Development of a Membrane Filtration Cascade for the Recovery of Biomass-Derived Fatty Acids

Master of Chemistry – Thesis Presentation

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July 2020

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Introduction

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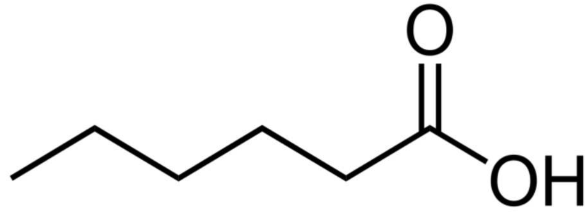
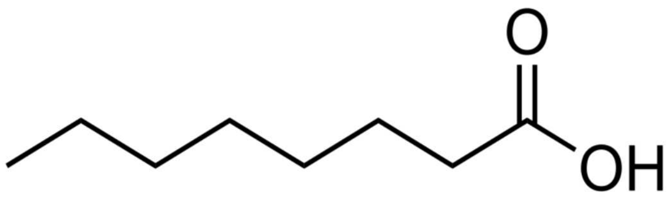
- A membrane filtration cascade was designed for the recovery of MCFAs from fermentation broth
- Three step filtration sequence
- First stage: membrane screening for UF and NF
- Second stage: optimisation of pretreatment and process parameters

Context

- The MCFAs are useful and valuable precursor chemicals
- Applications in lubricants, fragrances, pharmaceuticals, etc.
- Current source is food crops such as palm and coconut oil
- Separation from biogas broth is a potentially sustainable solution
- Most prior studies relate to extraction

