Biogas enhancement using membranes: crystallization and crystal harvesting mechanisms

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Introduction

Nowadays, many water companies are investing in biogas upgrading facilities for the production of natural gas equivalent, thanks to biogas incentivisation. Anyway, a digression of the incentive tariff has been announced, hence identifying routes to add value during biogas upgrading will de-risk the investment decision.

With novel hollow fibre membranes it is possible to remove CO₂ from biogas with aqueous ammonia and thanks to the ammonium bicarbonate crystallization it is also possible to remove nitrogen from liquor in the WWTP. This results in energy saving in the nitrification process, because a lower oxygen supply is needed, and also in the possibility to sell crystals as fertilizer byproducts.

Aim

Characterisation of the mechanisms which govern NH₄HCO₃ crystallisation in GAS/LIQUID processes

Advantages of ammonium bicarbonate crystals:
1) Regeneration of the reaction product;
2) Sale of ABC as fertilizer by-products.

In situ crystal formation

NH₃-CO₂-H₂O Reaction

NH₃(l) + CO₂(g) + H₂O(l) ⇌ NH₄HCO₃(s)

CO₂ MFC Module

Module with singular hollow fibre membrane

Mass transport depends on the individual mass transfer coefficients of the liquid phase, membrane and gas phase (respectively \( K_l \), \( K_m \), \( K_g \)). Effective diffusion coefficient of pure gas filled in the pores (\( D_{g,eff} \)) increases for \( V_{gas} > 0.3 \) m/s \( \Rightarrow \) \( k_m \) increases

Solution

Increasing the pressure from 1 to 2 bars, the JCO₂ is much more constant and similar to the literature

Future work

• Commence controlled nucleation (or crystal growth initiation) experimentation using new flat-sheet membrane system using membrane material with different pore properties.
• Ensure data reproducibility to characterise time-lapse crystal growth.
• Establish baseline CO₂ flux data under varied ammonia concentrations within appropriate process hydrodynamic boundary conditions.

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