dsti

DUTCH SEPARATION TECHNOLOGY INSTITUTE

DSTI Congress 2010

PREPARED FOR THE FUTURE

PROGRAM BOOK

24 June: Executives
25 June: DSTI partners and direct relations

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Table of Contents

Curriculum Vitae

Dr. Ir. Wridzer J.W. Bakker is director of the Dutch Separation Technology Institute and vice president of the European Federation of Chemical Engineers (EFCE). He acquired ample experience in various parts of the innovation chain such as: R&D manager Process Technology and New Business developer at Akzo Nobel, and researcher at the University of Delft. Furthermore, Bakker is co-founder and owner of a company that produces fuel cells.

Welcome

Welcome to the second DSTI congress.

It is a pleasure for us to be able to offer you an exiting program of keynote lectures, presentations, workshops, poster sessions, and a high tech innovation market.
The objective of the congress is to provide a platform for DSTI partners and direct relations to: share ideas, get an overview of the DSTI program and related themes, make new contacts, hear the latest results, and get inspired.

The theme of the congress "Prepared for the future" reflects the need for fast radical and sustainable innovation in the process industry. It also reflects one of the main reasons why the technology development and implementation platform DSTI was grounded under the motto: *"together we can take bigger steps, have more impact and share the risks"*.
The questions that will be addressed include: Why do we need sustainable innovation? Can we create business by a lower ecological footprint. What are the key elements for sustainable innovation? Is the DSTI open innovation model effective to speed up sustainable innovation processes? How can the process industry become the solution provider for a more sustainable society?

In parallel with the focus on the congress theme, we shall be covering the DSTI program and related themes in 6 parallel sessions and poster presentations. The themes are: *Energy/CO_2 reduction, Affinity separation, Membrane separation, Process intensification, Bio-separation, Novel distillation techniques, Process synthesis and control, High intensity separations, News from the Dutch Process Technology Community. There are also two workshops: researcher's competencies of the future, exploring sustainable innovation in the process industry.*

Innovations will not only be talked about during the congress. You will be able to see, feel, hear and smell real sustainable innovations at the *Innovation Market* with fifteen High Tech companies exhibiting their inventions.

We would like to thank our presenters and authors, participants and the many helpers who have made this congress possible. Please enjoy yourselves. We hope that you will find this an inspiring and valuable congress and a good reason to become even more active in the DSTI partnership.

On behalf of the organizing committee,
Yours sincerely,

Wridzer J.W. Bakker
Director DSTI

Practical information

PRACTICAL INFORMATION

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WARDROBE FACILITIES

The wardrobe is located one floor below, in the basement. Next to the reception are the stairs on your right. Down the stairs on your left-hand side are the wardrobe facilities. If you wish to have your valuables kept for safekeeping you can leave it with the reception on the ground floor.

QUESTIONS?

In the Regardz Meeting Center there are a number of hostesses who can help you find your way around the centre. You can recognize them by their uniform.

LUNCH

The lunch will be served in the foyer downstairs. In the foyer you will also find SME companies who present their current projects. In the adjacent lobby the latest separation technology projects are illustrated by digital poster presentations.

PARKING

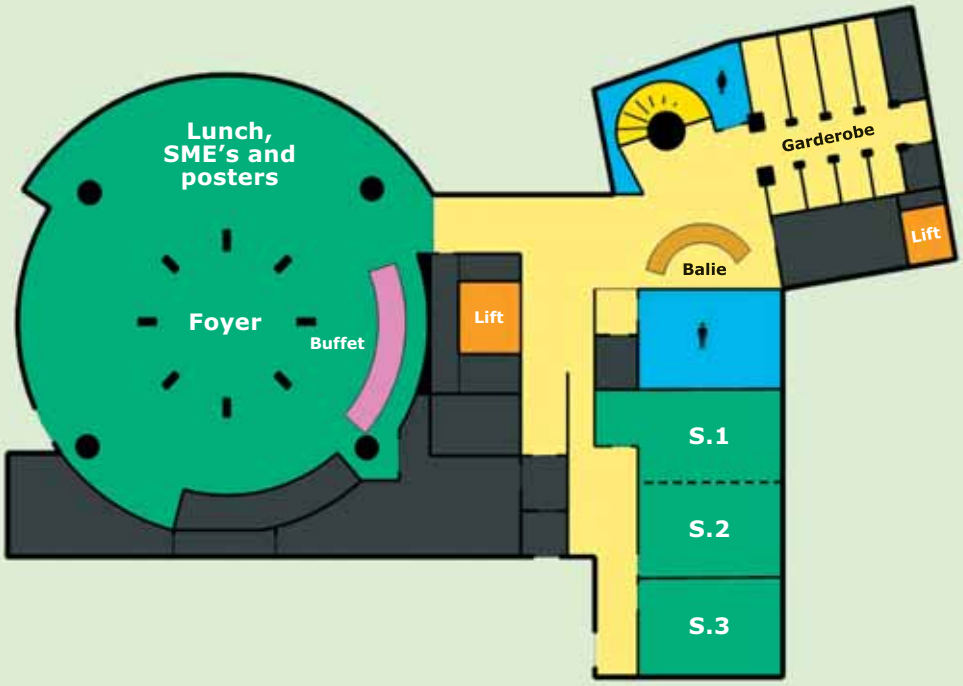
Regardz Meeting Centre offers parking facilities. The parking costs €2,35 per hour. A day ticket costs €16,00. You can also park your car on the P&R terrain nearby the central station Amersfoort. One hour cost is €1,70. A day ticket costs €10,00.

TRAVEL BY TRAIN

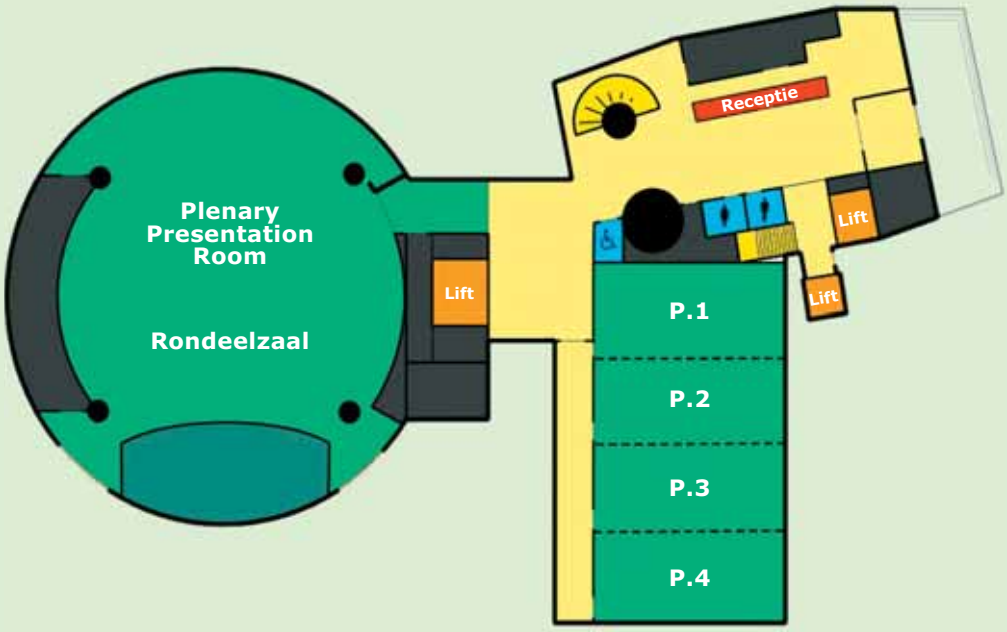
You can find Regardz Meeting Centre opposite the Amersfoort train and bus station. It is a five minute walk from the central station. It is therefore advisable to travel by train.

Destination	**Time (platform)**
Amersfoort – **Amsterdam**	17:29 (6) 17:36 (7) 17:59 (7) 18:06 (7)
Amersfoort – **Den Haag**	17:11 (6) 17:24 (6) 17:41 (6) 17:54 (6)
Amersfoort – **Rotterdam**	17:11 (6) 17:21 (4) 17:24 (6) 17:41 (6) 17:51 (4) 17:54 (6)
Amersfoort – **Zwolle**	17:08 (2) 17:13 (2) 17:33 (4) 17:38 (2) 17:43 (2) 18:03 (4)
Amersfoort – **Utrecht**	17:11 (6) 17:21 (4) 17:24 (6) 17:41 (6) 17:51 (4) 17:54 (6)

Map Regardz Amersfoort



BASEMENT



GROUND FLOOR

Thursday 24 June (Invited Executives)

PROGRAM 24 JUNE

12:00 – 13:00	Registration and Lunch
13:00	Welcome & Opening by **Gerard van Binsbergen** (Chairman Executive Committee DSTI)
13:10	Sustainability is an imperative for business success! Keynote speaker **André Veneman** (Director of Sustainability AkzoNobel)
13:50	DSTI Highlights by **Wridzer Bakker** (Director DSTI)
14:10	DSTI Experience from industry I: *"Industry Perception"* by **Emile van de Sandt** (Principal Scientist Downstream Processing DSM)
14:30	DSTI Experience from industry II: *"SME Perception"* by **Petrus Cuperus** (Director Solsep)
14:50 – 16:00	Break and a possibility to network, visit the SME market and join poster presentations
16:00	Society and Sustainability by **Wouter van Dieren** (Member Club of Rome and Director at IMSA Amsterdam)
16:15	Government & Sustainable Innovation by **Luuk Klomp** (Manager Programmatic Innovation Policy at the Ministry of Economic Affairs, acting representative Willem Zwalve)
16:30	Venture Capital – the growth engine for innovation, **Philipp Hasler** (Director Emerald Technology Ventures Switzerland)
16:45	Forum Discussion: Sustainable Innovation and the Process Industry with **André Veneman, Wouter van Dieren, Luuk Klomp, Philipp Hasler and Wridzer Bakker** led by chairman **Gerard van Binsbergen**
17:30	Drinks
18:15	Dinner at the NH Hotel Amersfoort
20:30	Watch the worldcup match: Cameroon versus The Netherlands

From good to great

IR. GERARD VAN BINSBERGEN (CHAIRMAN EXECUTIVE COMMITTEE DSTI)

Ir. Gerard van Binsbergen studied Chemical Engineering at the Technical University of Delft (the Netherlands). After his graduation (1987) he joined the Dutch multinational DSM. In this material and life science company he held several positions in Manufacturing & technology and Research & Development.

A few years ago he became chairman of the executive committee and the participants' assembly DSTI. He fully embraces the vision of a broader scope for process technology. That's why founding ISPT (Institute for Sustainable ProcessTechnology) is very important. This will bring process technology in the Netherlands in the end to an even greater level of performance. And this is needed from a business and societal perspective.

At the moment Gerard van Binsbergen is VP Manufacturing & technology for DSM Composite Resins with its principal head office in Schaffhausen (Switzerland).

Plenary lectures

Sustainability is an imperative for business success!

ANDRÉ VENEMAN (AkzoNobel)

Macro-economic trends such as growth in emerging markets, scarcity of raw materials and increased energy use will force market transitions, with winners and losers in our industry sector. All material- and energy-intensive industries do have tremendous opportunities to deliver higher Economic Value Added by a lower ecological footprint; the chemical - coatings industry is very well positioned to deliver sustainable solutions to key market segments, such as construction and transport & mobility. This is the right time for our industry sector to complete the U-turn: from being known for its contribution to environmental pollution to being recognized as a solutions provider for a more sustainable society. The challenges are high: our industry should accelerate its transition to sustainability through cooperation and product & process innovation across entire value chains.

CURRICULUM VITAE

André Veneman graduated as a Medical Doctor in 1983. From 1983 - 1988 onward he worked with UNHCR as a Medical Coordinator in Emergency and Refugee situations. In 1989 he joined Shell International as an advisor in Occupational Health Management and Preventive Health Programs.

He joined AkzoNobel in January 1999 as Director Corporate Health; as of October 2003 he was appointed as Corporate Director Sustainability/Health Safety and Environment. He is representing AkzoNobel in the Amsterdam Climate Initiative, the AIM initiative (Amsterdam Initiative against Malnutrition) and on the IDH advisory board (Initiative Sustainable Trade) and in international organizations such as World Business Council for Sustainable Development, UN Global Compact and World Resources Institute.

DSTI Experience from industry I:
"Industry Perception"

EMILE VAN DE SANDT (DSM)

DSTI: what is the added value for DSM?
From the start, the making of the separation roadmap, DSM has played an active role in bringing separation technology to a higher level. Currently, DSM is active in 4 different sectors within DSTI (bulk, specialty, pharma, and food sector) and in several technology evaluation projects together with small and medium enterprises (MKB). In total DSM is participating in around 20 projects which also include several projects from the 2nd wave. In four of those DSM is project leader.
In this presentation the expectations from DSM regarding DSTI will be discussed. Furthermore it will be shown how DSM is organized to benefit to the maximum and examples of already obtained results.

CURRICULUM VITAE

Emile van de Sandt (1968) studied Chemical Technology at Delft University of Technology (Netherlands). In 1997 he received his PhD from the same university with a thesis on the development of a catalytic process for the selective hydrogenolysis of CCl_2F_2 (CFK-12) into CH_2F_2 (HFK-32). This thesis won him the Royal Netherlands Chemical Society's Environment Prize 1997. In 1996 he started working at Gist-brocades at Delft in the R&D/DSP department of the Industrial Pharmaceutical Products Division. A few years later the company became DSM. Currently, he is principal scientist downstream processing at the DSM Biotechnology Center and responsible for the science management in this area within the company. He holds several positions such as DSM global competence manager separation technology, DSM program manager for the Dutch Separation Technology Institute, Workgroup leader of the workgroup Product Isolation of the Dutch Biotechnology Association (NBV), Board member of the "Advanced Course on Downstream Processing" of the Biotechnological Sciences Delft Leiden (BSDL) graduate school, Member of the Program Committee of the STW Smartsep program, Member of several Industrial Advisory Boards for projects within the Separations branch of the Netherlands Organization for Scientific Research (NWO/Separations) and the B(E) Basic (Bio-Based (Ecologically Balanced) Sustainable Industrial Chemistry) consortium.

DSTI Experience from industry II:
"SME Perception
Solvent stable membranes: a new product- a new technology"

PETRUS CUPERUS (SOLSEP BV)

Solsep BV produces membranes for use in organic solvents. As the use of these membranes not yet belongs to the technology toolbox of the (chemical) engineers we typically have to co-develop applications with our end-users. Actually, this means that Solsep BV develops products and technology but also has to invent its own market(s). These are very time consuming efforts in which technology plays an important role. Also, such work does not stop at the borders of The Netherlands or the EU.

A platform like DSTI typically can help to cross certain boundaries and is especially helpful for making an "entry" in an application (range). Though, in the end: the product must proof itself...

CURRICULUM VITAE

Present position: Managing director of Solsep BV
Cuperus is co-founder and current managing director of SolSep BV. SolSep develops and produces membrane separation devices for pharmaceutical and chemical industry. Solsep Bv is an SME and well involved in projects within DSTI.
Since 1990 Cuperus is involved in R&D leading to new separation and reactor technology for the environment-friendly processing. He has done extensive work on membranes and membrane reactors for food and non-food industry. He took part in many European projects (FAIR, CRAFT, Brite-Euram, FP6, FP7).
Cuperus has a Ph-D degree of the University of Twente (Prof. Dr C.A. Smolders) on Membrane Technology (1986-1990). The theme of his masters thesis was ceramic membranes (Burggraaf, TH Twente).
Cuperus is author or co-author of 50 publications and 7 patent applications.

Society and Sustainability

WOUTER VAN DIEREN (MEMBER CLUB OF ROME AND DIRECTOR AT IMSA AMSTERDAM)

CURRICULUM VITAE

Wouter van Dieren is Director of IMSA Amsterdam, a leading European think-tank and consultancy on sustainability and innovation. Since 1968 he has been engaged world-wide in environmental activities in the fields of management, science, media and politics. He has been awarded with several prizes and honorary functions for his pioneering work in the field of environmental management and sustainability policies.

In Autumn 2006, the Golden Rachel Carson medal 2006 was awarded to him by the Association of environmental experts VVM, which has two thousand members. The Rachel Carson Medal is their highest award. In that same year, he was also honoured with the Dutch Royal Order of Orange-Nassau in the high rank of Officer.

Among the twelve books that he published is the report to the Club of Rome Taking Nature into Account (1995), about the need to correct the GNP for environmental losses. Next to being the Director of IMSA Amsterdam, Van Dieren holds numerous other positions. From 1992 till 1997 he has been Vice-Chairman of the international Advisory Board of the Wuppertal Institute in Germany. Between 1978 en 1988 he was the Vice-President of Ecoropa, the European Ecological Association. He is President of Ocean Desert Enterprises. Also he is a member of the Club of Rome and of the World Academy of Art and Science. His different functions total a number of forty.

Government and Sustainable Innovation

LUUK KLOMP (MANAGER PROGRAMMATIC INNOVATION POLICY AT THE MINISTRY OF ECONOMIC AFFAIRS)

The Dutch Government stimulates the development of sustainability and innovation in the Netherlands. Through the innovation programs forces are joined, results are achieved and value is added. Developments in process technology can establish breakthroughs which may benefit industry, knowledge institutes and society. Topics like Energy, Water and Safety remain important issues for our society, also in the coming years where fundamental choices for the future have to be made. Not an easy task, considering the economical situation.

CURRICULUM VITAE

Luuk Klomp is unit manager of innovation themes of the Department for Innovation in the DG for Enterprise and Innovation at the Dutch Ministry of Economic Affairs (since January 2008). His previous position was unit manager of the research, monitoring & evaluations section of the same DG. Previously he worked at Statistics Netherlands in the Division of Business Economic Statistics, and as assistant professor in economics and statistics at the Erasmus University Rotterdam.

In 1996 he obtained his PhD for the thesis *Empirical Studies in the Hospitality Sector.* The empirics of firm and industry dynamics – firm survival, growth and job flows – as well as labour productivity and profit margins are studied through economic modelling in the thesis.

Key publications

Leeuwen G. van and L. Klomp (2006), On the contribution of innovation to multi-factor productivity growth, *Economics of Innovation and New Technology,* 15(4/5), pp. 367–390.
Klomp L., E. Santarelli and A.R. Thurik (2006), Gibrat's Law: An Overview of the Empirical Literature, in E. Santarelli (ed.), *Entrepreneurship, Growth, and Innovation,* chapter 3, pp. 41-73, New York: Springer.
Klomp L., and T. Roelandt (2004), Innovation performance and innovation policy: the case of the Netherlands, *De Economist,* **152(3)**, 365-374.
Audretsch D.B., L. Klomp, E. Santarelli and A.R. Thurik (2004), Gibrat's Law: Are the services different?, *Review of Industrial Organisation,* **24**, 301-324.
Gelauff, G, L. Klomp, S. Raes and T. Roelandt (eds.), (2004), *Fostering productivity:* Patterns, determinants and policy implications, Series Contributions to Economic Analysis 263, Elsevier Science, Amsterdam, The Netherlands.
Carree, M.A., L. Klomp, and A.R.Thurik (2000), Productivity convergence in OECD manufacturing industries, *Economics Letters,* **66**, 337-345.
Carree M.A. and L. Klomp (1997), Testing the Convergence Hypothesis: A Comment, *The Review of Economics and Statistics,* **79**, 683-686.

Venture Capital – the growth engine for innovation

DR. PHILIPP HASLER, INVESTMENT DIRECTOR (EMERALD TECHNOLOGY VENTURES AG)

Our economies are built on growth and permanent innovation. Our industries are in global competition and securing sustained profitability requires them to reach economies of scale. Large organizations with a focus on managing economies of scale are however not the ideal environment for entirely new businesses and innovations. Most companies developing innovations start at small scale, but eventually must compete on global scale and hence benefit from partnering with industry.
Venture capital bridges the gap between early-stage private / seed funding and the roll-out of large commercial operations. Venture capital plays a key role in the creation of new and future employment in the European community, fosters entrepreneurship and contributes to the building of the future global champions. However, there is a lack of venture capital and its culture in Europe compared to North America.

CURRICULUM VITAE

Philipp Hasler is an Investment Director with Emerald Technology Ventures and is focused on emerging energy technologies and advanced materials, with particular emphasis on biomass, electricity storage and waste recycling processes. Prior to joining Emerald in 2001, he held a project manager position for nine years at Verenum, a R&D and consultancy company specialized in energetic conversion of biomass. Before, he gained five years experience as a senior researcher in electrochemistry and fuel cell technology at the ETH Zurich. Fields of technical expertise include process engineering, electrochemistry, biomass-to-energy conversion technologies and air pollution control.
Philipp holds a Ph.D. in Chemical Engineering from the Swiss Federal Institute of Technology (ETH) in Zurich and a Bachelor Degree in Business Administration.

Forum Discussion Prepared for the Future – Sustainable Innovation and the Process Industry

GERARD VAN BINSBERGEN (FORUM CHAIR)
ANDRÉ VENEMAN
WOUTER VAN DIEREN
LUUK KLOMP
PHILIPP HASLER
WRIDZER BAKKER

Friday 25 June (DSTI partners and direct relations)

PROGRAM 25 JUNE

9:00 – 9:30	Registration		
9:30	Welcome and DSTI Highlights: **Wridzer Bakker** (Director DSTI)		
10:00	Financing Innovation – the VC investor's view. **Philipp Hasler** (Director Emerald Ventures Switzerland)		
10:30 – 11:00	Coffee Break		
11:00 – 12:30	Parallel sessions I		
	• High Intensity Separations	Page 30	Room 4.1 (4th floor)
	• Affinity Separation I: Adsorption processes	Page 33	Rondeelzaal (ground floor)
	• Novel Distillation Techniques	Page 36	Room 1.5 (1st floor)
	• Membrane Separation I: Nanofiltration	Page 38	Room P. 2-4 (ground floor)
	• Energy and CO_2	Page 42	Room 1.2-4 (1st floor)
	• Workshop I: Exploring the researcher's competencies of the future	Page 66	Room 5.1 (5th floor)
12:30 – 14:00	Lunch and a possibility to visit the SME market (page 113) and join poster presentations (page 69) See for complete overview page 26		
14:00 – 15:30	Parallel sessions II		
	• Process Intensification	Page 45	Room 4.1 (4th floor)
	• Affinity Separation II: Designer solvents	Page 48	Rondeelzaal (ground floor)
	• Process Synthesis and Control	Page 51	Room 1.2-4 (1st floor)
	• Membrane Separation II: Separation in mild conditions	Page 54	Room P. 2-4 (ground floor)
	• Bio-refinery	Page 57	Room 1.5 (1st floor)
	• From the Dutch process community	Page 60	Room 4.2 (4th floor)
	• Workshop II: Exploring sustainable innovation in process technology	Page 67	Room 5.1 (5th floor)
15:30 – 15:45	Break – Go recollect at plenary room		
15:45	NWO-Scheidingstechnologie, the Final Report. **André de Haan** (TU/e)		
16:00	A promising Research Project and it's boundary conditions **Henk Maatman** (R&D manager Teijin Twaron)		
16:30	Closing & acknowledgements by **Wridzer Bakker**		
17:00	Drinks		

Plenary lectures

Financing Innovation – the VC investor's view

DR. PHILIPP HASLER, INVESTMENT DIRECTOR (EMERALD TECHNOLOGY VENTURES AG)

Abstract: Many young entrepreneurs are excellent in developing new ideas and creative innovative solutions. Many professional investors have an excellent understanding of the underlying business opportunities and experience in managing financial and human risks. Crossing the chasm from an idea developing company to a revenue generating and profitable company however poses many challenges for both entrepreneurs and investors. And entrepreneurslife for their innovations, but investors are attracted by financial returns. The presentation addresses some of the merits and challenges in financing young companies by venture capital and characterizes the profile of an attractive investment opportunity.

CURRICULUM VITAE

Philipp Hasler is an Investment Director with Emerald Technology Ventures and is focused on emerging energy technologies and advanced materials, with particular emphasis on biomass, electricity storage and waste recycling processes. Prior to joining Emerald in 2001, he held a project manager position for nine years at Verenum, a R&D and consultancy company specialized in energetic conversion of biomass. Before, he gained five years experience as a senior researcher in electrochemistry and fuel cell technology at the ETH Zurich. Fields of technical expertise include process engineering, electrochemistry, biomass-to-energy conversion technologies and air pollution control.

