# Design of enzyme stabilisation systems for gas separation: Novel studies on formulation of enzyme-based W/O emulsions to prepare emulsion-based supported liquid membranes for $CO_2$ capture

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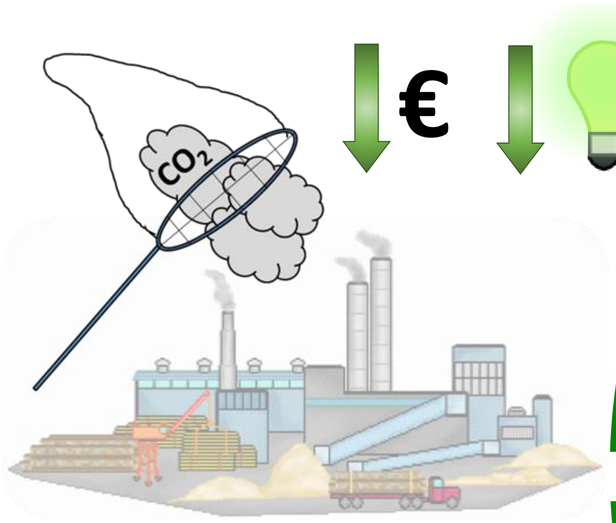
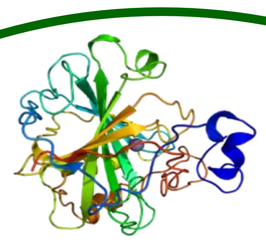
## Background

- Global warming, majorly due to $CO_2$ emissions, is one of direst threat and a highly debated topic on this planet.
- Post-combustion carbon capture technology, including membrane-based separation and enzyme-based methods are widely studied within the scientific community.
- Membrane-based gas separation is an essential unit operation in chemical industries due to its simplicity, ease of operation, compact structure & reduced energy consumption [1].
- The separation efficiency of membranes strongly depend on the type of materials used for its preparation [2].
- Membrane emulsification has widely gained attention due to its inherent characteristic of being a mild and low energy intensive technique, suitable for sensitive enzymes [3].

## Motivation



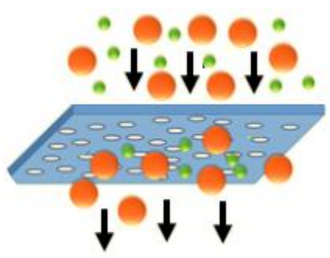

## Project in a Gist…



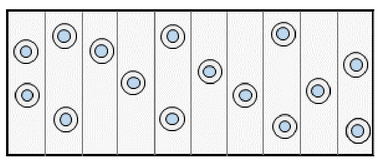
Enzyme stabilised in water

Plant-based oil


Membrane emulsification

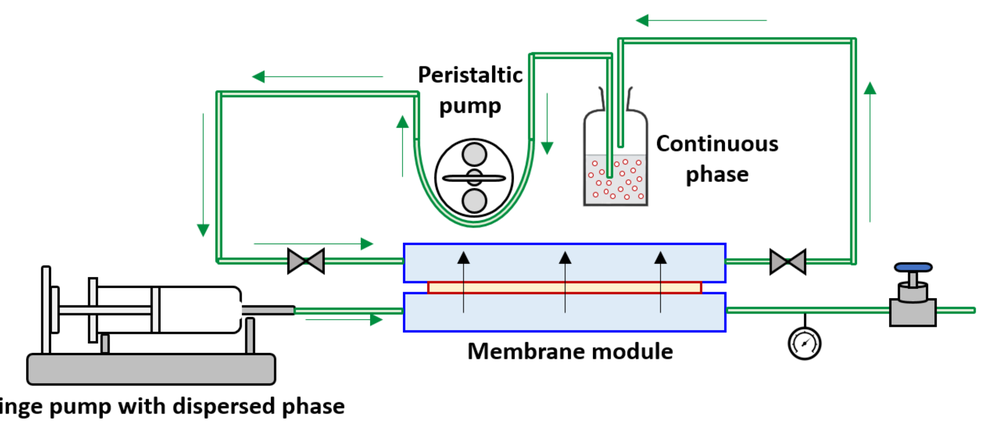


Gas permeability studies



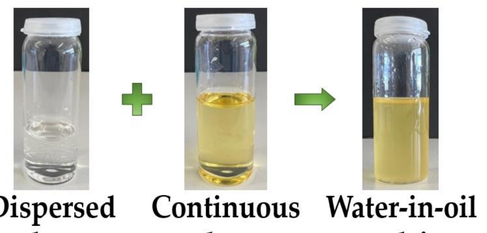
Membrane synthesis

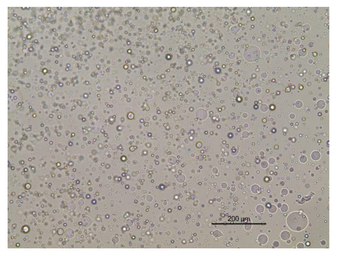
## Membrane Emulsification



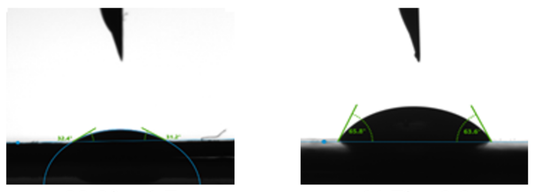

Dispersed phase: 0.5 g.L$^{-1}$ carbonic anhydrase enzyme with 5 % PEG 300 (w/w) in aqueous solution

