



# A Membrane-Based No-Waste Extract Decolorization Process

*by Steve Peacock,  
Cy Gaudet & Lily Crane*

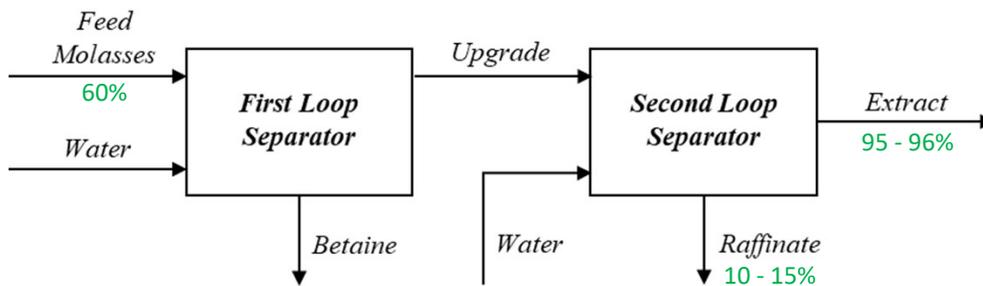


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# INTRODUCTION

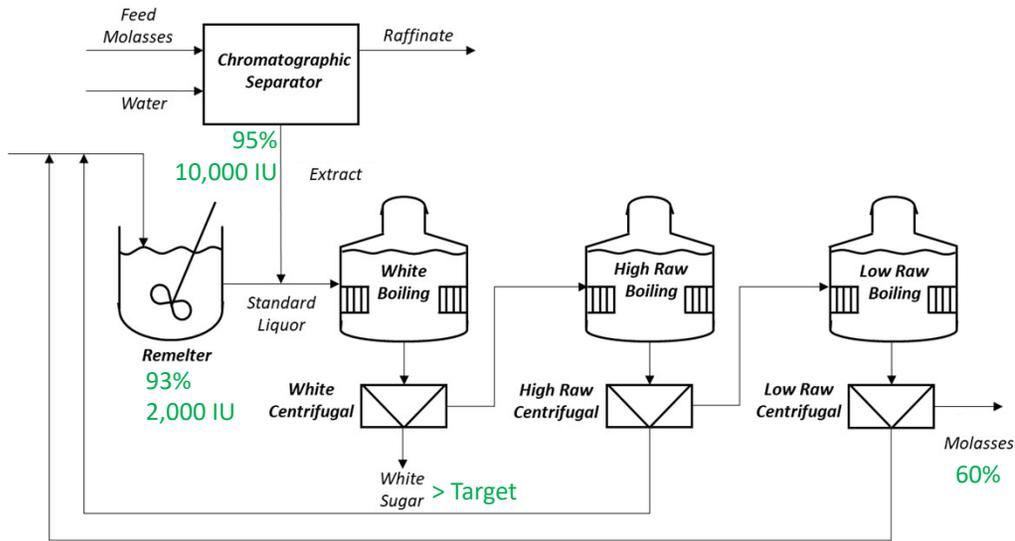
## Molasses Desugarization

Z value  $\geq 84\%$



# MDS INTEGRATION

## Extract Into First Boiling

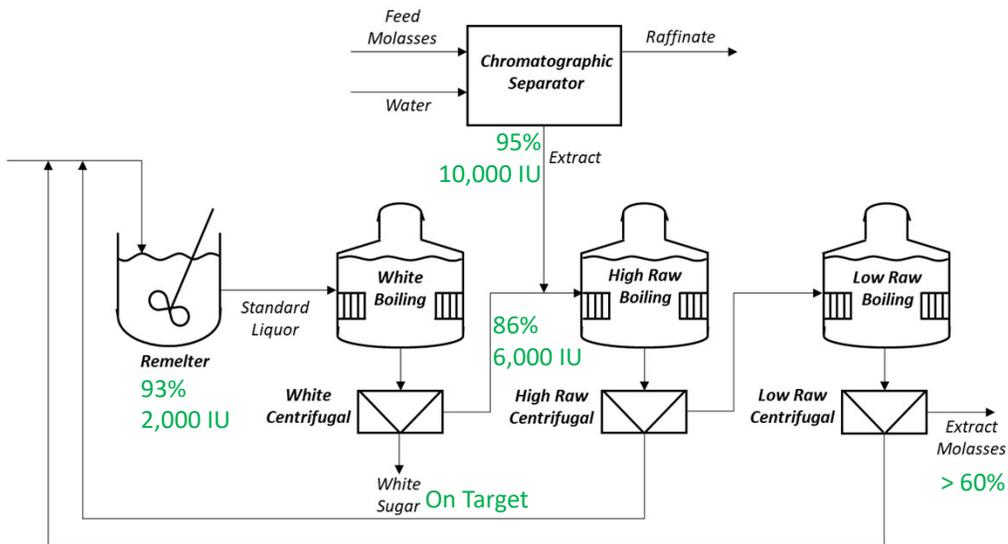


Good sucrose recovery  
Poor sugar quality



# MDS INTEGRATION

## Extract Into Second Boiling



Poor sucrose recovery  
Good sugar quality



# MDS INTEGRATION

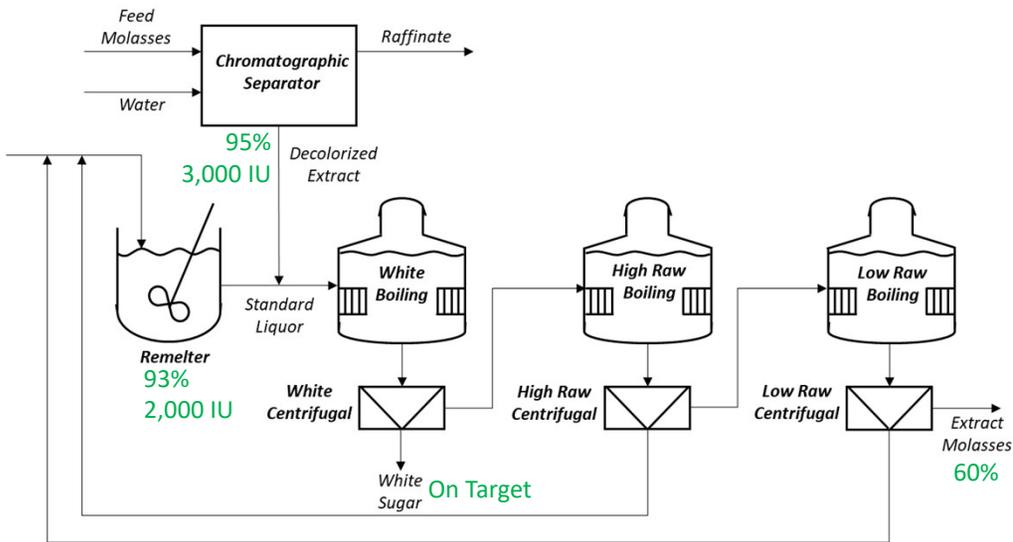
