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Comparative Evaluation of Membrane Contactor and Stripping Device for Ammonia Separation

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Extended Abstract

This study compares two semi-operational devices for ammonia separation from high-ammonia wastewater: a membrane contactor and a stripping device. The membrane contactor utilizes a bundle of hollow-fibre membranes, facilitating the transfer of ammonia nitrogen from the outer shell into an acidic solution inside the fibres. In contrast, the stripping device operates across various temperatures, with ammonia removal assessed by absorption into an acidic solution. Both devices were tested using a model solution simulating high-ammonia liquid digestate from a biogas plant to determine their optimal operating conditions. The pilot experiments evaluated separation efficiency and highlighted each technology's unique advantages and limitations.

Our results demonstrate that the membrane contactor achieved the highest efficiency using a KH_2PO_4 solution, long fibres, and elevated temperature, resulting in complete ammonia removal within 240 minutes without pH adjustment, with 50% efficiency at 60 minutes. Further measurements without any condition adjustments resulted in a final separation efficiency of 69 ± 6% after 300 minutes, with 50% efficiency achieved at 181 minutes. Subsequent experiments using a $KHSO_4$ absorption solution helped to investigate optimal conditions and process kinetics, but the separation efficiency was lower compared to using KH_2PO_4. When using $KHSO_4$, a maximum efficiency of 93 ± 3% was obtained in 90 minutes after adjusting the pH to around 12. However, while this pH increase enhanced ammonia desorption, the high base consumption makes it economically unfavourable.

In comparison, the stripping device achieved its best results at a pH of 10.5, a temperature of 60°C, and an airflow rate of 120 l/min, reaching 85% efficiency within 50 minutes. At a lower pH of 9, the efficiency dropped to 64% over the same period. These results highlight the stripping device's potential for faster ammonia removal, though efficiency depends heavily on pH and airflow conditions.

Each technology presents unique advantages and limitations. The membrane contactor is more suitable for applications requiring fine-tuned operating conditions, whereas the stripping device is preferable for faster ammonia removal under less controlled conditions. Future research should focus on integrating these two approaches to maximize ammonia recovery, combining both technologies' strengths to enhance efficiency while reducing operational costs. Such advancements could significantly improve the sustainability of ammonia management in biogas plants.

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