Continuous phase: 2 % Tween 80 (w/w) in corn oil

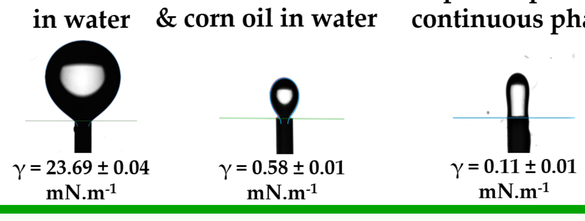


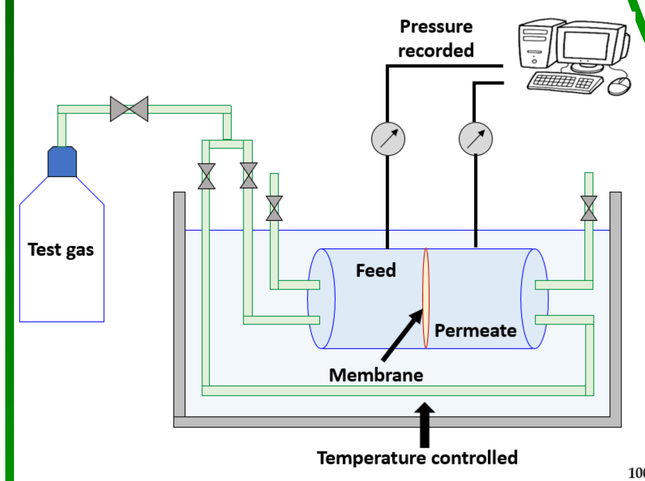
### Contact angle studies



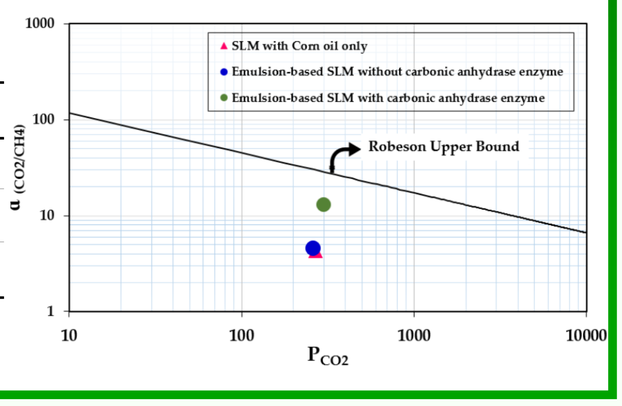

### Interfacial tension studies



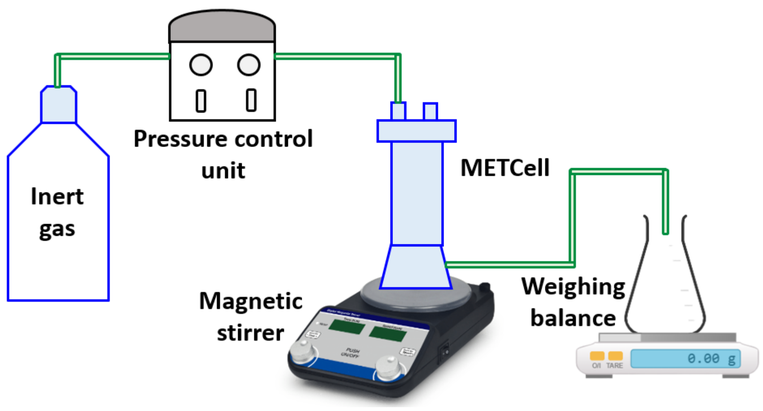

## Gas Permeation




| Membrane tested | $P_{CO_2}$ (Barrer) | $P_{CH_4}$ (Barrer) | Selectivity ($\alpha_{(CO_2/CH_4)}$) |
|---|---|---|---|
| Support Membrane + Corn Oil | 267.40 ± 3.60 | 62.00 ± 3.70 | 4.31 ± 0.20 |
| Emulsion based SLM without Carbonic anhydrase | 259.90 ± 3.30 | 57.30 ± 5.50 | 4.54 ± 0.40 |
| **Emulsion based SLM with Carbonic anhydrase** | **301.85 ± 7.45** | **23.55 ± 0.65** | **12.82 ± 0.10** |




## Emulsion-based SLMs




W/O emulsion impregnation onto polymeric membrane

## Outlook and Future Perspectives

- A detailed experimental methodology was incorporated to explore the biogas separation capabilities of a bio-based emulsion system impregnated onto a membrane support.
- More efforts can be channelised for the characterisation of the W/O emulsions produced by energy efficient and mild 'membrane emulsification' technique.
- $CO_2$ permeability increased by ~15 % and that of $CH_4$ decreased by ~60 % through the emulsion-based SLM containing carbonic anhydrase when compared to that without it.
- As a *proof-of-concept*, this work portrays the enhanced, synergetic effects of carbonic anhydrase within a bio-based emulsion system for $CO_2$ capture.

## References

[1] K. Friess et al., A review on ionic liquid gas separation membranes (2021), *Membranes*, 11 (2), 97.
[2] G. Genduso and I. Pinnau, Quantification of sorption, diffusion, and plasticization properties of cellulose triacetate films under mixed-gas $CO_2/CH_4$ environment (2020), *Journal of Membrane Science*, 610, 118269.
[3] U. T. Syed et al., Greening perfluorocarbon based nanoemulsions by direct membrane emulsification: Comparative studies with ultrasound emulsification (2022), *Journal of Cleaner Production*, 357, 131566.

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