## Recycle to Beet End

- Significant operating costs
  - Energy, consumables, labor, maintenance
- Unaccounted losses due to increased sucrose recycle



# MDS INTEGRATION

## Extract Decolorization

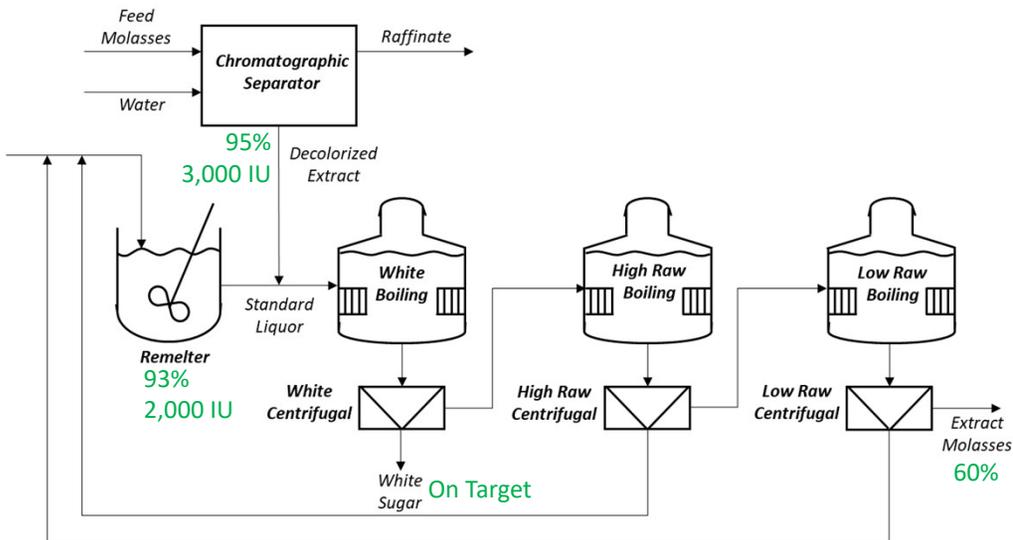


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Good sucrose recovery  
Good sugar quality

# MDS INTEGRATION

## Extract Decolorization



- Standard technology in cane sugar refining
  - Feed liquor colors 500 – 1,500 IU
- High color loads in extract decolorization
  - Short decolorization cycles
  - Frequent regeneration
  - High salt brine consumption
  - Large waste brine disposal costs



