SolSep BV

Dr Ir F.Petrus Cuperus introducing

Solsep BV

Robust Separation Technologies

Conference 13-15 September 2010

Imperial College, London, UK

Welcome to this talk!

SolSep BV
Robust Separation Technologies

Introducing Solsep BV

Separations in organic solvents

NF: stand-alone or hybrid technology?

Dr Ir F. Petrus Cuperus

Contents

SolSep BV

- SolSep BV
  - **Polymer membranes**
- Applications in organics

Where can membranes work now

What is their action

Combinations with other Unit Operations

The Challenge – what can we achieve?

SolSep BV

Replace current technologies?	Distillation, extraction,
Upgrade current techologies	Id, filtration,
Upgrade plants or systems	Increase output
Realize new things/separations	homogeneous catalysts, bio-molecules, (re-)use (other) solvents
Realize better safety	Less vapors
Save environment	Less exhaust
Save energy	Less heat

Nanofiltration of organic solvents

SolSep BV

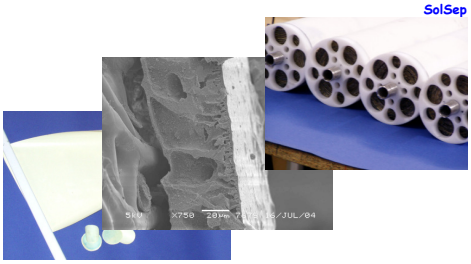
- Membrane technology is proven technology
- Solvent filtration is as simple as water cleaning

Provided:

You have the right membranes and modules

SolSep products: Stable Membranes - Robust Elements

SolSep BV



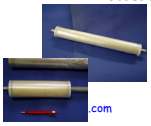
Elements Manufacturing

SolSep BV

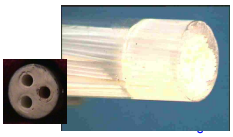
Robust Spirals:

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

Robust Custom elements:

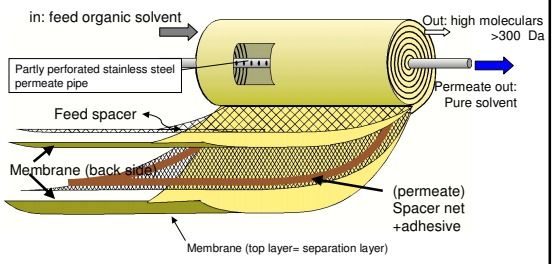


- hollow fiber
- tubular
- membrane reactors
- contactors
- Pervaporation (org)



SolSep spiral wound element for use in organic solvents

SolSep BV



Proven robustness in solvents

SolSep BV

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 (NMP, DMF)

Robustness includes membranes and elements

SolSep Membranes

SolSep BV

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

Applications (examples)

SolSep BV

Sterol recovery

Homogeneous catalysts recovery

Dye recovery

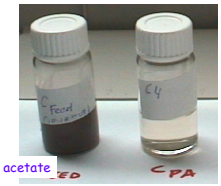
Solvent recovery:

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

Colorful Applications (ii)

SolSep BV

Fractionation of colors
In acetone and ethyl alcohol



Recovery of ethyl acetate

The Challenge – what can we (NOT) achieve ?

SolSep BV

seldomly☺ achieved:

100% separation

fully retained pure product

"no energy" separation

an implementation without lab-pilot experiments

separate 2 solvents

Increasingly demonstrated:

Demonstrate technology works!

Save money - energy!

Less heat impact

Hybrid technology or stand alone

SolSep BV

Hybrid refers to different more of less integatrated unit operations / technologies to achieve a process step (reaction, separation)

The "sum" of the hybrid is better than the sum of individual steps.

In this talk: "a loose definition"

e.g.,
distallation + pervaporation: acetylation, esterification
reactive distillation: acetylation, esterification
waste water cleaning: membrane reactor

NF of organic solvents "process combinations" examples

SolSep BV

- Paint and coatings
- High boiler re-use
- Chlorinated solvent re-use
- Biofuel preparation

Stand alones? Or else....

Competive (?) or easy solution

SolSep BV

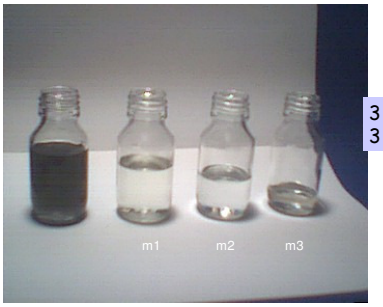
Flashing, distillation – so why membranes?

