Integration of Membrane Processes for Decolourisation of Starch Hydrolysates

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Introduction

- Starch Hydrolysates:

Brilliant
Light Coloured

Transparent Syrup

- Purification after saccharification necessary:
  - Yellow colour from Maillard reactions
  - Salt residues
  - Protein, Peptide, Amino Acid residues
  - Other organic molecules

Activated Carbon (AC)
Chitosan
Ion exchange resin adsorption
Chemical and biological reactions
Extractions, etc

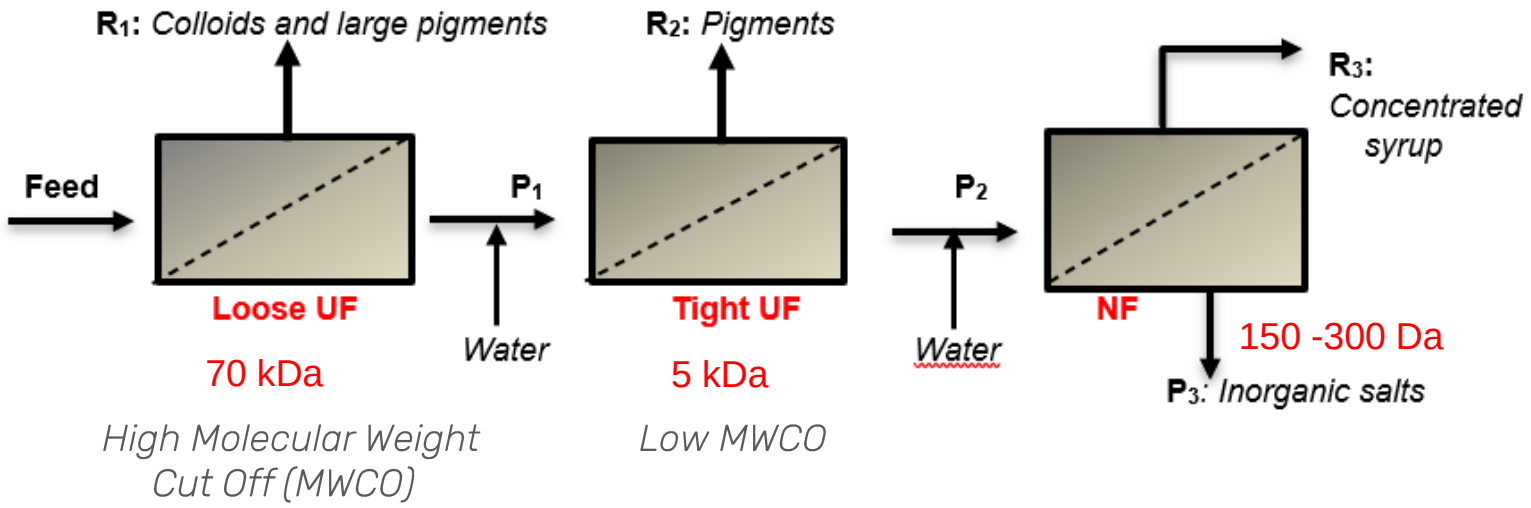
Adsorbent pre-treatment/regeneration
Extra chemicals
Environmental and safety problems

- Solution:
  - Membrane technology: a green method for separation and purification
  - Simple operation, small footprint, no chemical addition, and mild operation conditions
  - Applied in fermentation broth, soy sauce, palm oil, sugarcane juice treatment

Introduction

- Equilibrium between colour removal and sugar permeability
  - Single membrane filtration process is impractical in achieving both
  - Integration of membrane processes is proposed to increase performance

Limited selectivity
Low permeate fluxes
Membrane fouling
Hampering technological upgrading on an industrial scale.