Good sucrose recovery  
Good sugar quality

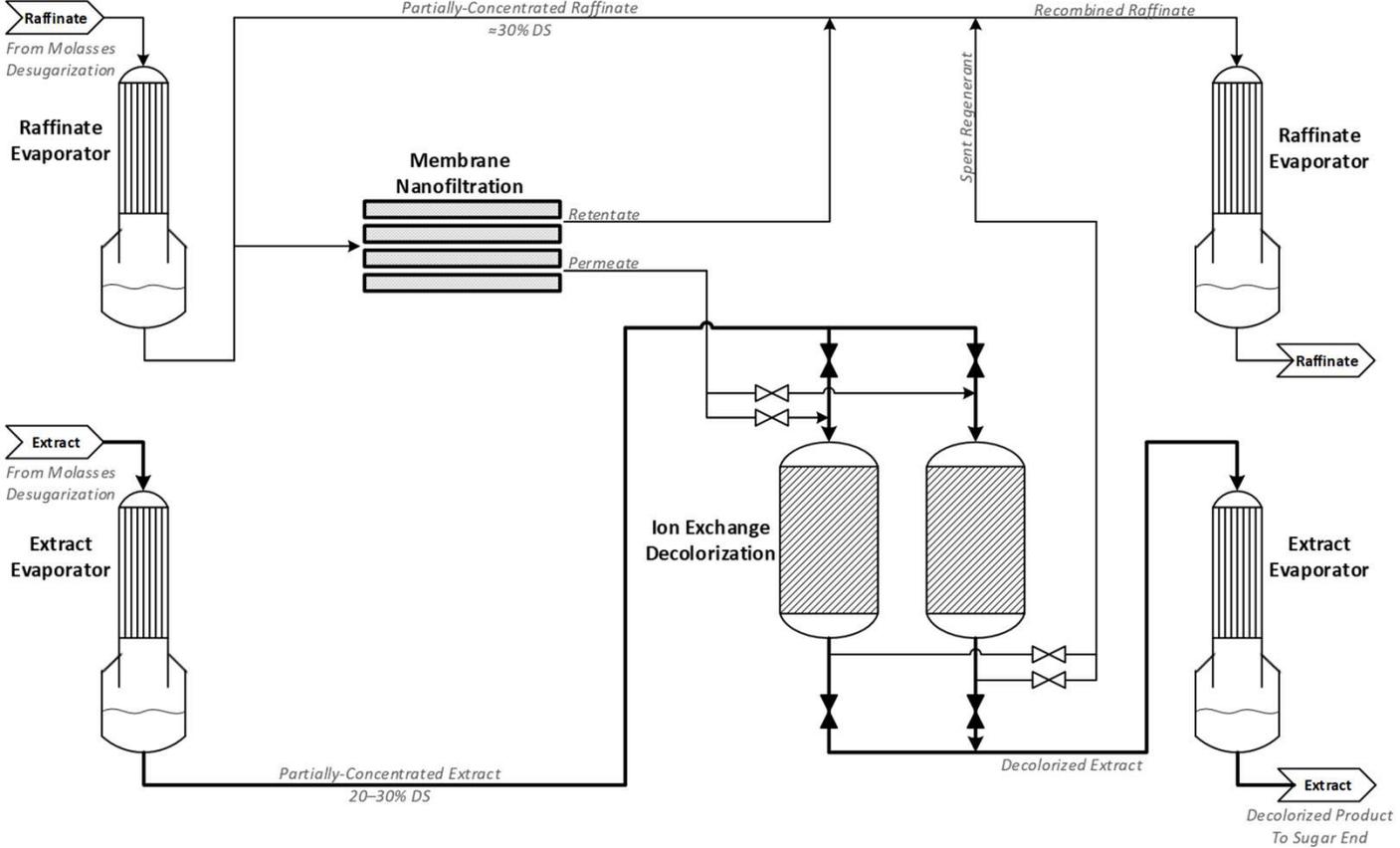
# NO-WASTE DECOLORIZATION

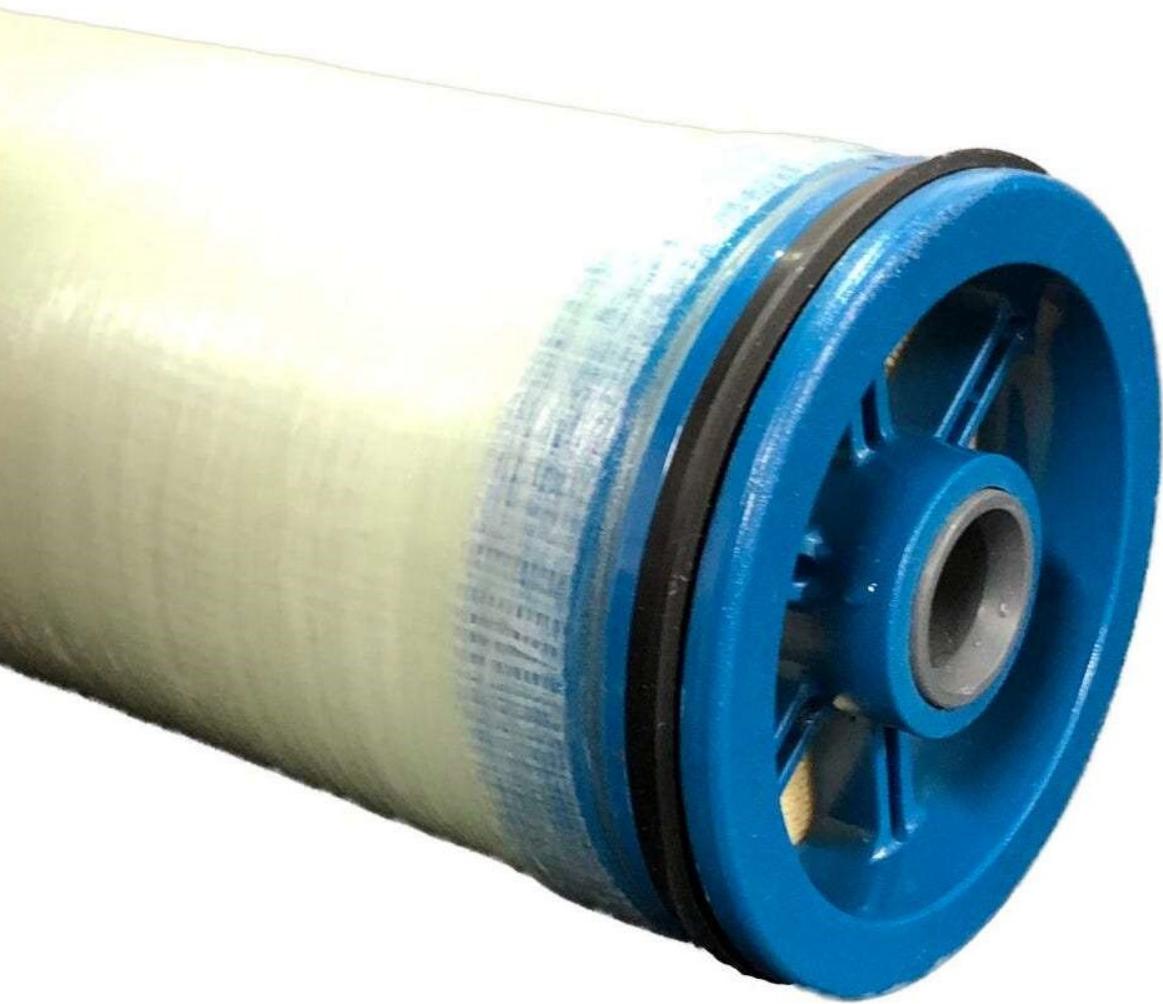
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## Integration Problem Solved !