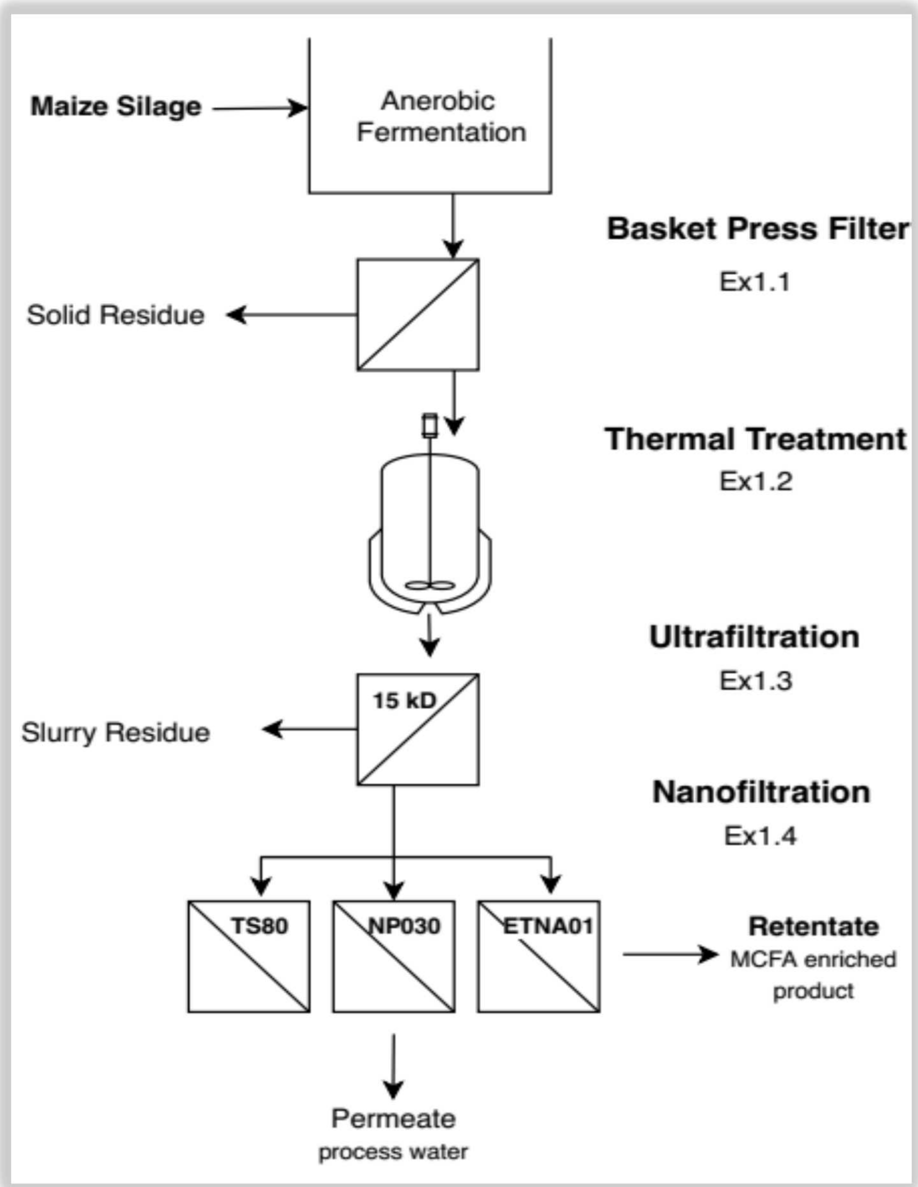




Experimental Plan

Stage One

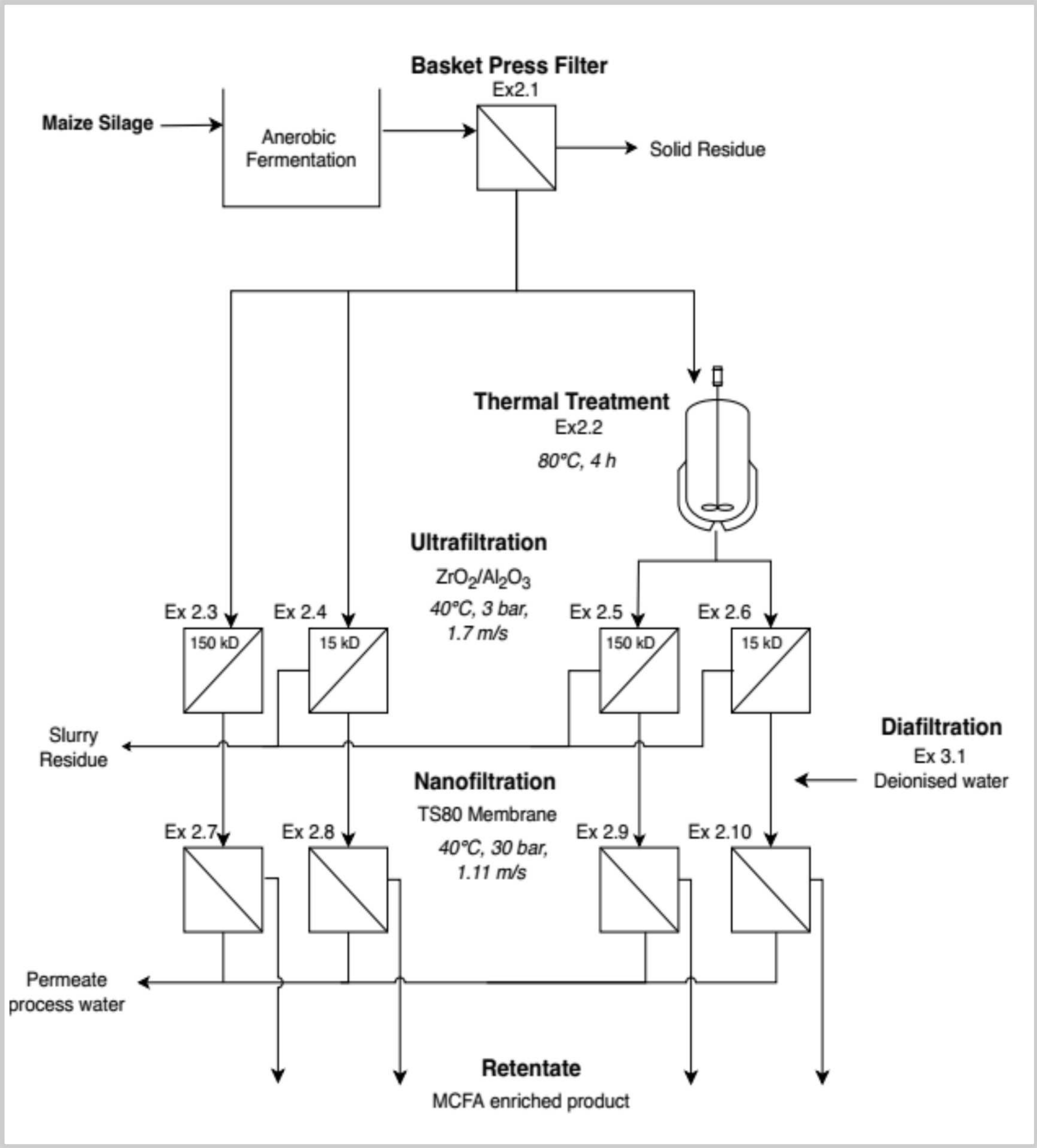
NF Membrane Screening



Experimental Plan

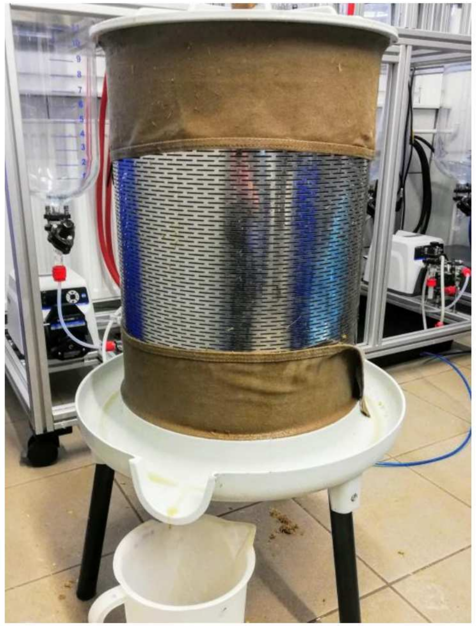
Stage Two

Process Parameter and Pretreatment Optimisation



The Process

- Step 1: Removal of course solids



Basket press

Fermentation Broth

Filtrate
80%

Solids
20%

