while membranes with higher surface energy are more vulnerable to wetting. The formation of a diffusion ring around the condensate droplet suggest an overall wetting of the microporous structure is taking place, confirming that PP membranes are not compatible with rendering facility condensate.

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