- Optimal integration of extract into a standard three-boiling sugar end
  - Decolorization of extract by ion exchange, allowing for return into the white boiling
  - Problem of salt consumption solved by creating a “free” regenerant from chromatography raffinate
  - Spent regenerant returned to raffinate without affecting its value as a coproduct
  - No additional waste streams generated
- 

# NO-WASTE DECOLORIZATION





# MEMBRANE NANOFILTRATION

# NANOFILTRATION

## Cane Refinery Decolorization

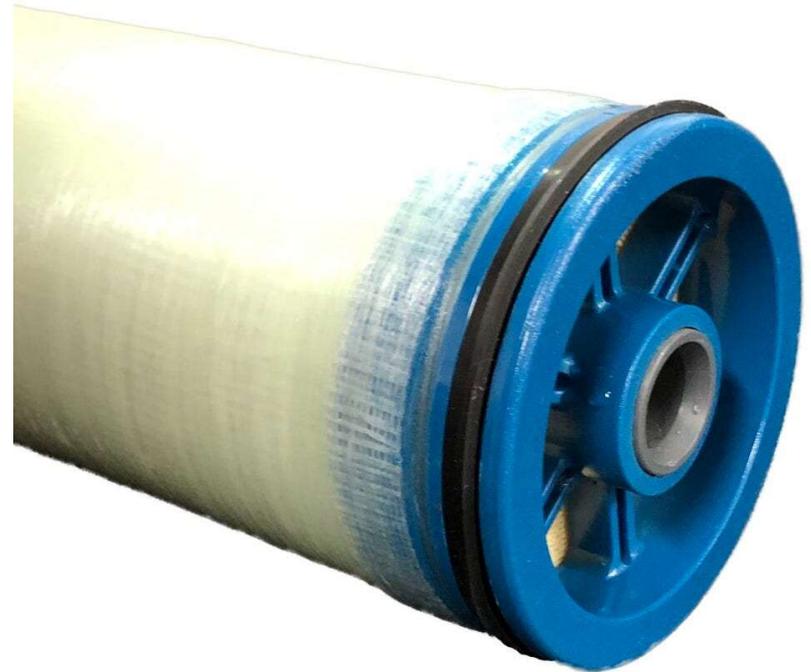
- Strong base anion exchange resins
- Regenerated with an alkaline brine
  - 10% NaCl + 1% NaOH
- Some of the spent regenerant brine can be reused
- Membrane nanofiltration used to treat the remainder
  - 90% recycle of regenerant salt for reuse



# NANOFILTRATION

## ARi No-Waste Decolorization Process

- Similar in nature to the cane refinery application
- Excess of raffinate available for nanofiltration
- Retentate stream retains its commercial value
- No need for high levels of nanofiltration efficiency
  - VCF of 2 (Feed splits evenly into permeate & retentate)
  - Low operating pressure of only 200 psi
  - Relatively high flux rates



<https://water-membrane-solutions.mann-hummel.com/en/products/nf-nanofiltration/trisep-nf.html>

# NANOFILTRATION

## Standard Nanofiltration Membranes

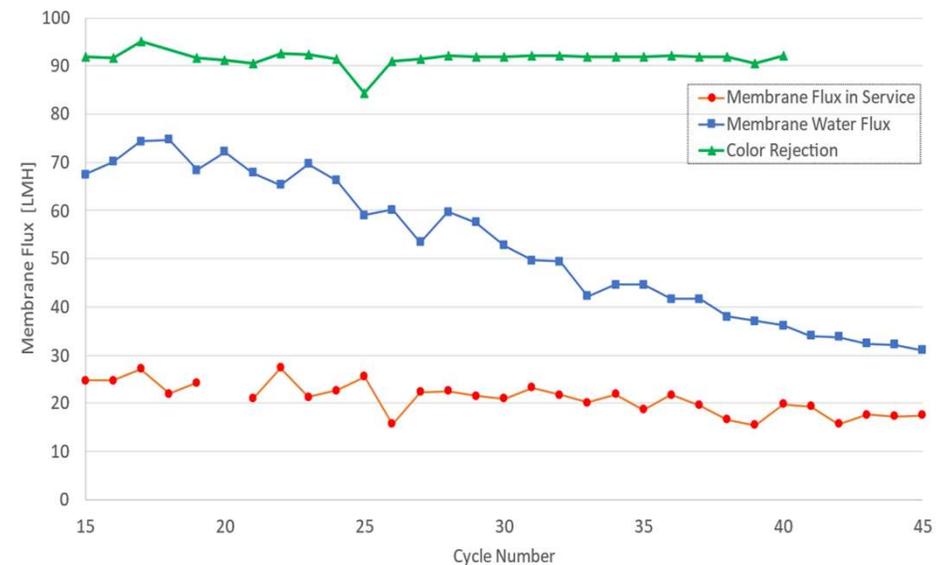
- Years of testing with dozens of membrane candidates
- Competing objectives
  - High color rejection into the retentate
  - High membrane flux
- Best candidate identified
  - TriSep Turboclean UA 60
  - Nominal 1,000 Dalton cutoff
  - Polymeric spiral wound membrane with 45°C limit
  - 90% color rejection, along with 2/3 of the sugars
  - Ash components split 50:50 between the stream