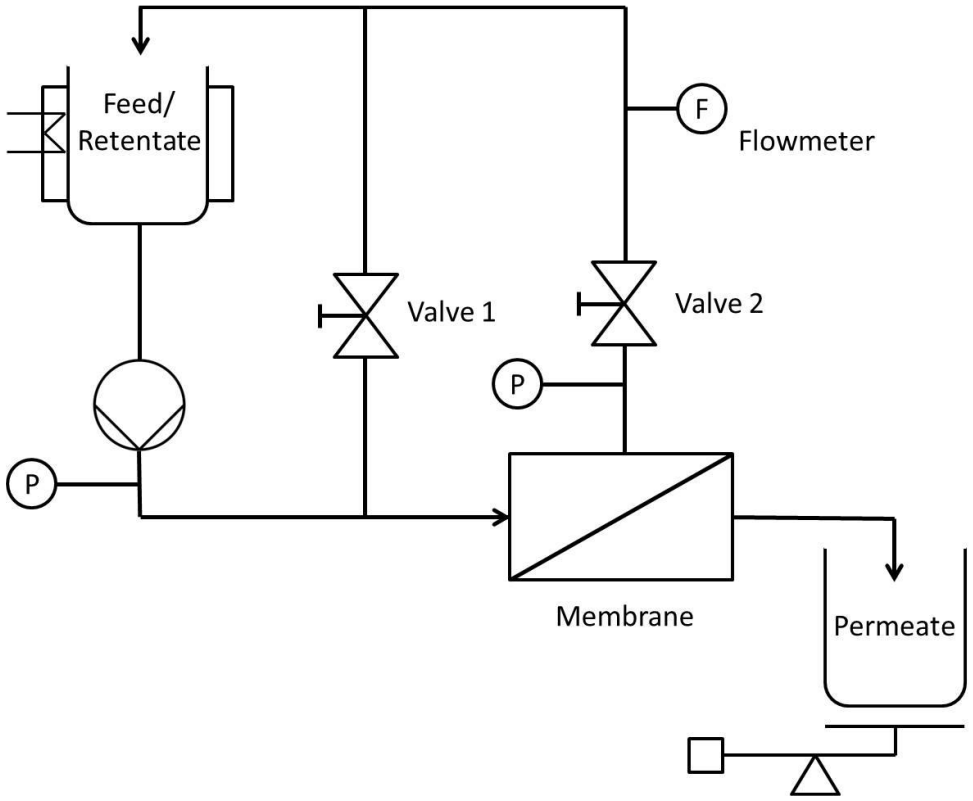


Three commercially available Ultrafiltration (UF) and Nanofiltration (NF) membrane were evaluated individually,

Membrane crossflow tests to analyse their behaviour in the proposed system

Diagram for starch hydrolysates treatment by an integrated membrane system (R=Retentate; P=Permeate).

Materials and equipment



- **Feed Syrup:** Prefiltered starch hydrolysates by AGRANA Stärke GmbH
  - *High viscous solution*
  - *High sugar concentration*
  - *70 % DS*
  - *Standard pH value = 4,5*
- **Lab-scale crossflow filtration unit:**
  - Effective area: 0,008 m^2 (0,04 m x 0,2 m)
  - Max. flow: 3,7 L/min
  - Max. pressure: 64 bar
  - Max. temperature: 70 °C
  - Initial load: 2 L feed tank
    - *1,5 L permeate (stop criteria)*
    - *0,5 L Retentate*
- **Operating conditions:**

Parameter	Loose UF	Tight UF	NF
Temperature (°C)	60	60	60
Transmembrane Pressure (bar)	8	8	30
Feed Concentration (°Brx)	30	20	15

Analytic Methods

- Colour: UV/visible scanning spectrophotometer, based on ICUMSA spectrophotometric Method at 420 nm
- Sugar concentration: Optronic Digital Refractometer (° Brx)
- pH and Conductivity: Digital multiparameter
- Fouling Mechanism: Water Permeability before and after filtration (L/m^2.h)
- *Membrane-performance parameter:*

$$\text{Colour/Sugar/Salts } Rejection\ \% = \left(1 - \frac{C_p}{C_f}\right) * 100$$

