ISPT

Institute for Sustainable Process Technology

ISPT

Technology Suppliers Booklet 2016

1 September 2016

Preface

Dear reader,

ISPT's mission is to connect various stakeholders in the field of Process Technology in order to improve and accelerate innovation and to develop technical talent thereby establishing a leading position for the Netherlands in the international innovation landscape. Within a wide variety of projects new technology concepts are developed and technological innovations are put to the test.

Within ISPT the technology suppliers are considered a corner stone in the development and implementation of new and sustainable technologies for the process industry. They have participated in ISPT from its onset and have contributed to the success of ISPT's programs. Technology suppliers, whether large, medium or small are for us entrepreneurs who turn technologies into hardware and as such into the operating processes of the companies that produce the things we use in our daily life. You will meet them in this booklet.

This booklet may serve process industries to explore technical solutions and expertise suitable for their route to increased sustainable production and may enhance the dialogue between technology suppliers for further improving their technologies.

In this edition of ISPT's technology demonstration booklet you will not only see presentations of the companies with their technology capabilities, but also the results of the 'Technoprojects', technology validation projects that ISPT has executed together with the Netherlands Group of Users of Technology for Separation NL GUTS.
You will read that the concept of validating new technologies together with process industries on real commercial streams is very beneficial for acceptance of new technologies on an operating production site; it enhances business contacts between (larger) operating companies and the suppliers, often SME's or start-ups. This success continues in the new 'Early Adopter Projects' program, of which you will find the first initiatives.

We have kept the presentations accessible and concise in form of posters. We are convinced that the many examples of innovations and capabilities will inspire you and may trigger you in identifying sustainability opportunities for your own company, of which the technology suppliers in this booklet undoubtedly will be reliable partners.

On behalf of the technology suppliers working with ISPT, we wish you great pleasure in the reading and you may contact ISPT at any time for more information, ideas or to explore cooperation,

Till then.

Jan Koning
Account Manager SME

Tjeerd Jongsma
Director ISPT

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Technology suppliers, whether large, medium or small are the entrepreneurs who turn technologies into hardware and as such into the operating processes of the companies that produce the things we use in our daily life.

Technology suppliers

Aquamarijn Micro Filtration BV

Future Technology, Engineered for Now

We transform your ideas into functional designs

High-Performance Precision Filters

Do you need:

- Do you need high–performance microfiltration solutions with reduced footprint and energy-consumption?

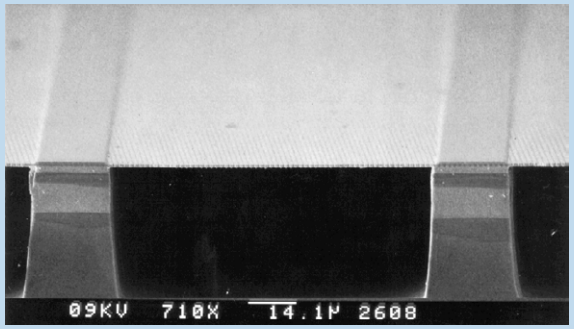
About us:

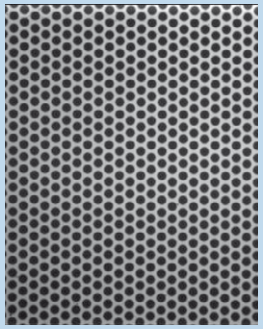
- Aquamarijn has the knowledge and infrastructure to design, prototype and manufacture micro-engineered filters (microsieves). Microsieves are produced using silicon micromachining. The most important features are the precision etched pores (0.1-20 µm) in a thin membrane (thickness of 0.5 to 5 µm) with a surface roughness down to 10 nm.
- In 1994, Aquamarijn was founded to develop high flux, precision microfiltration membranes, "microsieve membranes™".
- We aim to replace existing micro-filtration technology with our high-performance membranes.

What are we looking for?

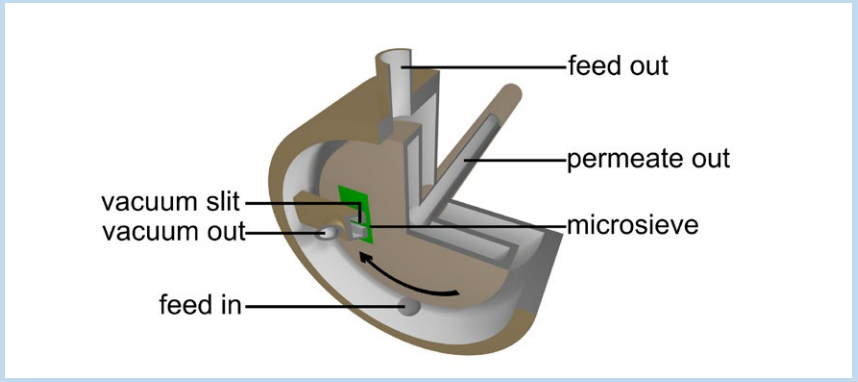
- Collaborations/partnerships to implement our revolutionary high-performance filtration plants

Examples





Micro-engineered Membranes (Microsieves)



Rotary-microfilter filtration systems

Contact: Jacob Baggerman
Phone number: +31-575-519751
E-mail: microfiltration@aquamarijn.nl
Website: www.aquamarijn.nl

Current/past involvement in ISPT

- Early Adopter Project: Rotating microfilters for sustainable microfiltration treatment of process streams

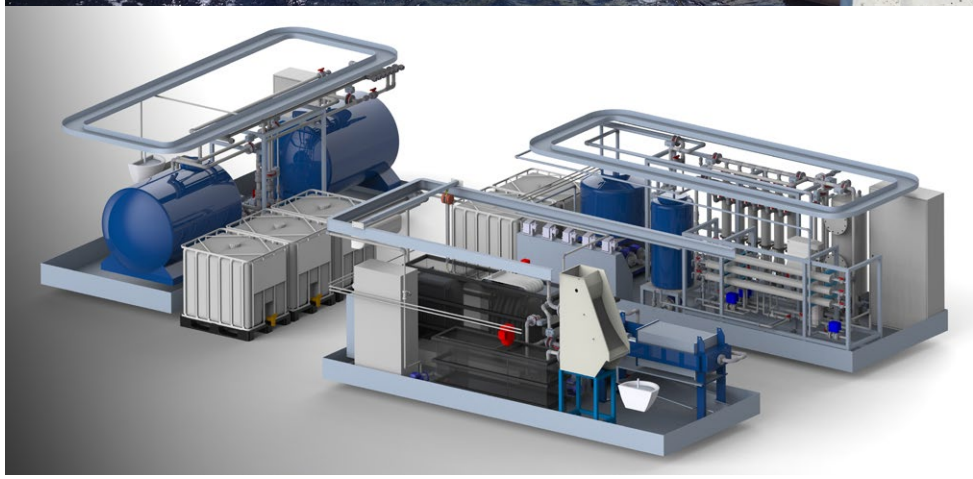
EAP

EColoRO B.V.

Efficient Colour & Fat-Oil-Grease Removal

Decrease the operating costs & the environmental pollution

Reuse the Industial Waste Waterstream by Electrogoagulation



Textile mills are able to reduce water consumption up to 90 % using the EColoRO concept, which consists of electrocoagulation followed by membrane filtration in order to treat and reuse wastewater.

About EColoRO

EColoRO Water Treatment Solutions works with customers around the world to design and implement innovative water purification solutions. Our main focus is reusing waste- water streams to decrease operational costs and reduce environmental pollution.

We are looking for

- Companies in the textile, paint & coatings, onshore oil & gas, food & beverage, paper and chemical sectors who want to reuse their waste water
- Partnerships to implement & improve our electrocoagulation & filtration concept

EColoRO
Effective Colour & FOG Removal from Waste Water

Contact: Eric van Sonsbeek
Phone number: 085 - 210 48 48
E-mail: info@ecoloro.nl
Technology: reuse of wastewater
Website: www.ecoloro.nl

ISPT & EColoRO B.V.

Both commenced in a 3.5-year Horizon 2020 project to demonstrate the technology on site at two full industrial scale mills. The first site is at a textile mill in Belgium and later at a textile mill in Italy.

FeyeCon

Adding Clean Value

Innovation & Game-Changing, Sustainable Technology

Mild Processing Resulting in Excellent Product Quality

Introduction SME:

FeyeCon develops & implements novel processes & products using CO_2 technology.

HISTORY: Started as a spin-off from TU Delft in 2001 and grew into the leading company for CO_2 technology innovations.

OUR GOAL: To provide to our clients clean processes and products, with superior quality at lower costs.

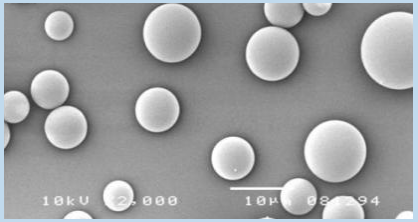
TECHNOLOGY EXAMPLES: SC-CO_2 extraction, mild drying, micro-encapsulation & targeted delivery of active ingredients, mild pasteurization, functional fat powders.

What are we looking for?

- Collaborations for novel ingredient processing
- Partnerships for scaling up

Examples

Mild drying & pasteurization using SC-CO_2



Product examples

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E-mail: cynthia.akkermans@feyecon.com
Technology: CO_2 technology
Website: www.feyecon.com

ISPT & FeyeCon

- Project CS-10-20: Adding value to the Inulin production process

TP

Flowid

Beyond Standards

Continuous processing on production scale

Process development – Continuous processing equipment & skids

SpinPro reactors R300 & R700

Invitation:
- SpinPro reactor implementations

Introduction SME:
- Spinning disc equipment
- SpinPro Reactor R10/300/1000
- SpinPro Extractors E300/1000
- Continuous process development
- Laboratory and pilot production faculties
- Dosing skids
- Application development
- High pressure (100Bar) high throughput

What are we looking for?
- We look for SpinPro reactor implementations or applications
- Collaborations/partnerships in the field of continuous processing

Examples:
- SpinPro reactors R300 & R700
- Continuous Process Development

Name contact: Jeoffrey van den Berg
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Technology: SpinPro – Spinning disc – Continuous
Website: Flowid.nl

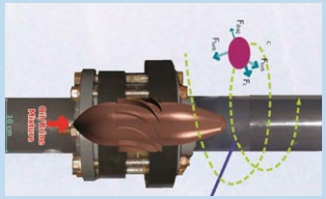
Current/past involvement in ISPT

- EAP energy savings: SpinPro Reactor BuLi
- Technoproject CS-10-24: Spinpro extractor with NL GUTS

Frames

Frames is the vital link between well and pipeline in the international upstream oil and gas industry. Frames delivers optimally designed and built solutions for sustainable processes. Compact, energy efficient integrated equipment packages.

Immobilized Amines



In Line Swirler

In need of compact, flexible designed and equipment for your gas or liquid treatment facilities?

- At Frames we design, build and deliver separation technology, oil and gas treatment, flow control and safeguarding systems, modules, and integrated solutions, such as total plants.
- We aim to provide our clients and stakeholders the best possible solutions for treating fossil and renewable fuels, minimizing energy usage and waste streams.

What are we looking for?

- We are looking for innovative ideas and technology solutions.
- We aim to accomplish this by partnering with all stakeholders.