# NANOFILTRATION

## Long Term Testing

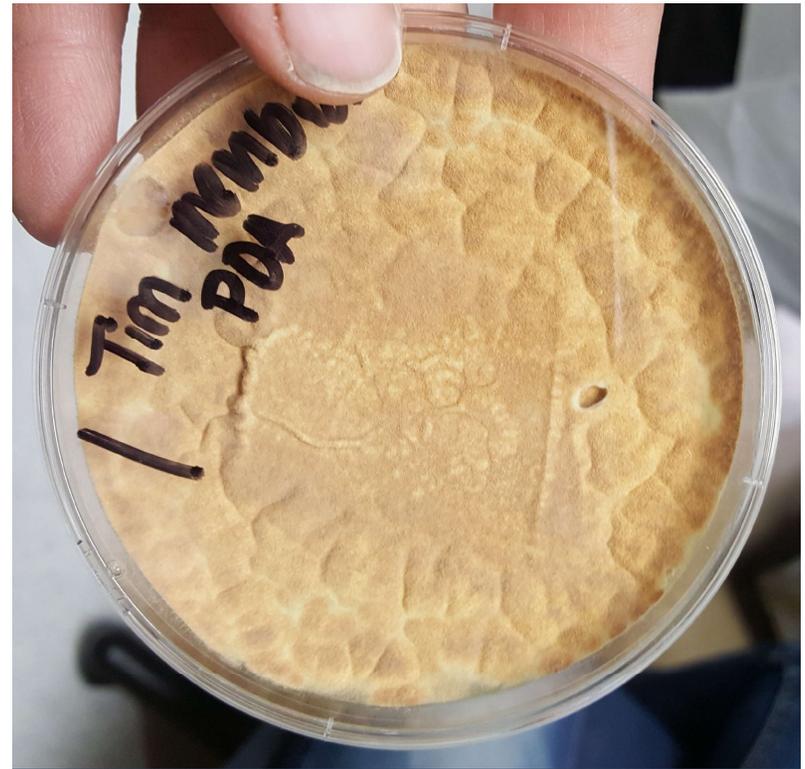
- Total of 45 operating cycles carried out
  - Operating pressure of 200 psi
  - Temperature of 45°C
  - Cycle length of 10 – 12 hours between cleanings
- Simulation of more than 20 days of continuous operation
- Color rejection remained high
- Slight reduction in flux in service
- Substantial decrease in water flux over time



# NANOFILTRATION

## Long Term Testing

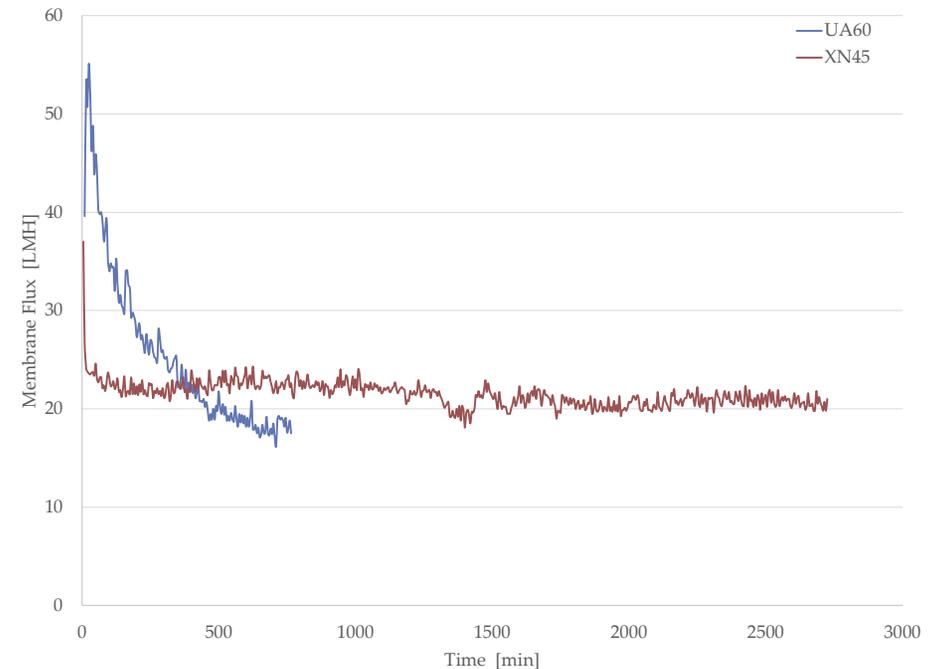
- Membrane dissection
  - Build-up of microbial growth within membrane
- Pilot-scale nature of the trial
- Intermittent raffinate collection in totes
- New membrane module installed
  - 200 hours of continuous operation
  - Biocide addition and improved cleaning
  - Problem persisted