Philipp holds a Ph.D. in Chemical Engineering from the Swiss Federal Institute of Technology (ETH) in Zurich and a Bachelor Degree in Business Administration.

NWO-Scheidingstechnologie, the Final Results

ANDRÉ DE HAAN (TU/e)

In 2002 NWO-CW and STW jointly launched the research program NWO-Scheidings-technologie. Within this program 8 projects on novel and hybrid separation technologies have been executed. The results of the program have been compiled into a final report which will be officially presented during this lecture. Furthermore some major achievements and the utilization of the results will be highlighted. Finally a status update on the new DSTI supported STW Perspectief program SMARTsep will be given.

CURRICULUM VITAE

André de Haan obtained his Chemical Engineering degree (1987), and his PhD (1991) at the Delft University of Technology. After his PhD he worked as head of the Applied Thermodynamics group at DSM Research, Technology Manager Styrenics at DSM Performance Polymers and Senior Researcher Life Sciences at DSM Research. In 1999 he was appointed full professor in Separation Technology at the University of Twente. Since September 2006 he is holding the chair of Process Systems Engineering at Eindhoven University of Technology. Furthermore he acts as scientific program manager for the industry sectors Pharma and Specialty Chemicals within the DSTI.

A promising Research Project and its boundary conditions

DR. IR. H. MAATMAN (R&D MANAGER TEIJIN TWARON)

The opportunities and pitfalls of research project based on the renewable polymer cellulose will be presented and discussed. Cellulose is one of the oldest polymers known. It is not meltable and has to be chemically modified (as derivatization with CS2 in the Rayon process to make the viscose) to process. Cellulose polymer powder is widely available in all kinds of grades and quantities, mostly from trees as Southern pine, Eucalyptus or from cotton. This polymer is still used today to produce yarns for textiles and technical applications. It is also a raw material for all kinds of chemical specialties as in e.g. adhesives, paints, food and mining applications. The first fiber processes were developed more than 100 years ago and are still in operation to day, in spite of their environmental problems and energy consuming aspects. But in the seventies of last century new solvents for direct dissolving, without the need of chemically modification, were developed as NMMNO (Lyocell process from Lenzing). The invention at the early seventies of liquid crystalline phases - based on strong acids - for aramid fiber spinning were a challenge to re-investigate cellulose for fiber spinning. The idea, found at Akzo Nobel, of using phosphoric acid as a solvent for cellulose (1994) offered an alternative to spin high tenacity cellulose yarns. Also a chemical reaction between Phosphoric acid components and cellulose occurs to give cellulosephosphate which degree of derivatization can either be suppressed (for yarn production) or stimulated (for water soluble products). This was a reason for a broad research study of the new cellulose products obtained with this phosphoric acid solvent. The development of this challenging research project with its technology and products will be presented. However a decisive boundary of the project was the change in strategy of the mother company. So a landing place for the project has to be found.

CURRICULUM VITAE

Henk Maatman studied Chemical Technology at the THTwente (now: University Twente) from 1968-1975. He studied the Chlorination of cyclic alifatic ketones during his PhD at RuG (Groningen University) and joined Akzo Research in 1980. He had several functions in R&D on fiber spinning. At the end of the nineties Akzo Nobel demerged the fiber activities and Teijin acquired the Aramid business. Henk became Manager of the Teijin Twaron Research Institute. He got into early retirement mid 2009.

Parallel Sessions

Overview

MORNING 11:00 - 12:30

Theme	**High Intensity Separations**	**Affinity Separation I: Adsorption processes**	**Novel Distillation Techniques**
Page	**30**	**33**	**36**
Room	**Room 4.1 (4th floor)**	**Rondeelzaal (ground floor)**	**Room 1.5 (1st floor)**
Chairman	**Peter Alderliesten (ECN)**	**Joost Clerx (MSD)**	**Aris de Rijke (DSM)**
Keynote	**Prof. Galip Akay (School of Chemical Engineering and Advanced Materials, Newcastle University) -** Nano-structured micro-porous materials in the intensification of separation processes	**Maaike C. Kroon (TUD) -** Latest developments in affinity separations: hybrid inorganic-organic materials as novel adsorbents/extractants	**Prof. Michael Jödecke (BASF N.V.) -** New Trends in Distillation Equipment
Speaker	**Paul Verbeek (Shell) -** Extended profitability of oil fields with breakthrough separation technology (OG-00-04)	**Mark Levisson (WUR) -** Development of novel affinity separations (SC-00-02)	**Mayank Shah (TU/e) -** Reactive distillation for multi-product continuous plant (SC-00-05)
Speaker	**Esayas W. Barega (TU/e) -** Entrainment quantification and reduction in a static-mixer settler (BC-00-07)	**Marcel Raedts (PROXCYS B.V.) -** The influence of column geometry in adsorptive separations (CS-01-10)	**Jaap Vente (ECN) -** Pushing membrane stability boundaries with Hybsi® pervaporation membranes

MORNING 11:00 - 12:30

Theme	**Membrane Separation I: Nanofiltration**	**Energy and CO_2**	**Workshop I: Exploring the researcher's competencies of the future**
Page	**38**	**42**	**66**
Room	**Room P. 2-4 (ground floor)**	**Room 1.2-4 (1st floor)**	**Room 5.1 (5th floor)**
Chairman	**Prof. Arian Nijmeijer (Shell & UT)**	**Arend de Groot (ECN)**	
Keynote	**Prof. Andréw Livingston (Imperial College London) -** Organic Solvent Nanofiltration - New Technology for Molecular Separations	**Hank Vleeming (Process Desig Center BV) -** Development and techno-economic evaluation of CO_2 capture technologies	Organized by DSTI **Gerda de Weerdt** Hosted by **Peter Coesmans (Coesmans Management)**
Speaker	**Nieck E. Benes (UT) -** NextCon -Nanofiltration for extreme conditions (BC-00-05)	**Henk van Veen (ECN) -** Azeotrope separation prevention (BC-00-03)	
Speaker	**Petrus Cuperus (Solsep BV) -** Solvent stable nanofiltration membranes: what is possible? (CS-01-01)	**Lesley Garcia Chavez & Miran Milosevic (TU/e) -** Designer solvents for water removal (BC-00-04)	

Overview

AFTERNOON 14:00 - 15:30

Theme	**Process Intensification**	**Affinity Separation II: Designer solvents**	**Process Synthesis and Control**	**Membrane Separations II: Separations in mild conditions**
Page	**45**	**48**	**51**	**54**
Room	**Room 4.1 (4th floor)**	**Rondeelzaal (ground floor)**	**Room 1.2-4 (1st floor)**	**Room P. 2-4 (ground floor)**
Chairman	**Arend de Groot (ECN)**	**Prof. André de Haan (TU/e)**	**Prof. Johan Grievink (Chem Engineering Dept, TUD)**	**Prof. Arian Nijmeijer (Shell and UT)**
Keynote	**Prof. Eugeny Kenig (University of Paderborn) -** Micro-separation technology: state of the art and perspectives	**Prof. Raquel Aires Barros (Instituto Superior Téchnico. Technical University of Lissabon) -** Affinity Aqueous Two Phase Systems for Bioseparations	**Prof. Peter Bongers (Unilever/ TU/e) -** Inseperability of Products, Processes and Control	**Peter van der Heijden (Paques) -** Membrane application for separation in biological processes in industry
Speaker	**Prof. Hans de Wit (TUD) -** Preliminary results of the Sky line Debates on process technology	**Mark Jongmans (TU/e) -** Ethylbenzene/styrene separation by extractive distillation with sulfolane (BC-00-06)	**Paul Bussmann (TNO Quality of Life) -** Modeling of Separation Processes and Unit Operations: Plotting the Playing Field for Process Innovation (SC-00-01)	**Jan Tholen (Elektrolyse Project) -** Reuse of effluent or upgrading process flows by electrodialysis technologies (CS-01-06)
Speaker	**Ramon Scheffer and Ad Zijl (Huntsman) -** Continuous suspension crystallization for the separation of MDI isomers	**Renze Wijntje (Shell) -** Designer solvents for natural gas treating (OG-10-02)	**Fred Hugen (Perdix Analytical Systems) -** Validation of In-Situ Particle Viewer, Measuring particle size distribution with an on-line imaging system (CS-01-04)	**André Mepschen (Norit X-Flow) -** Mild Fractionation and its Future

AFTERNOON 14:00 - 15:30

Theme	**Bio-refinery**	**From the Dutch process community**	**Workshop II: Exploring sustainable innovation in process technology**
Page	**57**	**60**	**67**
Room	**Room 1.5 (1st floor)**	**Room 4.2 (4th floor)**	**Room 5.1 (5th floor)**
Chairman	**Emile van de Sandt (DSM)**	**Peter Alderliesten (ECN)**	
Keynote	**Prof. Remko Boom and Prof. Johan Sanders (WUR) -** The biorefinery: integrating food and non-food production	**Maurits Clement (EOS) -** Separation technology in the Energy Research Subsidy Program	Organized by IMSA Amsterdam **George Wurpel and Janneke Pors** Hosted by **Peter Coesmans (Coesmans Management)**
Speaker	**Einte Karst Dijk (DSM) -** In-situ product recovery in a biorefinery, dream or future (Biorefinery challenge 5)	**Hans Keuken (Process Design Center) -** The road from R&D to real implementation in industrial processes	
Speaker	**Marco Brocken (Evodos) -** DSTI & Evodos - Joining forces (CS-01-07)	**Rombout Swanborn (Renaissance Oil and Gas BV) -** Process intensification leads to enhanced oil recovery of aging oil fields	
		Wiebrand Kout (Basic Membranes BV) - Proton conductive membranes for hydrogen conversion, production and distribution	

High Intensity Separations

BACKGROUND

Topic of the session is the use of process intensification principles in separation technology. Application of structured materials and external force fields such as centrifugal fields can drastically improve the performance of classical separation technologies such as extraction, demulsification and gravity separation as used in the bulk chemical and oil/gas industries. Recent advances in intensified separation processes will be presented and various aspects playing a role in the field will be addressed.

CHAIRMAN: PETER ALDERLIESTEN (ECN E&I)

CURRICULUM VITAE

Peter Alderliesten (1950) studied chemical technology at the Technical University of Delft. After finishing his study he worked for one year at the University of Oslo and four years at the Van t' Hoff Laboratory in Utrecht on physico and colloid chemical topics. Since 1980 he has been employed by ECN. He started as researcher in the field of coal combustion and gasification in particular in the field of gas cleaning and membrane separation technology. From the mid nineties he has been involved in setting up and carrying out R & D programs on energy conservation and energy efficiency for the process industry. Currently he is manager of ECN R&D program Energy Efficiency in Industry. He was involved in actions that led to the foundation of the Dutch Separation Technology Institute. At this moment he acts as interim scientific program manager for the Sector Bulk Chemicals. He is member of the Transition Platform Chain Efficiency, on behalf of which he took part in the activities of the Action Group Process Intensification, and member of the Industrial Advisory Board of the Dutch Research School on Process Technology.

SPEAKERS

PROF GALIP AKAY (SCHOOL OF CHEMICAL ENGINEERING AND ADVANCED MATERIALS, NEWCASTLE UNIVERSITY, NEWCASTLE UPON TYNE, NE1 7RU, UK)

Nano-structured micro-porous materials in the intensification of separation processes

Polymeric, metallic, ceramic or composite nano-structured micro-porous materials (NSMPM) have been developed and applied to AgroProcess, BioProcess and ChemProcess Intensification, including separation processes. Recent advances in intensified separation processes using NSMPMs with or without a second intensification field will be presented. These processes include separation (demulsification) of highly stable emulsions (encountered in nuclear re-processing and crude oil production), process water remediation, surfactant mediated metal ion/organic toxin removal from water, removal of particulate matter and tars from syngas produced via gasification and high temperature separation

High Intensity Separations

of hydrogen from syngas and oxygen from air. Such high temperature separation processes are important in the development of sustainable energy and chemical technologies. Gas separation and cleaning processes, funtionalization of polymeric NSMPMs and their use in Intensified Plants are under further study through two new large integrated EU projects; COPIRIDE (October 2009) and POLYCAT (July 2010).

CURRICULUM VITAE

Professor G Akay holds the established chair of Chemical Engineering at Newcastle University and leads the Process Intensification and Miniaturization (PIM) Centre (www.ncl.ac.uk/pim), currently with 20 PhD students, postdoctoral-visiting academics funded by 3-EU and 3-industrial grants. He has a highly interdisciplinary training and research gained in academia and industry. He has pioneered multi-disciplinary PIM technology leading to AgriProcess-BioProcess Intensification. He is the research director of ITI-Energy Ltd., which commercialises biomass gasifier and power generation plants developed in PIM-Centre. These plants integrate several intensified unit operations. ITI-Energy and PIM-Centre won 2007 Shell Energy prize. He pioneered the intensified processing of nano-structured micro-porous materials for process intensification in agriculture, biology, chemical, environmental and energy conversion processes. He is a member of the Institute of Stem Cell Biology and Regenerative Medicine; and Institute for Nanoscale Science and Technology. He is a founding director of UK Children's Neurological Research Campaign which funds research into paediatric neurology.

IR. PAUL VERBEEK (SHELL)
(OG-00-04 AND OG-10-04 OIL/WATER SEPARATION)

Extended profitability of oil fields with breakthrough separation technology (OG-00-04)

Close collaboration between industrial and academic partners is crucial for innovating the well-established technology for oil/water separation. Such innovation is needed since more oil will be produced from offshore locations and through enhanced oil recovery methods. The DSTI project leads to new fundamental knowledge of separation in rotating flow using pipe as opposed to a big tank/vessel. We anticipate that this knowledge will enforce a breakthrough in the development of new separation equipment, making it possible to produce oil and gas reserves from fields that are inaccessible using conventional methods.

CURRICULUM VITAE

With Shell since 1979 in a variety of jobs and work locations covering technology development and operations. Paul Verbeek is passionate about finding novel value-generating solutions to classical engineering problems that better fit the purpose and the environment, and are safer as well. Over recent years Paul Verbeek has worked in compact processing equipment, like downhole and inline separation, compression of untreated gas, and in produced water management pioneering solutions like Greening the Desert, emulsion treatment for improved and enhanced oil recovery. Early work experience covers multiphase flow, reliability engineering of production facilities and offshore structures engineering. Graduate from University of Technology in Delft (Aerospace).

High Intensity Separations

ESAYAS W. BAREGA (BC-00-07 INTENSIFIED EXTRACTION)

Entrainment quantification and reduction in a static-mixer settler (BC-00-07)

CURRICULUM VITAE

Esayas Barega (M.Sc) obtained his bachelor degree in chemical engineering from Addis Ababa University, Ethiopia. After his graduation he worked as "Graduate assistant" and "Assistant lecturer "in the same university for two years. He came to Netherlands in 2006 to pursue a master programme in process engineering at Tu/e. His graduation project was on modeling and exergetic evaluation of synthetic gas production from different biowaste streams. Following his successful finish of the master programme in August 2008, he started his PhD in November of the same year on DSTI project "Extraction intensification".

MORNING SESSION

Affinity Separation I: Adsorption Processes

BACKGROUND

Purification processes are key steps in the production of many products in various industries (bulk, petrochemical, specialty chemical, biotechnological, or food). In this session, advances in affinity separations are explored in which selective adsorption of the product of interest will lead to intensified processes.

CHAIRMAN: JOOST CLERX (MSD)

This session will explore the efforts made by universities, DSTI and small businesses that contribute to the improvement of affinity separations. An overview will be given of different types of affinity separations by M. Kroon (TU Delft) along with some examples, while M. Levisson (WUR / DSTI project SC-00-02) will present the development of specific and stabile affinity ligands for the biotechnology and food industries. Finally, M. Raedts (Proxcys BV) will focus on the opportunities of radial flow chromatography in affinity separations.

CURRICULUM VITAE

Joost Clerx (1979) completed his chemistry studies (MSc) at the Radboud University Nijmegen and subsequently pursued his PhD in the field of bio-organic chemistry in the group of Prof. Roeland Nolte and Prof. Alan Rowan at the same university. He then worked in the field of diagnostic assay development at bioMérieux in Boxtel, before he moved to MSD (former Organon/Schering-Plough) to become a project manager for biotechnology projects. In this role, he is involved in several projects of therapeutic protein development and commercial production support, with currently a focus towards development and application of bio-analytical techniques. Within DSTI, he is the project leader for the SC-00-02 project.

MORNING SESSION

Affinity Separation I: Adsorption Processes

SPEAKERS

DR. IR. MAAIKE C. KROON (TU DELFT)

Latest developments in affinity separations: hybrid inorganic-organic materials as novel adsorbents/extractants

Most important affinity separations include adsorption and extraction. During the last decade affinity separations have increased steadily in number and with them the number of affinity adsorbents and extractants. Hybrid inorganic-organic materials are especially promising candidates as novel adsorbents or extractants.
An example is the use of aluminum methylphosphonate polymorph alpha as adsorbent for the separation of corresponding olefins and paraffins, which is the first material that is able to adsorb the paraffin (minority compound) instead of the olefin, resulting in a significant increase in energy-efficiency of the process.
Another example is the use of ionic liquids as extractants, which can be used for extraction of carbon dioxide from flue gases or from water-gas-shift reactions, for extraction of salts from aqueous phases and to overcome azeotropes in extractive distillations. In all cases, considerable process intensification is achieved.

CURRICULUM VITAE

Maaike Kroon graduated cum laude for her study Chemical Engineering at Delft University of Technology in 2004, and received her PhD from the same university in 2006. She received the prize for the best graduate of TU Delft, the Unilever research prize, the study prize of the Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, admission as participant to the meeting of Nobel laureates in chemistry, the DSM-award and the KNCV environmental chemistry and technology award. She also followed an additional honour's track program in innovation management.
In 2007, she got a tenure track position as Assistant Professor at TU Delft. In the meantime, she spent one year at the Institute of Materials Sciences in Barcelona (2007) and two years at Stanford University in Palo Alto (2008-2009) doing research on the development of novel nanomaterials for energy-efficient processing and energy storage. Recently, she got a tenured position as Assistant Professor at TU Delft.

MARK LEVISSON (SC-00-02 / WAGENINGEN UNIVERSITY)

Development of novel affinity separations (SC-00-02)

CURRICULUM VITAE

In September 1999 Mark Levisson started studying Biological and Medical Research at the Hogeschool van Arnhem and Nijmegen (HAN). Mark Levisson obtained his BSc-diplomas in Biochemistry and Biotechnology in 2002 and decided to continue his studies at Wageningen University. Mark started with the study Biotechnology in September 2002, during which he specialized in Cellular and Molecular Biotechnology. Mark obtained his MSc-diploma in September 2004 and started subsequently with his PhD research at the Laboratory of Microbiology at Wageningen University. During his PhD Mark studied the biochemical and structural properties of hyperthermophilic esterases and Mark successfully defended his thesis in September 2009. Since January 2009 Mark works as

Affinity Separation I: Adsorption Processes

a Postdoctoral researcher for the Dutch Separation Technology Institute at the Laboratory of Microbiology at Wageningen University. Here, Mark works on the development of novel affinity ligands for the selective separation of peptides, proteins and oligosaccharides.

MARCEL RAEDTS (PROXCYS B.V.)

The influence of column geometry in adsorptive separations (CS-01-10)

Adsorptive separations with high selectivity like Affinity and Ion-Exchange, benefit from relatively short bed height columns. Partially by the increased throughput and the lower pressure drop, partly because of the added permeability to particulate matter and the more robust processes. Today the scale of operation of many processes add another parameter which is size. In the oral paper Marcel would like to address the above topics using a few practical examples to illustrate the benefit of the technology.
Some insight in economic consequences will be given which can be key to the application of chromatography in functional food manufacturing.

CURRICULUM VITAE

The Dutch company Proxcys b.v. was founded in 2003 by current owner Marcel Raedts (BSc,MSc). At the end of his Master in Biology/biochemistry, specifically during his last traineeship at "Bio-Intermediair" now DSM-Biologics in 1986, Raedts decided to focus for a prominent role in equipment development. After several jobs at "Applied Biosystems" in 1994 he moved to Emmen to set up "Dedicated Systems" at the Applied Science Group. Here the first contact with Radial chromatography and DownStream Processing was made. Sub-optimal performance of the RFC technology in those days made him decide to prove the technology's intrinsic power by creating Proxcys b.v.
Today Proxcys b.v. holds key patents to the technology and is recognized by the International Biopharmaceutical Industry as RFC technology leader. By continuous innovation and development in the facility in Emmen, RFC is being consolidated as important process & industrial scale purification technology.

MORNING SESSION

Novel Distillation Techniques

BACKGROUND

Distillation is a widely employed separation process in industry, although distillation is energy intensive. The focus on sustainability and targets on energy savings are important drivers to improve the thermal economy of distillation processes.

CHAIRMAN: ARIS DE RIJKE (DSM)

Distillation Intensification (Theme: Novel Distillation Techniques)

One effective method to reduce energy consumption of distillation units is so-called full thermal coupling i.e. internal heat integration by direct vapour/liquid coupling of two adjacent distillation columns. The fully thermally coupled column is often referred to as a Petlyuk column. In most cases a Petlyuk column is implemented by installation of a Dividing Wall Column (DWC), which can be applied to separate a three component mixture in a single column shell. A DWC can reduce both capital and energy costs compared to a traditional two column system.
Hybrid separation technologies, like reactive distillation or the combination distillation/ pervaporation can also offer serious potential for energy savings or enhanced reactor productivity.

CURRICULUM VITAE

After studying Chemical Engineering at Delft University of Technology, Aris de Rijke started as a Process Technologist at Norsk Hydro. In 2000 he joined TU Delft in a role as laboratory manager. In 2002 this role was combined with a PhD assignment on the development of an internally Heat Integrated Distillation Column (HIDiC). After finalizing this PhD study in 2007, he started to work for Shell Global Solutions as technologist distillation (R&D). In 2010 he accepted a position as manager of the molecular separations en applied thermodynamics cluster of DSM ACES (Advanced Chemical Engineering Solutions).

SPEAKERS

DR. MICHAEL JÖDECKE, BASF N.V. ANTWERPEN, BELGIUM

New Trends in Distillation Equipment

Distillation is the most important unit operation in chemical and petrochemical industry. The presentation gives an overview over new development trends in the field of distillation equipment, concerning the efforts oriented towards the reduction of energy consumption, increasing size of distillation towers, new generation column internals for trayed and packed columns and internal structures allowing effective increase of separation efficiency alone or in combination with reactions. Also there are some issues addressed, related to the appearance of a number of new column internals suppliers from all over the world (especially Asia) with new innovative products.

Novel Distillation Techniques

CURRICULUM VITAE

1992 – 1997: study of process engineering at TU Clausthal-Zellerfeld, Germany
1998 – 2003: scientific co-worker at the Department of technical thermodynamics at the TU Kaiserlautern (Prof. Dr. G. Maurer), Germany; promotion in 2004
2003 – 2006: research engineer distillation towers at BASF SE Ludwigshafen, Germany
2006 – 2009: research manager distillation towers at BASF SE Ludwigshafen, Germany
Since 2009: deputy plant manager, BASF N. V. Antwerpen, Belgium

MAYANK SHAH (SC-00-05; TU/e)

Reactive distillation for multi-product continuous plant (SC-00-05)

CURRICULUM VITAE

Mayank Shah was born on the 10th May 1984 in Vadodara, India. In April 2005 he obtained a bachelor degree in chemical engineering at Maharaja Sayaji Rao University (M.S.U) Vadodara. Between May 2005 and March 2006 he worked as process engineer at Gharda chemicals in Ankleshwar, India. In April 2006 he came to Germany for his master study. In September 2007 he completed master studies in chemical engineering at Otto-von-Guericke University Magdeburg. During the master studies he worked as research assistant at Max Planck institute for six months. He did the master thesis on "Drying of polymeric material in combination of flash and cyclone dryer" for duration of six months at Vinnolit GmbH. Since December 2007 he is pursuing Ph.D. at the process system engineering group of Prof. André de Haan at Eindhoven University of technology. In his research project, he is investigating the reactive distillation process for multi-product continuous plants.