Examples:

- Immobilized Amines
- In Line Swirler

FRAMES
a family of oil & gas solutions

Name contact: Jacco Mooijer
Phone number: +31 172 464200
E-mail: info@frames-group.com
Website: www.frames-group.com

Current/past involvement in ISPT

- OG-10-05: Designer Solvents for Natural Gas Treatment
- GT-20-00/01/03: PAS project
- WP-20-00/01/02:
  - Water processing
  - Produced water treatment
  - Oil water separation by Swirl – towards application
- UH cluster

MTSA Technopower BV

Pilot and demo plants

For the Energy, Process, Food, Pharma,

R&D sectors Customer specific design and realization

Membrane Filtration Unit for ISPT

Fuel Cell Power Plant

Bench Scale Process Unit

Invitation:

You want to validate and realize your innovative ideas?

Introduction SME:

- MTSA Technopower specialises in design and building pilot plants, gas and/or fluid systems, often in the form of a mobile skid installation: ranging from a flow rate of only a few ml per hour, using thin-walled tubing, to larger installations with a flow rate of hundreds of litres per hour.
- From concept study and basic engineering right up to commissioning.
- We are specialized in extreme temperatures, pressures and aggressive fluids.

What are we looking for?

- Partner and Consortia who want to scale up their innovation.

Examples:

- Fuel Cell Power Plant
- Bench Scale Process Unit
- Membrane Filtration Unit for ISPT

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Website: www.mtsa.nl

NewFoss

Biobased products and techniques

A green future for all of us

Converting biomass waste flows into valuable products

Thanks to her patented mild extraction technique (refining) NewFoss is able to convert agrofood biomass (waste) flows into 100% optimized value substreams/ intermediates. Through the use of a biotechnical conversion the process is made exceptionally efficient and robust. It has been made possible to convert agricultural products and waste flows into renewable biobased resources needing only a minimal investment and very little energy use.

Innovation is as well technical, technological and socio-economic in nature. By fully focussing on region-specific collaboration with potential partners and costumers , an optimal synergie in the regional collaborations is achieved.

Name contact: Geert van Boekel
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E-mail: info@newfoss.com
Website: www.newfoss.com

Current/past involvement in ISPT

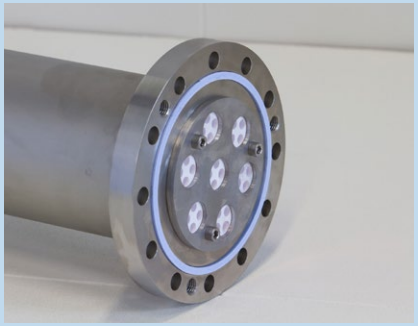
- Technoproject CS-01-16: Alternative method of pulp processing and processing the liquid phase with NL GUTS

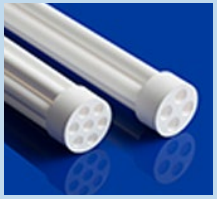
Pervatech BV

Innovating your business

Leading in membrane technology

Substantial energy savings (25%-75%)





Pervatech BV

Produces cutting edge membranes, membrane modules and test systems for pervaporation, vapour permeation and gas separation applications.

Our core activities are the development, production and marketing & sales of ceramic membranes for both hydrophilic and organophilic separation processes.

International scientific co-operation with leading Universities and Institutions secures today's and tomorrow's ceramic membranes with superior characteristics.

Our membranes can be used:

- In **pharma industries** for in-situ dehydration of condensation reactions.
- To break the azeotrope in distillation processes, eliminating the need for entrainers and drastically reducing the energy consumption in the **chemical and fine chemical industry**.
- To concentrate fragrances or to purify solvents in the **food industries**.
- For dehydration of alcohols in **bio-fuel industry**.

PERVATECH

Contact: Pervatech BV
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Website: www.pervatech.nl

Current/past involvement in ISPT

- Technoproject CS-01-05:
  Extension of the scope of Pervatech membranes
- CS-01-12:
  Recovery of aggressive solvents which are difficult to separate

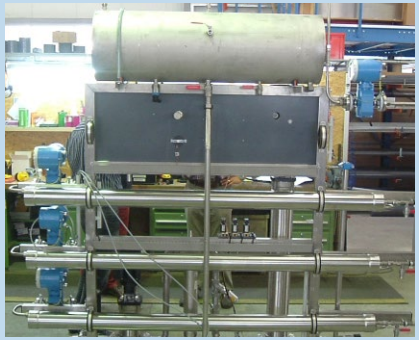
TP

SolSep BV-Membranes

Robust NF Membranes for Organic Solvents

Green Separation Technologies

Mild and efficient separation of/in Organic solvents



Recovery of high boiler solvents

Tool in extraction of goodies from plants

Solsep:
- Facilitates your separation in organic solvents

We are:
- A membrane producer
- Possessing 15 years of experience with membranes in organic solvents

We can help you to:
- Realize upscaling/upgrade
- Be energy friendly
- Use alternative solvents
- Facilitate alternative sep-s/synthesis

We are looking for:
- Your separation challenge
- We are a membrane filter producer and we prefer to work with end-user and system builders?

Examples:
- Recovery of high boiler solvents (Alternative for chlorinated solvents)
- Tool in extraction of goodies from plants

SolSep BV
Robust Separation Technologies

Name contact: F. Petrus Cuperus
Phone number: +31 55 534 9885
E-mail: cuperus@solsep.com
Technology: Nanofiltration membranes
Website: www.solsep.com

Current/past involvement in ISPT

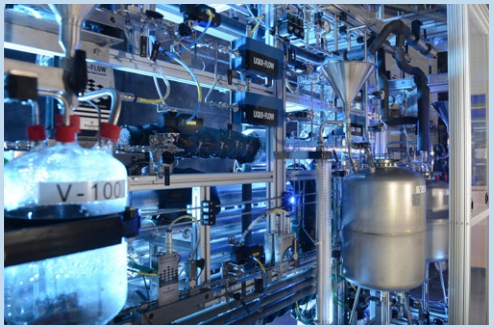
- Several feasibility projects in ISPT
- Several Technoprojets: NL GUTS and ISPT
- EEMBAR: Pilot Energy Efficient Membrane Based Acetone Recovery with IOI LodersCroklaan

Zeton BV

REALIZE THE FUTURE! From concept to integrated modular process plant

Bringing your technology to the next level

Engineering and construction to realize automated and integrated modular process plants



Are you looking for a partner which provides the expertise in designing and building process systems to prove your scaled up technology?

Zeton BV

One partner from early phase concept to real built process plants

- Technology independent with a proven track record on IP handling
- More than 700 projects at lab, pilot, demo and small production scale
- Solution provider in all process industries
- Strong involvement in Biobased, Sustainable, CO_2 utilisation and Power-to-products industries
- Vast experience of Standards, (Non-)ATEX, Norms at lab and industrial scale

Zeton is looking for companies developing new technologies, processes and products who would like to bring their technology to the next level

- Projects which require services for process design,
- engineering and assembly
- Collaborations in both consortia and 1-on-1

ZETON

Name contact: Rob van Dongen
Phone number: +31 (0)53 428 4100
E-mail: info@zeton.nl
Technology: Engineering, Construction and Modular Plants
Website: www.zeton.com

Current/past involvement in ISPT

- ISPT projects Cadans, Coriac and PH-00-04
- Food / Pharma / Chemicals / Process Intensification
- Realisation of intelligent and automated modular process systems

Bodec

Discover progress…

Efficient processes, lower investment & risk, shorten time to implement

Optimise and develop separation processes and technology

Are you looking for:

- Optimizing your production process?
- Innovative separation technology?
- Test facilities
- Small scale production

Introduction SME:

- Bodec optimizes production and develops new processes in the food & chemical industry since 1994. With our team of chemical and food engineers we have developed multiple new products and processes and implemented new technology for our SME and multinational customers. Since a few years we are located at FoodTechParkBrainport in Helmond with our pilot and production facilities. Here technologies can be tested and processes can be scaled up to produce batches for market introduction. All to lower risk, investments and time to market.

What are we looking for?

- New innovative products and technology
- Cooperation with technology suppliers
- Developing value chains from knowledge to production

Examples:

- True Moving Bed Adsorption Cadans
- Agitated Thin Film Dryer

Agitated Thin Film Dryer

True Moving Bed Adsorption Cadans

Name contact: Frank de Boeff
Phone number: +31 (0) 492 77 97 68
E-mail: deboeff@bodec.nl
Technology: Separation technologies
Website: www.bodec.nl

Current/past involvement in ISPT

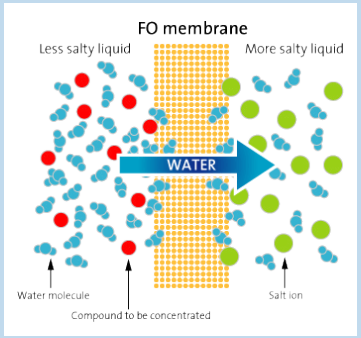
- Clusters Drying and Seperation small molecules
- Developing seperation technology on drying and adsorption, developing processing tools
- Technoproject: Thin film drying of food stuffs (with NL GUTS)
- EAP: Direct Adsorption with Cadans technology out of Complex Streams (with NL GUTS)
- Process selection of mild fractionation technologies in cooperation with NIZO

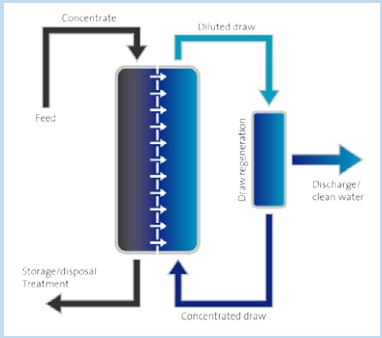
Blue-Tec

Low fouling membrane technology

Recovery of water and raw materials

Specialized in membrane contact processes, like Forward Osmosis





Principle Forward Osmosis

FO/MD pilot unit

Invitation:

BLUE-tec's vision is to create an abundant supply of water while at the same time recovering valuable materials, by optimizing and applying Forward Osmosis technology.

Introduction of BLUE-tec:

BLUE-tec's focus lies in developing and improving the application of membrane technology. BLUE-tec works on membrane contact processes. The current focus for development is the Forward (FO) technology. We've performed successful projects with different feed streams, some of which are municipal and industrial wastewater, product streams from the food industry, produced water from the oil and gas industry and concentration of manure/digestate.

What are we looking for?

Industrial clients who want to concentrate aqueous streams in an economic way without the problems of membrane fouling.

Forward Osmosis:

- Principle Forward Osmosis
- FO/MD pilot unit

bluetec
PROCESS WATER TECHNOLOGIES

Name contact: Lex van Dijk
Phone number: +31 653219323
E-mail: info@blue-tec.nl
Technology: Forward Osmosis
Website: www.blue-tec.nl

Involvement in ISPT

- EAP project FORWARD OSMOSIS
- Pilot scale tests of FO for DSM, FrieslandCampina, Shell and Marfo for concentration of aqueous streams.