The Process

- **Step 2: Removal of fine solids and macromolecules (15 or 150 kD ceramic membrane)**

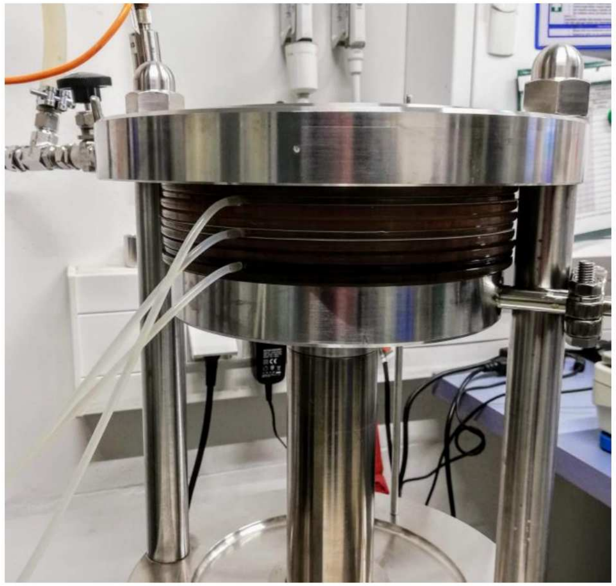
PiloMem 1

Permeate
90%

Retentate
10%

The Process

- **Step 3: Concentration of MCFAs in NF retentate (150, 400 & 1000 D polymer membranes)**



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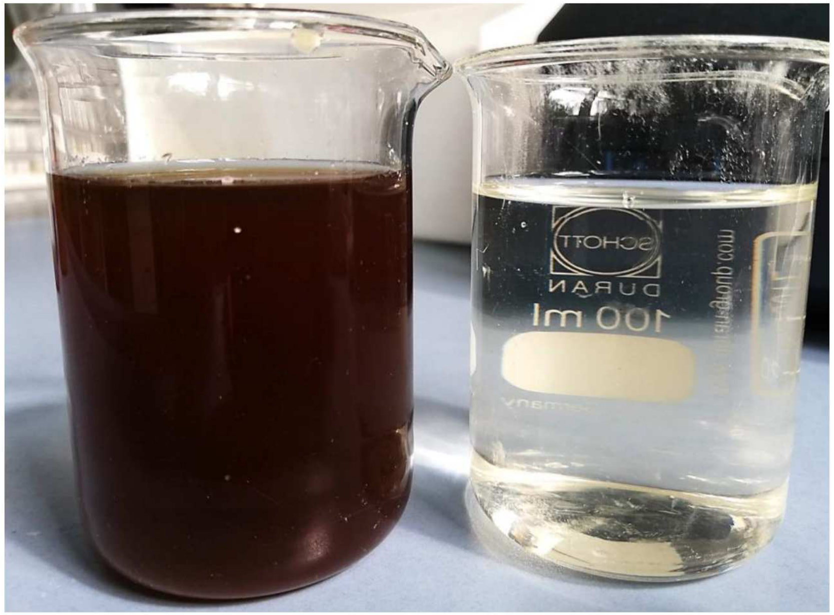