JAAP VENTE (ECN)

Pushing membrane stability boundaries with Hybsi® pervaporation membranes

CURRICULUM VITAE

Jaap Vente studied materials science and engineering at the University of Technology Delft. The topic of his master thesis was molten carbonate fuel cells. Subsequently, he moved to University of Leiden to study the magnetochemical and crystallographic properties of complex iridium oxides. In 1994, he accepted a position of post-doctoral research assistant at the Inorganic Chemistry Laboratory of the University of Oxford. After 4 years, he moved to Mexico to become an investigator at CINVESTAV. In 2003, he returned to his native Netherlands and started to work on membrane technology to enhance the industrial energy efficiency at the Energy research Centre of the Netherlands. Since 2007, he is the group leader Membrane Technology.
He is the (co-)author of over 65 scientific publications, two book chapters and two patents.

Membrane Separation I: nanofiltration

BACKGROUND

In the bulk chemicals sector the majority of the separation processes is accomplished by heating, evaporating and condensing in distillation or evaporation systems. Avoiding phase transitions through the use of membrane systems would lead to substantial reductions in energy consumptions and CO_2 emissions. Nanofiltration membranes offer great promise to separate liquid streams. However, the application of currently available nanofiltration membranes is hindered by a too high molecular weight cut-off (they are not selective enough for applications in which relatively small molecules should be separated) and/or limited stability under extreme conditions (e.g. high/low pH, solvents). This parallel session will deal with the progress in nanofiltration membrane technology to solve above issues.

CHAIRMAN: ARIAN NIJMEIJER (SHELL / UT / PA)

Membrane Separation I: nanofiltration

CURRICULUM VITAE

Education

1990-1995	Master study Chemical Engineering, University of Twente, The Netherlands. Master thesis on the preparation of relaxor materials for ceramic capacitors
1995-1999	PhD study on the preparation and characterisation of silica membranes for hydrogen at the University of Twente, resulting in PhD thesis, "Hydrogen-selective silica membranes for use in membrane steam reforming", December 17, 1999

Career:

Jan 2000 – Aug 2001	Postdoc at the University of Twente, subject area porous ceramics. From June 1, 2000 until August 31, 2001 working for 80% of the time at Shell Global Solutions in Amsterdam
Sep 2001 – Oct 2004	Researcher, exploratory research at Shell Global Solutions, Amsterdam. Subject areas: membranes, membrane processes, alternative desulphurisation, skid mounted processing units and novel upgrading technologies.
Oct 2004 – Now	Senior scientist and team leader membrane research and implementation Shell Global Solutions International BV
Nov 2006 – Now	Professor Inorganic Membranes (0.2 FTE), Faculty of Science and Technology, University of Twente

Additional activities:

2000-Now	Shell representative in various user committees of membrane related projects
2001-Now	Shell Campus Ambassador (University of Twente team)

MORNING SESSION

Membrane Separation I: nanofiltration

2003-Now	Shell Technical Representative and Vice Chairman of the Oil/Gas sector of the Dutch Separation Technology Institute
2004-Now	Board member Dutch Membrane Society
2005-Now	Chairman Advisory Board Separation Technology for the "Stichting Shell Research".
July 2012	Chairman of the 12th International Conference on Inorganic Membranes (ICIM-12), University of Twente, The Netherlands

PROFESSOR ANDRÉW LIVINGSTON (IMPERIAL COLLEGE LONDON AND EVONIK MEMBRANE EXTRACTION TECHNOLOGY LTD)

Organic Solvent Nanofiltration (OSN) - New Technology for Molecular Separations

OSN separates molecules present in solutions of organic solvents. In OSN, a pressure gradient is applied across a solvent stable nanoporous film, inducing transport across the film. Depending on relative permeation rates, molecular species in a feed liquid stream can be concentrated and separated. Typically OSN will use a small fraction of the energy of thermal methods such as evaporation and distillation and can work at temperatures around ambient. This presentation describes the development of membranes with wide solvent resistance, and which retain their nanostructure with exposure to aggressive liquids such as dipolar aprotic solvents (DMF, DMSO, THF). Moreover, these membranes can be produced with tuneable molecular weight cutoff curves and have minimum extractable components - they are being utilised in cGMP environments. The manufacture of these membranes has been successfully undertaken and they are available from Evonik MET Ltd, based in West London.

CURRICULUM VITAE

AGL was born (1962) and bred in Taranaki, New Zealand and studied Chemical Engineering in NZ. And worked for 3 years at in food processing. In 1986, started PhD at Cambridge. Upon finishing PhD, joined the Department of Chemical Engineering at Imperial College. Full Professor from 1999, published over 170 papers and granted 15 patents. Awards include Junior Moulton Medal, Cremer and Warner Medal of IChemE, and Silver Medal of Royal Academy of Engineering. Current research interests in separations for chemical & pharmaceutical applications using solvent stable nanofiltration membranes. Elected a Fellow of the Royal Academy of Engineering in 2006, became Head of Department of Chemical Engineering at Imperial College in 2008.

In 1993, graduated with an MSc in Economics from London School of Economics (LSE) In 1996, founded Membrane Extraction Technology (MET), which manufactures solvent stable nanofiltration membranes. MET was acquired by Evonik AG on 1 March 2010.

Membrane Separation I: nanofiltration

DR. IR. NIECK E. BENES (UT / BC 00 05)

NextCon (BC-00-05) Nanofiltration for extreme conditions

CURRICULUM VITAE

Nieck Benes is staff member of the Membrane Technology Group of the University of Twente (www.membrane.nl). Previous affiliations include the Process Development Group of the Eindhoven University of Technology and DSM Base Chemicals R&D. Nieck received his PhD degree from the University of Twente, on the subject "Mass transport in thin supported silica membranes". His current research activities revolve around the analysis of thin films that allow selective manipulation of multi-component mass transport. Main research themes are 1) fundamental studies of the superimposed effects of penetrant presence, length scale and timescale on materials properties of thin (< 200 nm) polymer films, and 2) the application of membranes under demanding conditions.

MORNING SESSION

Membrane Separation I: nanofiltration

PETRUS CUPERUS (SOLSEP BV, ST EUSTATIUS 65, 7333NW APELDOORN-WWW.SOLSEP.COM)

CS-01-01 Solvent stable nanofiltration membranes: what is possible?

In the last years the possibilities of membrane processes for organic solvent recovery have increased significantly. Besides the traditional pressure driven membrane processes applied for aqueous systems it is now possible to apply them to treat organic fluids. In fine chemistry solvent NF is of particular interest. Recovery of organic solvent, removal of (bio) catalysts from organic solvents and solvent exchange are frequently applied processes. The application of solvent resistant NF/RO membranes can avoid distillation and thus reduce energy costs significantly. However, process integrated membrane systems are rare in chemical and fine chemical industry because of their non-proven large-scale stability.

In non-aqueous systems, solute, solvent, and membrane material properties all influence membrane performance and have to be taken into account. As there are many solvents and solutes the theoretical variety of membrane materials and processes is enormous. The choice for a certain membrane and process should be supported by relevant data and experience that are missing at this moment. The goal of the project is to evaluate SolSep NF membranes for use in organic media and to monitor their performance regarding flux and retention in close relation to the parameters mentioned above and process phenomena like fouling and concentration polarization. SolSep BV is a SME with lots of experience in the use of membrane technology for organic media.

The aim of the work in this project is to test SolSep membranes under industrial conditions with industrially applied fluids. A quick win situation should be created for the application of existing SolSep nanofiltration membranes for organic media in two industrial applications, by increasing the confidence of end-users in the available technology.

CURRICULUM VITAE

Present position: Managing director of Solsep BV.
Cuperus is co-founder and current managing director of SolSep BV. SolSep BV develops and produces membrane separation devices for pharmaceutical and chemical industry. Solsep BV is a SME and well involved in projects within DSTI.
Since 1990 Cuperus is involved in R&D leading to new separation and reactor technology for the environment-friendly processing. He has done extensive work on membranes and membrane reactors for food and non-food industry. He took part in many European projects (FAIR, CRAFT, Brite-Euram, FP6, FP7).
Cuperus has been working for the Agrotechnological Research Institute (ATO DLO), Wageningen, 1990-2000, The Netherlands.
Cuperus was involved part-time as a Research Coordinator with the "Stratingh Institute" of the University of Groningen. Within this institute chemical engineers and experts on organic synthesis and catalysis are working on integrated projects.
Cuperus owns a Ph-D degree of the University of Twente (Prof. Dr C.A. Smolders) on Membrane Technology (1986-1990). The theme of his masters thesis was ceramic membranes (Burggraaf, TH Twente).
Cuperus is author or co-author of 50 publications and 7 patent applications.

MORNING SESSION

Energy and CO_2

BACKGROUND

In the past decade the world has experienced a widening gap between the predicted future demand for oil and known reserves, fuelled particularly by the growth of new economies like China and India. This represents a particular challenge for the chemical industry in Europe, which relies on more than 70% imports for its oil needs. A challenge of similar impact for the chemical industry is global climate change, which could lead to higher cost for the process industry emitting substantial amounts of CO_2.
In this session we will see how application of advanced separation technology can play a crucial role, not only in addressing these challenges, but also in increasing the competitiveness of the industry. Specific characteristics of the chemical industry, such as the large material streams and the large variation in separation requirements, issues and technologies provide unique opportunities.

CHAIRMAN: AREND DE GROOT (ECN)

CURRICULUM VITAE

Dr. Arend de Groot has a PhD in Fuel Cell Systems and Exergy Analysis. He joined the ECN in 1996 and worked several years in fuel cell development (MCFC, PEMFC). He has published on a wide range of subjects, including scenario's for the future EU chemical industry, implementation of hydrogen in the energy system, membrane reactors and process intensification. His current work within the program Energy Efficiency involves various separation technologies, including membranes and advanced distillation systems.

SPEAKERS

DR. HANK VLEEMING (PROCESS DESIGN CENTER BV)

Development and techno-economic evaluation of CO_2 capture technologies

With the continuing dependence of industry and power production on fossil fuels, carbon capture and storage (CCS) becomes more and more accepted as an essential technology to mitigate greenhouse gas emissions. Over the past decade R&D efforts to develop novel or improve existing CO_2 separation and purification technologies have been heavily intensified. In view of the ambitious CO_2 emission reduction targets, the high CO_2 capture cost at present and the short timeframe for implementation, there is a clear need to focus R&D efforts, improve efficiency, reduce cost per ton of CO_2, and evaluate and compare technologies on an equal basis.

PDC applies in-house tools for the development, optimization, techno-economic evaluation and benchmarking of CO_2 capture technologies for industrial clients as well as in R&D consortia. In the presentations generalized findings and trends are shared and

Energy and CO_2

examples given of the essential elements for the development and evaluation of CO_2 capture technologies.

CURRICULUM VITAE

Hank Vleeming has been working for 10 years as a senior consultant with Process Design Center. His expertises are process - and reactor development, design and optimization, technical and economic assessment, benchmarking and industrial auditing. He has profound knowledge and experience in the field of large-scale industrial production of (bulk) chemicals, such as steam cracking, synthesis gas related processes, refining and CO_2 capture technologies.

Hank Vleeming holds a master degree in Chemistry from Leiden State University and a PhD degree Chemical Engineering from Eindhoven University of Technology. Before starting his career with Process Design Center, Hank Vleeming worked with Technip/KTI (ethylene, hydrogen, synthesis gas, methanol) and IFP (Institut Français du Pétrole) in France (refinery processes).

HENK VAN VEEN, ECN (BC-00-03 AZEOTROPE SCHEIDINGS PREVENTIE)

Azeotrope separation prevention

CURRICULUM VITAE

Henk van Veen obtained a BSc degree in Chemical Engineering in 1986. His graduation work in the field of polymeric membranes for the separation of CO_2 from CH_4 was performed in the Membrane Technology group at Twente University. Subsequently, he started to work at the Energy research Centre of the Netherlands in the field of ceramic membranes. After managing several projects he became responsible for the coordination of all activities in the field of membrane applications within ECN in 2000. Since 2007 Henk is senior scientist and deputy Group Leader Membrane Technology. The work focuses towards energy and costs savings using membranes including the use of membranes in (bio) conversion processes.

LESLY GARCIA-CHAVEZ & MIRAN MILOSEVIC (BC 00-04 DESIGNER SOLVENTS FOR WATER REMOVAL)

BC-00-04 Designer solvents for water removal

Water separations belong to the most costly and energy intensive separations within the sector bulk chemicals. Especially for bulk scale (>100 kt/yr) the state of the art is still mostly distillation, evaporation, absorption through glycol and adsorption. A breakthrough compared to the current state of the art would be the establishment of a generally applicable technology based on specially designed solvent systems that are capable of selective action on the water and not on the other components. Specific solvents and operating systems will be developed for this purpose. Start-up companies may be interested to produce the newly developed designer solvents.

Energy and CO_2

CURRICULUM VITAE LESLEY GARCIA CHAVEZ

Lesly Garcia-Chavez studied chemical engineering at the Universidad de las Americas–Puebla (Mexico 2002). After getting the bachelor degree she worked for 2 years in the Instituto de Investigaciones Electricas in the Department of Thermal Processes doing feasibility studies for gasification and combined cycle technologies. In 2007 she obtained a master degree in Chemical Engineering with a specialty in process Integration from the Universidad de Guanajuato (Mexico). In April 2008 she started a PhD. at Technische Universiteit Eindhoven in the Process Systems Engineering Group under the supervision of Prof. André de Haan and in collaboration with DSTI.

CURRICULUM VITAE MIRAN MILISOVIC

Miran Milosevic was born on 2nd of January 1979 in Belgrade, Serbia. After finishing his high school at the Nature science Gymnasium he studied Chemical Engineering at the Faculty of Technology and Metallurgy, University of Belgrade, Serbia. During his studies he participated in a research project about particle generation in plasma reactor at the Institute for hard material and particles at the Technical University, Munich, Germany. Hereafter he graduated at the Department of Process Engineering, University of Belgrade where he worked for one year. In 2007 he started his TOIO education in Process and Product Design at Eindhoven University of Technology (TU/e), The Netherlands. after obtaining a PDEng in 2009 at TU/e working on the novel continuous process of soft wood acetylation in Titan Wood Arnhem, The Netherlands he started his PhD in the Process Systems Engineering Group, in the department of Chemical Engineering and Chemistry, TU/e.

AFTERNOON SESSION

Process Intensification

BACKGROUND

Process intensification is seen as one of the main enabling technologies for a more sustainable chemical industry (see for example: Innovating for a Better Future: Putting Sustainable Chemistry into Action - Implementation Action Plan, SusChem 2006). In the Netherlands the Roadmap Process Intensification and the subsequent Action Plan are bringing together new public-private partnerships to develop key PI technologies. In this session we will highlight three different aspects: prof. Hans de Wit will help us look forward several decades to see what are the key challenges Process Intensification needs to solve. Prof. Kenig will highlight novel emerging technological possibilities which create opportunities driving PI. In addition Huntsman will share its insights what it takes to transfer PI technology from the lab to industrial practice.

CHAIRMAN: AREND DE GROOT (ECN)

CURRICULUM VITAE

Dr. Arend de Groot has a PhD in Fuel Cell Systems and Exergy Analysis. He joined the ECN in 1996 and worked several years in fuel cell development (MCFC, PEMFC). He has published on a wide range of subjects, including scenario's for the future EU chemical industry, implementation of hydrogen in the energy system, membrane reactors and process intensification. His current work within the program Energy Efficiency involves various separation technologies, including membranes and advanced distillation systems.

AFTERNOON SESSION

Process Intensification

SPEAKERS

EUGENY KENIG (UNIVERSITY OF PADERBORN, GERMANY)

Micro-separation technology: state of the art and perspectives

In recent years, chemical micro-processes have attracted a significant interest of both chemical process industry and research community. These processes are performed in equipment with characteristic dimensions at micrometer and sub-millimeter scale. As a consequence, high surface areas per unit volume and small diffusion paths are achieved resulting in intensified mass transfer. By now, research activities have been focused on micro-reactors, and the portfolio of micro-module vendors is meanwhile quite large. On the contrary, only very few modules are available that can be used for separation purposes, though the interest to micro-separation equipment has been growing. This presentation gives an overview of the recent research work in the area of micro-separation technology focusing on operations extraction, absorption, stripping und distillation.

CURRICULUM VITAE

Eugeny Kenig studied applied mathematics in Moscow and finished his PhD in 1985 at the Russian Academy of Sciences in Moscow. From 1994 to 1995 he was an Alexander von Humboldt Fellow at the University of Dortmund. Afterwards he worked as a scientific associate at Universities of Dortmund and Essen as well as a developing engineer at BASF in Ludwigshafen. In 1999 he finalized his habilitation in Dortmund and became an associate professor. He declined two full professor offers before accepting the offer of the University of Paderborn in 2008 where he has been chairing the Fluid Process Engineering. His scientific interests comprise kinetic modelling of diverse processes and phenomena, reactive separations, CFD, micro-separations and reduction of process-related energy consumption.

PROF.DR. HANS DE WIT (TUD)

Preliminary results of the Sky line Debates on process technology

The Delft Sky line Debates will result in about ten PI oriented long term perspective vision papers for process technology. The papers are being written by international experts based on discussions in two extensive workshops. The papers will be published in a special issue of Process technology and form the base of new research lines to be developed in the near future.

CURRICULUM VITAE

Prof.dr. Hans de Wit is a member of the platform Chain Efficiency (Creative Energy) and chairman of the Task Force Process Intensification. He is member of the EC of the DSTI and parttime professor in Delft. In the past he was respectively full time professor in Delft, CTIO of Corus, and Executive Board Member of TNO.

AFTERNOON SESSION

Process Intensification

RAMON SCHEFFER AND AD ZIJL (HUNTSMAN)

Continuous Suspension Crystallization Process realized by Huntsman at bulk scale for the separation of MDI isomers. Prime example of Process Intensification in Holland

Huntsman Polyurethanes has successfully developed Suspension Crystallization technology for the separation of MDI isomers. Starting with a theoretical comparison of separation technologies in 2004, via pilot plant trials in 2005, this has led to the installation and commissioning of a plant unit in the summer of 2007. Crystallization offers significant advantages compared to distillation in terms of energy usage and investment costs. Huntsman has a long history in batch layer growth crystallization both as static and dynamic technologies. This new technology offers great advantages versus layer growth:

- **High selectivity**
- **Energy** usage is tiny compared with distillation. Compared with layer growth it is much better because the utility streams are continuous enabling easier heat integration.
- Process is **very intensive** resulting in low capital costs and small units.

The lecture will give an animated demonstration of the process and its advantages and how the implementation could be achieved at an amazing pace.

CURRICULUM VITAE RAMON SCHEFFER

Studied Chemical Engineering at the TUDelft, after which he obtained a PhD at State University of Campinas, Brazil, on Advanced control and optimization with extended Kalman filters, publishing various papers and a book chapter in this area. He started his professional career at Rhodia Brasil in 2001, working on the research center implementing advanced control and optimization, process improvements and problem solving. Since 2006 he works on process development at the research center of Huntsman (Europe) Bvba, being actively involved in identifying new technologies and interaction between public private partnerships.

CURRICULUM VITAE AD ZIJL

Studied Chemical Engineering at the TU Twente. He joined ICI Polyurethanes in Rozenburg, Netherlands in 1987, working on process research & development, in particular for ICI PU's downstream manufacturing plants. After some years holding several positions in production on the Rozenburg site, he moved back to process development at the research center of Huntsman (Europe) Bvba, in 2001. Besides his activities in identifying new technologies and giving global support to the manufacturing site he has a special interest in Process Safety.

AFTERNOON SESSION

Affinity Separation II: Designer solvents

BACKGROUND

Affinity Separations have been identified as one of the key technologies to achieve the ambitious goals of DSTI. This session will focus on what is possible and the progress within DSTI projects using designed affinity solvents.

CHAIRMAN: ANDRÉ DE HAAN (TU/e)

Affinity solvent separation systems are one of the important routes selected to achieve the ambitious goals of DSTI. This session will start with a key note lecture on recent developments of affinity aqueous two phase systems for biomolecules separation and purification, highlighting the transition from laboratory up to pilot plant scale. Hereafter the progress achieved within two DSTI projects will be presented. One presentation will illustrate the importance of sound thermodynamics in the design of affinity solvent based distillation processes. The second DSTI presentation will illustrate the interaction between molecular modelling and affinity solvent design for absorptive gas separations.

CURRICULUM VITAE

André de Haan obtained his Chemical Engineering degree (1987), and his PhD (1991) at the Delft University of Technology. After his PhD he worked as head of the Applied Thermodynamics group at DSM Research, Technology Manager Styrenics at DSM Performance Polymers and Senior Researcher Life Sciences at DSM Research. In 1999 he was appointed full professor in Separation Technology at the University of Twente. Since September 2006 he is holding the chair of Process Systems Engineering at Eindhoven University of Technology. Furthermore he acts as scientific program manager for the industry sectors Pharma and Specialty Chemicals within the DSTI.

SPEAKERS

RAQUEL AIRES BARROS (ASSOCIATE PROFESSOR, INSTITUTO SUPERIOR TÉCNICO, TECHNICAL UNIVERSITY OF LISBON, PORTUGAL)

Affinity Aqueous Two Phase Systems for Bioseparations

The number of biotechnology-based pharmaceuticals in the large-stage pipeline has been increasing more than ever. As a result, there is an enhanced demand for more efficient and cost-effective processes. Aqueous two-phase systems (ATPS) is a potential alternative to the currently used platforms for the downstream processing of biopharmaceuticals, which can combine a high recovery, selectivity and biocompatibility with an easy scale-up and a continuous operation mode. A continuous operation process, based in ATPS, for the capture of human immunoglobulin G (IgG) from different mammalian cells culture supernatants has been developed and validated in a pump mixer settler battery (MSB). Almost all the IgG could be recovered from the cells supernatants with a final protein and total purities of more than 95% and 97%, respectively. Accordingly,

Affinity Separation II: Designer solvents

a comparison of the developed ATPS based process to the currently used protein A chromatography step was performed and its economical feasibility evaluated.

CURRICULUM VITAE

Associate Professor at the Department of Chemical and Biological Engineering of Instituto Superior Técnico(IST) and President of the Centre of Biological and Chemical Engineering (CEBQ) of Institute for Biotechnology and Bioengineering (IBB).
Research is focused on the development of a new generation of processes for the purification of value added products, complying with stringent quality standards. Process is optimized for higher efficiency and lower cost by designing and integrating affinity ligands with different types of supports, including magnetic particles, liquid polymeric matrices and solid matrices. These tailored materials are integrated with aqueous two-phase systems and chromatography and evaluated as generic tools for recovery of biopharmaceuticals, namely antibodies. Professor Aires Barros Has published more than 100 scientific publications including scientific peer view papers and book chapters.

MARK JONGMANS (EINDHOVEN UNIVERSITY OF TECHNOLOGY)

BC-00-06 Ethylbenzene/styrene separation by extractive distillation with sulfolane

CURRICULUM VITAE

Mark Jongmans was born on 24 July 1983 in Noordhoek, the Netherlands. After finishing his secondary school, he studied Chemical Engineering at the Avans Hogeschool in Breda, where he received his BSc degree in 2005. He continued studying Chemical Engineering at Eindhoven University of Technology, where he obtained his MSc degree in 2007. Currently he is employed at the group of Prof. De Haan, Process Systems Engineering Group at Eindhoven University of Technology as a PhD student.

DR. IR. RENZE WIJNTJE(SHELL GLOBAL SOLUTIONS INTERNATIONAL)

OG-00-02 Designer solvents for natural gas treating

The current gas market is driven by an increasing demand and a decreasing number of gas fields that provide sweet, easy to treat gases. Therefore, international oil companies are being forced to consider exploitation of highly contaminated fields, containing high levels of contaminants (CO_2 and H_2S, as well as RSH, COS, CS_2). The objective of the current project is to develop the know-how for a process employing new solvent(s) capable or treating these contaminated gases in a cost- and energy-efficient manner. The final deliverable of the project is a new solvent(s) capable of absorbing either CH_4 or all of the contaminants from highly contaminated gas fields along with the process design and operating guidelines based on the technical and technological know-how gained in the development process. The newly developed solvent(s) should poise the Dutch gas separation industry to seize vast opportunities in the area of contaminated natural gas processing.