EAP

Innovation Concepts

CO_2 to products

CO_2 from waste to value

Mineralization: solid products from CO_2

Invitation:
- Partners for product replacement

Introduction SME:
Activity
Use CO_2 to produce solid
(Carbonate materials & Amorphous Silica)

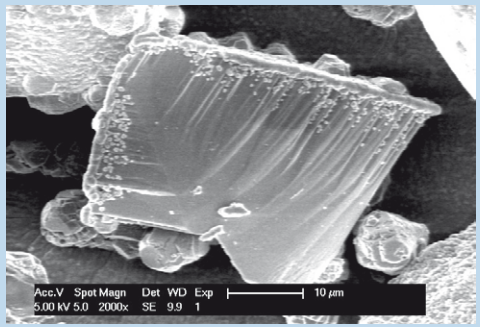
History
- 5 Years research: Idea -> Batch reactor
- O -> TRL4

Goals
- Replace existing products with "CO_2 negative products"

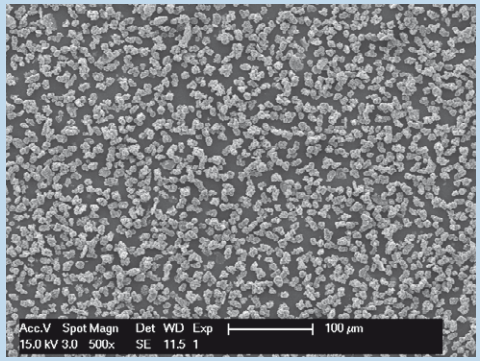
What are we looking for?
- **Applications** in:
  - Concrete (packing density)
  - Paper (PCC replacement)
  - Polymer (functional filler)
- Research collaborations towards applications (see above)

Examples:
- Making products from CO_2

Batch autoclave



Reaction



Reaction products

Name contact: Keesjan Rijnsburger
Phone number: Tel: +31 6 4937 1779
E-mail: rijnsburger@innovationconcepts.eu
Technology: CO_2 to minerals
Website: www.innovationconcepts.eu

Current/past involvement in ISPT
- CEP (CO_2 to Products)
- Technology supplier

Early Adopter Projects, EAP's in short, offer the opportunity of validating an innovative energy saving technology on real industrial streams of at least two end-users industries, to either SME Technology Suppliers or to research organisations, as technology owner, together with an SME wishing to market this technology.

EAP's

Inorganic Hollow Fiber Module

Project Leader: Paul Peeters (LouwersHanique)
Researcher(s): M.W.J. Luiten-Olieman
E-mail: Paul.Peeters@louwershanique.com
Partners: LouwersHanique, FrieslandCampina, Dishman Netherlands, Shell, University of Twente, NL GUTS
Duration: 1 year

Motivation:

Polymeric hollow fibers are widely used in various industrial fields. However, they are not fully stable in aggressive environments (e.g. high/low pH, solvents) and/or at higher temperatures.
Inorganic tubes have excellent thermal and chemical resistance but are commercially not available in diameters smaller than 3 mm, which results in a low surface area per module.

Objective of this EAP project:

Performance test of inorganic hollow fibers modules in 3 industrial streams of ISPT or NL GUTS companies.

Project scope:

Inorganic hollow fibers with diameters smaller than 2 mm will be sealed in a module with a glass sealing. The performance of these modules (>10) will be tested in 3 industrial streams of ISPT or NL GUTS companies.

Applicability:

Inorganic hollow fibers modules can operate at higher temperatures (e.g. sterilization) or in aggressive environments (e.g. solvents) where the long term stability of polymeric membranes hinders its application.

Dishman envisions to use the filter modules in the upstream process flow which so far has not been possible using conventional filtering techniques. Upstream filtering will reduce maintenance and downtime.

For FrieslandCampina the use of the Inorganic Hollow Fiber Modules was technically feasible for the removal of lactose from whey permeate.

Status:

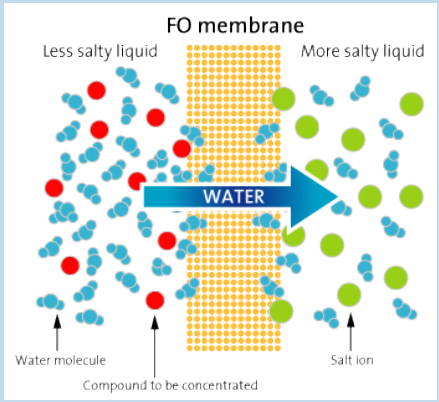
Performance tests of inorganic hollow fibers modules are performed at the moment.

NL GUTS Netherlands Separation Process Network
FrieslandCampina nourishing by nature
dishman
LouwersHanique
UNIVERSITY OF TWENTE.

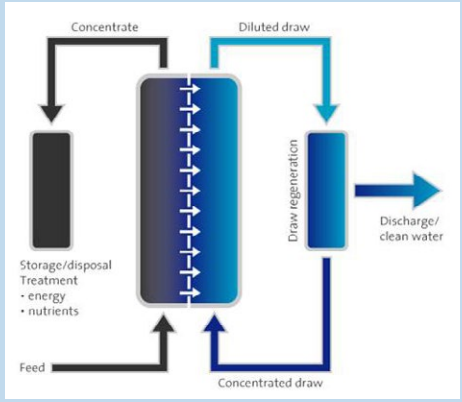
Forward Osmosis:

Concentration of liquids and recovery of clean water and/or raw materials

Project Leader:	BLUE-tec bv
Contact person:	Lex van Dijk
E-mail:	lvd@blue-tec.nl
Partners:	BLUE-tec, DSM, FrieslandCampina, Shell, Gaz de France, Marfo, NL GUTS
Budget:	€ 199.904,-



Principe of FO



FO with draw solution recovery

Objective:

The project is focused on the commercial use of forward osmosis to concentrate highly fouling streams.

Motivation and backgrounds:

Forward Osmosis (FO) is based on the principle that water separated by a semi-permeable membrane goes from a liquid with a low osmotic pressure to a liquid with a high osmotic pressure. This process doesn't take any energy or pressure to happen. FO is a low fouling separation process. FO membranes rejects organics, minerals and other solids, similar to RO, but doesn't have the typical fouling problems. The high osmotic solution is called the draw solution. During this process the draw solution is diluted and should be separated in clean water and a concentrated draw solution. In this project Reverse Osmosis and Membrane Distillation are applied for this.

Applicability:

Examples for the application of FO are:

- Concentration of products in the food and beverage industry
- Concentration of difficult wastewater (Zero Liquid Discharge)
- Osmotic-MBR
- Reuse of wastewater and recovery of raw materials
- Concentration of digestate or manure
- FO in combination with cooling towers

Project scope:

Four different types of industrial feed streams are tested for concentration using FO on pilot scale:

- A case for DSM.
- The concentration of whey for FrieslandCampina.
- The concentration of food industry wastewater, for the production of reusable water and biogas for Marfo.
- The concentration of the produced water released during oil extraction for Shell in co-operation with Gaz de France.

Status:

The pilot tests confirm the low sensitivity for fouling of the FO membranes. Tests are done with different concentration factors and different concentrations for the draw solution using either RO or MD as a draw recovery method. The tests have been finished in February 2016.

FO-MD pilot unit

Making the impossible possible; The Spinning Disc Reactor

Project Leader: Wessel Hengeveld (Flowid) – wessel.Hengeveld@flowid.nl
Researcher(s): Frans Arts (Flowid), Bert Metten (OmniChem), Sander de Wilde, Gerjan Kemperman (ChemConnection)
Partners: Flowid B.V., Ajinomoto Omnichem N.V., ChemConnection B.V.
Budget: € 163.800,- (In Kind: € 88.000,-)
Duration: up to 30 November 2015

Objective:
Feasibility test of the innovative SpinPro reactor for an organic synthesis with n- butyllithium as reagent.

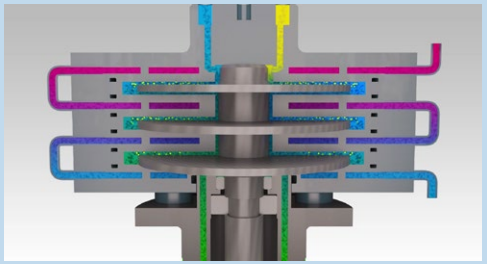
Motivation:
Proving the outstanding performance of the SpinPro reactor for extreme reaction conditions to the conservative chemical industry.

Project scope:
Experiments need to proof a significant energy saving for these kind of chemical reactions. Ambient reaction temperatures instead of the conventional -80°C will enable this.

Applicability:
Flowid realized a transportable pilot set up with SpinPro reactor. This reactor is capable to control reactions even on production scale throughputs, enhancing safety. Increased mass and heat transfer capabilities enable process intensified conditions. In practice this means increased pressure and temperature.

Status:
Initial tests indicated that these type of reactions indeed benefit economically if performed in the SpinPro reactor.
A reaction is supplied by OmniChem. In October 2015 the SpinPro reactor of Flowid is placed at ChemConnection facilities for proof of principle experiments.

Results & conclusions:
The proof of principle experiments were positive. It is demonstrated that a BuLi reaction can be performed at +30°C. Furthermore, compared to other continuous reactors, the SpinPro reactor proved that it operates stable for applications in which gasses and liquids are dosed, and a suspension is formed.
Additionally a lot has been learned regarding the hydrodynamics in the reactor. Back-mixing has been demonstrated under certain conditions and a calculation model has been produced to predict back-mixing.



Direct Adsorption with Cadans technology out of Complex Streams

Project Leader: Bodec – Réne Houben
Researcher(s): Edwin Poiesz, Rene Daniëls, Robin Spelbrink, Marco Giuseppin, René Houben, Frank de Boeff, Paul Craenen
E-mail: houben@bodec.nl
Partners: Bodec, Avebe, Cosun, NL GUTS
ISPT Budget: € 111.120,-
Duration: 1/11/2014 – 01/05/2016

Objective:

To prove Cadans technology on relevant industrial feed streams, to show feasibility for scale-up of Cadans technology and validate technical and economical feasibility. Using relevant industrial cases from agrofood applying Cadans technology the potential for valorisation of these streams can become clear. Finally the activities and results in this project will help to promote application of Cadans Technology.

Motivation:

To extract economically valuable substances from viscous or turbid agrofood side streams, we need innovative separation techniques. The ISPT roadmap identifies Cadans as a promising technology. A pilot installation has been developed, which in this project will extensively be tested on three industrial streams to determine its industrial applicability and economic feasibility.

Project scope:

The partners in the project will define relevant cases. For these cases a test program is designed to define process window and optimization of the technology. With the information from the tests a scale up study is performed for industrial scale application. This is input for the business cases for the chosen applications containing the technical risks and economical feasibility. Based on that a solid business decision could be taken.

Applicability:

The cases are chosen from agrofood industry but application of Cadans Technology is also possible for chemical and pharmaceutical industry. Application can be isolating specific components or cleaning streams from residuals. Cadans technology can be an alternative for adsoption systems in bio based processes to valorize side streams or replace existing adsorption systems in food and other industries.

Status:

With the partners in the project industrial cases are selected and initial trials are performed. During the current campaign a test program is performed to analyze the process window. After the process window is analyzed an optimization is done. With long trials the robustness of the technology is checked. When the test program is finished scale up can be performed and the business cases can be developed.

Rotating microfilters for sustainable microfiltration treatment of process streams

Project Leader: Aquamarijn Micro Filtration BV
E-mail: microfiltration@aquamarijn.nl
Partners: Aquamarijn Micro Filtration, Cosun DSM, NIZO food research, NL GUTS
Budget: 161 k€
Duration: 1 year (2015-2016)

Objective:

Evaluation of a prototype rotating-filtration system with microsieves for high-performance energy-efficient filtration of raw process streams containing complex molecules and proteins.

Motivation:

Conventional filtration systems based on ceramic tubes require energy-intensive operation, as they require high pressures and require large membrane surfaces in order to achieve acceptable process capacities. In conventional systems, a large part of the energy is used to generate along the membrane shear forces in the fluid in order to reduce the layer thickness of contaminating particles, and in addition, a considerable part of the energy is used in order to achieve a sufficiently high operational flux. In addition, a lot of energy is lost due to the continuous circulation of all the liquid flows.

In this project, we primarily use energy to initiate the movement (rotation) of flat membrane filtration elements (Figure 1) in a filtration chamber. This allows considerable energy saving without loss of high-shear forces. By applying high-flux membranes (e.g. microsieves) in combination with an innovative flow-reversal device 10 to 100 fold increase in fluxes can be achieved with reduced energy consumption.