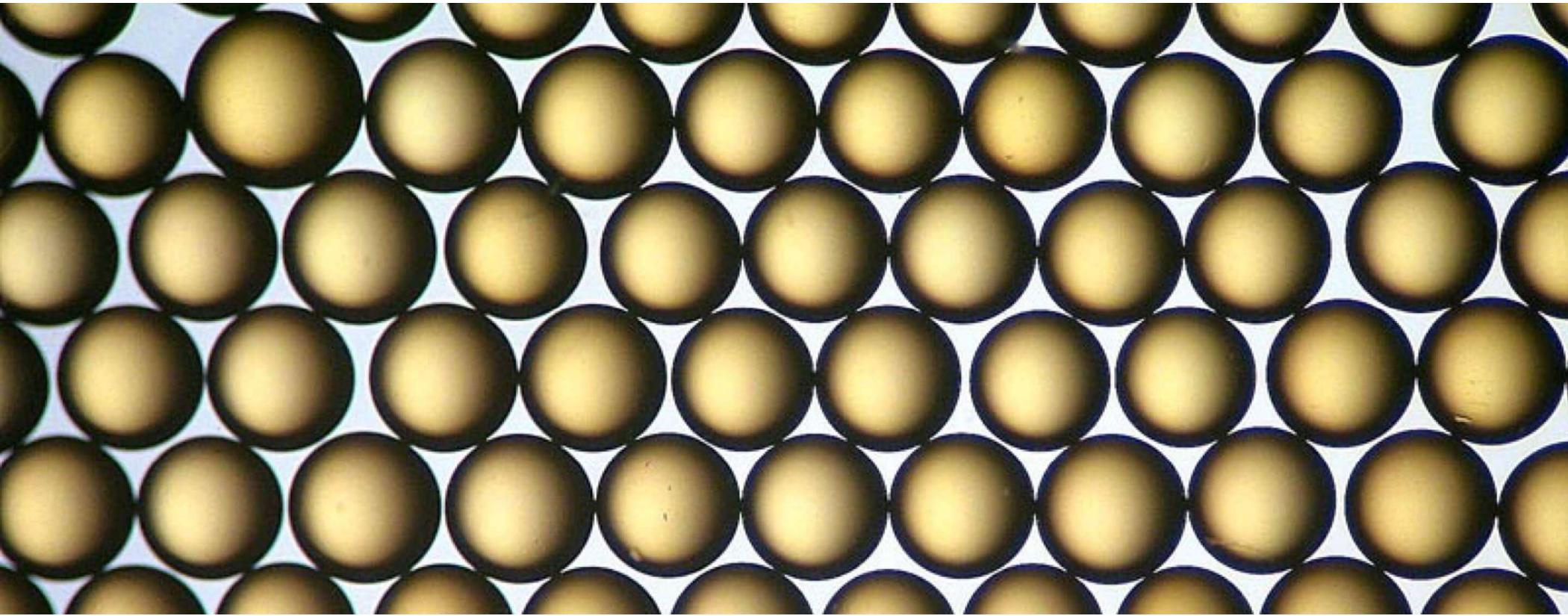


# NANOFILTRATION

## High Temperature Nanofiltration Membranes

- Best candidate identified
  - TriSep Turboclean High Temperature XN 45
  - Nominal 500 Dalton cutoff, 80°C temperature limit
- Total of 23 operating cycles carried out
  - Operating pressure of 250 psi
  - Temperature of 70 – 75°C
  - Cycle length of 20 hours between cleanings (and more)
- Simulation of more than 20 days of continuous operation
  - Stable flux in service
  - Slight reduction in water flux over time



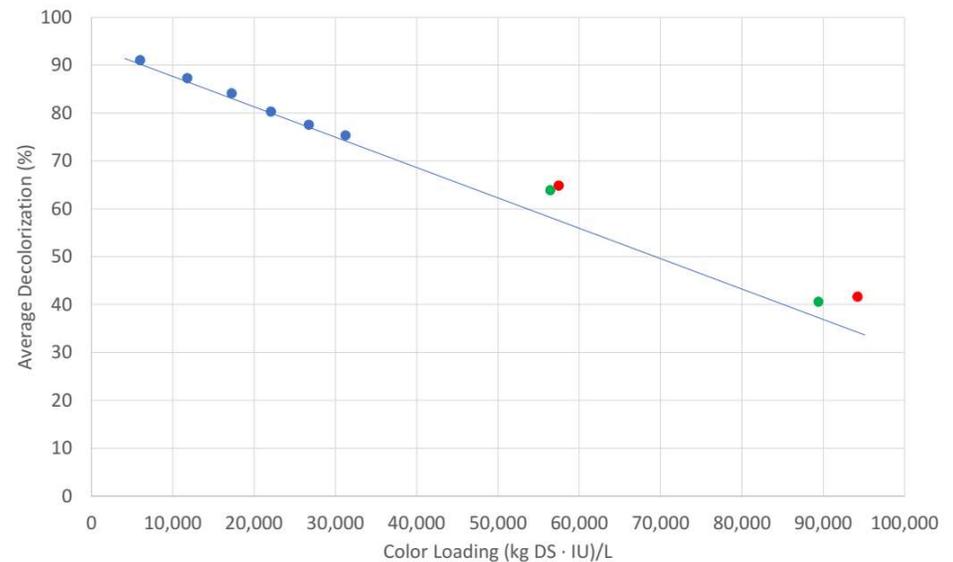


# ION EXCHANGE DECOLORIZATION

# EXTRACT DECOLORIZATION

## Background

- Extract color typically 8,000 – 12,000 IU
- For optimum sugar end processing, require 3,000 IU
- Extract decolorization of 60 – 75% required
- Ion exchange performance can be represented graphically