Affinity Separation II: Designer solvents

CURRICULUM VITAE

- Wijntje Graduated in 2002 as Chemical Engineer from the University of Twente and obtained Ph.D. in 2007 at the University of Twente in the group of professor De Haan in separation technology ("Separation of oligopeptides from bulk process water streams using adsorption".
- Wijntje joined Shell in 2007 as part of the R&D team in the Gas & Liquid Treating group.
- Wijntje joined the Gas Technology group in Shell in 2010.

AFTERNOON SESSION

Process Synthesis and Control

BACKGROUND

Separation technologies have a wider scope than the word 'separation' suggests. It may also involve operations to create and structure a new thermodynamic phase as a product. In any case, when synthesizing a process separation technologies must be selected and integrated with appropriate control structures to accomplish the overall processing task: to deliver an on-spec product, robust against disturbances.

CHAIRMAN: PROF. JOHAN GRIEVINK (CHEM. ENGIN. DEPARTMENT, TU DELFT)

Separation technology and product formation are often perceived as opposite operations. Yet they are highly complementary. Many modern products have a complex internal structure, comprising one or more thermodynamic phases with distributed properties. Each phase is a building block for the product. These phases must each be purified and prepared with the right composition and conditions before being integrated into a product. When setting up a process flow scheme the problem of selecting and ordering the processing tasks & operations must addressed and resolved in such a way that final product specs can be achieved against an acceptable economical and ecological performance under a variety of conditions. Therefore, the synthesis of the process and its control go hand in hand.

CURRICULUM VITAE

Johan Grievink (1946) is currently an emeritus professor in Process Systems Engineering of the Department of Chemical Engineering at Delft University of Technology. He is also a scientific consultant to industrial R&D. His ambition for his final professional episode in Chemical Engineering is in making practical scientific contributions to process synthesis, modelling and design leading to more sustainable chemical production cycles.

SPEAKERS

PETER BONGERS (UNILEVER/TU/e PRODUCT DRIVEN PROCESS DESIGN)

Inseparability of Products, Processes and Control

The result of a separation process is often an intermediate that is used to manufacture consumer products. As the aim for businesses is to enlight the consumer, by selling products, the obvious route is to translate the consumer wants to define the product properties. Throught the end product properties, the specifications of the intermediates can be propagated. Depending on the end product use, the specification of the separation process results will be different.
The infeed of the separation process, consisting of a number of interconnected unit operations, is often biomass of which the properties are not constant over time.

Process Synthesis and Control

In order to ensure best output quality and highest capacity a plant wide control methodology need to be applied. The incorporation of the control in process synthesis will deliver the most optimal process, as the controllability one of the selection criteria in the designs. In this presentation we will illustrate the above with some examples.

CURRICULUM VITAE

Peter Bongers graduated in mechanical engineering and obtained his PhD in systems and control theory at Delft University of Technology. He joined Unilever Research Vlaardingen in 1994 to work in process modelling and control. In 1998 he transferred to the Unilever Ice Cream Research in the United Kingdom. Afterwards he moved to the Hellendoorn ice cream factory to implement novel process technology and subsequently led the European roll-out. From 2005 he was responsible for the process systems engineering skill base in Unilever Food Research in Vlaardingen. In March 2008 he was appointed part-time professor in the Hoogewerff chair in 'Product Driven Process Engineering' in the department of Chemical Engineering and Chemistry at Eindhoven University of Technology. His research interests are process design and optimisation over various length scales (product structure, unit operations, manufacturing lines and supply chains). In his current work he is responsible for processing and manufacturing science within Unilever Research.

DR. IR. PAUL BUSSMANN / TNO QUALITY OF LIFE TNO

Modelling of Separation Processes and Unit Operations: Plotting the Playing Field for Process Innovation

The modelling of processes and process unit operations are essential tools in process synthesis. The modelling tools have, however, a wider application as they are also used to assess the boundary conditions for innovative technologies and to define research directions. New innovative processes usually consist of several unit operations which interact, moreover they also affect the efficiency of the remaining unit operations. Flow sheeting is used to get insight in these dependencies. With flow sheeting the various unit operations are coupled and the mass and energy balances are drawn. The required modelling tools might vary from relatively simple to very complicated. In a case study within the DSTI-project 'Intensified selective recovery of highly water soluble components from fermentation broths' those modelling tools are developed and used to get insight in the consumption of raw materials and utilities like steam and electricity for the production of the desired products. Knowing the flows, the size of the new equipment is estimated. Coupling the prices to the flows and equipment, results in an economical evaluation of the overall process.

CURRICULUM VITAE

Dr. ir. Paul J.T. Bussmann is research coordinator at TNO in the field of processes for the agro food and the specialty chemistry industry respectively. He has specific knowledge on both thermal processes and affinity separation processes. In this field he carried out numerous contract research projects for industry and he also holds several patents. Prior to his present position at TNO he was TNO's senior expert on heat exchangers and heat exchanging equipment. Paul Bussmann has a degree from the University of Technology

Process Synthesis and Control

in Eindhoven in applied physics (fluid dynamics and heat transfer). After his study he joined the company BTG (Biomass Technology Group) in Enschede where he became deputy director and carried out a large number of consultancy assignments for the World Bank. In the time period at BTG he wrote his PhD thesis on biomass combustion which he successfully defended at the University of Technology in Eindhoven.

FRED HUGEN (PERDIX ANALYTICAL SYSTEMS)

Validation of In-Situ Particle Viewer (CS-01-04)

Measuring particle size distribution with an on-line imaging system

Crystallization is a powerful separation technology. Impurities usually do not fit in the tight and organized crystal lattice structure of the base product. Herewith crystallization has an enormous potential to remove trace molecules in one single process step. Optimization of crystallization processes requires a thorough insight in the thermodynamics, kinetics, but also appropriate sensors to monitor crystal size distribution and crystal shape. Objective of this project is the technology validation of in-line measurement of particle size (distribution) en crystal shape parameters

CURRICULUM VITAE

Fred Hugen is active in image processing since 1994. He obtained a master in Electronics Engineering in 1989 at the University of Twente and performed a PhD research at same University concerning a high speed image processing system for 3D body parameter estimation. Since 1994 he has one of the owners of IMIX vision systems, a high-tech SME company in machine vision and image processing. Starting from 2006 he is assigned as well as R&D manager of Perdix Analytical Systems.

AFTERNOON SESSION

Membrane Separation II: Separation in mild conditions

BACKGROUND

The need to develop and apply technologies able to realize separations under mild conditions is growing, for instance for streams using or resulting from biological processes. As an example highly selective and mild isolation and fractionation of components having high molecular weight (proteins, carbohydrates) from foods or from other bio-based feedstock will become increasingly important. Use of membrane technology to realize the required separation performance under relative mild conditions is an option.
An example thereof will be given in a presentation about actual membrane application for separation in biological processes in industry. Next attention will be given how reuse of effluent or upgrading of process flows is possible by application of electro dialysis technologies, as was shown in one of the DSTI techno projects. The status, development and future of mild fractionation – especially of suspensions and emulsions in the food industry will be addressed in the last presentation of this parallel session. One of the actually started DSTI projects focuses on a recent development is the use of shear-induced migration.

CHAIRMAN: ARIAN NIJMEIJER (SHELL / UT / PA)

Membrane Separation I: nanofiltration

CURRICULUM VITAE

Education

1990-1995	Master study Chemical Engineering, University of Twente, The Netherlands. Master thesis on the preparation of relaxor materials for ceramic capacitors.
1995-1999	PhD study on the preparation and characterisation of silica membranes for hydrogen at the University of Twente, resulting in PhD thesis, "Hydrogen-selective silica membranes for use in membrane steam reforming", December 17, 1999.

Career:

Jan 2000 – Aug 2001	Postdoc at the University of Twente, subject area porous ceramics. From June 1, 2000 until August 31, 2001 working for 80% of the time at Shell Global Solutions in Amsterdam.
Sep 2001 – Oct 2004	Researcher, exploratory research at Shell Global Solutions, Amsterdam. Subject areas: membranes, membrane processes, alternative desulphurisation, skid mounted processing units and novel upgrading technologies.
Oct 2004 – Now	Senior scientist and team leader membrane research and implementation Shell Global Solutions International BV.
Nov 2006 – Now	Professor Inorganic Membranes (0.2 FTE), Faculty of Science and Technology, University of Twente.

AFTERNOON SESSION

Membrane Separation II: Separation in mild conditions

Additional activities:

2000-Now	Shell representative in various user committees of membrane related projects.
2001-Now	Shell Campus Ambassador (University of Twente team).
2003-Now	Shell Technical Representative and Vice Chairman of the Oil/Gas sector of the Dutch Separation Technology Institute.
2004-Now	Board member Dutch Membrane Society.
2005-Now	Chairman Advisory Board Separation Technology for the "Stichting Shell Research".
July 2012	Chairman of the 12th International Conference on Inorganic Membranes (ICIM-12), University of Twente, The Netherlands.

SPEAKERS

PETER VAN DER HEIJDEN (PAQUES)
MEMBRANES IN ENVIRONMENTAL BIOTECHNOLOGY

Since decades Paques is active in environmental biotechnology for the treatment of water and gases. Membrane technology is a valuable add-on to biological processes with respect to the re-use of water and valuable resources, and minimizing discharge products. Examples of the combination of biotechnology and membranes will be presented as well as an outlook.

CURRICULUM VITAE

Peter van der Heijden obtained his PhD in the Membrane Technology Group at the University of Twente in 2001 in the field of membrane formation. Afterwards he was researcher at the CEA (Commissariat à l'énergie atomique) in Grenoble (France), working on properties of membranes for the hydrogen / oxygen PEM fuel cell. Since 2004 he is employed at Paques in Balk working on the biological removal of organic pollutants from water streams and (electrochemical) membrane processes.

JAN THOLEN (ELEKTROLYSE PROJECT / TECHNO PROJ. CS-01-06)

Reuse of effluent or upgrading process flows by electrodialysis technologies

For 5 companies a feasibility study has been performed including laboratory testing for the application of electrodialysis with or without bipolar membranes. The objectives of these applications were the following:

- Desalting an organic product to save costs, waste and chemicals compared to ion exchange.
- Separation of NaCl and KCl from $MgCl_2$.
- Removal and recovery of sulphuric acid from an organic stream with bipolar membranes.
- Removal of hydrochlorid acid from an organic stream.
- Splitting of an organic stream into acid and caustic with bipoar membranes.

In the presentation the results of these studies will be presented and also the role of DSTI in this type of projects and future development.

Membrane Separation II: Separation in mild conditions

CURRICULUM VITAE

Jan Tholen is the founder and owner of Elektrolyse Project, a company that develops and produces complete units for the application of electrodialysis, (membrane)electrolysis, diffusion dialysis and membrane filtration for a wide variety of inductrila markets since 1992. Since april 12, 2010 all activitiesof Elektrolyse Project b.v. have been taken over by Paques b.v., and Jan Tholen now is acting as consultant to Paques b.v.

ANDRÉ MEPSCHEN (NORIT / FO-00-01 MILD FRACTIONATION)

Mild Fractionation and its Future

Many bio-based raw materials are multi-phase materials; i.e., two or more immiscible phases are present. These phases may be liquid or solid, and even may have a state in between. Fractionation of such materials begins with isolating the different phases from each other. Many bio-based streams consist of a great many different particles and droplets; their composition is often related to their size. Thus, a fractionation of the phases based on size of the domains already gives a fractionation in different compositions.
Various techniques are available for this. Sedimentation and centrifugation are used when the difference in density and the domain size are both large. Membrane fractionation has developed over the last few decades but is still hampered by fouling of the membranes and cake layer formation.
A recent development is the use of shear-induced migration, which is the usage of hydrodynamic interactions between the various phase domains (suspension particles) in the system. When a non-uniform shear field is applied to a suspension, larger particles move towards regions of low shear rate, while smaller particles concentrate in regions with higher shear rates. This phenomenon is effective for suspensions with particles sizes down to app. 0.1 µm; below this value, Brownian diffusion takes over.

CURRICULUM VITAE

Since 2001 André Mepschen is working on the Norit Beer Membrane Filtration, after more than 3 years experience at the R&D Department of X-Flow working on membrane modules. Nowadays he is responsible for the development of the BMF process as R&D Manager Beverage.

AFTERNOON SESSION

Bio-refinery

BACKGROUND

The use of renewable resources as raw materials for production processes is essential for a sustainable future. Chemicals, food, feed and transportation fuels could especially be obtained out of biomass. In order to use the biomass as efficient as possible, separation technologies are essential and these need to be integrated in an efficient way in biorefineries.

CHAIRMAN: EMILE VAN DE SANDT (DSM)

There is an increasing demand for the use of new resources because the current raw materials are becoming scare due to economic growth and limitations which are enforced because of climate change. Chemicals, food, feed and transportation fuels could especially be obtained out of biomass. Biorefineries are and will be setup in which separation technologies play an essential role. A big challenge will be the handling of large, diluted streams. Next to that in the near future 2nd generation feed stocks –like lignocellulosic based- which are less pure but further improve the sustainability of the process, will be used. This means additional separation challenges. In this session the importance, developments and challenges of separation technologies for biorefineries will be discussed.

CURRICULUM VITAE

Emile van de Sandt (1968) studied Chemical Technology at Delft University of Technology (Netherlands). In 1997 he received his PhD from the same university with a thesis on the development of a catalytic process for the selective hydrogenolysis of CCl_2F_2 (CFK-12) into CH_2F_2 (HFK-32). This thesis won the Royal Netherlands Chemical Society's Environment Prize 1997. In 1996 he started working at Gist-brocades at Delft in the R&D/DSP department of the Industrial Pharmaceutical Products Division. A few years later the company became DSM. Currently, he is principal scientist downstream processing at the DSM Biotechnology Center and responsible for the science management in this area within the company. He holds several positions such as DSM global competence manager separation technology, DSM program manager for the Dutch Separation Technology Institute, Workgroup leader of the workgroup Product Isolation of the Dutch Biotechnology Association (NBV), Board member of the "Advanced Course on Downstream Processing" of the Biotechnological Sciences Delft Leiden (BSDL) graduate school, Member of the Program Committee of the STW Smartsep program, Member of several Industrial Advisory Boards for projects within the Separations branch of the Netherlands Organization for Scientific Research (NWO/Separations) and the B(E) Basic (Bio-Based (Ecologically Balanced) Sustainable Industrial Chemistry) consortium.

AFTERNOON SESSION

Bio-refinery

SPEAKERS

PROF.DR.IR. R.M. (REMKO) BOOM (WUR)

The biorefinery: integrating food and non-food production

Co-auteurs: R.M.Boom, J.P.M. Sanders

With an increasing global population that acquires ever better affluence, plus a dwindling supply of fossil resources, it is clear that agricultural, renewable feedstock will play a central role in the production of food, but also of non-food products, such as chemicals, materials and fuels.
It is clear that there is only a limited amount of biomass, and therefore we must take great care to use this resource as efficient as possible. Biorefining has (or should have) as goal to completely convert agricultural resources into the most valuable and useful combination of products. It is clear that great care has to be taken in the balanc between the various products, since food comes close to people existence. However, well-balanced and efficient of all fractions may well offer good opportunities to provide a more sustainable, and enjoyable future for all of us.

CURRICULUM VITAE

Summary

Remko Boom is Professor of Food Process Engineering at Wageningen University in the Netherland. His current group has 4.5 FTE assistant and associate Professors and 6 supporting staff. He leads around 25 – 30 research projects in the field of separation science, with app. 25 – 30 PhD students and a few postgraduate researchers. His group work closely with many of the national and multinational food companies present or based in The Netherlands, but also with a range of small technology driven companies. He has (co-)authored more than 230 peer reviewed publications (ISI).

Remko Boom is the Scientific Program Manager for the Food and Water sectors of the Dutch Separation Technology Institute. In addition, he is director of the food program in the High Tech Systems and Materials program, program manager in the MicroNed program, is member of the programme committee on the recent Smart Separations program of the Dutch National Foundation for Applied Sciences, of the Process-on-a-Chip programme of the same organisation, of the Separation Technology program of the Dutch National Science Foundation, and is member of the Top Institute for Food and Nutrition (TIFN) and the Top Institute for Water, Wetsus.

His research focuses on the exploration of new principles for production of food products, that allow significant improvements in sustainability while yielding tastier and more healthy products. This includes separation technology, but also structuring food products, both via the application of intensified processes (e.g., working at extreme concentrations and temperatures), new types of flow fields and microstructured systems.

AFTERNOON SESSION

Bio-refinery

EINTE-KARST DIJK (DSM BIOTECHNOLOGY CENTER)

Challenge 5: In-situ product recovery in a biorefinery, dream or future.

CURRICULUM VITAE

Ir. Einte-Karst Dijk (Einte-Karst.Dijk@DSM.com) is a Scientist Bioprocess Development at the DSM Biotechnology Center and acts as Project definition manager for challenge 5, in situ product recovery. Mr. Dijk has worked for several years on process development and process optimization of pharmaceutical and white biotechnology processes.SESSION

MARCO BROCKEN (EVODOS)

DSTI & Evodos ; Joining Forces (CS-01-07)

After positioning the Evodos SPT technology an overview will be given of how DSTI and Evodos cooperate with each other. The results of the technoproject done with Nedmag, Cosun and DSM will be shown. In this project three mixtures have been processed; MagnesiumHydroxide with the objective to obtain a high dry solid content in the discharged material. Digestate and Biomass are processed with the objective to get a clear centrate. Next a case will be discussed in the field of dewatering cells. Harvesting algae will be used as an example. It will be shown how the SPT technology concentrates algae from a DS content of 0.05% to over 95% (vol.) without shearing the cells. From this example it will be clear how the SPT technology works.
Finally some insight will be given in new technologies under development, the position of Evodos in the market and how DSTI contributes to this.

CURRICULUM VITAE

Marco finished his study Econometrics at the Erasmus University in Rotterdam in 1985. He made a career in the field of Management & Technology Consulting at Accenture where he became Executive Partner in 1990. In 1997 he started Evodos where he is General Manager.

AFTERNOON SESSION

From the Dutch process community

BACKGROUND

The Dutch chemical process community is of significant importance, large, diverse and active. Originally DSTI, meant as platform for this community, started with the execution of an industry driven program focused on development and implementation of new separation technology. The platform has now expanded its activities to process intensification. Further expansion may occur in near future to address more intensively sustainability aspects – but how and to which extent this should be done in a public private partnership program as executed by the platform, is still subject of a first further exploration with the industrial partners.

Yet, there are many other worthwhile initiatives taken and results obtained within the community which are related to, but not (yet) part of the DSTI activities. A good contact between DSTI and such activities is maintained, to stay complementary, avoid overlap and making most effective use of each others' resources. Such topics deserve it to bring to the attention of the Dutch chemical process community, as they are also improving and enforcing the innovative strength of Dutch process industry and stimulating and accelerating the implementation of relevant new technology in it.

In this parallel session four examples of such topics will be presented. First, attention will be paid to the project types and technologies funded by the Energie Onderzoek Subsidie (EOS). The next presentation will reveal how to improve the success rate of transferring Dutch R&D projects results into real industrial implementation and how limited available resources can be uses more effectively, by intensified use of existing expertise. The third presentation in this session will highlight how new process intensification technology has lead to enhanced oil recovery of aging oil fields. Finally, the fourth presentation will reveal the status of some specific new developments regarding proton conductive membranes for hydrogen conversion.

CHAIRMAN: PETER ALDERLIESTEN (ECN E&I)

CURRICULUM VITAE

Peter Alderliesten (1950) studied chemical technology at the Technical University of Delft. After finishing his studies he worked for one year at the University of Oslo and four years at the Van t' Hoff Laboratory in Utrecht on physico and colloid chemical topics. Since 1980 he has been employed by ECN. He started as researcher in the field of coal combustion and gasification in particular in the field of gas cleaning and membrane separation technology. From the mid nineties he has been involved in setting up and carrying out R & D programs on energy conservation and energy efficiency for the process industry. Currently he is manager of ECN R&D program Energy Efficiency in Industry. He was involved in actions that led to the foundation of the Dutch Separation Technology Institute. At this moment he acts as interim scientific program manager for the Sector Bulk Chemicals. He is member of

From the Dutch process community

the Transition Platform Chain Efficiency, on behalf of which he took part in the activities of the Action Group Process Intensification, and member of the Industrial Advisory Board of the Dutch Research School on Process Technology.

MAURITS CLEMENT (AGENTSCHAP NL)

Separation technology in the Energy Research Subsidy Program.

Separation technology is an important area of interest in several research themes of the Dutch Energy Research Program (Energie Onderzoek Subsidie, EOS). It can contribute in improving energy efficiency in industry. Besides that, there is a need for new separation technologies for biorefineries. In this presentation, an overview is given of the project types and technologies funded by EOS.

CURRICULUM VITAE

Maurits Clement works at Agentschap NL for the Energy Research Program, where he is responsible for the area of energy efficiency in Industry. In the past, he worked for other programmes (E.E.T., innovation subsidies) always with separation technology as his main interest.

IR. HANS KEUKEN (PROCESS DESIGN CENTER BV)

The road from R&D to real implementation in industrial processes

It is well known that most of the Research and Development work performed in the Netherlands will not lead to a final, full market implementation of the results. On the average only about 10 out of 100 R&D projects will get a follow up, out of which only 1 or 2 will finally get a position as application in the market. The inevitable conclusion, hence, must be that a smarter and more successful approach has to be possible. In other words: what can we do to improve the success rate of our R&D projects, enabling also to become much more effective with the limited resources we have available.
Hans Keuken, director of Process Design Center, will present some observations and will offer some leads to consider whilst executing R&D projects, for instance within the DSTI program, and may enhance further the chance that their results will find their way to real industrial implementation.

CURRICULUM VITAE

Ir. Hans Keuken is the founder and managing director of Process Design Center one of the leading independent consultancies in chemical engineering, energy efficiency and new biofuel concepts. Hans studied physics and chemistry at the University of Amsterdam and mineral processing & extractive metallurgy at TU Delft.

From the Dutch process community

R. A SWANBORN, (RENAISSANCE OIL & GAS BV)

Process intensification leads to enhanced oil recovery of aging oil fields

Improving the reservoir recovery of existing and aging oil and gas fields is often associated with costly subsurface interventions. This does not always have to be the case. Recent applications in the very efficiently produced fields on the Norwegian continental shelf show that new, compact oilfield separation technologies can increase well flow rates and improve reservoir recovery rates to levels beyond traditional expectations, even without modifying the existing subsurface infrastructure. These opportunities become especially pronounced when:

- the well pressure becomes so low that the back pressure of the production system starts to severely limit the production flow rates.
- the water cut and/or GOR have increased to that extent that the fluids produced from the wells are limited by the present handling capacity of the processing facility.

Renaissance, based in The Netherlands, has developed proprietary oilfield separation and processing technologies and innovative system design methods in order to increase the profitability of marginal fields in general and aging fields in particular.

CURRICULUM VITAE

Dr. Swanborn holds a M.Sc. degree in Mining Engineering from Delft University of Technology, and a Ph.D. degree in Process Engineering (1988) of the same university. During his Ph.D study, financed by Shell, he developed compact separation equipment for application on offshore oil production platforms. This equipment formed the basis for 'CDS Engineering' the company he founded in 1995 and that rapidly became market leader in its field. Afterwards Rombout Swanborn founded Renaissance Oil & Gas to promote actively the use of advanced separation technology to increase the efficiency of maturing oil fields.

AFTERNOON SESSION

From the Dutch process community

ING. WIEBRAND KOUT (HEAD OF PROCESS DESIGN, BASIC MEMBRANES BV)

Proton conductive membranes for hydrogen conversion, production and distribution

Innovative **proton conductive membranes** are needed for the transition to a sustainable Hydrogen Economy. New membrane technology developed by Basic Membranes could remove all three technological barriers to the large-scale use of hydrogen as an energy carrier:

1. Efficient Conversion into electricity in a high temperature PEM fuel cell (>150°C).
2. Sustainable Production in an electrolyser with improved efficiency.
3. Efficient Distribution using electrochemical compression to 800 Bar.