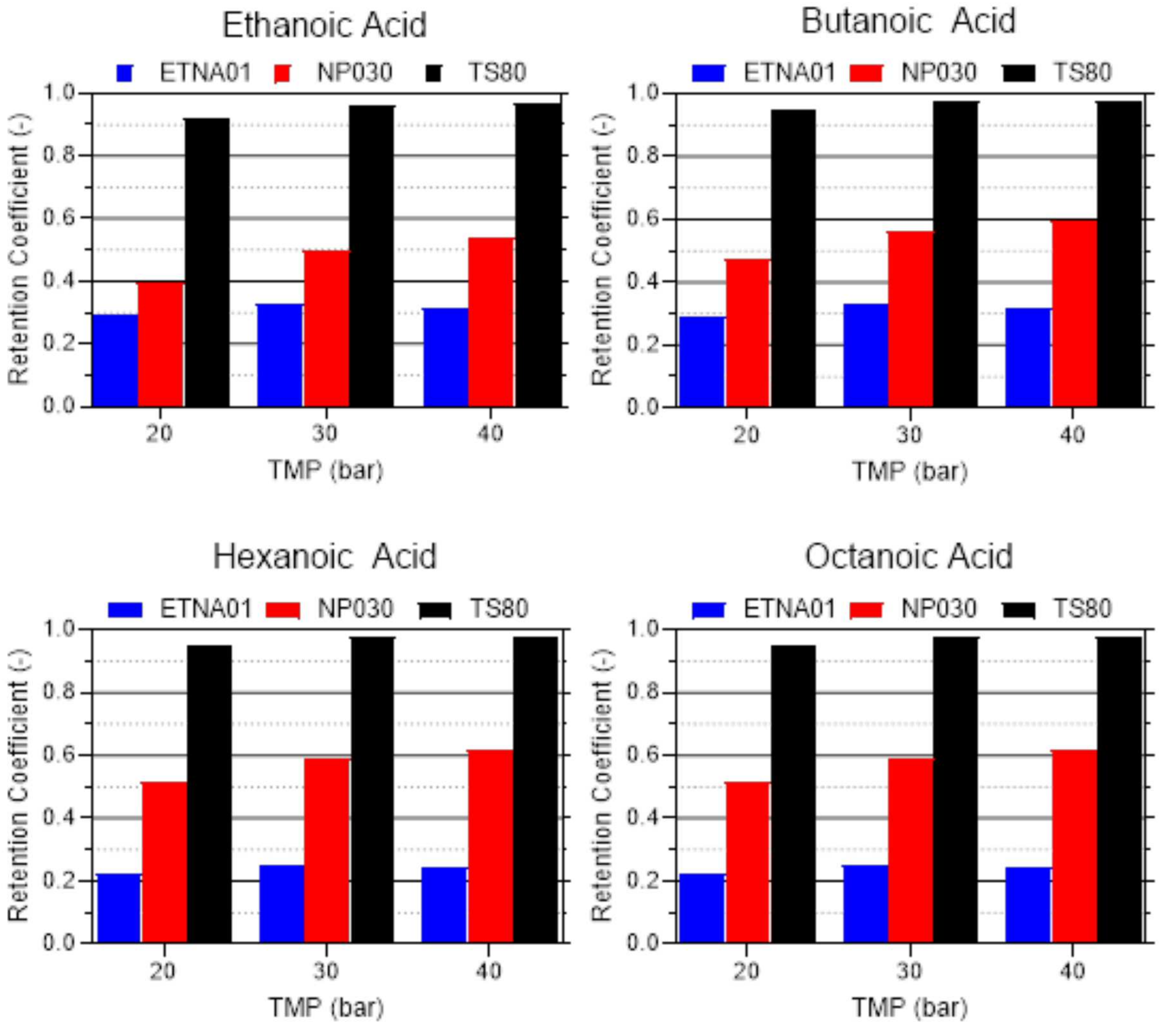
Retentate 60% **Permeate 40%**

The Results

Membrane Screening

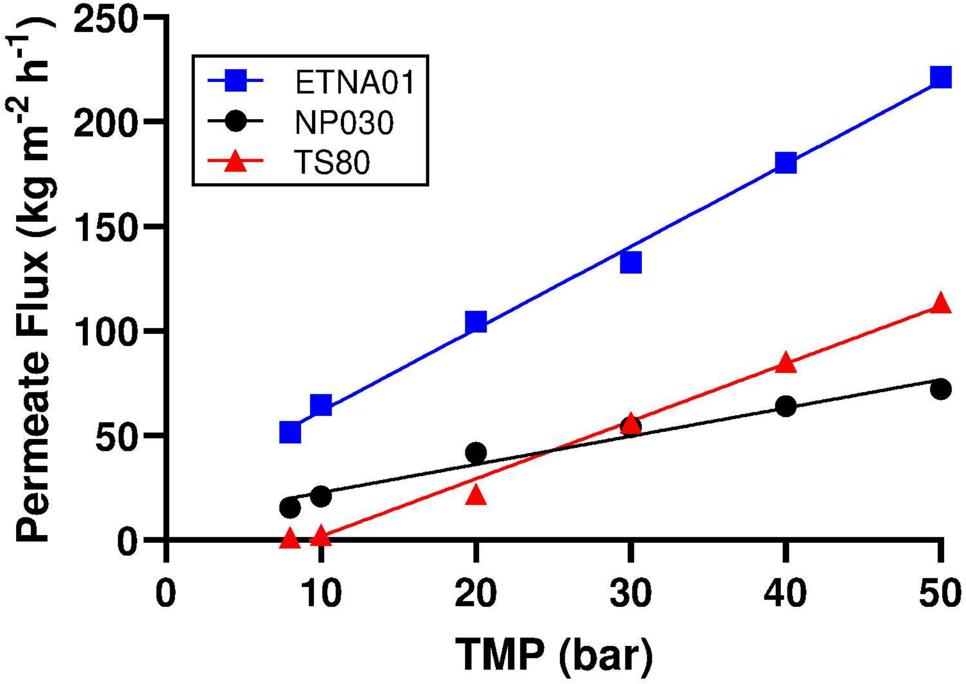
Retention of C2-C8 FAs

- ETNA01 (1000 D): 20-30%
- NP030 (400 D): 40-60%
- TS80 (150 D): 90-100%