Project scope:

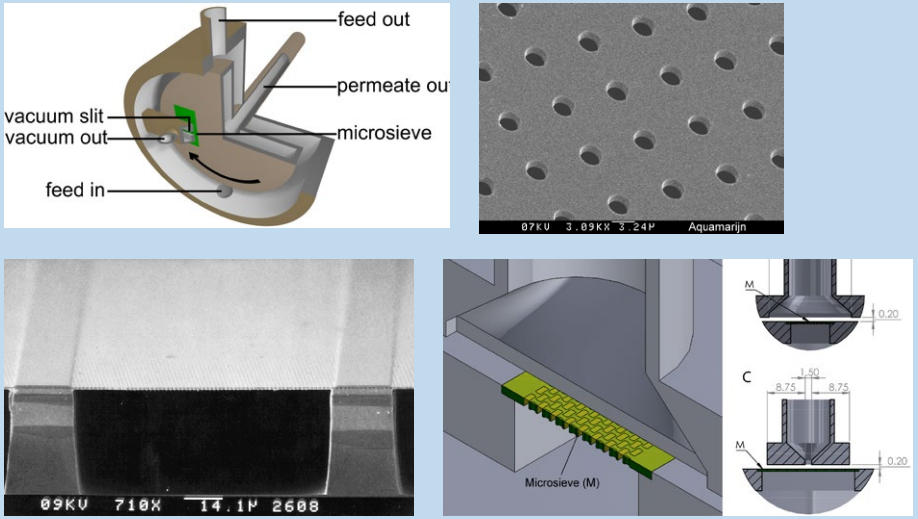
- Insight in the energy savings and the application of rotary-microfilter filtration for reduction of microbiology in process streams.
- Feasibility of scaling up the prototype rotary-microfilter filtration systems with respect to energy consumption, footprints etc.

Applicability:

High-Frequency Flow Reversal (HFFR) is the process that allows to stabilize high filtration performances of ultrathin hi-flux membranes, such as microsieves, by removing non-permeable substances concentrating on the membrane surface very effectively. Small sectors of less than 1% of the total membrane area are cleaned 10-50 times per second during the HFFR process. The short flow reversal concentrated on a small membrane area effectively prevents adhesion of organic substances such proteins inside the pores and at the surface of the microsieve.

Status:

The project started fall 2015 and experiments are planned during fall/winter 2015/2016.



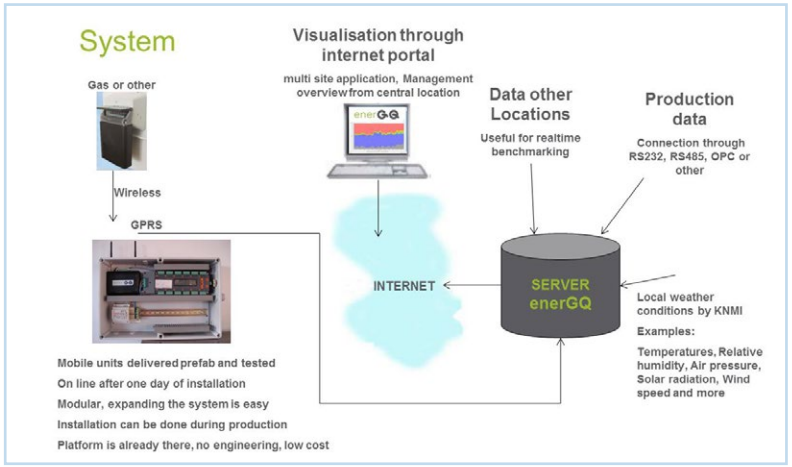
Rotating-Filter System with High-Frequency Flow Reversal

we-CARE, we Create Awareness and Reduce Energy

Project Leader: Ton van Ewijk,
E-mail: tvewijk@energq.com
Budget: k€ 85
Partners: NL GUTS Netherlands Separation Process Network, PROMENS, TEIJIN Human Chemistry, Human Solutions, Klesch Petroleum, enerGQ more awareness. better business.

Objective:

- Big data analysis in the process industry enables a 10-20% improvement in energy efficiency
- enerGQ supports the optimalization of the operational management
- Further development of enerGQ into advisory software for production staff
- Plug in software development for the process industry



Motivation:

- Early detection of abnormal situations in current processes
- Processes with better configurations
- Increased knowledge regarding processes and factors that influence processes
- Increase energy awareness

Project scope:

- Real time data collection and analysis

Applicability:

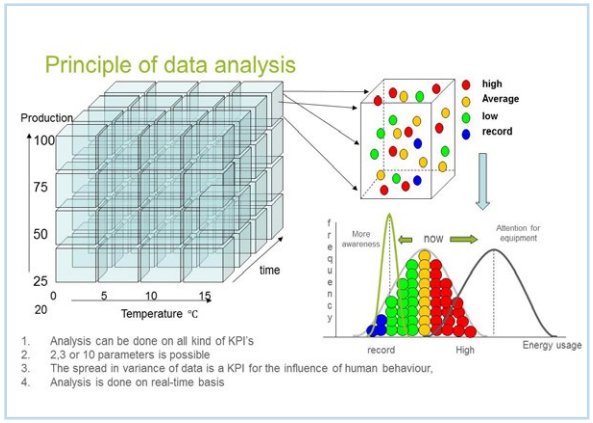
- Food, feed, pharma, chemistry, metal, synthetic
- All assets available with data

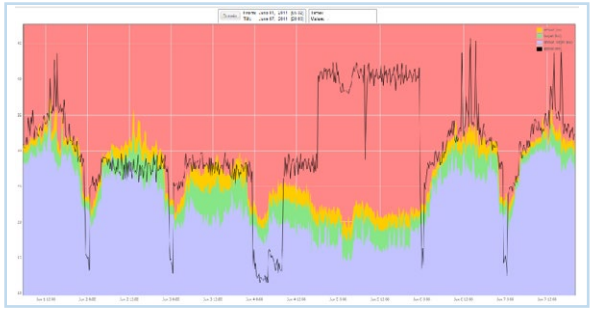
Status:

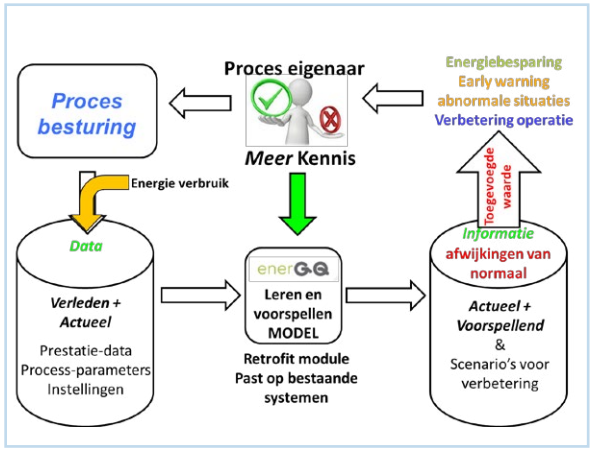
Project has started on 01-12-2015

- Installation measurement equipment and server/ software
- Data collection
- Benchmarking/baseline measurement
- Data analysis
- Interpretation measurement data and optimalization of settings and operational management

End of project: 30-05-2017







Technology validation projects, 'Technoprojects' in short, are the predecessors of EAP's. Technoprojects predominantly focused on separation technologies with a broader scope of higher separation efficiency, better product quality and energy saving, directly or indirectly in the value chain. Multiple success stories prove that this leads to fast implementation of new technologies.

Technoprojects

Use of SolSep membranes in strong solvents

Proof of robustness in chemical and petrochemical industries

Project: CS-01-01
Project leader: F. Petrus Cuperus
E-mail: cuperus@solsep.com
Partners: SolSep BV, AKZONobel, DSM, LyondellBasell, Schering-Plough, Shell, NL GUTS
Budget: 50 k€
Duration: Successfully completed

Incentive

Make separation of high value products from organic solvents more efficient, mild, and work at low temperature.

Thus:

- Establish better product quality
- Gain process flexibility
- Use less energy
- Design safer processes

Objective

Demonstrate the robustness of SolSep nanofiltration membranes in strong organic solvents on industrial relevant systems.

Approach

SolSep NF membranes (polymeric) were evaluated. Their performance regarding flux and retention in relation to process phenomena like fouling and concentration polarization was monitored.

Seven different systems were evaluated. This included solvents like acetone, aromatic C8- C11 mixtures, methanol, toluene, THF, toluene, MBTE , benzene and NMP.

The Solsep membranes were robust in all solvents. Pilot work was done in the NMP-cholesterol (model) system.

Testing involved lab scale experiments to determine basic performance data.

On the base of these the partners determined which systems should be tested on pilot scale.

Results

- SolSep membranes and elements are stable in all systems investigated.
- A pilot with NMP-cholesterol was successfully performed for 6 months. In other a-protics it works as well.
- Fouling and CP effects were not significant.
- Results proof the technical possibilities. Work on non-model systems should be done to validate the economics.
- Scale up for DMAc-pyridine system (France).

Membrane fouling

Nanofiltration tests on organic acid solution using V-SE

Project: CS-01-02
Project leader: Ton Franken
E-mail: franken@mact.nl
Partners: MACT, Purac, NL GUTS
Budget: 50 K€
Duration: Successfully completed

Separation task:

In one of the production processes a process stream containing an organic acid and some contaminants (typically polymeric impurities) is obtained. This stream needs to be treated in such a way that the polymeric impurities are removed. A suitable process is nanofiltration. Due to the nature of the contaminants cross-flow conditions have to be used to avoid fouling and to maintain an acceptable flux.

Approach:

One of the characteristics of the organic acid solution is that it has a high concentration of several components and its viscosity is rather high. As such it is proposed to perform tests with a system that uses increased mechanical support. The system used in the test is V-SEP, in which the mechanical support is supplied by vibration.

In the membrane system, a stack of discs is moved at high speed in a torsional oscillation creating a shear rate of around 150,000 s-1 which is more than 10 times higher than the maximum shear in cross-flow operation. As no cross-flow is needed the total energy consumption for a V-SEP system is only about 10 to 15% of the energy costs for cross-flow operation, whereas filtration rates of up to five times higher than in cross-flow filtration can be obtained.

Equipment:

The tests were carried out using a vibrating membrane system from New Logic equipped with a membrane stack (1.55 m^2) with nanofiltration membranes with a MWCO of 250 Dalton.

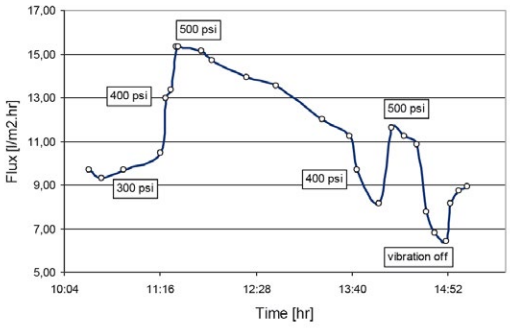
Results:

The following graph shows some of the results that were obtained with V-SEP. In this graph effects of time, concentration, pressure and vibration are presented.

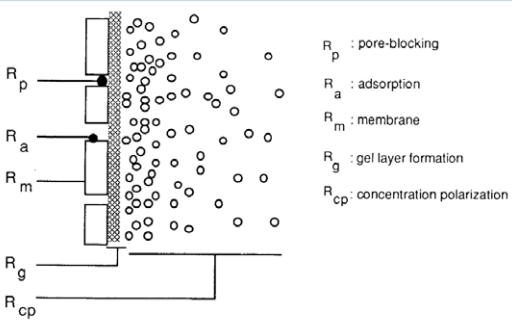
Some observations:

- Vibratory enhanced filtration is good method in avoiding flux decline in a NF process.
- Pressure increase leads to near proportional flux increase if vibration is used to minimize fouling.
- During a concentration run, V-SEP can avoid a strong flux decrease despite a concentration factor of nearly 3.
- During filtration an irreversible deposition of feed components occurs on the membrane that can be easily removed by using a commercial cleaning agent.