The knowledge needed for the realization of these membranes shows strong overlap. Synergistic benefits can therefore be achieved by simultaneous research. Basic Membranes, together with its partners, conducts research into:

1. Simplification of the monomer synthesis and polymerization.
2. Processing of these polymers and polymer – acid combinations into membrane films.
3. Proton conductivity and stability under oxidative operating conditions at high temperature.
4. Preparation and high temperature operation of three different Membrane Electrode Assemblies in a fuel cell, electrochemical compressor and electrolyser.

CURRICULUM VITAE

Ing. Wiebrand Kout (HAN University of Aplied Sciences, 2000) has ten years experience in research(-management), primarily gained within the fuel cell and hydrogen industry. At NedStack Fuel Cell Technology BV he was responsible for the mechanical design of the fuel cell stack. At Spark Holland BV (automated UHPLC and SPE instrumentation) he was responsible for the engineering quality , supervising a team of eight engineers. He holds the position of Head of Process Design since the start-up of HyET and Basic Membranes.
Wiebrand.Kout@HyET.nl

Workshops

WORKSHOP

Exploring the researcher's competencies of the future

When a industry chooses to strive for innovation via a community like DSTI this means that within the company a shift should take place. Involving other parties when developing new products and technologies is of great added value but asks for reflection on organization and behaviour. Research in an open environment has impact on more than the business model of the organisation. It influences items like leadership and communication and asks for new research competencies that are needed to perform research in a team located at different organisations and locations. New demands are made to skills like delegating, motivating, dealing with diversity, conflict handling and escalation. Also new demands for the group appear: How do individuals feel member of the group, how can they identify with the team ? Questions need to be answered about communication and sharing results. In the workshop we will indentify success factors for research/development skills in an open environment like DSTI.

PETER COESMANS (COESMANS MANAGEMENT)

CURRICULUM VITAE

Peter is an interim manager, project/program manager and workshop facilitator. He works both in commercial and non-commercial environments. He is an expert in the field of non-linear projects, which he has implemented in ICT environments, (corporate) research environments and learning situations. Peter always tries to capture the talents of the people and focus them on the task at hand, providing them with tools and methods to be their best. Peter is an IAF CPF and international facilitation assessor. He has lead many different types of workshops and conferences, focused on problem solving, co-operation, conflict resolution and creative brainstorming.

GERDA DE WEERDT (DSTI HR MANAGER A.I.)

CURRICULUM VITAE

Gerda de Weerdt has extensive experience in change management consulting, coaching and training. In a role as change management consultant for Arthur Andersen, she coordinated the people aspects of many large restructuring and reorganization projects. Her focus is on alignment of HR strategies with organizational goals and ambitions, such as implementing performance management, leadership development, communication, optimizing individual and team performance. At DSTI, she acts as interim HR manager and is responsible for the talent pool of researchers. This afternoon, Gerda will facilitate the group discussion around competencies of the future together with Peter Coesmans of Coesmans Management.

WORKSHOP

Exploring sustainable innovation in process technology

As a result of the long-term trends in population growth, economic growth, energy use, resource scarcity and damage to ecosystem services, the future of the processing industry is likely to change dramatically. As ever more resources become scarce, while population grows to 9 billion people, who all need to be fed and all strive for a more luxurious lifestyle, we need to find solutions for resource use that allow us to use about one tenth of the virgin resources we use today for producing products or services of at least the same quality. We are working on being more eco-efficient, but probably that will not be enough. We also need to identify new sources for materials and resources, e.g. in our waste heaps, and to use other sources of energy. How can process and separation technology play a role in this major transition process? What can you do within your own company to make it better fit for this future? What are joint challenges of the separation technology that should be taken up by DSTI? These and other sustainability related questions that you would like to discuss, will be addressed in this workshop.

DR. GEORGE WURPEL (RESEARCHER/CONSULTANT, IMSA)

CURRICULUM VITAE

George Wurpel obtained a PhD in physical chemistry, after which he worked for several years as a researcher and later assistant professor on the interfaces of physics, chemistry and biology. He started his career in the sustainability sector in 2008 at Econcern in the department of Innovations in Energy Systems. As a senior researcher he was a project leader for the development of a novel Gas-Liquid Contact system. In 2009 he joined IMSA Amsterdam, where he specializes in sustainability trends in resources and energy.

JANNEKE PORS, MA (RESEARCHER/CONSULTANT, IMSA)

CURRICULUM VITAE

Janneke Pors has a MA in Dutch language and culture with a specialisation in argumentation, rhetoric and debate. She is currently graduating in M Sc Industrial Ecology on societal positions and perceptions affecting corporate sustainability strategies of chemical industry. After working as a policy adviser and consultant in the financial sector, she started working for IMSA Amsterdam in 2008. She is mainly involved in the organisation of mullti-stakeholder dialogues and partnerships on the issues of marine litter and water trade.

Posters

Poster overview

Project code – Project title – Author - Affiliation

Display 1: 4 posters

SECTOR: OIL & GAS

Display 2: 6 posters

SECTOR: BULK CHEMICALS

Display 3: 8 posters

SECTOR: FOOD

Biorefinery

Display 4: 6 posters

SECTOR: SPECIALTY CHEMICALS

Display 5: 5 posters

SECTOR: PHARMA

Display 6: 8 posters

Methane Separating Membrane

Project #: OG-00-01
Project leader: Dr. ir. Nieck Benes
E-mail: N.E.Benes@tnw.utwente.nl
Partners: Shell, FMC-CDS, Frames, University of Twente, ECN
Budget: 1,4 MC
Duration: Project started Oct. 2008 and will run up to 2012

Incentive

Inorganic membranes have superior thermal and chemical stability as compared to their organic counterparts. Conversely, polymeric membranes are cheaper and easier to fabricate, and more importantly allow for larger versatility in separation performance. Intimate integration of inorganic and organic materials could grant access to an unsurpassed combination of the beneficial properties of both types of materials. Recently, it has been demonstrated that such membranes can be selective for nitrogen over carbon dioxide[1].

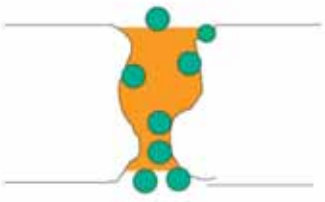
Objective

The objective of the project is the design of surface modified organic-inorganic hybrid membranes, with properties tailored to achieve selectivity for methane over carbon dioxide.

Approach

The general approach is to graft organic moieties on the surface of a meso-porous metal oxide.

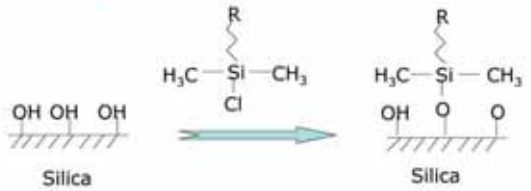
Membranes have been shown successful for separation of gases. Generally, in membrane gas separation selectivity results from differences in affinity for the membrane, and differences in mobility inside the membrane. Surface modification of a porous material will allow for simultaneous alteration of surface chemistry and pore morphology. In turn, this will allow for tailoring of affinity and mobility.



Schematic representation of molecular transport through a surface modified organic-inorganic hybrid membrane

[1] *Ind Eng Chem Res* **47** 201-208 (2008)

Graft polymerization



Reaction of alkylchlorosilanes with silicon dioxide surface

Results

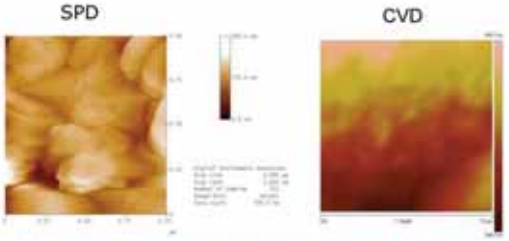


Fig. 1. Layer thickness of the alkylsilane, functionalyzed on silicon wafer, characterized by atomic force microscopy

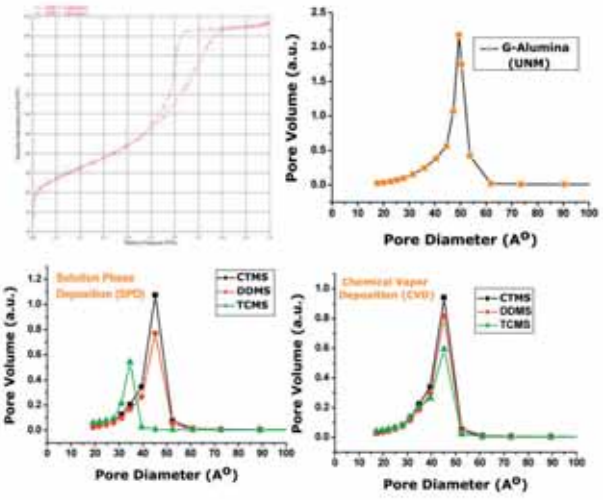


Fig.2. N_2-Physisorption characterization of γ-Al_2O_3 material surface modified with alkylsilanes by solution phase and vapor phase deposition methods

Conclusion

➢ Thin, homogeneous layers and pore blocking can be controlled by chemical vapor deposition method.

Designer Solvents for Natural Gas Treatment

CO_2 and H_2S Absorption Removal

Project #: OG-10-02
Project leader: Renze Wijntje
E-mail: renze.r.wijntje@shell.com
Partners: Shell, Wintershall, ECN, TU Delft and RWTH Aachen.
Budget: 1,1 MC
Duration: 2nd Phase. September 2009 to July 2012

Incentive:

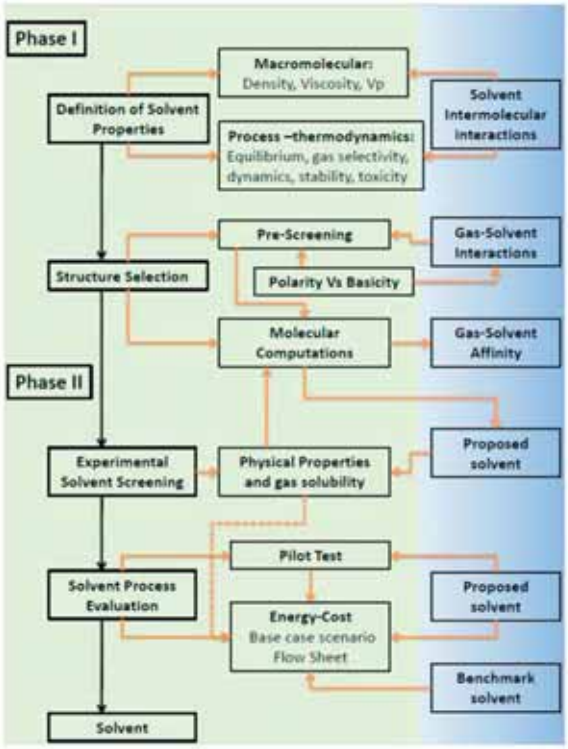
The high impurity levels of the remaining accessible natural gas fields compared to the performance of the current absorption technologies has generated a need for improved solvents that are more energy and cost-efficient in gas sweetening processes.

Objective:

Design a solvent capable of delivering CH_4 at pipeline conditions from a highly contaminated gas stream. Reduction on process energy demand is a main design parameter. Initially, H_2S and CO_2 are the only gas contaminants considered for the design.

Approach:

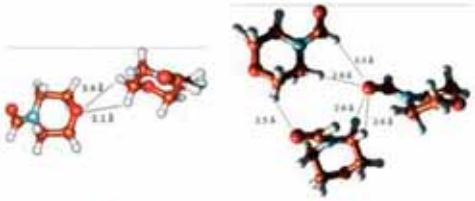
The activities and methods used to design the solvent are given in the following flowchart:



Methodology for design, screening, evaluation and selection of absorption solvents.

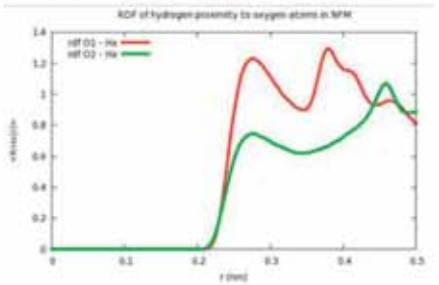
Designing with Molecular Computations:

1. Density functional theory calculations are used to obtain optimized geometries, charge distributions, potential energy surfaces and solute-solvent interaction energies. This information is needed in setting up the molecular dynamics simulations.



a *b*

The proximity of neighboring molecule's hydrogen atoms to (a) the ring oxygen (O2) and (b) Formyl oxygen (O1).



Radial distribution function in the liquid phase of N-formyl morpholine (NFM). Average proximity of hydrogen atoms to the Formyl (O1) and ring (O2) oxygens

2. Classical molecular dynamics simulations deliver thermodynamic and dynamic properties, such as density, cohesive energy density, viscosity and self-diffusivity.

3. Gas solubility estimates are obtained from Configurational-biased Monte Carlo simulations.

Results:

- Structures of possible new solvents.
- Methodology for a fast screening of solvents.

Future Activities:

- Measure gas solubility on promising solvents.

Separating what really matters www.dsti.nl

A Swirl Element for Oil / Water Separation

More profitable oil production from the same reserves

dsti
DUTCH SEPARATION TECHNOLOGY INSTITUTE

Project #:	**OG-00-04**
Project leader:	**Paul Verbeek**
E-mail:	**paul.verbeek@shell.com**
Partners:	**Shell, FMC-CDS, Frames, Wintershall, UTwente, TU Delft, Wageningen UR**
Budget:	**1,4 MC**
Duration:	**Project started July 2007 and will run up to 2013**

Incentive:

Win more oil from fields in an economical profitable way.
Increasing water cuts in the produced oil/water mixtures from oil fields, makes current gravity based separation technology insufficient and too expensive due to its large volume and large weight.

Objective:

Develop a device which separates oil and water separation directly at the well head, by placing it in the production stream. The water is re-injected into the field. Result: limited loss of pressure (no recompression needed; energy saving); prevention of vents and large and heavy tanks on platforms; enabling distance controlled oil recovery at well head (no platform needed).

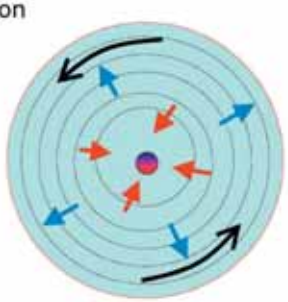
Oil volume fraction downstream of internal swirl element, Euler-Euler multiphase simulation

Approach:

A swirling flow acts as an enhanced gravity field (compare with a Dyson vacuum cleaner)

The project aims at understanding all relevant physics for a centrifugal water/oil flow field and to use this for better separator design.

'gravity' in centrifugal flow field



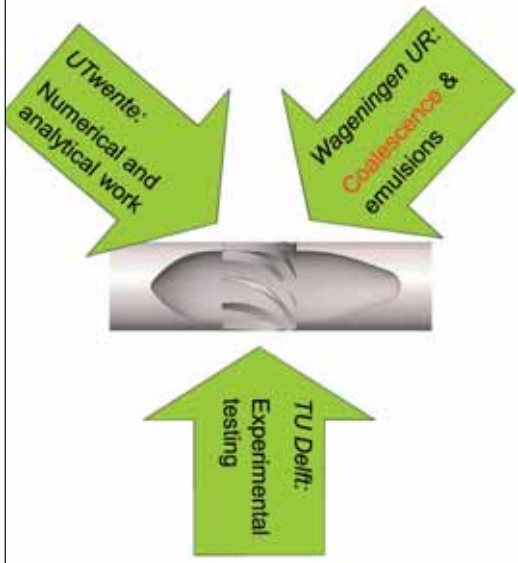
Achieved milestones:

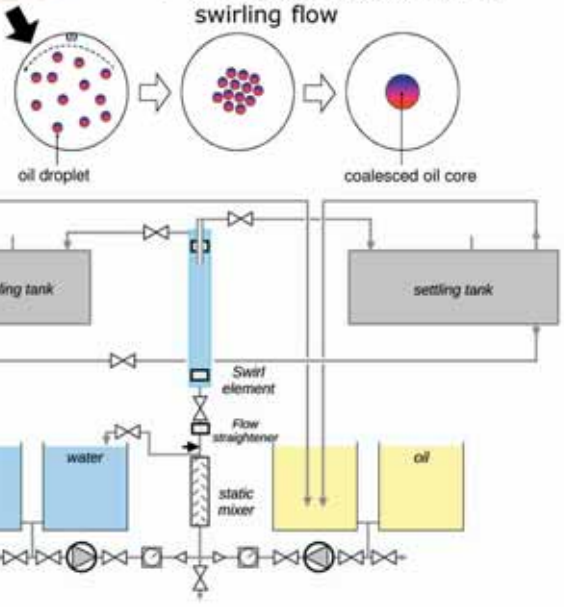
- Detailed analysis of single-phase flow
- Configuration chosen for further research
- Test rig in Delft completed and operational for oil and water mixtures

Future:

- Improve CFD modeling based on experiments
- Visualise flow field in test rig
- Understand coalescence in swirling flow

Project cooperation:





Inline Swirl Element in the Delft test rig

Separating what really matters www.dsti.nl

Reuse of effluent or upgrading processflows by electrodialysis technologies

Project #:	**CS-01-06**
Project leader:	**Jan Tholen**
E-mail:	**tholen@elektrolyse.nl**
Partners:	**NL GUTS,Cosun,DMV International,Huntsman,Nedmag,Purac**
Budget:	**50 kC**
Duration:	**Project started March 2008 and will end may 2009**

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.

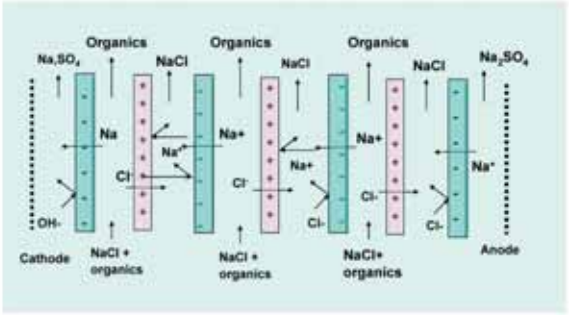
Approach:

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

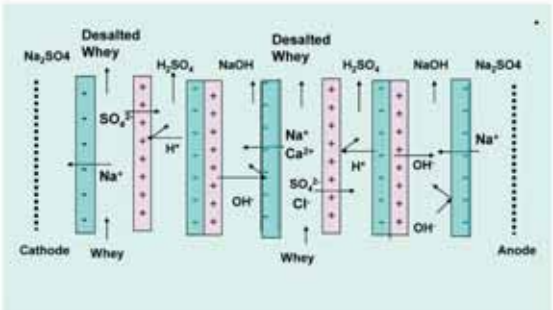
Lab scale unit

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



- 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.



Thermoacoustic heat pumps in distillation

More sustainable production of bulk chemicals

Project #:	**BC-00-02**
Project leader:	**Edwin Hamoen**
Researcher:	**Simon Spoelstra**
E-mail:	**edwin.hamoen@akersolutions.com**
Partners:	**Aker Solutions, AkzoNobel, DSM, ECN, Bronswerk, Huntsman, LyondellBasell, TU Delft**
Budget:	**2,4 MC**
Duration:	**Project started October 2007 and will run up to 2012**

Incentive:

The efficiency of distillation systems can be increased by heat integration of reboiler and condenser using high lift high temperature heat pump. Conventional heat pumps provide limited temperature lift. Therefore heat pumps are required, which can operate at the temperature levels of the column and provide the desired temperature lift. These heat pumps are presently not commercially available and therefore need to be developed.

Objective:

Develop a novel heat pump based on thermoacoustic technology that matches with the temperature conditions of the column, demonstrate the required efficiency and temperature lift. An exergetic efficiency of 40 % is set as the target.

Thermoacoustic heatpump:

The working principle of the thermoacoustic heat pump is similar to that of a Stirling heat pump with the difference that the mechanical displacer (moving part) is replaced by a combination of an inertance (inertia) and a capacitance (buffer). Because of fewer moving parts thermoacoustic heat pump is more reliable and cheaper to produce.

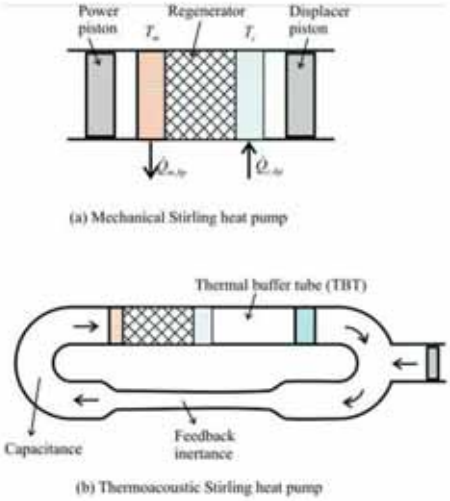
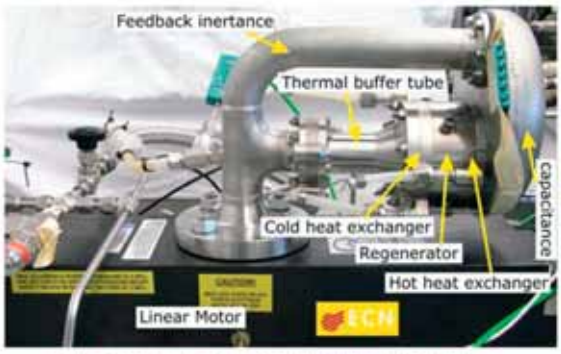


Illustration of the difference between classical Stirling and thermoacoustic heat pump.

Lab-scale setup:

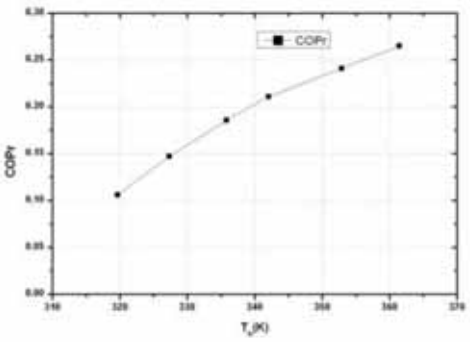
An electrical linear motor driven thermoacoustic heat pump is built and tested at ECN. The maximum mechanical power output of the electrical motor is about 100 W.



Lab-scale setup of thermoacoustic heat pump.

Results:

Initial experiments were performed at temperatures less than 100 °C. A temperature lift of 70 °C is recorded (from 10 °C to 80 °C). The exergetic efficiency, COP_r is about 26 % under those conditions.



The exergetic efficiency of the thermoacoustic heat pump for several hot temperature conditions. The cold temperature is 10 °C.

Next Steps:

Project on schedule; Thermal and acoustic improvements to the lab setup will be carried out and experiments will be performed at industrial test case temperatures; The system will be further scaled up to a bench-scale setup.

Compression Resorption Heat Pumps in Distillation

More sustainable production of bulk chemicals

dsti
DUTCH SEPARATION TECHNOLOGY INSTITUTE

Project #: BC-00-02
Project leader: Edwin Hamoen
Researcher: Dennis van der Bor
E-mail: edwin.hamoen@akersolutions.com
Partners: Aker Solutions, AkzoNobel, DSM, ECN, Huntsman, LyondellBasell, TU Delft
Budget: 2,4 MC
Duration: Project started October 2007 and will run up to 2012

Incentive:

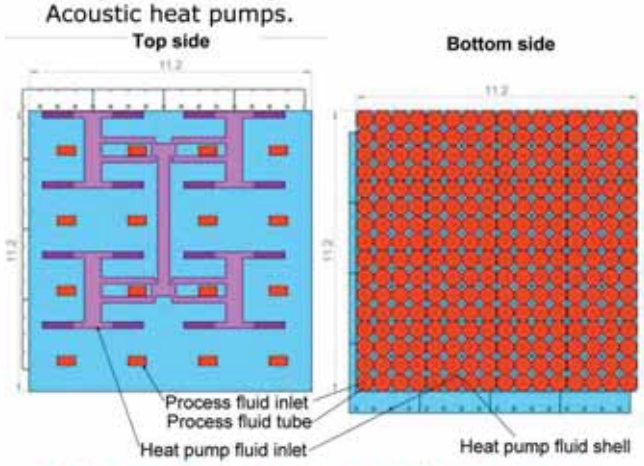
Reduce the primary energy use of energy-intensive separation processes in the bulk chemicals sector, such as distillation columns in an economical way by using innovative heat pumps. Compression-Resorption and Thermo acoustic Heat Pumps have been selected for further research. This poster focuses on the Compression Resorption type.

