

Valorization of ammonium from urban waste waters as liquid fertilizers by integration of liquid-liquid membrane contactors and electro dialysis

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Introduction

Nowadays, industrial and urban wastewaters have a huge ecological challenge due to the excessive release of reactive nitrogen compounds into the environment that pollute it and endanger human health (such as nitrogen oxides (NO and NO₂), nitrous oxide (N₂O), ammonia (NH₃), ammonium (NH₄⁺) and nitrate (NO₃⁻)) (Sareer *et al.* 2016). For this reason, in this work the use of two innovative membrane techniques is proposed: liquid-liquid membrane contactors (LLMC) (Licon Bernal *et al.* 2016). and electro dialysis (ED) (Reig *et al.* 2014). By means of this integrated system it was possible to separate, concentrate and valorise the ammonia from urban effluents.

On the one hand, the LLMC allowed the separation and recovery of NH₃ as ammonium phosphate (an added value to ammonium salts is their use as liquid fertilizers), and on the other hand, ammonium salts concentration was increased by ED to reach the required nitrogen percentage to be used as liquid fertilizer in the industry.

Material and Methods

Closed-loop experiments were carried out using a lab-scale LLMC (2.5x8 Liqui-Cel Membrane Contactor X-50 PP fiber, supplied by 3M Company (USA)) during 12.5 h at room temperature (25 °C). The NH₃ feed solution (60L (lumen tank), 1.6 g/L, pH=12), was pumped through the lumen side of the LLMC contactor at 450 mL/min, whereas the stripping phosphoric acid solution (0.5 L (shell tank), 0.4 mol/L) was circulated through the shell side in a counter-current mode at the same flow rate.

ED set-up PCCell ED 64-004 (from PCCell GmbH (Germany)) with a cell of 11×11 cm was used (5 cell pair). Membranes, with an active area of 64 cm² each one, were supplied by Fujifilm and PCCell companies. Moreover, the effluent obtained from LLMC (NH₄H₂PO₄ solution) was used as feed solution in the ED system. The initial volume of each stream was 1L. Diluate and concentrated solutions were pumped at 15-20 L/h, while the electrode rinse stream was pumped at 90-100 L/h. Constant voltage of 7.5 V was applied for all the experimental assays (voltage drop of 1 V for each cell pair (5 V) plus 2.5 V across the electrode compartment), while current

density varied up to 4 A \sim 0.63 kA/m² (5 A was the upper limit allowed by the power cell, Manson HCS-3202).

Results and Discussion

The results showed that the separation of ammonia from lumen tank (feed solution) to shell tank (ammonium phosphate solution) using LLMC was 86 \pm 3%; whereas it was possible to concentrate the ammonia 33.9 times after 12.5 h. Additionally, the concentration of ammonium phosphate achieved (from shell tank) as N and P₂O₅ were around 5 \pm 2% and 15 \pm 3%, respectively. Subsequently, the ammonium phosphate stream produced by LLMC was concentrated (concentration factor \approx 50%) using both types of membranes (there were no differences in performance results) after 3.5 h of ED process.

Conclusions

Overall, these results highlighted the possibility to separate, concentrate and valorize ammonia from industrial streams, as ammonium phosphate salt, for producing liquid fertilizers through the integration of liquid-liquid membrane contactors and electro dialysis techniques.

References

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