-thermal not possible/difficult
-less heat
-less heat impact
-easier upgrade

cheaper
environment-friendly

Tetrachloroethylene recovery (ii)

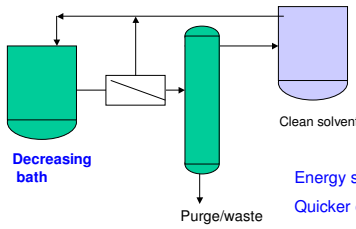
SolSep BV



3 membranes
3 thru put values

Tetrachloroethylene recovery (i)

SolSep BV

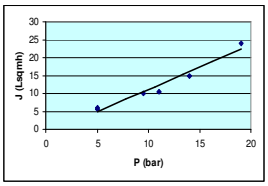


Energy saving 50+ %

Quicker operation

Data PCE

SolSep BV



Πcalc = 4 bar

Πextr ~1.2 bar

- Thru put: 100 L/h/SR5
- Should be used with evaporation
- PBT: 2-3 yrs – but much cheaper than a vacuum cabinet

Recycling of solvents from paint industry

SolSep BV

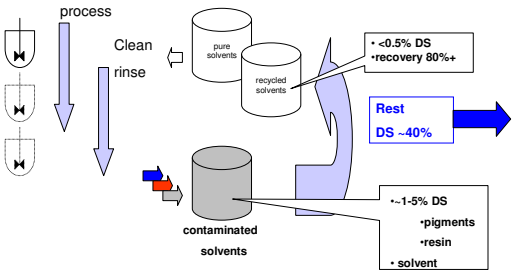
Process and Requirements

- Solvents from rinsing baths
- Mixtures
  2 main components - acetone, ethylacetate
  more than 15 minor components
- "Debris": pigments, resin(s)

- Currently: evaporation

Process logistics

SolSep BV



Process and Requirements (ii)

SolSep BV

- Process thru put ~150 L/h unit
- Independent, stand-alone unit
- De-bottlenecking
- Save energy
- Safety aspects

R&D:
- UF or NF
- Polymeric or ceramic
- Design-configuration

Some final figures

SolSep BV

- NF is a viable alternative
- De-bottlenecking - hybrid ! (PB <2)
- Quality of regenerated solvent is crucial

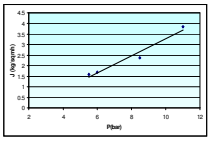
Solvent separation

Can we separate solvents?

water	**18**	**cats**	**100-1000**
ethanol	**46**	**B-blocks**	**100-1000**
acetone	**70**	**colorants**	**200-700**
ethyl acetate	**88**	**oil**	**300-1000**
toluene	**92**	**FFA**	**~330**
heptane	**100**	**sterol**	**~500**

Sterical aspects can not be the single base for separation

Osmotic pressure and retention (P060306)



TG's in acetone; R =100%

(Π In bar)	Πcalc	Πext
TG	1.6	2
FFA	1.6	~0

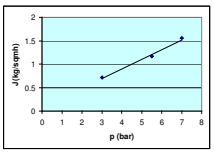
Flux: J = L (p-Π)

Osmotic pressure (1885):

ΠV = nRT or Π = cRT

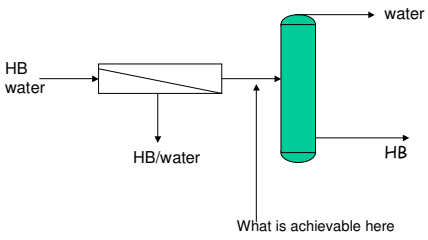
Mind c<1%: sometimes large deviation occurs

1914 (Caspari) Π meas= 2 x Πcalc

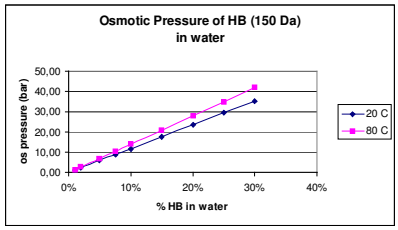


1.5 wt% FFAs in acetone; R=99%

High boiler (solvent) - water



Osmotic pressure of a HB



HB membranes –when?

Profitability vs performance of the membrane
flux-R

No "waste" energy present

Environmental problem
Product price

Final remarks – general (1)

SolSep BV

With polymer membranes

Molecular separation can be done in solvents

Very strong solvents can be processed (NMP, DMF)

High temperature (150 degC) can be done

Solvent (water) mixtures separation will become realized

Long term stable high and low pH are a challenge-but coming

Final Remarks (2) – Technology Hybrid/combinations

SolSep BV

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

NF mainly combination with flashing

Increase possibilities of "difficult applications"

Up to 50% energy saving

Cost cutting by re-use and avoiding fines ($$,€€)

Solsep BV provides ""membrane platform"" for such applications

SolSep BV

Solvents Separation? – We have the Membrains!

SolSep BV
St. Eustatius 65
7333NW Apeldoorn
+31 55 534 9885

cuperus@solsep.com

WWW.SOLSEP.COM

For an update of these sheets go to website!