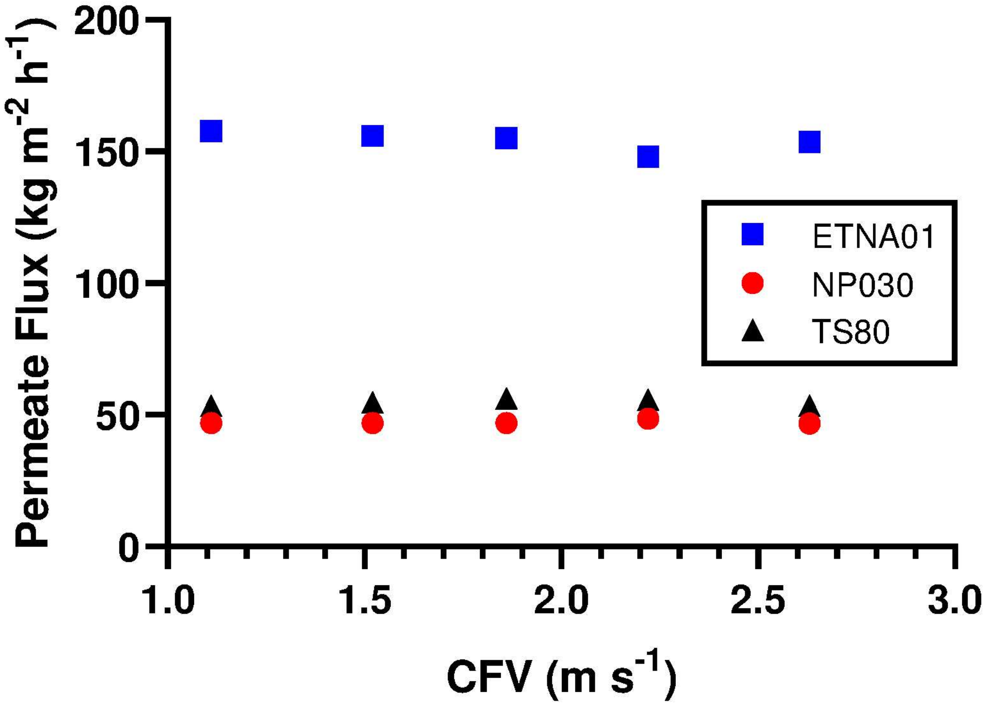


The Results

Membrane Screening



Flux vs Transmembrane Pressure



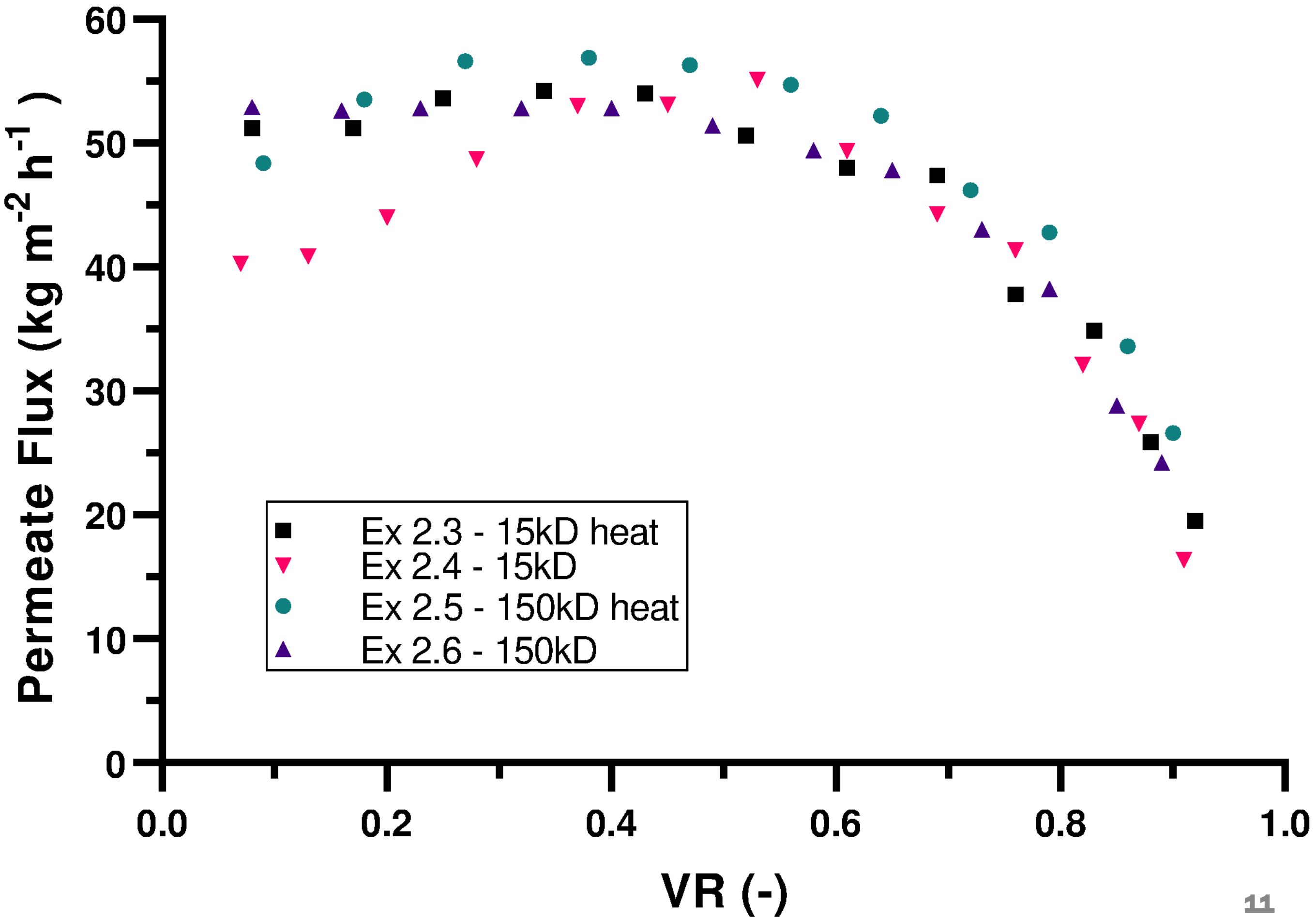
Flux vs Crossflow Velocity

The Results

Process Parameter and Pretreatment Optimisation

Ultrafiltration

- Little effect from pore size or heat treatment
- Initial flux increase from process instability or "prefilter" cake formation
- Similarity of 15 and 150 kD suggests flux limitation by surface layer