# EXTRACT DECOLORIZATION

## Long Term Testing

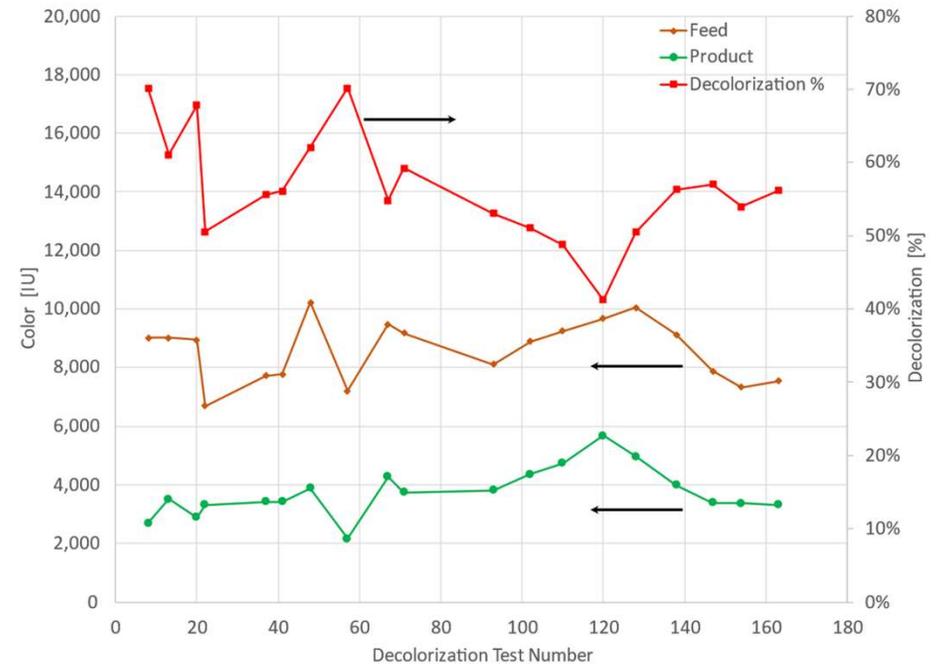
- Extract and raffinate collected from Twin Falls
- Regenerant obtained by nanofiltration of raffinate at 30% dissolved solids
- Decolorization carried out at 30% dissolved solids



# EXTRACT DECOLORIZATION

## Long Term Testing

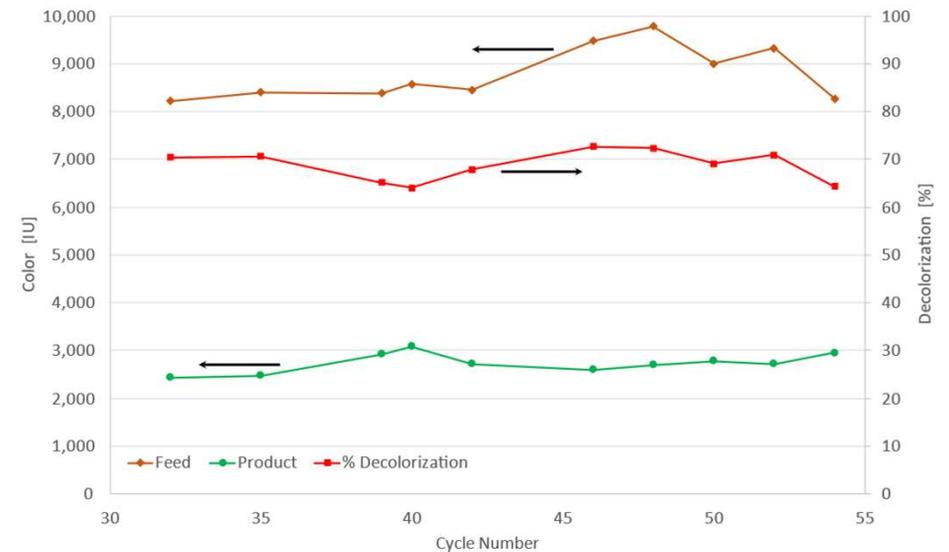
- Total of 163 cycles carried out while experimenting
  - Typical resin life 300 cycles
- Long cycle time and high loading per cycle
  - Worst case scenario for the ion exchange
  - Lower decolorization levels than 60 – 75% target range
- No significant decrease in performance observed over time



# EXTRACT DECOLORIZATION

## Customer Feedstocks

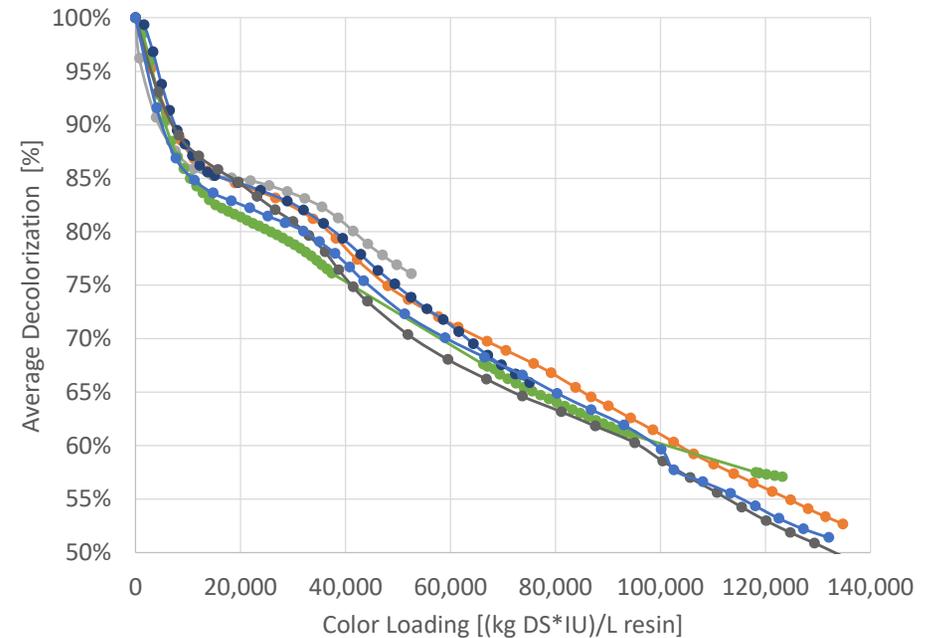
- Bulk samples of customer extract from Europe
  - Concentrated for shipping & then diluted for testing
- Total of 54 ion exchange cycles carried out, using regeneration with permeate obtained from raffinate nanofiltration
- Color loading per cycle better matched to the target decolorization performance of 60 – 75%