Objective:

To increase the energy efficiency of bulk separation processes by the integration of Compression Resorption type high temperature lift heat pumps. Demonstrate the process at lab- and bench scale, increase heat transfer efficiency and design economically and technically feasible process.

Approach:

Use a Compression Resorption heat pump to provide the heat to the (re)boiler of the column by upgrading the quality of the heat delivered at the condenser. To reduce cost of the heat exchangers, mini channels of 0.5 to 2mm have been proposed and will be tested in a lab setup as these allow high heat transfer coefficients and have high surface to volume ratios. Heat transfer rates will be modelled and experimentally validated. If positive these heat exchangers can be applied for both Compression Resorption as well as Thermo Acoustic heat pumps.



Inlet geometry for heat exchangers in bench scale setup. Dimensions in mm.

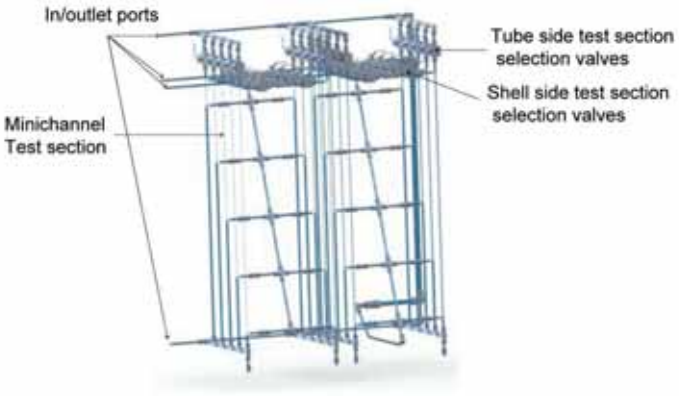


Illustration of the 3D model for the lab scale heat exchanger setup for Compression-Resorption Heat Pump. Four diameters with five section lengths each and one pipe with 6mm test section

Results:

-Heat pump operating conditions have been fully optimised for the process conditions considered.
-Lab scale design has been finalised and construction is under progress.
-A bench scale compressor was found to be able to operate at moderate (up to 140°C) conditions. There is an ongoing search for a compressor allowing higher discharge temperatures.

Future work:

-Bench scale design
-Selection of suitable high temperature compressor
-Modelling of heat and mass transfer processes
-Building laboratory scale setup
-Laboratory scale experiments: Determine heat and mass transfer coefficients
-Building bench scale setup
-Bench scale experiments: Determine real-world performance & verify the heat exchanger inlet design

Separating what really matters www.dsti.nl

Energy and costs savings using pervaporation

Azeotrope separation prevention

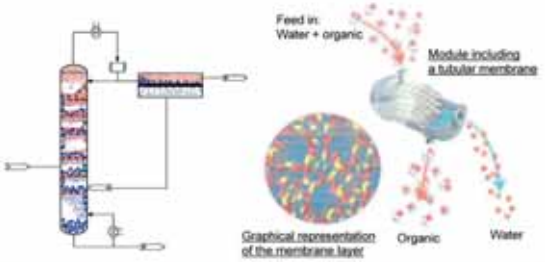
Project #: BC-00-03
Project leader: Henk van Veen
E-mail: vanveen@ecn.nl
Partners: ECN, TNO, Sabic IP, Huntsman (+ subcontractor Molatech)
Budget: 0,6 MC
Duration: Project started 1 April 2008 and will run up to 30 June 2010

Incentive:

Separation of complex liquid mixtures by (azeotropic) distillation consumes enormous amounts of energy. Pervaporation is an attractive alternative.
Implementation of low cost dewatering technologies of more complex chemical mixtures for bulk applications at temperatures < 100°C are wished by industry.

Objective:

To come to cheaper and improved separation processes by implementing HybSi® membranes in the dewatering of industrial process streams.



Combination of membrane pervaporation and distillation system (left) and a HybSi® membrane and module (right).

Approach:

Pervaporation is the selective evaporation of one component from a mixture of liquids via a membrane. In distillation the complete feed is evaporated, which uses much more energy.

Tasks:
1. Develop an empirically based tool (in ASPEN Custom Modeller = ACM) for predicting the performance of pervaporation membranes.
2. Definition of most profitable membrane and module concepts.
3. Lab scale testing of state of the art HybSi® pervaporation membranes in selected industrial applications.

Anticipated business result:

1. Market potential for inorganic pervaporation membrane systems in NI is about 385 MEuro.
2. Payback times of 2-3 years for end-users.
3. Up to 50% energy savings: NI. ~7 PJ/year, representing at least 35 M€/year.
4. Energy savings in EU and worldwide resp. factor 5 and 40 higher than Netherlands.

Project results:

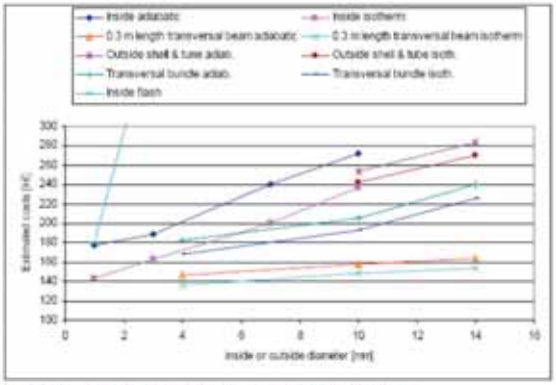
The prediction tool in ACM is available. The model is general applicable for any process.

Example process: feed 7341 kg/hr at 80°C, 87.9w% HC, 10.9w% MeOH and 1.2w% water

Model	PerfMix_Isothermal	PerfMix_Adiabatic
Model output:		
Membr. area, m^2	82.1	129.5
Heat supply, kW	66.1	0
Feed temp. drop, °C	0	15.2
Mass flux, $kg/(m^2 \cdot h)$	2.01	1.19
Permeate composition:		
HydroCarbon (ppmw)	512	565
Methanol (wt.%)	55.5	52.4
Water (wt.%)	44.5	47.5

Results obtained for a process mixture using the ACM tool

Tubular module concepts have been evaluated:
1. Isothermal better than adiabatic.
2. If selective layer is on the inside:
   - Liquid flow should just be turbulent.
   - Small diameters lead to lower costs.
   - Flash PV not preferred.
3. If selective layer outside, shell & tube baffled.
   - Inner diameter of tube > 7 mm.
4. If selective layer outside, transversal.
   - Shorter tubes with smaller ID can be used.
   - Costs seem lower, development needed.



Costs vs. tube diameter vs. module concept

Industrial process test have started. Some membrane fouling observed. Selectivity is good but a higher selectivity is wished.

Future Steps:

Demonstrate the pervaporation technology on pilot scale and start commercialization.

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Designer Immobilized Solvents for Water Removal

Project #: BC-00-04
Project Leader: Jan Harmsen
E-mail: jan.harmsen@shell.com
Partners: Akzo Nobel, Shell, TU Eindhoven
Duration: Project started April 2009 and will run up to 2012

Incentive:

Among the most energy intensive processes in the chemical industry are water removal processes from polar mixtures with high boiling components. Under rather harsh conditions in concentrated salt mixtures water is usually removed by triple effect evaporation, a very energy demanding operation due to the high enthalpy of evaporation of water.

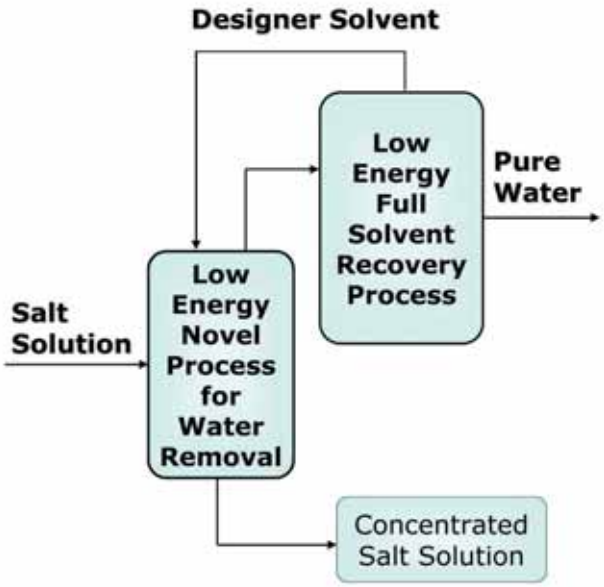
Main Objective:

- Novel Process for Water Removal
- 75% Energy Savings
- ½ Capital Investment Savings

Full Recovery of Solvent

Objective:

The objective of this project is to develop novel, energy efficient processes for water removal from salt solutions. Hereto affinity solvent separation processes are aimed at. In the first stage available separation technologies are screened. Next, the most promising technologies are explored experimentally. Finally, successful operations are examined in detail and used to develop energy efficient alternative separation processes. A major issue is recovery of the solvents, in all stages of development, possible full recovery of the solvents is considered essential to proceed with the technology.



Main Challenge

Defining a Suitable Solvent(s)

Strategy:

- *Concentration Technologies Screening*
- *Search for a Suitable Solvents*
- *Experiments Design*
- *Process Development*
- *Full Recovery of Solvents*
- *Process Simulation and Optimization*
- *Possible Alternatives*

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Nanofiltration at Extreme Conditions (NEXTCON)

Project #: BC-00-05
Project leader: Dr. Dimitrios Stamatialis
Researchers: MSc. M. Dalwani; MSc. A. Pinheiro de Melo; Dr. J. Zheng
Supervisors: Dr. L. Winnubst; Dr. N. Benes; Prof. A. Nijmeijer; Prof. M. Wessling
E-mail: d.stamatialis@utwente.nl
Partners: AKZO Nobel Chemicals, Shell, Lyondell, ECN, UTwente
Budget: 1,7 MC
Duration: Project started July 2007 and will run up to 2012

Incentive:

Most potential applications in the chemical industry require separation processes at extreme conditions: low or high pH, and operation in environments with more aggressive organic chemicals. In specific cases commercial membranes are available which often do not show sufficient separation efficiency, as their molecular weight cut-off (MWCO) is too high.

Objective:

The project aims to deliver a "toolbox" containing robust (chemically stable) NF membranes for bulk liquid separations in the chemical industry. In fact, we will develop NF membranes:

- Stable in highly aggressive solvents and oxidative environments;
- Stable in aqueous solutions at extreme pH;
- With MWCO below 500 Da and some preferably as low as 200 Da.

Approach:

Three different, strongly connected approaches are used to tackle our challenges.

1. Interfacial polymerised composite membranes

Thin film composite (TFC) pH stable NF membranes are prepared via interfacial polymerization (IP) (Fig. 1) and a novel method to characterize them under extreme pH conditions is developed. The membranes (produced in A4 size) have MWCO of 220-240 Da and are currently tested at the laboratories of the users.

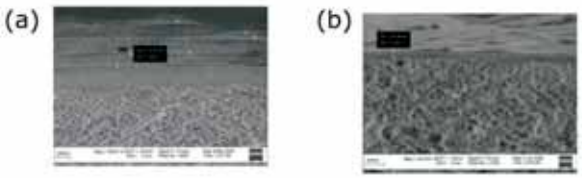

Figure 1: *SEM pictures of the a) PAN support & b) developed IP membrane*

2. Mixed matrix membranes (MMM)

Polymer blends and derived MMM containing nano-sized zeolite are investigated for solvent resistant NF (Fig. 2). Our objective is to reduce the MWCO and to increase the membrane stability.

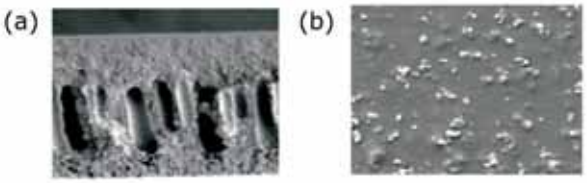

Figure 2*: SEM picture of a) cross section of a blend membrane & b) surface of a blend derived MMM*

3. Surface graft polymerisation of ceramic membranes

Silylation is used to graft hydrophobic molecules onto the pores of ceramic support membranes. The pore modification is confirmed by XPS analysis (Fig. 3). The solvent resistance in toluene of the developed membranes is currently being tested.

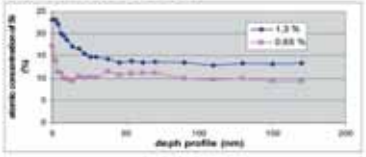

Figure 3*: XPS profile of a 5 nm TiO_2 membrane grafted with trichloromethylsilane*

Results:

1. A4 size IP membranes have been developed and currently being tested under industrially relevant conditions.
2. Polymer blend membranes have been prepared and their separation performance in SRNF is being studied.
3. Silylated ceramic membranes have been prepared. Evaluation as SRNF membranes is in progress.

Next steps:

Long term testing of developed NF membranes with industrially relevant solutions.

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Trace removal I

Remove low concentration of impurities in a more energy- and cost-efficient way

Project #:	**BC-00-06**
Project leader:	**Dolf Bruinsma**
E-mail:	**bruinsma@ecn.nl**
Partners:	**DSM, AkzoNobel, Sabic, Shell, Lyondell, TU Delft, TU Eindhoven**
Budget:	**2,2 MC**
Duration:	**Project started March 2008 and will run up to 2012**

Incentive:
The term "trace removal" refers to the removal of impurities at feed concentrations in the range 100-1000 ppm. These traces, often molecularly similar to the product, are to be removed effectively and economically.
Due to this similarity the physical properties of the byproduct(s) are close to those of the product. For trace removal novel separation methods have to be developed that are more efficient than the traditional options.

Objective:
The objectives of the project are:
1. Design break-through technologies to remove traces in a more energy- and cost- efficient way.
2. Develop a toolbox to solve trace removal problems in the industry in a systematic way.

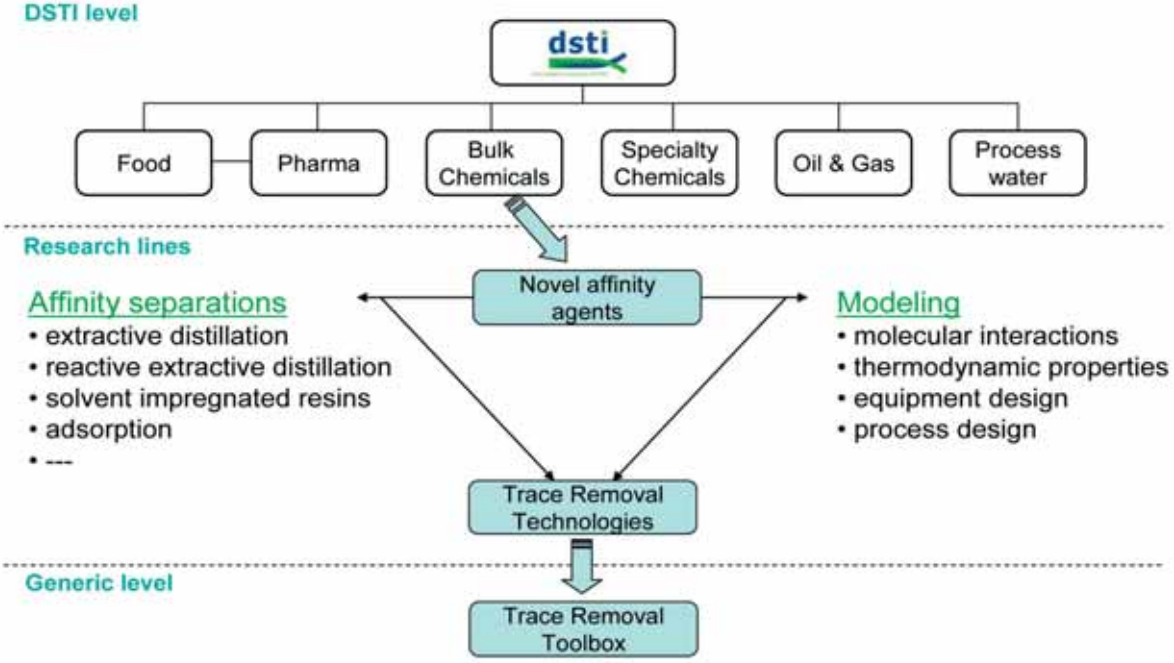
Approach:
In order to achieve these objectives affinity separation techniques are applied to industrial cases from the bulk chemicals sector. For the design and selection of affinity separation agents molecular modelling and simulation are combined with experimental measurements.

Two R&D phases:
In Phase I exploratory research was performed, in which the applications of the technologies for the different cases were tested. For each industrial case a promising technology has been selected.

In Phase II research lines have been defined combining experimental affinity separation methods and different modelling tools.
Novel affinity agents will thus be designed and tested resulting in a number of well selected Trace Removal Technologies.
The final outcome of the project is a Trace Removal Toolbox containing a systematic set of rules for dealing with other trace removal tasks.

The Trace Removal project is an initiative of the Bulk Chemicals sector, but it is foreseen that the Trace Removal Toolbox will be generically useful in a number of other sectors.

The approach in Phase II is visualized in the scheme below.



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Trace Removal II

Research lines

Project #: BC-00-06

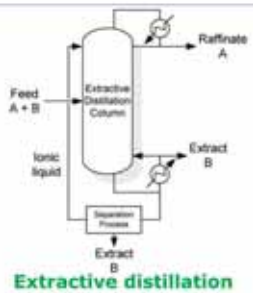
dsti

DUTCH SEPARATION TECHNOLOGY INSTITUTE

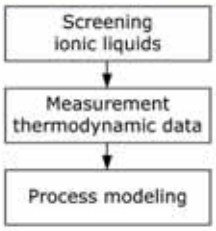
Separation of close boiling mixtures by Extractive Distillation with Ionic Liquids

Main challenge: identification of suitable ionic liquids based on distribution coefficient, selectivity and thermal stability.

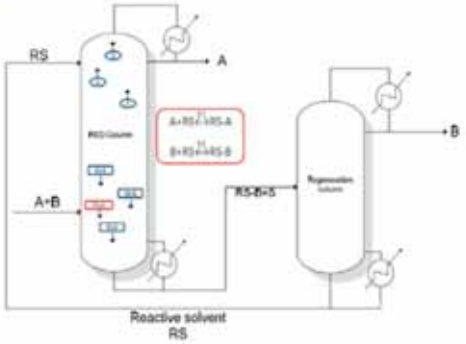
Reference cases: ordinary fractional distillation and extractive distillation with sulfolane (common organic solvent).



Extractive distillation with ionic liquids.



Approach



Separation of close boiling components by Reactive Extractive Distillation (RED)

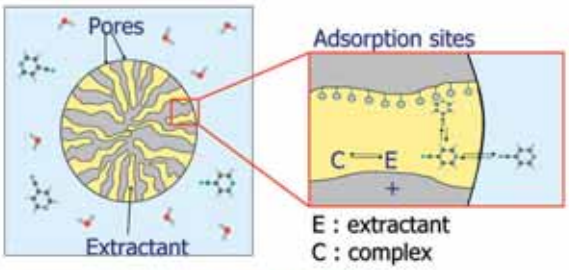
The reaction of an added reactive solvent (RS) with one of the close boiling components leads to the formation of a third component with a high boiling point. This high boiling point component can be separated from the remaining component in the RED column.

The main challenge: a selective reactive solvent.

Solvent Impregnated Resins (SIR)

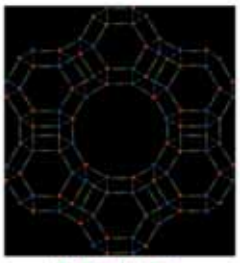
SIR's are porous adsorbing particles filled with an extractant. Components are transferred from the aqueous to the solvent phase inside the pores of the solid support.
In this hybrid process capacity and selectivity can be enhanced by this combined system of adsorption and extraction.

The challenge: design the optimum SIR



The SIR mechanism

1. Activated carbon



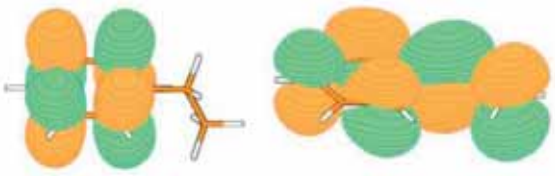
2. Faujasite

Design of new adsorbents for trace removal

Appropriate adsorbents will be selected or synthesized. Selection or synthesis of adsorbents for the targeted molecules is based on the adsorption isotherms.
The adsorption isotherms of 1. commercial adsorbents and 2. zeolite adsorbents will be obtained by screening experiments and molecular simulations.

Molecular simulations in solvent design

The number of possible solvents that could be used in separation processes is huge. Firstly, using molecular simulations we can limit the experimental testing of existing solvents by screening them. Secondly, molecular simulations can be used in designing totally new types of solvents that have not been synthesized yet.



ethylbenzene LUMO styrene LUMO

Lowest Unoccupied Molecular Orbitals (LUMOs) showing conjugation effect in n-bonds.

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Intensified Extraction for bulk processes

Reduce entrainment to minimize end solutions and product losses

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DUTCH SEPARATION TECHNOLOGY INSTITUTE

Project #: BC-00-07
Project leader: Karla Danen
E-mail: karla.danen@dsm.com
Partners: DSM, LyondellBasell, TU Eindhoven and TU Delft
Budget: 0,8 MC
PhD: Esayas Barega (TU/e)
Duration: Project started November 2008 and will run up to 2012

Incentive:

Increase extraction efficiency and/or capacity of existing liquid-liquid extraction columns and mixer settlers. Look also for solutions outside current design and operation window.

The optimal conditions for liquid-liquid extraction are a compromise between good mass transfer and good separation. Good mass transfer requires small droplets but fast separation requires large droplets. Both mass transfer as well as separation are part of extraction efficiency.

In industrial processes small entrained droplets cause product losses or problems down stream and therefore expensive end solutions are required.

Objective:

1. Enhance coalescence and separation of emulsified systems resulting from industrial extraction operation such that the given separation requires a shorter residence time and/or smaller equipment (reduce end of pipe solutions).
2. Increase the capacity of existing extraction equipment by stable operation in the proximity of flooding regime.

Constructed Static-mixer settler experimental setup for investigation of entrainment and droplet coalescence

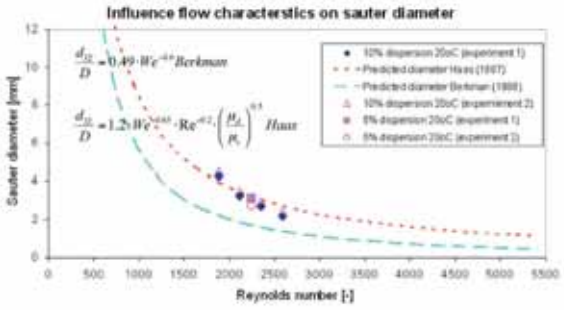
Approach:

Use fundamental knowledge to develop methods that can be used to control the formation, separation and coalescence of the droplet, which leads to a reduction in product losses and prevents the need for extra separation steps.

Working at stable higher flooding conditions will increase the capacity without high investments.

Results:

Preliminary results of relationship between drop size and flow for toluene-water system



Reynolds number 2584, Temperature 20°C, 10% dispersion, Sauter diameter 2.16mm

Next Steps:

Project on schedule;

Experimental study of separation/entrainment behaviour in the presence of interfacial tension decreasing compounds

Measurement of entrainment for different operating conditions and incorporation of entrainment reduction technologies

Mild fractionation of suspensions and emulsions (ShIFT)

Project #: FO-00-01
Project leader: André Mepschen
E-mail: a.mepschen@noritpt.nl
Partners: FrieslandCampina, Norit X-Flow, Cosun, Wageningen UR
Budget: 1.8 MC
Duration: Project started November 2007 and will run up to 2012

Incentive:

In the food industry (e.g. in the production of beer and diary products) separation of components is of great importance, and membrane filtration is a technique that is often used. It is commonly known that during filtration accumulation of components takes place near the membrane (often referred to as fouling) leading to loss of production capacity, increased production costs and more pressure on the environment. Besides, an even more important implication of fouling is that retention behavior of components changes in time, which in turn implies that it is impossible to separate components that don't differ too much in size (fractionate).
If operation of membrane processes under non-fouling conditions were possible, this would lead to a break-through in separation technology, and fractionation of feed streams in various components would become available.