Membrane module on torsion spring



Flux as a function of time



Validation of In-Situ Particle Viewer

In-Situ Imaging technology for chemical / physical processes

Project	CS-01-04
Project leader:	Fred Hugen
E-mail:	Fred@perdix.nl
Partners:	Perdix Analytical Systems, Friesland Foods Domo, Albemarle Catalysts Company, TU Delft, NL GUTS
Budget:	50 K€
Duration:	Successfully completed

Incentive:

Important steps in chemical processes are the production of crystals, production of emulsions, or reactions with catalysts particles. The behaviour of particles/droplets in these steps are often not well understood. Therefore there is a need for real-time monitoring of the size, and shape of the particles/droplets.

Objective:

Perdix Analytical Systems (PAS) has developed submersible microscopes for in-situ imaging of particles. The imaging software is capable of measuring the size and shape of the particles in the images. The goal of the project is to validate the applicability of these probes for monitoring crystallization processes.

Approach:

Tests have been defined in order to validate the operating conditions and accuracy of the measurements of the ISPV.

The defined tests are:

- Laboratory tests on the size distribution of Lactose crystals in ethanol and in H_2O
- Monitoring the size distribution of Lactose particles in H_2O in real batch crystallization in a production plant

Results:

The results of laboratory testing of lactose crystals show that the accuracy of the measured D05 of the PSD is accurate within 10 micron and reproducible within 3 micron. Even the influence of abbreviation of crystals due to stirring is visible.

The crystallization process could easily monitor the PSD of the particles during the growth up to 5% mass. Also it was clear from the images that agglomeration already takes place in an early stage of the process.

Extension of the scope of Pervatech pervaporation membranes

Demonstration of the usefulness of silica-based ceramic membranes for pervaporation

Project:	CS-01-05
Project leader:	Frans Velterop
E-mail:	info@pervatech.nl
Partners:	Pervatech, DSM, Huntsman, NL GUTS
Budget:	49,8 K€
Duration:	Successfully completed

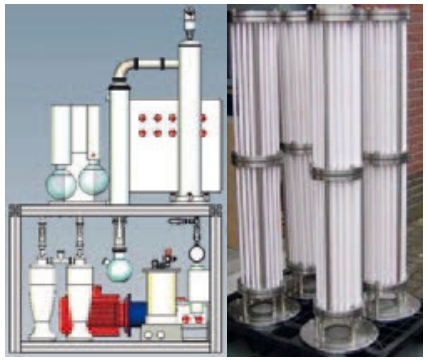
Incentive:

The incentive of the project is to demonstrate the usefulness of Pervatech membranes in a few new applications and broadening the scope of applicability.
In one industrial application both organophilic and hydrophilic pervaporation will be studied for the selective separation and dehydration of a specific organic molecule
Two processes are to be researched:

At DSM:
Selective separation of an organophilic compound by organophilic pervaporation, followed by dehydration with ceramic hydrophilic pervaporation membranes.

At Huntsman:
Dehydration of methanol streams.
Better use of the methanol in the chemical reaction

Objective:



DSM:
With organophilic pervaporation membranes the by-products of the fermentation and chemical reaction can be selectivily separated. The permeate contains water, reaction products and low molecular weight species which poison the chemical reaction. In-situ removal of those species during the reaction will result in higher yield and higher quality of the desired product. After organophilic separation the permeate is further dehydrated by means of the ceramic pervaporation membranes.

Huntsman:
By introduction of ceramic pervaporation membranes the impact of the build-up of the impurities can be reduced or eliminated. Other technologies were not successful to get rid of the impurities.

Approach:

A test program is defined for the specific point of implementation of the pervaporation process. Tests will be carried out to determine the feasibility and process impact with pervaporation.

Step one is “proof of principal” with model feed stock, followed by testing with real life feed stock.
The pervaporation process parameters will be optimized according to the findings of the measurements.
Cleaning protocol will be studied, as the project will continue.
Evaluation and recommendation for scale up towards industrial implementation.

Results:

1) Proof of eliminating the drawbacks of the conventional process compared to pervaporation with ceramic membranes.
2) Indication of economical feasibility, process stability and sensitivity for fouling, cleaning protocol.
3) The outlines for industrial implementation of ceramic pervaporation membranes in the target processes at DSM and Huntsman.

Reuse of effluent or upgrading processflows by electrodialysis technologies

Project: CS-01-06
Project leader: Jan Tholen
E-mail: jan@timtholen.nl
Partners: Purac, NL GUTS, Cosun, DMV International, Huntsman, Nedmag
Budget: 50 K€
Duration: Successfully completed

Incentive:

Separaration of effluent in reusable parts, such as water, salt, acid or lye.
Effective upgrading of process fluids without the use of chemicals.

Objective:

- Desalting without chemical use
- Upgrading products
- Acid recovery

Approach:

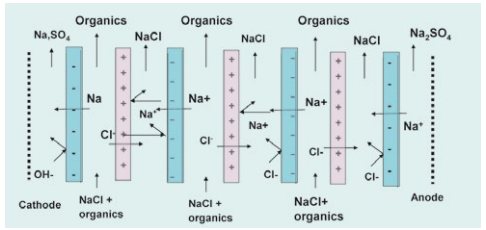
On labscale different separations are tested to find out the technological and economical feasibility of electrodialysis with or without bipolar membranes.

Example of results

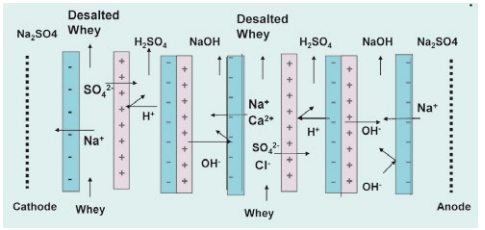
- **Salt removal with electrodialysis**
  Currently this organic product is desalted with ion exchange with high costs for chemicals and a salty waste stream. Present costs for this treatment are Eur 8/ton With electrodialysis abt. 80 % of the desalting can be achieved at costs of abt. Eur 2/ton

Lab scale unit

- **Acid recovery with bipolar membranes**
  From a process stream now the sulfuric acid is removed with calcium resulting in a calciumsulfate waste stream. With electrodialysis with bipolar membranes the sulfate can be removed as sulfuric acid and reused in the process.



Salt removal with electrodialysis

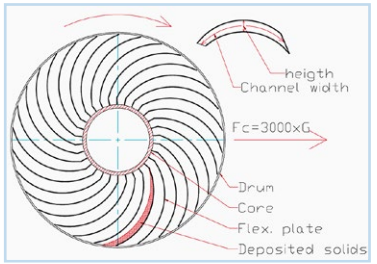


Acid recovery with bipolar membranes

Evodos Centrifuge

Chemical free separation using Evodos Spiral Plate Technology

Project: CS-01-07
Project leader: Marco Brocken
E-mail: marco.brocken@evodos.eu
Partners: Evodos, Cosun, DSM, Nedmag Industries, NL GUTS
Budget: 50 K€
Duration: Successfully completed



Spiral Plate Technology, top view, (H.A. Boele, 2007)

Incentive:

For the participating companies a cost improvement is the incentive, either by achieving a higher dry solid content in the discharged solids or by obtaining a more clean centrate.

Objective:

Nedmag
At NedMag Magnesium-Hydroxide is separated out of the process liquid and concentrated to a high dry solid percentage. For NedMag a successful test generates a higher DS% than the drum filters. This might result in replacing the energy consuming drum-filters and to use less energy in the subsequent drying/evaporation process.

Cosun
At Cosun a process stream is clarified. For Cosun a positive test result will mean a more cost effective water treatment process.

DSM
The feed stream is a biomass containing liquid. The objective is to clarify this liquid. For DSM a positive test result means that they might replace their current filtration technology.

Approach:

Tests have been executed with the Evodos Spiral Plate Technology demonstration machine.

Characteristics of the Evodos technology

- Curved vanes which can open for superb discharge performance.
- High separation efficiency due to the smallest settling velocity possible in combination with long delay times and Y-flow (no cross-flow).
- No need to apply chemicals to separate suspendable solids.
- Self adjusting on changes in process parameters, no fixed interface level to be set.
- Performance is independent of the size, shape, consistency (e.g. sticky, greasy, abrasive) or permeability of the solids.

Results:

At Nedmag the tests proved that Evodos improves the dry solid content with 13%. Although this leads to substantial reduction in energy for drying, calculations showed there is no positive business case since the dry solid content of the feed is too high, At Cosun the objective was to achieve a centrate with a dry solid content lower than 1%. With a decantable dry solid content of 0,68% Evodos did meet the test objective. Based upon results in the downstream process Cosun had to set a new objective. It will be investigated if Evodos machines can meet this new objective.
At DSM is showed that the Evodos technology is able to produce a clear centrate. The test objective is achieved.

Evodos SPT machine, closed and open view

Oscillating Baffled Flow Crystallizer

From batch to continuous crystallization

Project: CS-01-08
Project leader: Henk Akse
E-mail: henk.akse@traxxys.com
Partners: Nitech, Cosun, Purac, Croda, NL GUTS
Budget: 50 K€
Duration: Succesfully completed

Incentive:

- Significant reduction in crystallization time (from 8 hours down to 15 minutes)
- Continuous production: no batch to batch variation
- Better filterability
- Narrower particle size distribution
- Many independent operating variables to affect the crystallization process
- Many design parameters to optimize crystallizer design for specific mixtures

Objective:

Proof of principle of continuous crystallization of real product mixtures from participating companies leading to reduction of crystallization time.

Approach:

Nitech Labs investigated Mixing conditions, Amplitude, Frequency, Starting temperature, End temperature, Cooling profile, Seeding, Hold times, concentration/ solvent, ratio/solids loading and Filtration index.

OBFC consists of a tubular crystallizer through which the mixture is pumped continuously that has to be crystallized.

1. Superimposed on the feed flow is an additional flow that can be manipulated in amplitude and frequency.
2. The tubular Crystallizer contains baffles with orifices perpendicular to feed flow. This introduces various design parameters: distance between baffles, diameter of orifices, variation in diameter and distance along the tube.
3. It is possible to superimpose a heating and/or cooling profile axially along the tubular crystallizer.

Results:

Three Proof of Principle tests performed Successful combinations of OBFC/mixtures identified.

Thin film drying of liquid foodstuffs

Project: CS-01-09
Project Leader: Carry Schoofs
Researchers: Argyro Sotiriadou, Rene Houben, Anke Hermans
E-mail: schoofs@bodec.nl
Partners: Bodec, Purac, Givaudan, DSM, Bodec, NL GUTS
Budget: 50 k€
Duration: dec 2010 – dec 2011

Incentive:

To provide an alternative for spray dryers for the drying of liquid foodstuffs. Agitated Thin Film Dryers should offer more energy efficient drying processes for liquid foodstuffs than a spray dryer, also combined with lower investment costs.

Objective:

Demonstrate the feasibility of an ATFD for the drying of different types of food stuffs.

Approach:

- The 1st part of the project is smallscale lab tests (drying, distillation). During these tests the drying behavior of the products (foaming, stickiness, crystallization, gelling etc) will be investigated.
- The pilot trials will be performed based on these observations.
- Designs of Experiments will be used to determine an operating window and the obtained powders will be characterized.
- A preliminary benchmark can be made based on the information from the tests.