# EXTRACT DECOLORIZATION

## Amalgamated Sugar Feedstocks

- Pilot campaign carried out with extract samples from two Amalgamated Sugar factories
- Consistent performance obtained despite variations in feed source and time of the campaign
- Very high color loadings compared to typical cane refinery decolorization performance
  - Reduced number of regenerations
  - Extends service life of the resin



# PATHWAY TO COMMERCIALIZATION



# COMMERCIALIZATION

## Technologies Involved

- Overall process similar to the standard technology package routinely employed in cane sugar refining
- Ion exchange decolorization system
  - Pilot tested by ARi at various times using chromatography extract since the late 1980's
  - Example Peacock & Kochergin (2022) at SIT conference
  - Relatively well understood
  - Small number of commercial installations for extract decolorization took place historically (salt regenerated)
  - Likely to pose little commercial risk

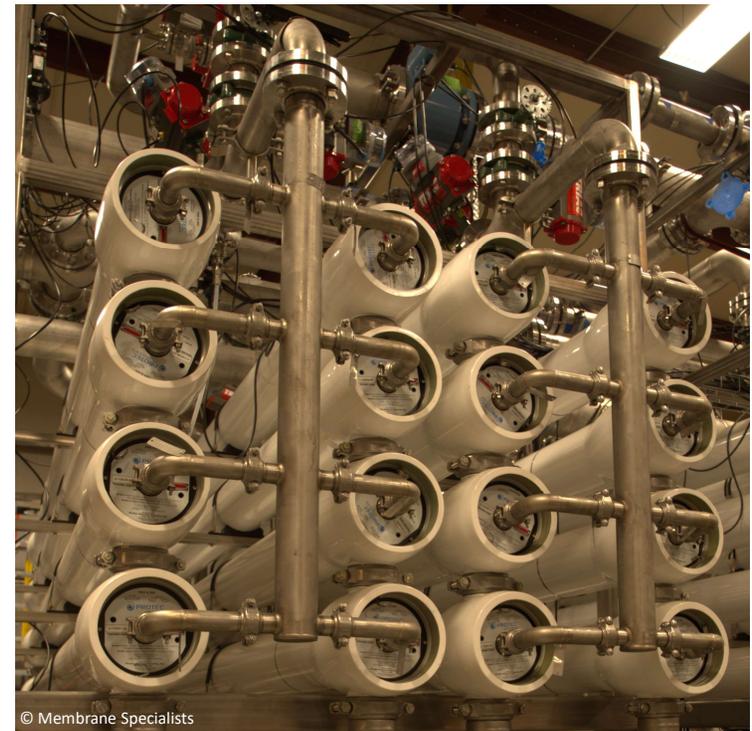


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# COMMERCIALIZATION

## Technologies Involved

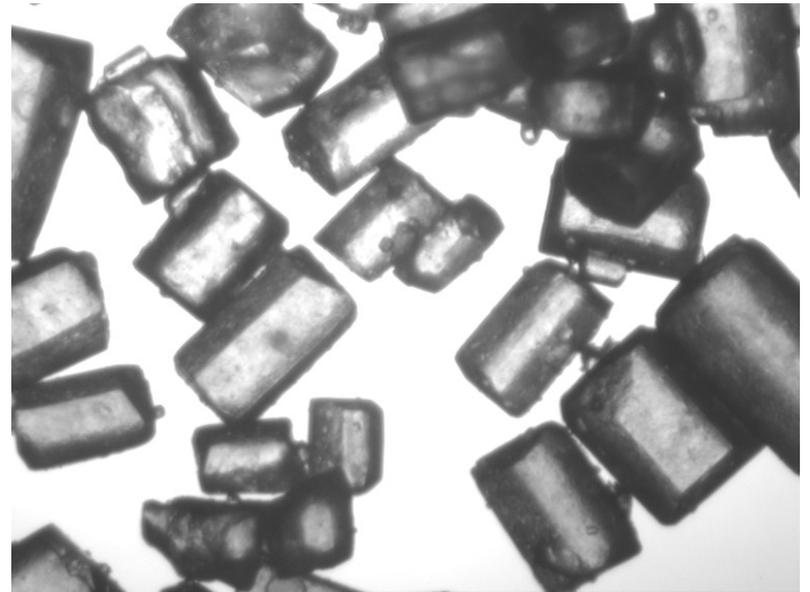
- Membrane nanofiltration system
  - Decades of industrial experience with spent brine regenerants (but no chromatography raffinate)
  - Operating life of the nanofiltration membrane not yet demonstrated
  - This is the major outstanding factor for completion of a business case for implementation
  - Will require membrane system installation in a beet sugar factory, for an extended period
- ARi is currently pursuing this work



# CONCLUSIONS

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- Solves the problem of optimally integrating chromatography extract into the sugar end
- Creates a “free” salt-rich regenerant from chromatography raffinate using nanofiltration
  - After use, this is recombined with the raffinate without affecting its value as a coproduct
- Ion exchange & nanofiltration are already standard operations in the sugar industry
  - Commercial implementation carries little technical risk
  - Life of the membranes in this application still needs to be demonstrated in an industrial setting
  - ARi is currently pursuing this testing





## CONTACT INFORMATION



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