Objective:

Development of a mild method to fractionate components, typically between 0.1-10 micron, from suspensions and / or emulsions. For membranes, this implies that ideally prevention of fouling must be achieved.

Approach:

To reduce fouling two routes are followed: influencing particle migration by fluid flow and reducing interaction with the membrane by surface modification.

Particle migration:

Fluid flow can induce several migration mechanisms. Shear-induced migration is most relevant in this particle size range, causing particles to migrate away from walls (*fig. 1*).

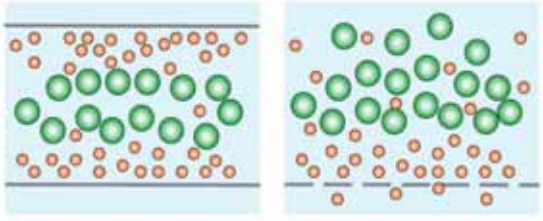


Figure 1: Size separation based on shear-induced diffusion in narrow channel flow (left) or close to membrane (right).

Within ShIFT, component migration is actively targeted to reduce fouling, and studied:
•Experimentally: the influence of process conditions on particle migration will be studied in a membrane set-up, through flux and retention analysis. Additionally, the process will be studied in separate devices that allow quantification of the migration. The data will also be used to validate the computer models.
• Computationally: the factors that influence migration most will be derived from computer models that describe particle migration. From this, design rules for optimal use of shear-induced migration will be derived, that subsequently will be used in the experimental part to determine the window of operation for fractionation.

Surface modification:

Because not every contact between component and surface can be prevented through fluid flow, also surface modification is an integral part of fouling prevention / reduction. This part of ShIFT aims at developing a coating that prevents these contacts (*fig. 2*), and essential is that the coating is specifically designed for components relevant for the industrial partners (proteins and polysaccharides).

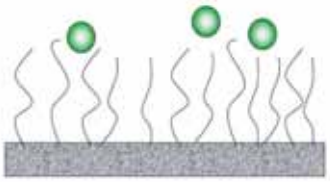


Figure 2: Schematic drawing of brush coating.

Results:

First experimental set-up is ready, promising quantification methods identified; first design rules derived and used for experimental set-up; coatings and coating analysis method developed. Results lead to first 'rough' sketch of window of operation for fractionation.

Next Steps:

Experimental quantification of particle migration, also to be used as model validation, which will be developed further. Fine-tune current coatings to specific fouling agents.

Mild Isolation and Fractionation of Biomacromolecules from Agro- and Biofeedstocks

Project #: FO-00-02
Project leader: Albert Schaap
E-mail: Albert.Schaap@dsm.com
Partners: DSM, Friesland Foods, Cosun, Norit/VITO and Wageningen University
Budget: 1,6 MC
Duration: Project started January 2009 and run up to 2013

Introduction:

Membrane technology has led to significance importance with a wide number of applications in recent decades. With the knowledge available it is ideal for the development of membrane cascades (Fig. 1) for downstream processing (DSP)) [1, 2]. Membrane cascades gaining importance for the separation of the macromolecules and small molecules [3]. Membrane filtrations are giving growing competition to variants of chromatography for final polishing stages of DSP. Most of them suffer from the high capital cost, low space velocities and dependence on concentration diffusion within absorbed pores. Slow diffusion is a problematic for the macromolecules for which the choice of the suitable absorbents is severely limited.

Membranes can greatly increase transport rates by convection relative to those only by diffusion. However, the most efficient membrane filter cannot provide the best separation performance with respect to chromatographic processes. Thus, it is a conviction that integrated membrane cascade system with different configurations might over come this problem [1, 2].

Objective:

Development of membrane cascades to fractionate small molecules.

Scope definition :

A general model will be developed with the minimum amount of input parameters for the design of a membrane cascade. The model will be validated on the lab scale. Cascade membrane systems will be tested on pilot scale.

Research Approach:

1. Single stage Experiments: flux and rejection evaluation
2. Development of the membrane single stage and cascade model
3. Cascade experiments and model validation

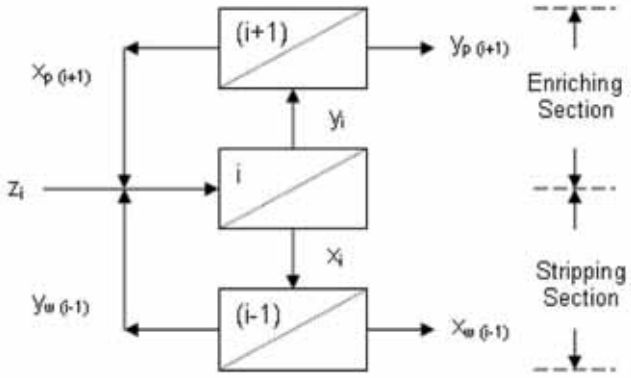


Figure 1: Membrane Cascade Scheme .

Ideal cascade condition:

(i) $y_{i-1} = x_i+1 = z_i$ (i = 2, 3, ..., n-1)
(ii) $\beta = y_i(1-z_i)/z_i(1-y_i)$ is constant

when condition 1 and 2 are met, α is constant and $\beta = \sqrt{\alpha}$; where, x_i, y_i, z_i are stream compositions, β is the head separation factor and $\alpha = y_i(1-x_i)/x_i(1-y_i)$ is the stage over all separation factor.

Acknowledgement:

This research project is sponsored by Dutch Separation Technology Institute (DSTI).

References:

[1] E. N. Lightfoot, *Separation Science and Technology* **2005**, *40*, 739
[2] E. N. Lightfoot, T. W. Root, J. L. O'Dell, *Biotechnology Progress* **2008**, *24*, 599.
[3] B. Van der Bruggen, M. Mänttäri, M. Nyström, *Separation and Purification Technology* **2008**, *63*, 251

TOPS Toolbox Oligosaccharides and Peptides Separation

Subproject: Optimization Chromatographic process

Authors: Floor Boon, Paul Bussmann, Ronald Vroon
E-mail: floor.boon@tno.nl

Project #: FO-00-03
Project leader: Floor Verdenius
Partners: Cosun, DSM, FrieslandCampina, TNO, TU Delft, WUR
Budget: 2 MC
Duration: Project started in 2006 and will run up to 2013

Introduction:

Functional peptides and oligosaccharides are valuable ingredients in food industries. These components occur in large product streams as minor components. Isolation of these components in higher purity generates large industrial value. This requires new separation technologies based on molecular affinity.
In this project new process principles based on molecular affinity are explored, resulting in design rules. The project focuses on understanding the thermodynamic behaviour of peptides and oligosaccharides (TUD), the optimization (TNO) and development of new separation technologies (WUR).

Objective Subproject:

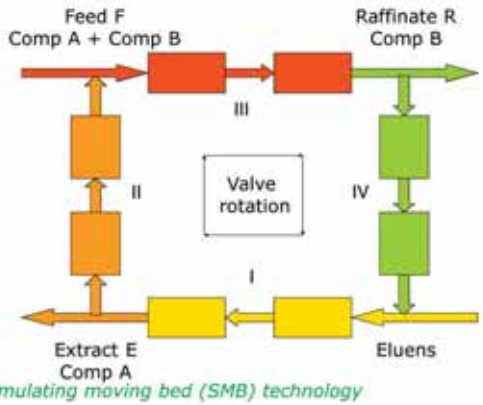
Compare new technologies with the conventional chromatographic process based on packed beds.

Conclusion:

Using the optimization tool it was possible to maintain a high recovery (95%), reduce the volume with 30% and improve purity and dilution of both component A and B with 5%.

Approach:

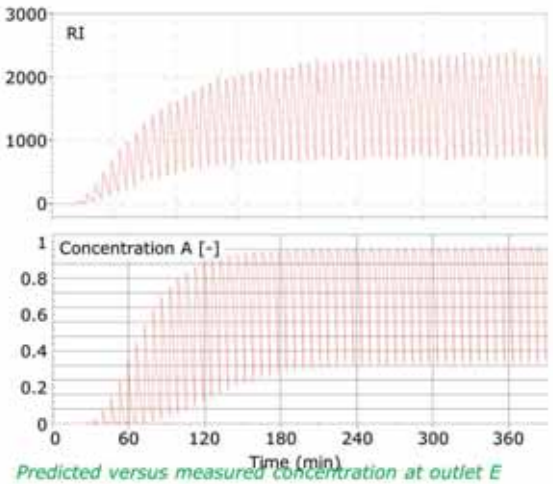
A meaningful comparison can only be made when operating all technologies optimally. For the conventional process (simulating moving bed technology (SMB)) an optimization tool is developed and the model is experimentally validated.



Simulating moving bed (SMB) technology

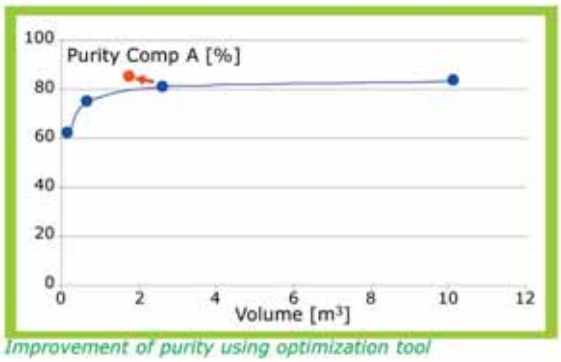
Results:

The SMB is modelled in gProms®, predicting the concentration profile in the columns and the concentration at the outlet. The first comparison is promising.



Predicted versus measured concentration at outlet E

For obtaining the process settings for an optimal performance, an optimization tool is developed. First the SMB volume is estimated using a theoretical optimum operation point. Second, the performance is improved and the volume is reduced using the optimization tool.



Improvement of purity using optimization tool

Next Steps:

- The SMB model will be validated by performing experiments on lab scale.
- The optimisation tool will be further improved (including the valve rotation speed as variable) and used for multi-objective optimisation.

TOPS Toolbox Oligosaccharides and Peptides Separation

Subproject: Affinity Separation of Oligosaccharides and Peptides using microstructured carrier systems

Author: Marta Rodriguez
E-mail: marta.rodriguezillera@wur.nl

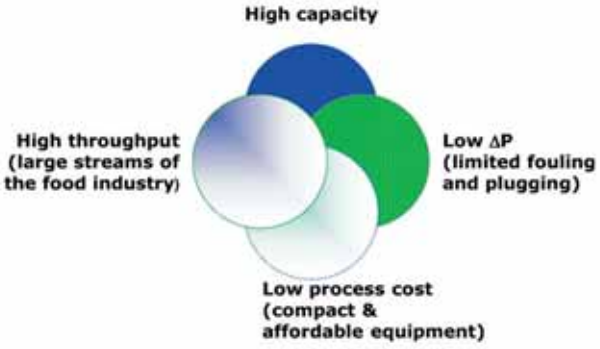
Project #: FO-00-03
Project leader: Floor Verdenius
Partners: Cosun, DSM, FrieslandCampina, TNO, TU Delft, WUR
Budget: 2 MC
Duration: Project started in 2006 and will run up to 2013

Introduction:

Functional peptides and oligosaccharides are valuable ingredients in food industries. These components occur in large product streams as minor components. Isolation of these components in higher purity generates large industrial value. This requires new separation technologies based on molecular affinity.
In this project new process principles based on molecular affinity are explored, resulting in design rules. The project focuses on understanding the thermodynamic behaviour of peptides and oligosaccharides (TUD), the optimization (TNO) and development of new separation technologies (WUR).

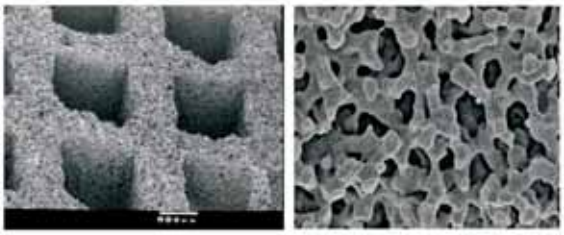
Subproject objective

The development of a food grade carrier system with high throughput, low process cost (compact and affordable equipment), and low pressure drop (with limited fouling and plugging). The system should handle the food product streams separating functional peptides and oligosaccharides using affinity ligands. This project aims at obtaining a window of operation for this technology as a function of the process conditions.



Approach

Some relatively new structures in the field of adsorption, the monoliths, are going to be compared with the conventional packed beds used in affinity adsorption. These microstructures have already been proven in other applications and might be a good alternative due to their increased convective transport and permeability, small diffusive lengths (cycle time reduction) and high surface area available.
For a given processing capacity and using packed beds as a reference, the size and mass transfer performance of some theoretical and available monoliths are being compared using the characteristics of the oligosaccharides and peptides streams. This comparison is based, at this stage of the project, on mathematic modeling with the determination of contact times and number of cycles, volume of system and pressure drop to determine the most suitable equipment for this adsorption process and to study the influence of design and process variables.



Parallel channels monolith and silica monolith found in literature used in the comparison.

Future Research

A screening of the different carriers will be done by modelling and doing experimental work.
Firstly, we will build an experimental setup including the immobilisation of appropriate ligands on the supports matrixes.
Secondly, carry out binding and desorption experiments of the target molecule(s).
Thirdly, perform model validation and parameter estimation.
Finally, obtain a clearer window of operation linking technologies to stream and process conditions.

Separation of Vitality Ingredients

Project #: FO-10-03
Project leader: Olivera Trifunovic
E-mail: olivera.trifunovic@unilever.com
Partners: Unilever, TU Eindhoven, TU Delft, Wageningen University
Budget: 2.1 MC
Duration: Project started March 2010 and expected to last to Q1 2014

Incentive:

Plant phytochemicals are bioactive compounds with a wide range of health benefits, usually present in low amounts (<1 %) in solid matrix of plant materials. Substantial amount of phytochemicals can also be found in waste streams in food production. The key challenge is to obtain these compounds in concentrated and purified forms from large process streams. Furthermore, if compounds are harvested from waste streams less valuable resources are needed.

Objective:

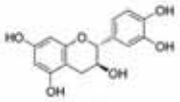
Development of separation toolbox for isolation and purification of polyphenols from large process streams (5-100 t/h). The developed toolbox should satisfy following constraints:

- Low process cost (high throughput, high capacity, etc.), food grade materials and hygienic design
- Non-toxic solvent route is preferred, so compounds can be labelled as natural
- Only mild separations can be used in order to preserve the quality of the treated process stream and isolated polyphenols

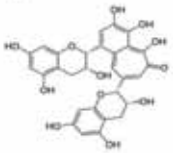
Approach:

In order to construct and validate the toolbox 3 different classes of polyphenol compounds from industrial practice in different food matrices were selected. Selected polyphenol classes have different physicochemical properties (isoflavones are scarcely soluble in water, while catechins are more polar and theaflavins are catechins are dimers). To incorporate matrix effects one fiber containing stream (concentrated stream) with simple polyphenols (isoflavones) and two liquid streams with simple (catechins) and complex (theaflavins) were introduced.

Isoflavones

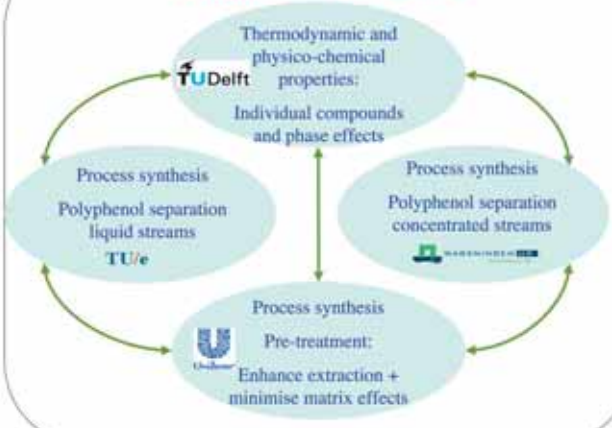


Catechins



Theaflavins

Project workstreams



Process design

Currently no structured synthesis method for these type of separations exists so the toolbox including design rules, heuristics, short-cut models needs to be developed. Process synthesis methodology will be applied and build up in such a way that no viable processing options get overlooked. We will develop processes starting form "blank sheet of paper" and by using thermodynamic and physicochemical properties of compounds will get to optimal processing solutions.

Next steps:

All project workstreams apart of one at TU Delft have been resources. Project will have its kick-off session in May 2010.

Mild Dewatering Systems

Energy efficient food processing

Project #: FO-00-04
Project leader: Anton Wemmers
E-mail: wemmers@ecn.nl
Partners: FrieslandCampina, COSUN, AquaStill, BODEC
Budget: 0,6 MC
Duration: Project started December 2006 and will run up to 2011

Incentive:

In the sugar and milk industry dewatering of food and feed is applied at the expense of fossil energy. The energy costs are a substantial part of the operation costs
The current technology is based on good practice, availability and acceptable prices of fossil fuel. There are no state of the art solutions for the sugar and milk industry to make a real shift in the energy consumption for dewatering.
There are no technologies available to reduce the energy dependency drastically.

Objective:

Many bio-based food products contain large amounts of water; 75% for sugar beet and 90% for milk are not unusual. Water reduction is needed for product properties, logistics, microbiological stability.

There are different techniques for dewatering. Finding better solutions for concentrating and drying will have most impact in the industry of sugar and milk.
The scope is dewatering at 50% of the fossil energy input and at 90% of the operation costs (excl. raw material).

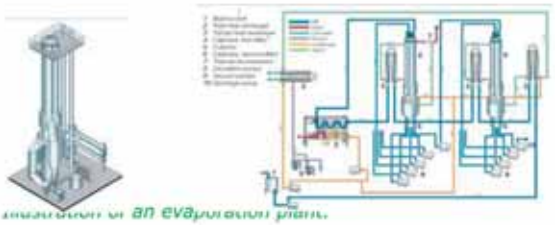


Illustration of an evaporation plant.

Approach:

In a pre-project alternative technologies were identified by idea generation, application of TRIZ techniques and literature survey. Energy calculations are a part of funneling the alternative technologies to business solutions.

Four possible alternative technologies were identified: membrane distillation, freeze concentration, reverse osmosis and vapor recompression. These four technologies are

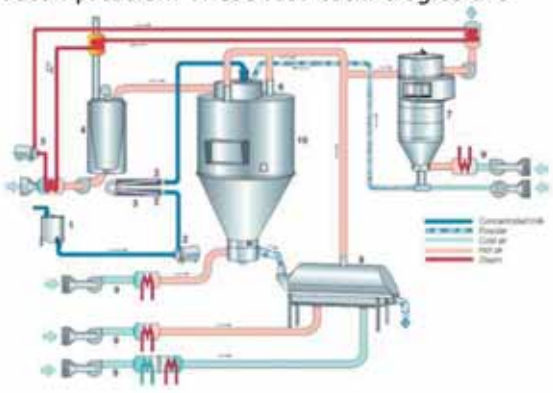


Illustration of a spray drying tower

Research method:

The four technologies are compared in a benchmark using the following parameters: Product quality, process implications, energy use and economics. The parameters for freeze concentration, reverse osmosis and vapor recompression are determined through literature research, calculations and expent opinion. The parameters for membrane distillation are determined through experiments, calculations and expert opinion.

Results:

The results consist of:
1.A rating matrix in which the performance of the technologies is listed;
2.An opinion of the project team which technology is best for which process;
3.A report that demonstrate how the performance is determined.

Selective removal of flavouractive components

Project #: FO-10-05
Project leader: Reinoud Noordman
E-mail: Reinoud.Noordman@Heineken.com
Partners: Heineken, Unilever, TOP, VITO, Solsep, Syncom
Budget: 0,3 MC (pre-project)
Duration: Pre-project started June 2009. Go/No Go decision for full project will be made end Q2 2010

Incentive:

Flavour control is a crucial element in food production processes. This may require **extra process time**, extra process steps leading to **higher costs** and/or higher **risks of product failure**. The challenge of this project is to develop separation technology for downstream control of the flavour profile of food products. This would create more flexibility in the upstream process and give opportunities on cost saving and/or product variation. Opportunities that this project may deliver are:

- Quality improvement and control
- Improved cost efficiency in processing
- Recover new valuable (by-) products

Objective:

Develop new technology for selective extraction of flavour-active components which is applicable and scaleable to the production processes of the industrial partners and cost efficient. The technology should have the following capabilities:

- Dealing with large process streams (10-100 m3/hr)
- Removing components that are present in low concentrations (ppb-ppm level)
- Selectivity in separating components that are not very specific in their molecular structure and/or thermodynamic properties

Approach:

The project will consist of 3 phases :

- Phase 1 (12 months): Preproject: screening of most relevant (new) technologies.
- Phase 2 (3-4 years) Full project Development of selected, most promising separation routes;
- Phase 3 (3-5 years) Industrialization of most promising industrial applications.

In this pre-project, a technology scan was performed in order to score promising technologies on selectively with respect to removal of target compounds from beer and soy milk.

Technologies to be experimentally tested were identified by literature and brainstorming sessions with technology experts (Workshop 1).

Results:

Tests have been completed on the individual technologies with beer and soy milk. Presence of alcohol (beer) and fat (soy milk) show to have significant impact on overall process performance. The evaluation has not been completed as not all analytical results have been performed.

Target components beer
Diacetyl (-)
Esters
Alcohols (+,-)
Aldehydes (-)
Sulphury components (-)

-: off-flavour
+: desired flavour

Typical beer composition	
Water	89%
Ethanol (mass)	6%
Carbohydrates	4%
Proteins/ amino acids	0.5%
Organic volatiles	<0.05%
Other	0.5%

Target components soy milk
Aldehydes
Ketones

Typical soy milk composition	
Water	90%
Proteins	5%
Carbohydrates	3%
Fat	2%
Minerals/vitamins	0.5%

Next steps:

When analytical work has been completed, technologies can be evaluated on their potential and economic feasibility. Based on results, industrial partners will make a Go/No Go decision for full project continuation. The full project is concerned with the development of maximum two promising technologies.

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Selective opening and extraction of natural raw materials

Project #:	**FO-10-06**
Project leader:	**Olivera Trifunovic**
E-mail:	**olivera.trifunovic@unilever.com**
Partners:	**Unilever, Heineken, Bodec, VITO, TU Berlin. Hosokawa**
Budget:	**0.3 MC for pre-project**
Duration:	**Pre-project started June 2009. Go/No Go decision for full project will be made end Q2 2010**

Incentive:

Functional components in plant cells are naturally protected from degradation by different mechanisms. During classical processing in food industry, very often this natural protection layer is destroyed which leads to many undesired effects, such as loss in quality and/or more difficult separation task afterwards. The challenge is to remove these type of compounds early in the process before any degradation occurs. This leads to higher quality products with enhanced levels of desired compounds for sensorial and health benefits.

Objective:

The goal of the project is to investigate the feasibility to obtain selectively different components from raw materials at different moments in time/process, preferably in their natural protective state. These components usually are in large process streams (5-100 m3/h) and some of them have to be removed in natural protective state, while others should be removed because they negatively influence final product quality or downstream processing.

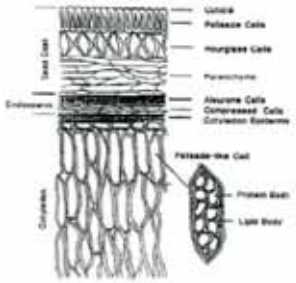
Approach:

In this pre-project a technology scan was performed in order to score its potential to selectively and gently remove target compounds from different raw materials. Technologies to be tested experimentally were indentified by literature survey and brainstorming session with technology experts (Workshop 1).

The impact and potential of technology were tested on two different grain matrices (soybean and barley) and one leafy type of material (tea). The main differences between grain materials:

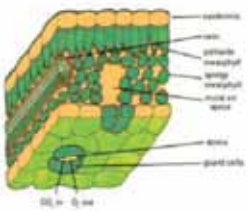
- In soybeans the structural compounds are evenly distributed over the whole grain structure- no compartialisation is present.
- In barley different structural components are present in different parts of the grain: starches in inner layers, enzymes in outer layers and fats in embryo.