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The Results

Process Parameter and Pretreatment Optimisation

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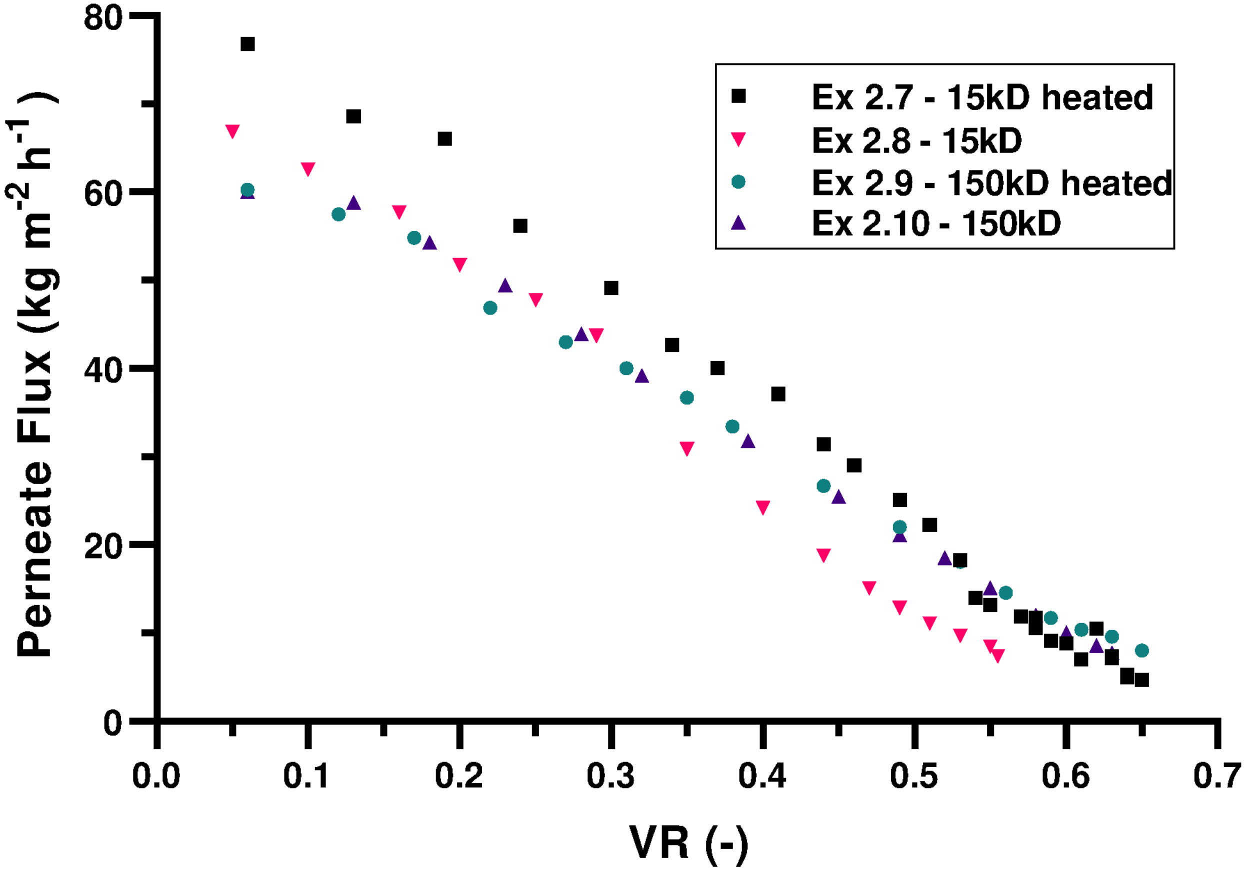
Nanofiltration

- High initial flux but rapid flux decline, limit of 0.55-0.65 VR
- 15 kD heated flux initially high, but had similar endpoint
- No advantage of feed reintroduction after membrane cleaning