Cp = concentration in the permeate/retentate
Cf = concentration in the feed

Membrane Separation Performance

- Loose UF:

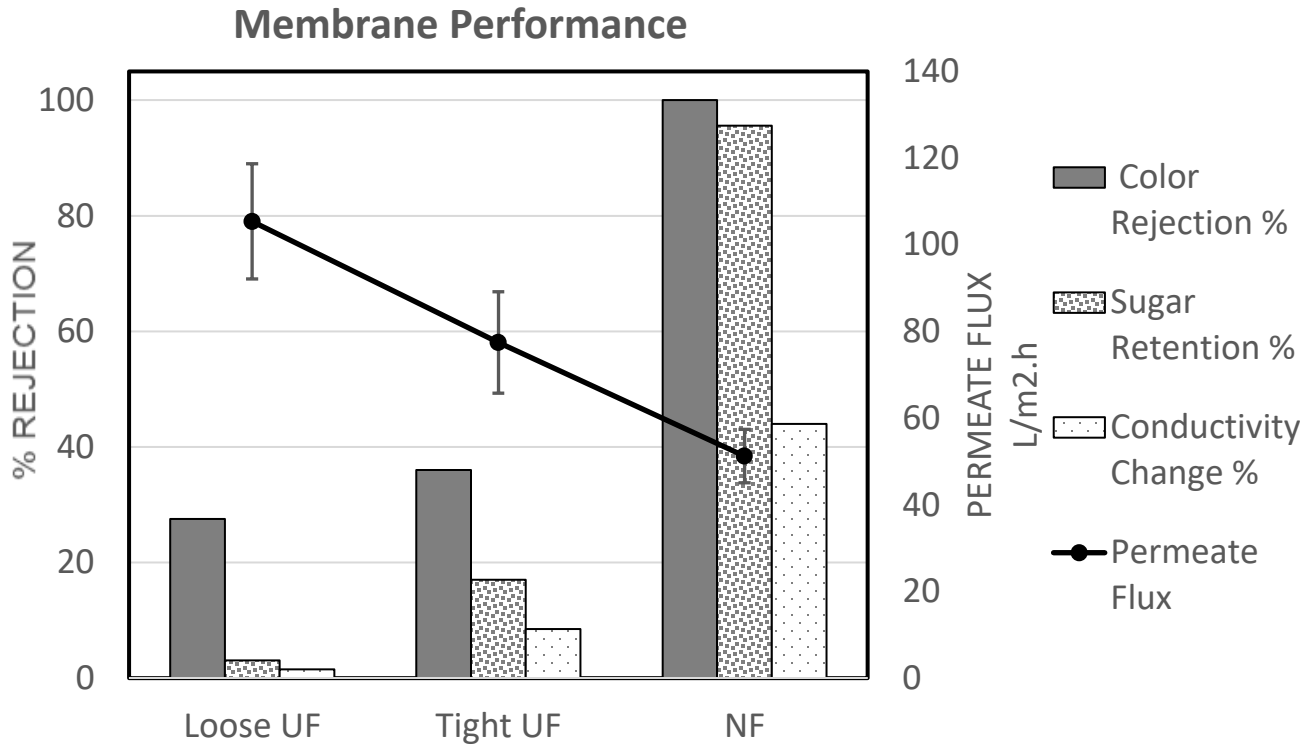
No fouling effect due to large pore size
No significant changes in conductivity and sugar content
28 % of colour removal

- Tight UF:

Water flux permeability diminished by 30 %
Highest colour removal up to 36 %
17 % of sugar retention.

