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Dr Ir F.Petrus Cuperus introducing

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Robust Separation Technologies

XXV EMS Summer School
'Solvent resistant membranes'

KU Leuven, September 8 - 11, 2008

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Robust Separation Technologies

SolSep membranes for regeneration of organic solvents

and recovery of valuable components

Dr Ir F. Petrus Cuperus

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Outline

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Introduction SolSep BV

Membrane separation in organic solvents

Driving forces – Goals and Benefits

How to come to applications

Application examples

Final remarks

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Membranes in non-aqueous environments

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- SolSep BV makes membranes and elements for separations in organic solvents
- NF in organic solvents is fairly unknown
  - Technology development
  - Typical scale 10 -1000L/h (currently-2008)

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Nanofiltration of organic solvents

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- Membrane technology is proven technology
- Solvent filtration is as simple as water cleaning

Provided:

You have the right membranes and modules

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SolSep products: Stable Membranes - Robust Elements

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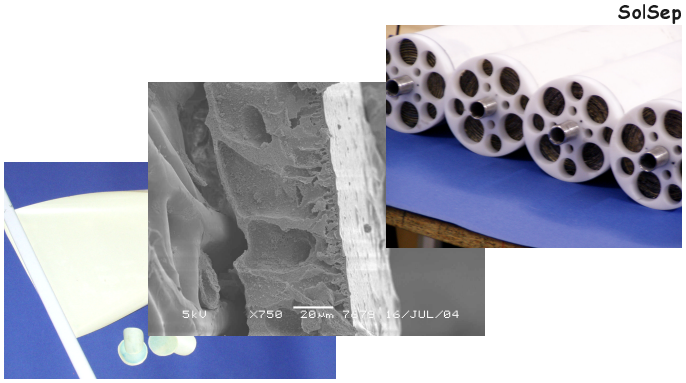

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Membranes and elements

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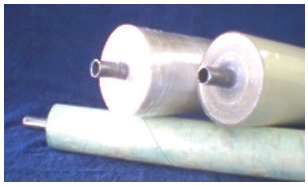

Robust Spirals:

organic solvents
reducing/oxidizing atmosphere
temperature: 140 °C
pressure: 40 bar
high viscosities
extra safety measures

Robust Custom elements:

hollow fiber
tubular
membrane reactors
contactors
pervaporation (org)

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SolSep SW Elements

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element	S[1] (m2)	size (l x d) (mm x mm) ("x ")
SR-1	1-1.8	62x505 (2.5"x20")
SR-2	2-4	62x1010 (2.5"x40")
SR-5	5-8	100x1010 (4"x40")
SR-20	16-28	200x1010 (8"x40")

[1] Filtration area (S) depends on spacer thickness.

Standard spacers feed: 50mil (1.2 mm), permeate 30 mil (0.7mm).

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Proven robustness in solvents

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Technical grade solvents - may include water

hexane	ethyl acetate
acetone	butyl acetate
MEK	ethanol
MTBE	methanol
toluene	iso-propyl alcohol
benzene	xylene
chloro benzene	methoxypropyl acetate
chloro methylene	adiponitrile
tetrachloro ethylene	ethylene oxide
“fusel” oil	propylene oxide
white spirit	vegetable oil
aldehydes	some aprotic solvents

Robustness includes membranes and elements

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Membranes Performance in different solvents

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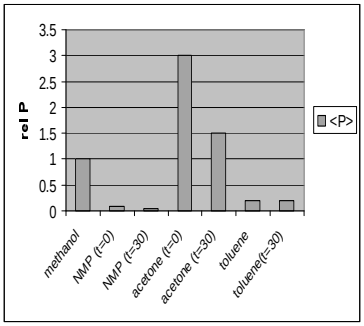
Relative permeability vs solvent type – incl a-protic



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SolSep xxxx	Tmax (degC)	Pmax (bar)	Separation characteristic	Remarks – other solvents
UF010104	90	20	Typical retention of larger molecules ca 10,000 Da	Alcohols, aromatics, esters, ketones
NF010206	120	20	R(95%) ~300 Da	Alcohols, esters
NF010306	150	40	R(95%) ~1000 Da ionics/acetone R(99%)~300	Alcohols, esters, ketones, aromatics, chlorinated solvents, reducing
NF030306	150	40	More hydrophobic solvents than 010206/010306	alkanes, esters, ketones, aromatics, reducing atm, chlorinated solvents
NF030306F	120	40	More hydrophobic solvents than 010206/010306 extremely stable	alkanes, esters, ketones, aromatics, chlorinated solvents
NF030705	90	20	Ethanol, methanol R(95%) ~300	alcohols, aromatics, ketones R>>500Da

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The perspective – why use membranes

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Some reasons to go for membranes (NF/PV)

- Less heat impact
- Specific separation (e.g. new product wanted)
- Safety
- Easy combination (hybrid)
- Energy

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Colorful Applications (i)

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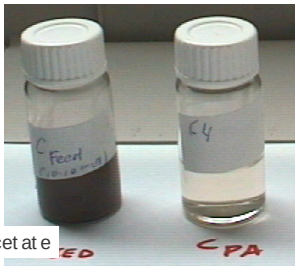
Fractionationation of colors
In acetone and ethylalcohol



Recovery of ethyl acetate

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Applications (examples)

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-Membranes are part of the solution

-Often combination of techniques

Sterol / wax recovery

Homogeneous catalysts recovery

Dye recovery

Solvent recovery:

various
paints
pharmaceuticals
oligomers
refining soy bean oil
carbohydrates- cellulosics
waxes

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Example 1

Solvent recovery in sterol and wax procesing

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Solvent recovery in “de–waxing”