Results:

What was observed by the lab tests is that different product types will probably require different settings and operation on the ATFD.
Adapting the feed temperature was sometimes needed to decrease the viscosity to get a uniform film.
Some products showed a sticky phase. It is desired for sticky products to go through the sticky phase as fast as possible in the dryer to prevent fouling.
If a product foams in the dryer inlet it will be difficult to create a uniform film. To avoid foaming the feed temperature can be lowered or anti-foaming agents can be used.

Wireless Sensors with Thermoharvesting Power

Project: CS-01-11
Project Leader: Don Mulder (Mutrees) - don.mulder@online.nl
Burkhard Habbe (Micropelt)
Researchers: Arend Jan Zeeuw, Luc Zeelenberg,
Mieke Sibeijn, Rob Sosef, Olga de Jong
Partners: Micropelt, Huntsman, Dishman,
Mutrees, Emerson, NL GUTS
Budget: 50 k€
Duration: 2011 - 2012

Objective:

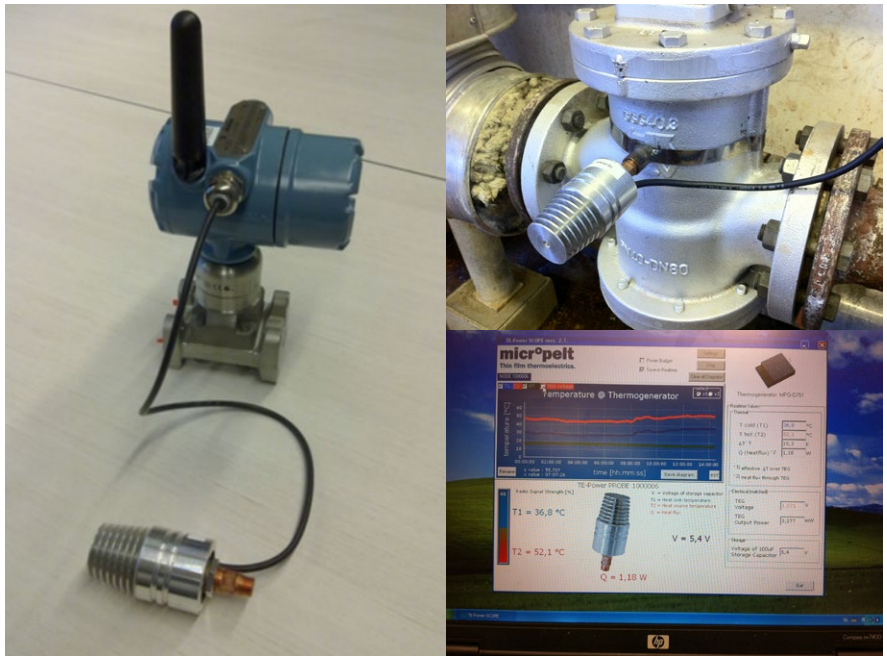
Demonstrate the ease of planning, installation and operation of SFWI.
Describe and quantify the value for process intensification and optimization, and asset management purposes.
Test long term reliability and response to seasonal and weather influences.

Motivation:

Flexibility in installing sensors additional at any place in existing process equipment for monitoring process and equipment parameters in an ATEX environment.
Self-sustaining Fully Wireless Instruments (SFWI) allow for lifetime maintenancefree operation in any place.

Project scope:

Based on test results identify more use cases and locations for SFWI applications with substantial, proven operational benefits.
Evaluate and quantify autonomous wireless sensor technology's value for chemical and process industries. Collect experience and advice for systematic deployment in industrial environments. In a joint effort via NL GUTS & ISPT, this technology has been tested a two chemical plants.



Maintenance-free Wireless Sensor System

Results:

Huntsman: 2 SFWI's installed & logged in sustainable operation since March 2012
Dishman: Harvesters under power loggin

Applicability:

SFWI configuration composed of Emerson wireless transmitters (p, T) with Micropelt thermoharvester and battery-backed power module. Demonstrate planning, deployment and operation in both indoor and outdoor retrofit installations across seasonal changes.

Project team

Complete long-term study at Huntsman. Add instruments to create full mesh network, demonstrate sustainable EH operation. Provide feedback to optimize power module Completion of this NL-Guts, ISPT project Atex certification of harvester.

Recovery of aggressive solvents, which are difficult to separate

Project:	CS-01-12
Project Leader:	Frans Velterop
Researcher:	Frans Velterop, Tom Schols
E-mail:	info@pervatech.nl
Partners:	Pervatech, Givaudan, X-Flow, NL GUTS
Budget:	€50.100

Objective:

Recovery of aggressive solvents by applying membrane technology.

- Givaudan: Re-use of water/ ethanol mixture with aggressive organic aromatics.
- X-Flow: Re-use of NMP

Motivation:

- Reduction of processing costs
- Reduction of emissions
- Reuse of solvents

Applicability:

- HybSi is chemically very robust compared to other membranes.
- HybSi has good selectivity for water in solvents.
- Small molecules will also permeate, possibly allowing permeation of ethanol.

Project scope:

Givaudan:

- Perform testing
- Tailor membrane
- Generate data enabling techno/economic plant evaluation
- Recommendations towards full scale plant integration

X-Flow:

- Perform testing
- Generate data enabling techno/economic plant evaluation
- Recommendations towards full scale plant integration

Results:

Givaudan:

- Recovery of ethanol from real media economically feasible

X-Flow:

- flux on real waste NMP low compared to model liquid
- fouling to be resolved

In-line recovery of solvents for chromatographic uses

Project: CS-01-13
Project Leader: Dr Ir F. Petrus Cuperus - SolSep BV
Researcher: SolSep BV: Dr Ir I.M. Wienk, Dr Ir F.P.Cuperus
Avantor Materials BV: ing. J. Oosterholt, Dr Ir R. de Lange
E-mail: cuperus@solsep.com
Partners: SolSep BV, DSM, Avantor Materials BV, NL GUTS

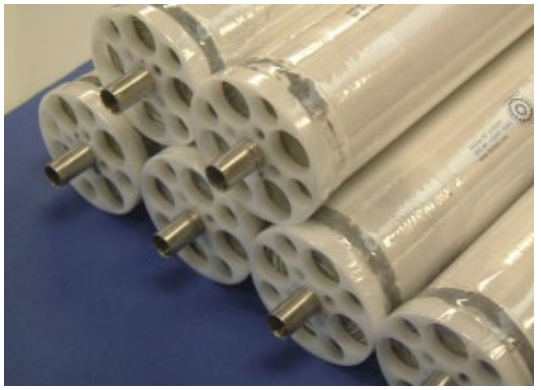
Objective:
Use membrane technology to recover organic solvents esp. methanol, ethyl acetate and acetonitrile.

Motivation:
In many preparative downstream processing steps, very clean solvents have to be used. The consumption of these solvents contributes considerably to the costs of the operation. In would be very favorable if such solvents could be re-used. In-line recovery and re-use would be even more interesting. However, the current possibilities are very limited, specific and hence difficult to use as a generic technology.
The project aims for the development of technology to open-up in line recovery of chromatographic solvents on preparative scale.

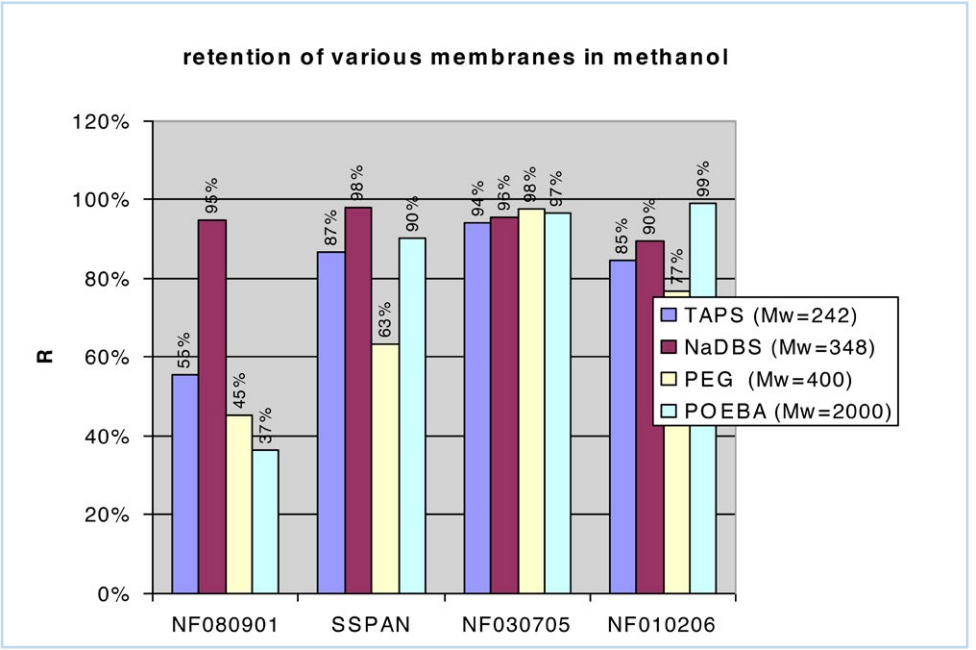
Project scope:
Evalution of membranes of small (pilot) scale. Strive for maximum level of purity. Analysis in ppm and ppb level. Set-up of small scale process.

Applicability:
Add-on to present technology and should lower energy consumption as well as chemical waste (adsorptive waste). In-line and eventually also off-line.

- chemical industries
- pharmaceutical
- food
- cosmetics
- analysis laboratories
- toll recyclers



Results:
It has been proven that molecules can be retained by membranes.
E.g. in methanolretentions of 94+% were found. Still, this tends to be too low for chromatographic application were only ppms or ppbs are allowed. Multi-passes through a membrane could lead to acceptable levels. Finalization of the work includes process design.



Membrane Distillation to concentrate Salt Streams

Project: CS-01-14
Project Leaders: Don Mulder (Mutrees), Eric van Sonsbeek (Aquastill)
E-mail: don.mulder@online.nl
Researchers: Jacob Visser, Ronald Capel, Arjen Postma, Erik Hoving
Partners: Aquastill, Nedmag, Purac, Royal Cosun, DSM, Mutrees, NL GUTS
Budget: 50 k€
Duration: 2010 - 2011

Incentive:

Originally Membrane Distillation (MD) was designed to produce drinking water from sea water. This MD technology however, can also be used to concentrate salt streams (in other words: dewater salt streams). In a joint effort via NL Guts, this MD technology have been tested at 4 companies, each company tested 2 process saltwater streams.

Objective:

Industry loses product streams that contain large amounts of water.
Dewatering these streams, using an MD system that utilizes waste heat, can turn a product loss into a valuable product that can be recovered, resold or reused.

Approach:

The Aquastill screening unit was used to test the dewater-ability of the selected process streams.
Based on project results, Capex and Opex calculations were also performed.

Results:

- MD can be used to dewater valuable process streams and even recover product losses from drainage streams
- MD requires less energy than other technologies to dewater process streams
- MD produces a very high quality distilled water during dewatering
- Hydrophobic MB membranes don't foul as fast as other types of membranes
- When fouling does occur, it is easy to clean the MB membranes
- Various types of MB membranes can be used
- Capex/Opex calculations show that this technology is economically very interesting for dewatering process streams

Pulsed Electric Field for food conservation or other applications

Project: CS-01-15
Project Leader: Myriam Knopf
E-mail: Knopf@top-bv.nl
Partners: TOP-bv, FrieslandCampina, Purac, Royal Cosun, VION, NL GUTS
Budget: 50 K€

Objective:

Demonstrate the feasibility of PEF for actual applications focusing on microbial inactivation and focusing on enhanced extraction.