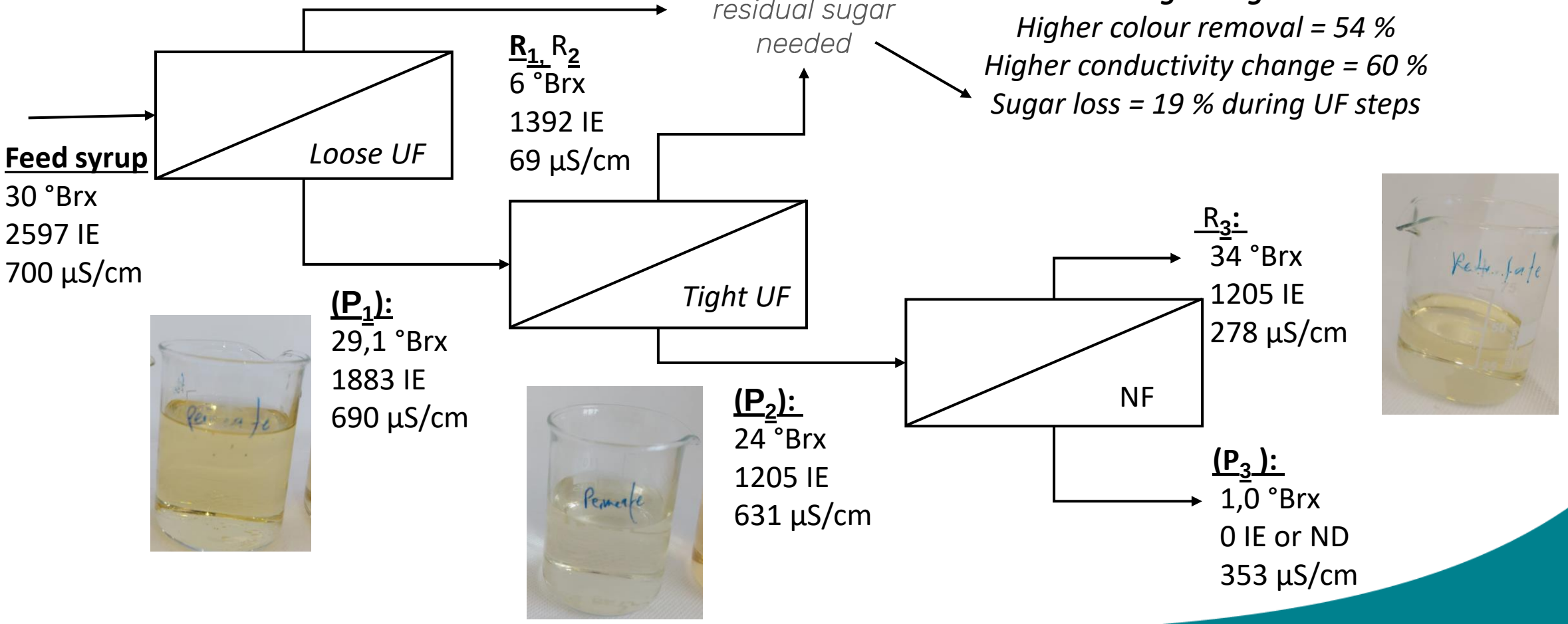
- NF: *(The final product in retentate)*

No colour removal
The concentration of the final product up to 96 %
56 % of demineralisation
Only 5 % flux reduction



Benefits of the membrane integration

Theoretical Balance across filtration process:



The final product in comparison with a single stage:

Higher colour removal = 54 %

Higher conductivity change = 60 %

Sugar loss = 19 % during UF steps

Conclusions and recommendations

- Membrane process integration could improve partially decolourisation and demineralisation of starch while concentrating the final product
- Sugar recovery methods should be investigated in the following studies to further improve the system's benefits
- Membrane integration could also attenuate the fouling effect, avoiding fouling aggravation in the following steps.
- If a better performance of membranes is achieved during the integration, like better permeate fluxes and colour removal, the reduction of membrane area and chemicals could also be achieved.
- More analysis of the multistage membrane system is needed to assess the fouling mechanisms, optimal operating parameters, improve colour removal and sugar recovery, and select cleaning methods.

Thank you!!

Questions?

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