Results in bio-wax processing

based on an earlier development in sterol recovery

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Reasons why

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Improve product quality

Decrease amount of solvent

Decrease energy (one site operation)

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Processing of vegetable waxes

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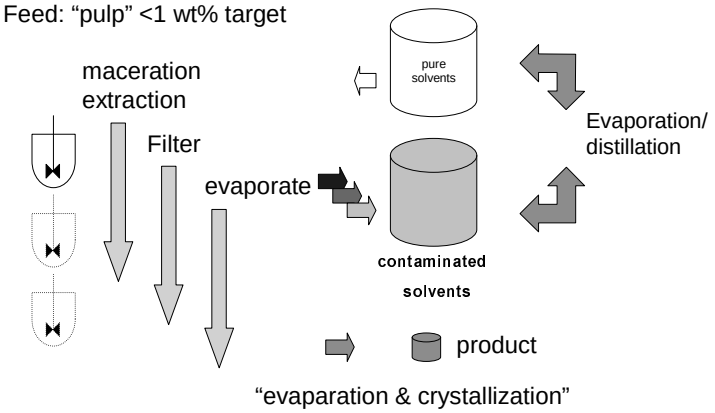
Feed: “pulp” <1 wt% target



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"Membrane Dewaxing"

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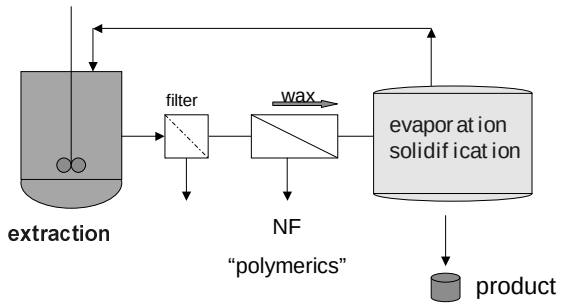
First aim: facilitate recovery of solvent



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Process

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- effects of cleaning

Increases the predictability of the process - the robustness of the process

costs

- effect membrane

25% less solvent
Product change – relevance?
Process change - less energy (~30%)

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Example 2

Recovery of solvent T

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Solvent T recovery

- Recovery of expensive solvent (substitute for X solvent)
  - High boiler
  - No heat available
- ~1000 L/day
- "Clean" solvent
  - can clean (cosmetic)
  - can cool

⇨ A cost effective recovery is vital for substitution

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Solvent T recovery (i)

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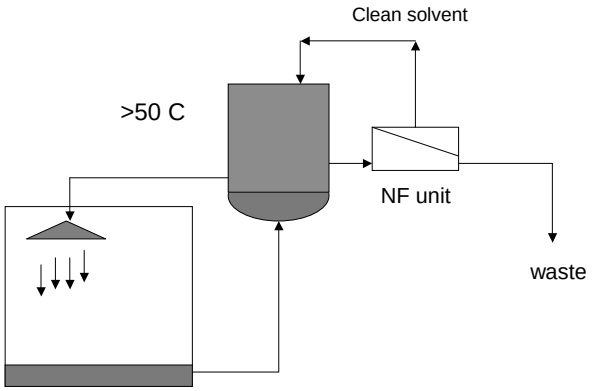

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Solvent T recovery (ii)

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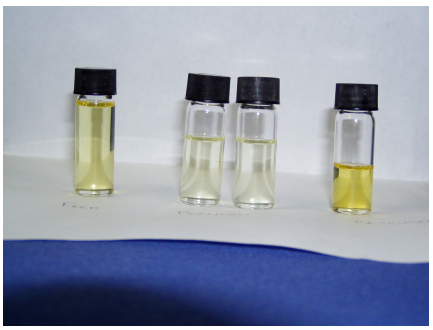

Yellow color

Component Mw~250 Da

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Pilot Solvent T (i)

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Design specs:

20 bar

Tmax 80 C

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Pilot Solvent T (ii)

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- Flux decline
- cleaning rinse ~frequency 1/month
- Upgrade to full scale

- And …optimization of the process

Because: Recovery Membrane unit = 80%

Add on: flash / short path

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Process

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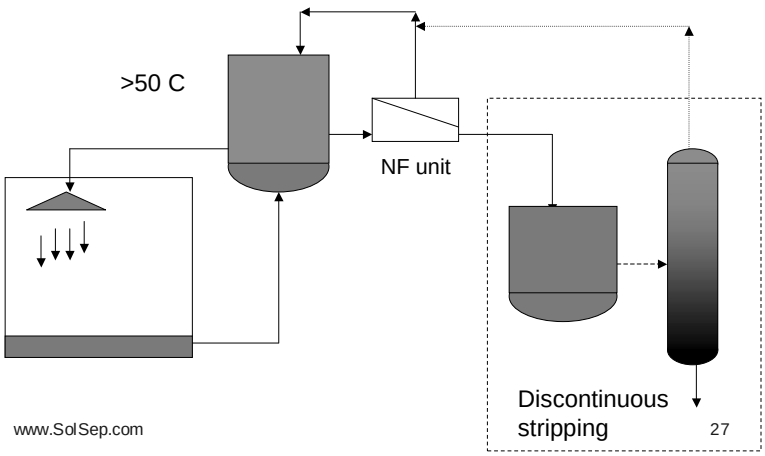

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Final Remarks

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NF is becoming a valuable tool in chemical processes
specialties - now
commodities - future

NF mostly in combination with other Engineering Units

Many solvents can be processed

Robust Spiral facilitate simple and cost effective construction

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thanks for your attention

SolSep BV
Solutions for Separations

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