Motivation:

With the new PEF 2.0 has the following advantages:

- Mild process for microbial inactivation
- Less quality degradation during microbial inactivation
- Lower energy input
- Lower costs compared to HPP
- Enables to extract more desirable components
- Increase product yield and quality

Project scope:

For the microbiological inactivation and the extraction enhancement applications the feasibility of using PEF will be performed.
Relevant PEF operating parameters will be determined for the applications based on product characteristics.
Experimentally, the best PEF operating conditions (field intensity, pulse duration, number of pulses, frequency, and temperature) will be determined.

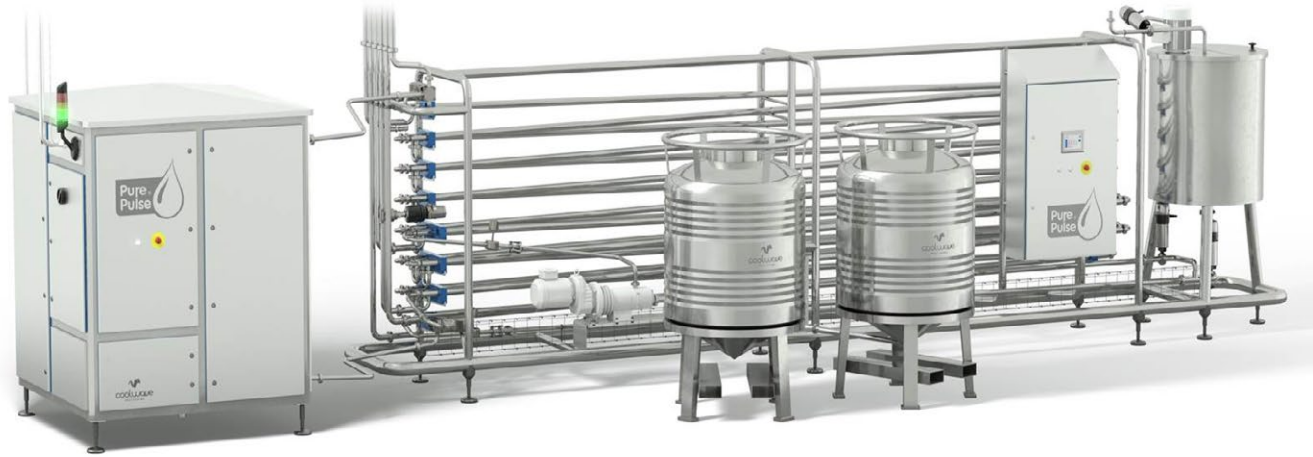
Applicability:

TOP has developed a new PEF-concept, called PurePulse. During the whole treatment products remain below 40 degrees Celsius.
The method works best at acidic juices such as apple or orange juice, where the low pH and electrical pulses extend the shelf life.
Liquid foods with undissolved particles larger than 5 millimeters cannot yet be treated with PurePulse.

Results:

Extraction of both tested cases was enhanced considerably by PEF:

- Juice yield
- Juice purity
- Field strength, number of pulses and temperature affect efficiency



Digestate processing

Project: CS-01-17
Project Leader: Herre Hoekstra
Researcher: Remko van Dam
E-mail: Herre.Hoekstra@evodos.eu
Partners: Evodos, VION Ingredients, Bio Energie Herk
Budget: 50.000 Euro

Objective:

For Vion Ingredients the objective is to investigate how much cost saving can be realized using the Evodos SPT when dewatering the digestate.
For Bio Energie Herk bvba the objective is to investigate what the maximum % of phosphates is that can be recovered using the Evodos SPT.

Motivation:

The cost of disposing the digestate is an important element in the profitability of a digester. To limit the use of chemicals and to take out the maximum of water will reduce this disposal cost. At the same time phosphate is a valuable mineral when recovered and the more this phosphate is recovered in a dewatered cake the better this is for the business case.

Project scope:

In this project several streams of digestate will be tested with the Evodos SPT. The DW % of the centrate and the cake will be measured. Also the
% recovery of phosphates will be investigated. When during the project extra parties are interested to offer their digestate streams to test this will be taken into consideration.

Applicability:

VION Ingredients produces high-quality products such as proteins, fats, haemoglobins, plasmas and gelatines from by-products of the meat-processing and meat industries. These products are used as ingredients in such highly diverse markets as pharmaceuticals, food, feed, energy, and technology. VION Ingredients is the global market leader for gelatine and invests in innovative processes, including the production of biofuel. VION Ingredients operates a digester of which one of the by-products is digestate.

Bio Energie Herk bvba has built a digester with a capacity of 20.000 T/a. The purpose of the installation is to produce energy in a sustainable way. Beside producing energy, Bio Energie is looking for ways to recover phosphates and to optimise the process to balance the Nitrogen en Phosphate in the separated streams.

Evodos has developed an innovative separation technology based on centrifugal force. This patented technology is better known under the name Spiral Plate Technology (SPT). At the moment Evodos has successfully applied the SPT for several companies around the world in the business of algae harvesting.

Results:

VION

- Good dewatering without flocculants
- Extra drying cost from higher moisture content balanced by flocculant savings

Bio Energie Herk

- 60% phosphorous removed from vegetable and animal based digestate

HYPERCATCH I

New High Performance separation platform Efficient purification of valuable compounds at large scale

Project:	CS-02-01
Project leader:	Ria Rhemrev-Boom
E-mail:	rhemrev@kpn-officedsl.nl
Partners:	ResQ Lab, MSD, DSM, FrieslandCampina, Mosaic Systems
Budget:	50 k€
Duration:	Successfully completed

Incentive:

Downstream processing of valuable compounds is responsible for 60 - 90% of total production costs. Usually, a multi-step procedure is necessary, whereas ideally, such a process should take only one single step, combining isolation from the matrix, concentration and purification.

Objective:

The development of highly selective, functionalized resins with high capacity combined with new types of chromatography modules based on its proprietary technology of functional particles in a porous matrix (mixed matrix membrane structures) (see Phase II).

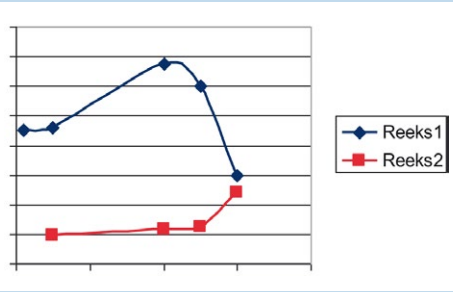
Approach:

Phase I deals with the chemical coupling of specific ligands to functionalize beads with a defined particle size and pore size. Base resins (silica, acrylate- and styrene-based polymers) are chosen with a particle size ranging between 2 – 60 um and a pore size of between nonporous and 1000 Angstrom. Depending on the ligand immobilized, these resins are applied for respectively Hydrophobic Interaction Chromatography, affinity and immunoaffinity chromatography type of separations. Model components, like albumin and immunoglobulin are chosen for benchmarking.

Phase II of the Hypercatch project concerns the embedding of these resins in the mixed matrix hollow fiber membranes and testing of these separation devices. Specific resins, with appropriate characteristics (high capacity and selectivity), which allow one step downstream processing, are currently not available, nor is adequate knowledge available what the criteria are for the particular resins to obtain these high capacity separation modules.

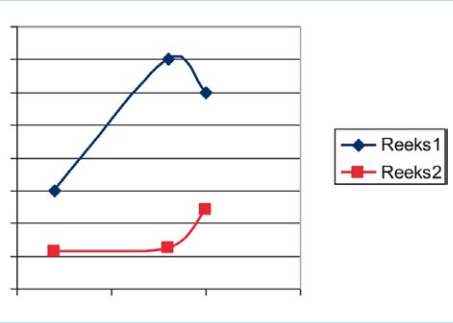
Results:

- Decreasing the particle size of a specific resin leads to an increase in binding capacity.



- The surface area of chromatographic resins is mainly determined by the available pores. To enable high binding capacities, the pore size (and/or in combination with surface area) should be defined in relation to the size of the target analyte.

- In contradiction to other modes of chromatography, the coupling of ligands have to be optimized for each type of ligand in order to obtain affinity and immunoaffinity resinswith high capacity.



HYPERCATCH II

New High Performance separation platform Efficient purification of valuable compounds at large scale

Project: CS-02-02
Project leader: Ria Rhemrev-Boom
E-mail: rhemrev@kpn-officedsl.nl
Partners: Mosaic Systems, MSD, ResQ Lab, DSM, FrieslandCampina
Budget: 50 k€
Duration: Successfully completed

Incentive:

Downstream processing of valuable compounds is responsible for 60 - 90% of total production costs. Usually, a multi-step procedure is necessary, whereas ideally, such a process should take only one single step, combining isolation from the matrix, concentration and purification.

Objective:

The development of highly selective resins with high capacity (see phase I) combined with a new type of chromatography based on the proprietary technology of resins in a porous matrix (mixed matrix membrane structures).

Significant advantages of the Mosaic Systems' platform technology are:

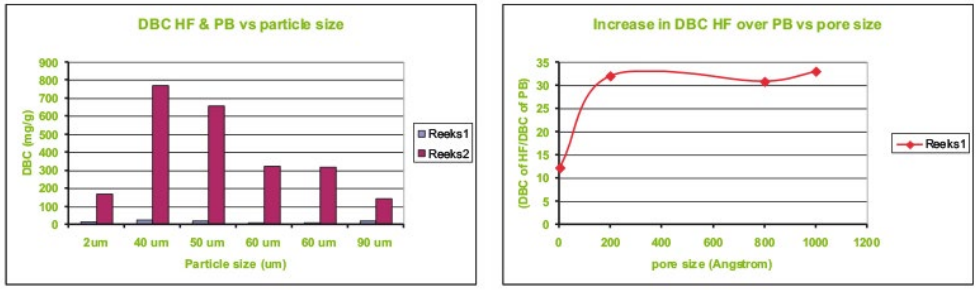
- High capacity combined with high throughput;
- Embedding each type of resin available is possible (platform technology!);
- Decreased cycle times;
- No fouling, clogging, channeling and bed compression;
- Ready-to-use separation modules (no validation prior to production);
- Easy scaling up of modules.

Approach:

Selective resins with high capacity (obtained from Phase I) are embedded into porous mixed matrix membrane fibers. Depending on the resin embedded, high capacity separation modules are obtained, which are selectively capturing the compound of interest (model components chosen are albumin and immunoglobulin).
To allow the efficient and one step downstream processing, the combination of high capacity (small particle) resins with defined selectivity with the Mosaic Systems' technology is entirely new. No information is yet available how much expensive resin can be saved, nor is sufficient knowledge available what the criteria are for the particular resins to obtain these high capacity separation modules.

Results:

- Decreasing the particle size of a specific resins leads to an increase in binding capacity;
- Depending on the resin, after embedding into hollow fiber membranes an increase in the dynamic binding capacity of a factor 7 – 35 was noticed;
- Increase in dynamic binding capacity is predominantly determined by the pore size (and/or in combination with surface area);
- 40 -50 um particles gave the best results;
- 2 um nonporous particles did not give the expected results.