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The Results

Process Parameter and Pretreatment Optimisation

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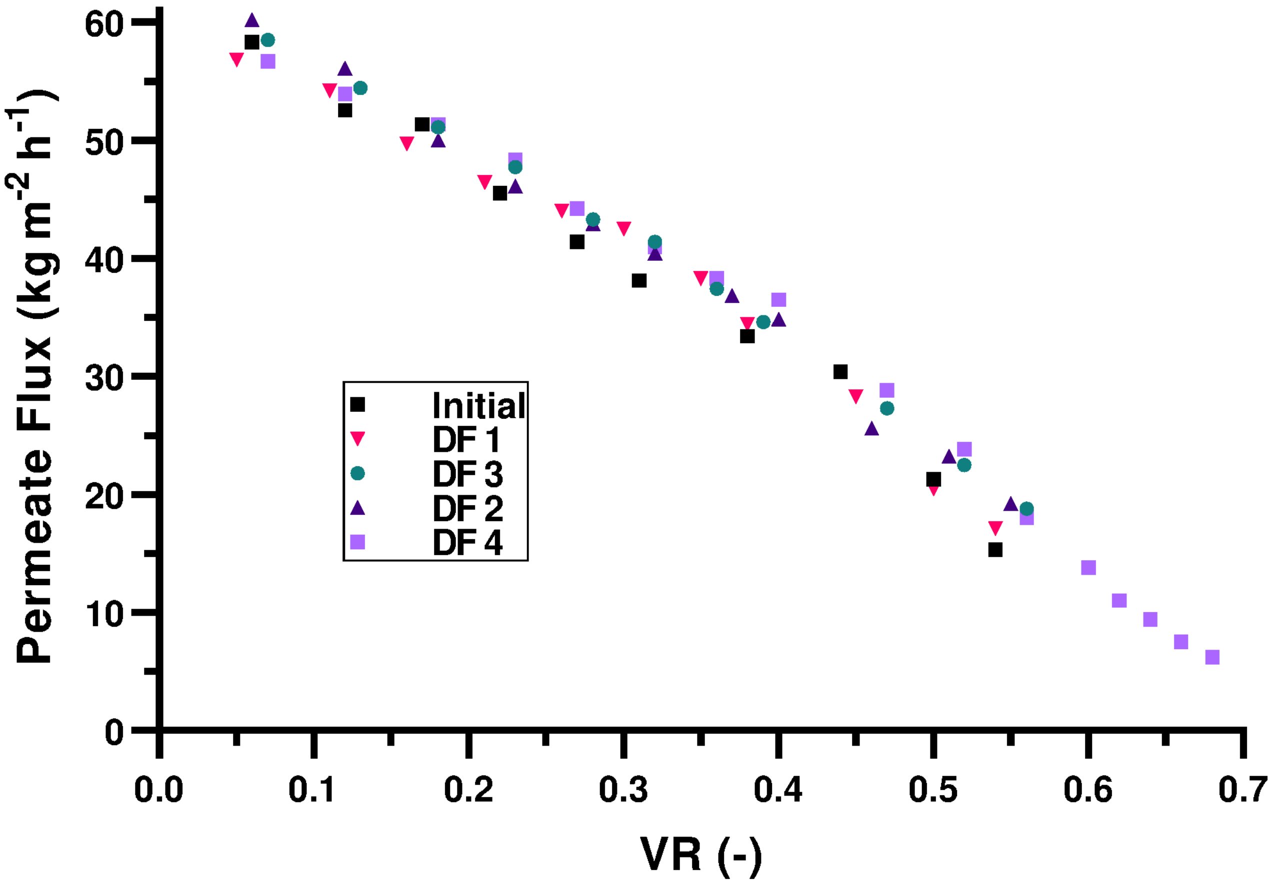
Diafiltration

- **Negligible flux increase**
- **No advantage for DF considering the significant costs**
- **Impurities and foulants could not be washed through the membrane**



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The Results

DBFZ

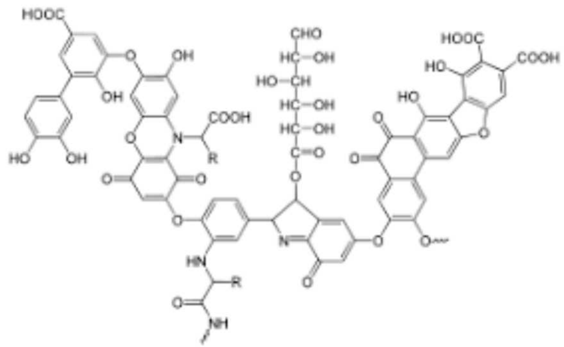
Membrane Fouling

- Possible foulants isolated from NF retentate
- Both pass through UF and precipitate during NF
- Their removal or breakdown must be investigated

Pyruvate?

NH_4MgPO_4

Humic Substances?



The Conclusions

Very effective separation in the first two steps:

- Basket press ~80%
- Ultrafiltration ~90%

Pretreatment and UF pore size had no effect on flux

Nanofiltration concentration limited by membrane fouling

Diafiltration was ineffective

Until fouling is controlled, process is not feasible

Partially concentrated NF retentate is an improved feedstock

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What's next?

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Identify NF foulants and attempt to remove them

Perform UF with tighter membranes (10, 5, 1 kD)

Screen other NF membranes

Still no luck? Optimise filtration cascade as a pretreatment for further purification