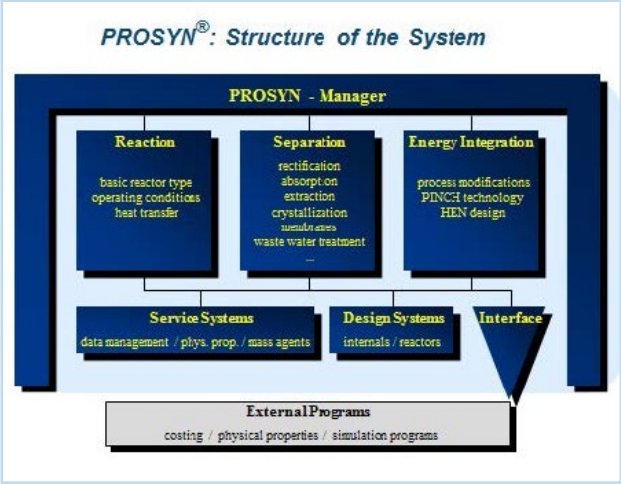
Influence of particle size and pore size on increased Dynamic Binding Capacity of Hollow fiber membrane modules

Prosyn possibilities

Project: CS-02-06
Project Leader: Kees de Weerd
E-mail: deweerd@process-design-center.com
Partners: PDC (Process Design Center), Frames, Heineken, Huntsman, Royal Cosun, Synthon
Budget: 50K€

Objective:

To evaluate PROSYN with ISPT members who have no prior experience with the software.

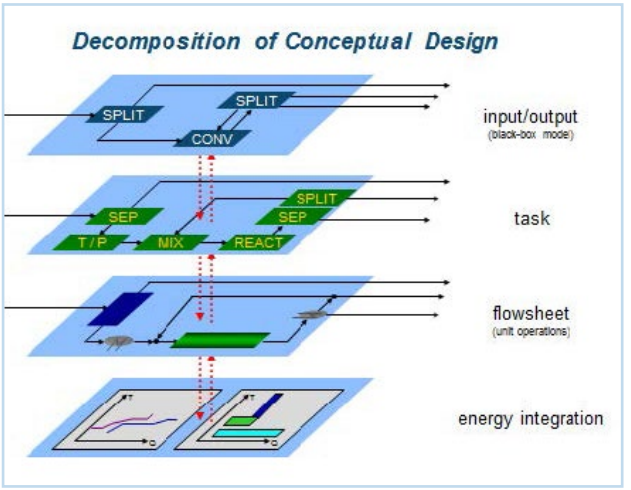


Motivation:

The PROSYN expert system is a large base of generic knowledge rules, developed in a collaborative effort with the chemical industry. PROSYN is used to perfrom conceptual process design in a structured way by generating process flow sheets that employ the largest driving forces for chemical and physical processes, leading to more efficient processes.

Project scope:

PROSYN requires a serious development effort initially to be able to properly access all existing PROSYN knowledge rules and modules next to the embedding of additional knowledge rules in existing modules or new modules.
The PROSYN project will involve chemical engineers (M.Sc.'s & Ph.D.'s) supported by IT specialists and guided by an industrial ISPT user group.



Applicability:

PROSYN contains generic process knowledge rules which could be applied cross sector.

Results:

PROSYN evaluated four case studies:

- Identified four options to separate a two organics and water mixture in three streams
- Developed a list of solvents suitable to recover a compound from water
- Listed suitable biochemical reactor configurations; separation steps were not isolated from lack of input data
- Generated a list of processes and their sequence to recover minerals from a side stream

PROSYN:

- Is valuable for conceptual process design
- is suitable for relatively inexperienced designers
- proposes feasible alternatives in a short time with few efforts
- justifies regular update for full functionality

Recovery of hexane (acetone) from hexan/oil extraction liquids in the edible oil industry


Project: CS-10-18
Project Leader: dr.ir. A.C.M. Franken
Researchers: dr.ir. A.C.M. Franken - dr.ir. F.P. Cuperus
E-mail: franken@mact.nl - cuperus@solsep.com
Partners: SolSep / MACT, Cargill, Loders Croklaan, Akzo Nobel, NL GUTS
Budget: 50.000 €

Objective:

Demonstrate the use of solvent resistant nanofiltration (SRNF) in the processing of vegetable oils in the processes:

A. Oil-rich phase with solids (miscella extract to remove as much solvent as possible).
B. Oil-rich phase without solids (refined oils; removal of triglycerides is envisaged).
C. Fatty acids including solids.

Motivation:

The use of membrane technology has been considered in several processes in edible oil processing. However, trials of membrane technology in organic solvent processing were hardly successful.

Applicability:

A. Energy savings
   Existing hexane (acetone)-recovery systems in edible oil refinery demand evaporation of the hexane (acetone). Membrane technology have the potential for huge energy savings.
B. Improved product quality
   The previously mentioned substrates have the potential to lead to improved products (e.g. removal of triglycerides).

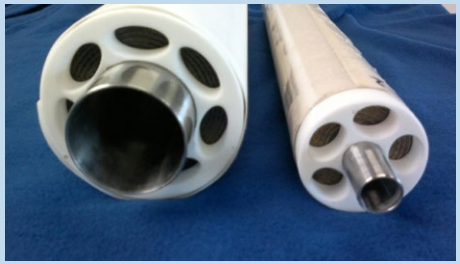
Project scope:

Demonstrate the use of the newest solvent resistant nanofiltration (SRNF) membranes in the processing of edible oils.
The project focuses on:

a. SRNF-membranes (Solsep).
b. Compare spiral wound technology with vibration enhanced systems (V-SEP).
c. Cleaning methods in organic environments.
d. Test in the extremes of the possible window(s) of operation.

Results:

- Retention of target compounds high
- Recovered solvents of good reuse quality
- Debottlenecking of distillation seems technically and economically feasible
- Decision to pilot in industrial environment



Solsep SWEs Membranes

V-Sep setup

Adding value to the inulin production process

Production of pharmaceutical ingredients from existing product streams

Project: CS-10-20
Project Leader: Frank van de Manakker
Researchers: May Young Lin, Inaki Arruabarrena Guirao
E-mail: frank.vandemanakker@feyecon.com
Partners: FeyeCon, Sensus (Royal Cosun), Avebe, NL GUTS
Budget: 67 k€

Objective:

Preparation of pharmaceutically attractive ingredients from inulin (and related) production streams.

Motivation:

Improving profitability and resource efficiency of the inulin production process and related food ingredient production processes.

Project scope:

Isolation and purification of active pharmaceutical ingredients from existing by-product streams (1).
Prepare pharma grade inulin product from food grade starting material (2).

Applicability:

FeyeCon's sustainable technologies based on carbon dioxide (CO_2) are applied in a wide variety of industries, such as pharma, food, and cosmetics.

Advantages:

- Fast and flexible processing steps
- Clean and solvent-free end products
- High production yields
- Straightforward upscaling
- Non-polluting / less waste

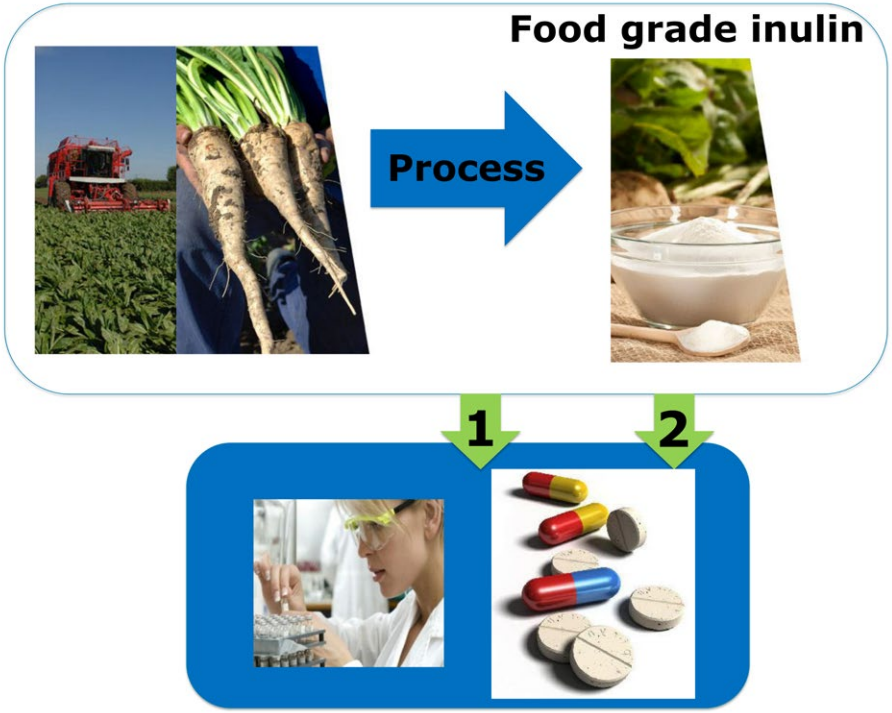
Results:

Sensus

- Stream 1 bio-active compounds cannot be extracted
- Stream 2 bio-active compounds extracted successfully seems economically feasible

Avebe

- Extraction results promising



Membrane filtration of high viscosity solutions

Project: CS-10-21
Project Leader: Dr Ir F.P. Cuperus
E-mail: cuperus@solsep.com
Partners: SolSep, Dishman, DSM, Sabic, Shell, AKZO Nobel, NL GUTS
Budget: 50k€

Objective:

Membrane separation is increasingly used for the processing of organic solvents systems. However, the recovery of solvents from viscous media (e.g. polymers) is a very new area. The project focuses on the removal of solvents from (very) viscous streams to be recycled in the process.

Motivation:

Currently used distillation/evaporation is expensive (energy) and sometimes introduces degradation of products(lowering quality). Less heat input by membranes should improve continuous quality at lower costs.
Hence, better products for lower cost price.

Project scope:

Two industrial cases are evaluated on small scale. Technical possibilities for (very) high viscosities are explored.

Applicability:

Application is tested in systems that have or get a high viscosity during processing. E.g. in processing of:

- Polymers
- Coatings and paints
- Oils (vegetable oils, petrochemicals)
- Cosmetics
- Pharmaceuticals

Results:

- NF can be used up to high viscosity and concentration factors
- NF is clearly an alternative for production and reduces energy consumption
- Flux is acceptable
- Spacer design and crossflow have considerable effects
- Limited osmotic pressure increase

Waste heat recovery from corrosive flue gas

Project: CS-10-22
Project leader: Bart van den Berg (HeatMatrix Group B.V.)
E-mail: bart.vandenberg@heatmatrixgroup.com
Partners: HeatMatrix, VION food ingredients / Indorama, NL GUTS
Budget: 50,000 Euro

Objective:

The objective of this project is to demonstrate waste heat recovery from corrosive flue gas with a demonstration size plastic heat exchanger from HeatMatrix. This plastic heat exchanger is fully corrosive resistant to concentrated acids.

Motivation:

Many combustion processes have acidic flue gasses, which makes heat recovery close to or beyond the acid dew point very complicated. Corrosion resistant metal heat exchangers are expensive and are frequently too heavy for easy implementation in existing infrastructure. This is unfortunate because this waste heat could be easily integrated with cold combustion air, which increases the efficiency of such furnaces by up to 4 %.

Project scope:

A skid based demonstration size plastic heat exchanger with flue gas and combustion air fans and instrumentation will be constructed. The heat exchanger will be tested with two different kind of acid flue gasses.

Applicability:

There is a need for a low weight corrosion resistant and cost effective gas/gas heat exchanger for waste heat recovery from hot flue gas from a variety of combustion processes. The flue gas temperature from a typical combustion process that fires sulphur containing fuel (refinery gas, oil) is 150 °C or higher. Significant energy savings and carbon reductions can be realized on a global scale.

Results:

Cooling against ambient air

- Stable heat recovery at constant low pressure drop
- Some fouling at flue gas side
- No fouling at ambient air side
- Material properties not affected

Cooling against fouling process air

- Stable heat recovery similar to cooling against ambient air
- No fouling at flue gas side
- Fouling at process air side but with stable pressure drop
- Material properties not affected

Colophon

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1 September 2016