In tea leaf only waxes are located in the outer layer and the rest of the structural material is distributed over the whole leaf structure.



Soybean

Barley



Tea leaf cross-section

Results:

The technology workshop resulted in 94 ideas and 24 full technology descriptions. Technologies were evaluated based on their availability, existence of the actual experimental rig for testing (conceptual ideas had to be excluded in this stage) and potential (destructive) influence on raw materials. A short list of 4 different technologies to be tested were selected and technology scan was completed.

Next steps:

We are waiting for the analytical results to be ready to be able to complete the technological and economic feasibility. Based on results, industrial partners will make Go/No Go decision for full project continuation. It is envisaged to continue in the full project with no more than two technologies to be optimized.

It has been a huge challenge to identify one analytical laboratory that can reliably measure the components.

Biorefining

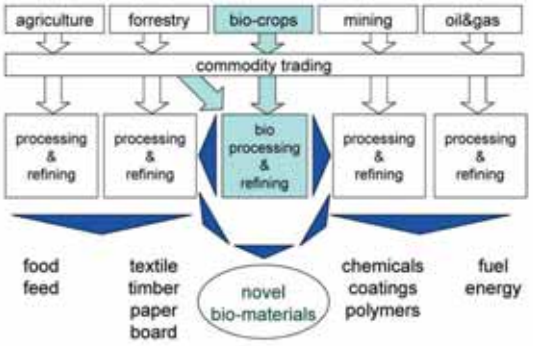
A developing market for better and more sustainable materials

dsti
DUTCH SEPARATION TECHNOLOGY INSTITUTE

Developing a DSTI Roadmap topic
Project leader: Frans van den Akker, Jeroen de Kempenaer
E-mail: Frans.vandenAkker@dstioffice.nl, JeroendeKempenaer@thebridge.nl
Partners: more than 100 partners, academics, technology suppliers and industry
Duration: Project started December 2008 and ongoing

Incentive:

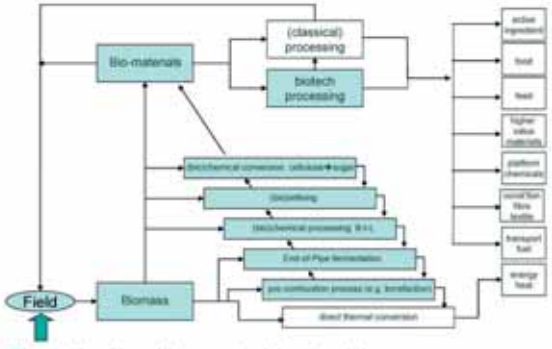
Biorefinery is the sustainable processing of biomass into a spectrum of marketable products and energy. Given the world's scarcity of resources, renewable resources like biomass are attractive. Not only to replace current sources of raw material, but also for novel bio-materials and manufacturing routes.
DSTI believes that Biorefining could prove to be a new market area of specific activities bridging the worlds of classical bio processing and classical (petro) chemistry.



Biorefining, a new market area

But since no more low-hanging-fruit value chains, like corn, cotton, rapeseed, are available anymore, more complex chains will have to be developed. For these no organizations covering the whole value chain do not yet exist, like the "well-to-wheel"-coverage by oil companies.

Secondly, Biorefinery might be an important enabler, but activities are sometimes competition with the 'classical' biobased activities. Of these, food and feed are the most sensitive issues, very directly impacting on health and well being of people. Biorefinery will have to move up the stairs.



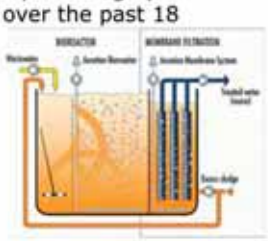
The stairs from biomass to biomaterials

Objective:

Develop a portfolio of biorefining technologies that have the highest impact on biorefining business development amongst DSTI current and future participants.

Approach:

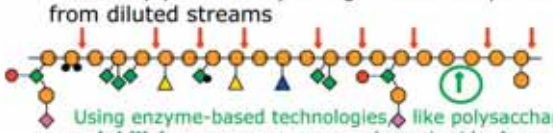
In series of interactive workshops we Highly interactive, DSTI has worked over the past 18 months on the definition of DSTI Biorefining portfolio with more than 100 partners, academics, technology suppliers and industry, also internationally.



Results:

March 2010, this process has culminated in selection of a number projects that is now entering the definition phase.

- Mild fractionation and disentanglement of raw and processed biomass, requiring limit energy and chemicals
- In-situ product recovery from fermentations and/or enzyme treated slurries
- Avoiding unwanted transportation of water in biomass
- End-of-pipe recovery of high-value components from diluted streams



Using enzyme-based technologies, like polysaccharide **solubilizing** enzymes versus polysaccharide **degrading** enzymes

Partners involved:

Aker Solutions, Akzo Nobel, Cosun, DSM, Fytagoras, FrieslandCampina, Heineken, Norit, Purac, RWTH Aachen (D), Synthon, TNO, Utwente, Vito (B), WUR

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Easy Recovery of Acidic and Basic Fermentation Products

Cost-efficient process without by-product streams

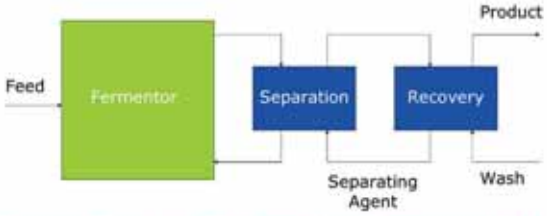
Project #: SC-00-01
Project leader: Floor Boon
E-mail: floor.boon@tno.nl
Partners: PURAC, DSM, TNO, Syncom, TU/e and WUR
Budget: 1,3 MC
Duration: January 2008 – March 2012

Incentive:

Production of bio-based chemicals is becoming increasingly important. Developing cost-efficient fermentation processes remains a challenge. Selective product removal and avoiding by-product streams are the main technological challenges.

Objective:

Development of highly selective systems for recovery of **neutral** acids and bases from aqueous fermentation broth which enables good product recovery yield at higher final concentration levels without use of excessive salt amounts.



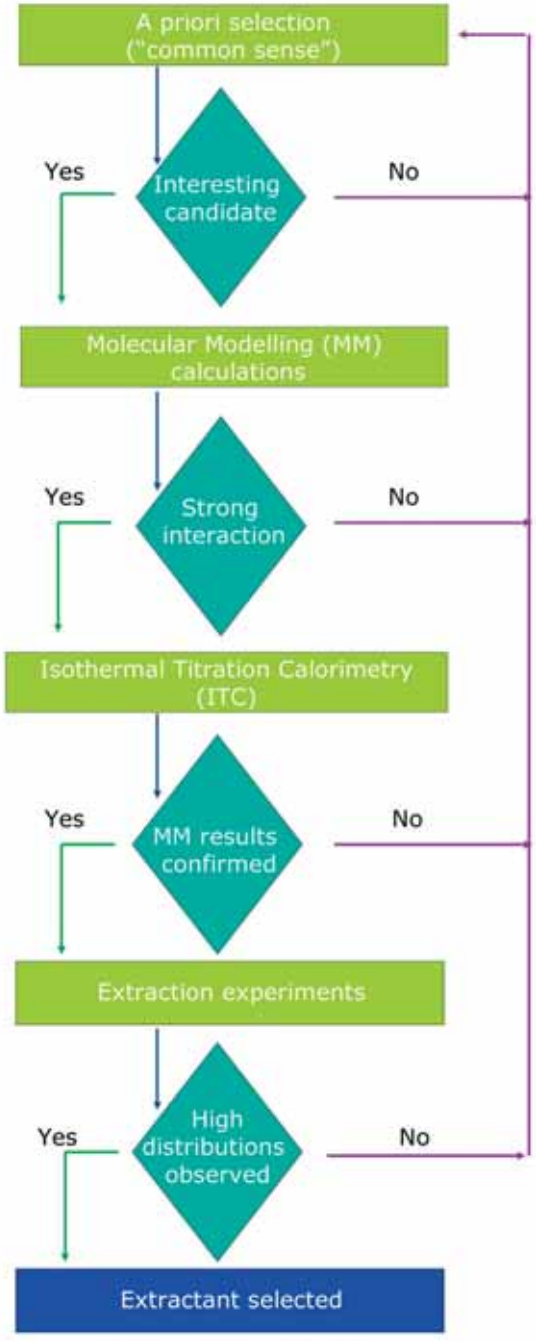
Process scheme product removal from fermentation broth

Approach:

The problem is approached from different disciplines:
- molecular modeling (MM): identification of separating agent;
- chemical synthesis: production of the separating agent;
- chemical engineering: design and operation separation unit;
- process engineering: design separation process.

Two extraction systems are studied:
- Liquid extraction;
- Micellar extraction (using modified pluronics).

The separating agent (solvent) is mixture of two components: extractant and diluent. First an extractant is selected. Second the influence of the diluent composition, temperature and concentration is determined.



Procedure extractant selection

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Liquid extraction: Recovery (Back extraction) concepts

The dependency of the distribution coefficient on the diluent composition, temperature and concentration is exploited to develop a back extraction strategy.

Back extraction concepts identified as economical feasible are:
- *Temperature swing*: extraction is carried-out at relatively low temperature and back-extraction at elevated temperatures.
- *Volatile anti-solvent*: the diluent composition is changed by **adding** a component. For example the solvent is pressurizing with a gas anti-solvent.
- *Co-solvent*: the diluent composition is changed by **removing** a component. For example using a co-solvent with a low boiling temperature and low evaporation heat.

The process concepts are translated to solvent requirements using process models:
-To obtain a concentrated product stream, a high ratio between distribution coefficient forward and backward extraction is required;
- To obtain a product with a high purity, a high distribution coefficient in the forward extraction is required.

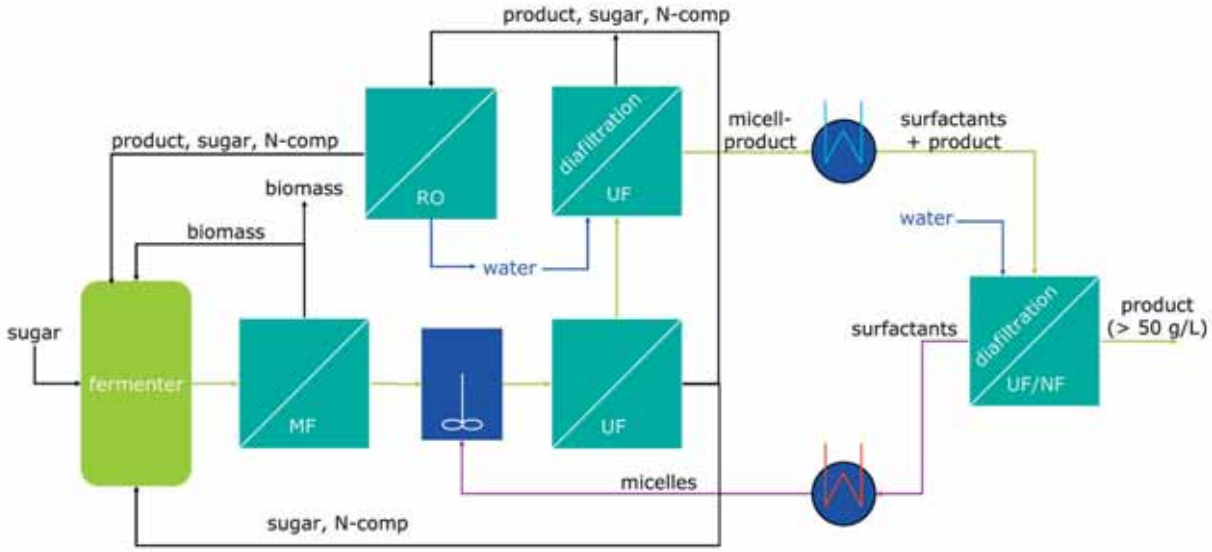
Results micellar extraction (Pluronics):

- Chemical evaluation: feasibility of obtaining modified pluronic with specific interaction with undissociated LA and DAB.
- Technical evaluation: identification of most important pluronic property for technological feasible process.

No pluronic was obtained with selectivity for undissociated target compounds. In the future, pluronics can be modified with functional groups identified within extractant selection.

Process concepts are based on principle of micellar enhanced ultrafiltration (MEUF) in combination with temperature induced product recovery.

It is concluded that the recovery of small acids and bases by micellar extraction is only feasible in the concentration range 20 – 2,000 ppm.



Process concept micellar extraction (pluronics) based upon MEUF

Intensified processes for selective recovery of active peptides and proteins

Project #: SC-00-02
Project leader: Joost Clerx
E-mail: joost.clerx@merck.com
Partners: DSM, MSD, Mosaic Systems, Synthon, University of Twente, Wageningen University
Budget: 1.4 MC
Duration: Project started July 2007 and will run up to 2013

Incentive:

Efficient recovery of peptides and proteins in large quantities remains challenging and expensive in industrial food and biotechnology applications. Current technologies are reaching their limits with regard to throughput.

Objective:

The aim is to develop efficient and cost-effective separation of active biomolecules from fermentation broths and food waste streams using novel matrix-membrane technology: fast, cheap, and without pressure build-up!

A Module Evaluation

Goal:
Evaluate MMM technology for application in industrial setting. Improve production process MMM and test MMM by industrial partners.

Work performed by:
Mosaic Systems, MSD, DSM

Status:
Project is completed

Mixed module membranes consist of chromatography resins embedded in membrane fibers. Throughput and capacities are high.

Highlights:
- ⊕ Production improved & reproducible
- ⊕ Increase in capacities with commercial resins with smaller diameter
- ⊕ Membranes are resistant to cleaning and can be re-used up to 10 x
- ⊕ Leachables production process quantified

⊖ Module design need to be improved for quantitative recovery of protein
⊖ Performance and cost evaluation by MSD and DSM are on-going

B Ligand Development

Goal:
Develop a stable ligand that can be used for industrial affinity separations. Candidate ligands will be screened for binding, characterized, and coupled to resin beads.

Work performed by:
Wageningen University

Status:
1 post-doc: 2nd yr; 1 post-doc: 1st yr

LamA is a thermo-stable protein able to bind a sugar. The protein is engineered such that it captures proteins in industrial applications.

Deliverables & Progress:
⊕ Construction ligand libraries based using phage display techniques:
T7 system unsuccessful;
M13 system being evaluated
⊖ Ligand characterization: no ligands obtained yet, wild-type LamA characterized (NMR, HPSEC, etc)
⊖ Coupling to beads: coupling reaction selected and being optimized

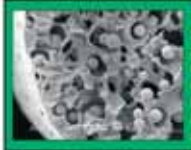
Highlight:
Preparation of ligand libraries remains a challenge is current bottleneck

C Affinity Separations

Goal:
Develop protocols to perform affinity separations in MMMs. The industrial case of MSD is used as model, and ligands prepared in B will be used when they become available.

Work performed by:
University of Twente

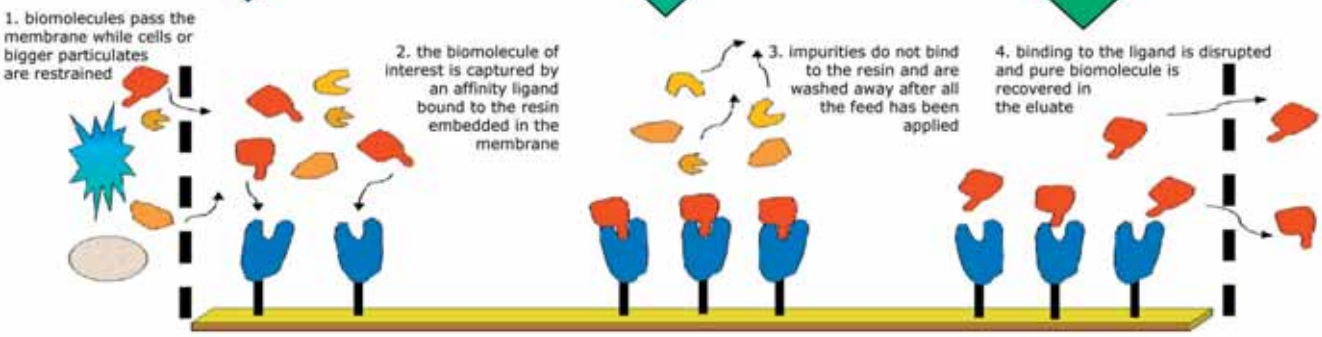
Status:
1 post-doc: 1st yr



Strategies and protocols will be developed to incorporate resins modified with affinity ligands in mixed mode membranes.

Deliverables & Progress:
⊕ 1st yr: Develop affinity purification strategy for MSD case
carbohydrate-based affinity ligands have been coupled to the resin
⊕ 2nd yr: Develop strategy to incorporate LamA-modified particles in MMM: no ligands obtained yet
⊕ 2nd/3rd yr: Make MMM with affinity ligand and test performance.

Highlight:
First year goals are well on schedule



Acknowledgement: Mark Levisson (WUR), Astrid Geerke-Volmer (WUR), Kishore Tetala (UT), and Ria Rhemrev (Mosaic Systems) are acknowledged for their contribution to the project

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Removal of compounds present in ppm Concentrations in aqueous streams

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Project #:	**SC-00-04**
Project leader:	**Peter Baets**
E-mail:	**p.baets@purac.com**
Partners:	**Akzo-Nobel, Purac, TU Eindhoven, Universiteit Twente**
Budget:	**1.0MC**
Duration:	**Project started March 2008 and will run up to 2012**

Incentive:

The term "trace removal" represents the removal of impurities at concentrations <500 ppm. These traces, often molecularly similar to the product, are to be removed from the main product. Due to the large similarity between the structures, the physical properties of the byproducts and the product are similar. This leads to expensive and high energy demanding traditional processes.

Objective:

The objective of this project is twofold:

1. Design breakthrough technologies to remove traces in a more energy- and cost-efficient way by using **adsorption** and **molecular imprinted membranes**.
2. Obtain a toolbox to solve trace removal problems in the industry in a systematic way.

Adsorption

Christine Wegmann TU Eindhoven

In chromatography a separation in which the mobile phase composition changes during the separation process is described as gradient elution.

The adsorption/desorption process which is designed for the removal of acrylonitrile (AN) from an aqueous solution will make use of the same principle. It has been shown that certain solvents lower the adsorbed amount of AN in equilibrium with the concentration in the liquid. By switching the solvent from water in the adsorption step to a solvent or a water-solvent mixture in the desorption step, AN can be removed from the adsorbent material (fig. 1).

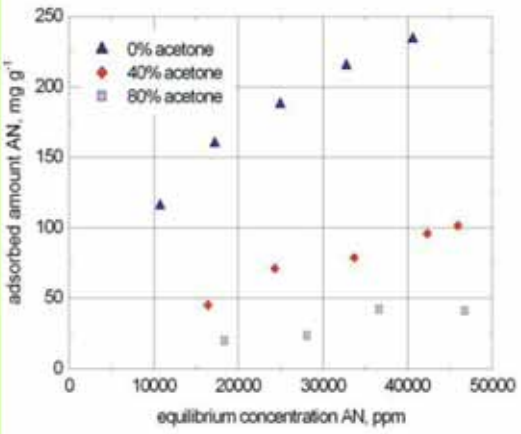

Figure 1: Adsorption isotherms for acrylonitrile onto Dowex Optipore L493 at different compositions of the liquid phase.

Molecular imprinted membranes (MIMs)

Anne Corine IJzer University of Twente

MIMs are membranes that have functional groups, but that were processed or polymerized in the presence of a template molecule. By this means the membrane not only contains specific binding sites, but these binding sites are also ordered in a three dimensional structure making the membrane shape selective for the target molecule.

The general method to make an imprint in a polymer is by polymerization of functional monomers and crosslinking of these monomers in the presence of the template molecule (the target molecule) (see Figure 2) A template molecule (green), functional monomer (blue), crosslinker (grey) and solvent are mixed (1). During mixing complexes are formed between the template molecule and the functional monomer (2), these are stabilized by crosslinking the polymer (3). Extracting the template from the polymer results in an imprinted polymer with recognition functionality for the molecule (4).

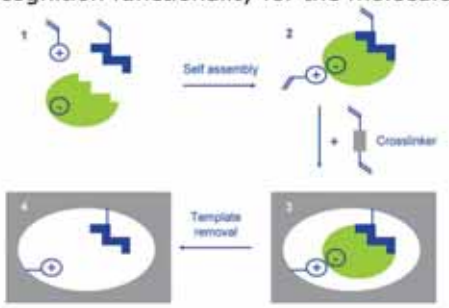

Figure 2: Illustration of molecular imprinting: 1, mixing of template and reactants; 2, self-assembling of template and reactants; 3, stabilization of template molecule; 4, extraction of template molecule.

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Reactive distillation for multi-product continuous plants

Project #: SC-00-05
Project leader: Maarten Oudshoorn
Project pHd: Mayank Shah
E-mail: maarten.oudshoorn@dsm.com / m.shah@tue.nl
Partners: DSM, AkzoNobel, TU Eindhoven
Budget: 618 kC
Duration: Project started Dec 2007 and will run up to 2011

Incentive:

Continuous reactive distillation is a well-known technology for reactive-separation systems close to equilibrium. The integrated reaction and separation holds clear advantages in comparison with subsequent batch wise reaction and separation for many systems. The removal of reaction water in condensation/estherification systems is a good example of such a system and has already been extensively studied. However, the current scientific and industrial research is often limited to the optimization of reactive distillation columns for a single product type and/or for relatively large capacities. This makes the application of the outcome of these studies not useful for applying reactive distillation in a multi-product environment with relatively small capacities (such as (poly-)condensation products).

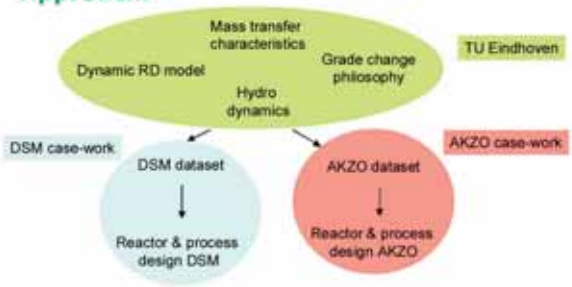
The challenge: How to make a wide range of small volume products in those columns?

In order to be able to apply reactive distillation technology in multi-product environments, new concepts need to be developed which allow the combination of significant increase in volumetric productivity with sharp product transitions while new raw materials and catalysts systems are fed to the reactor and process settings like temperature, residence time and column loading are being adapted.

Objective:

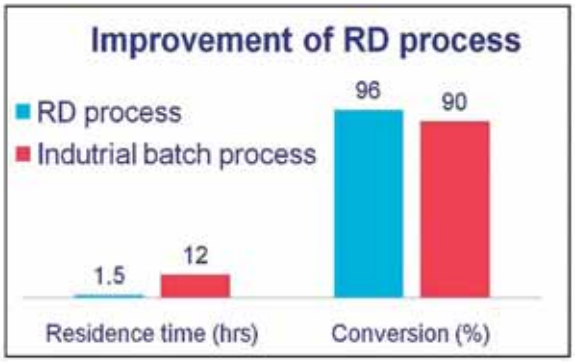
Development of a technical and economical feasible reactive distillation concept which can be implemented in multi-product plant environments.

Approach:



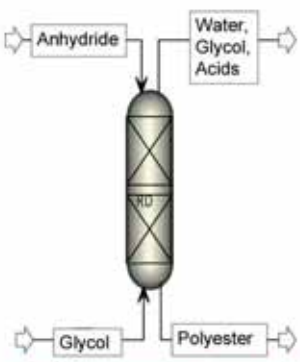
Results:

1) 6% higher conversion achieved in RD process
2) Required residence time is only 1.5 hours
3) Intensification factor 6 to 8 is feasible



Next Steps:

1) Hydrodynamic experiments
2) Reactive distillation experiments
3) Internals & process configuration selection
4) Develop grade change strategy



Left: Process scheme PE production with reactive distillation
Right: 3ltr. column at TUE for RD experiments

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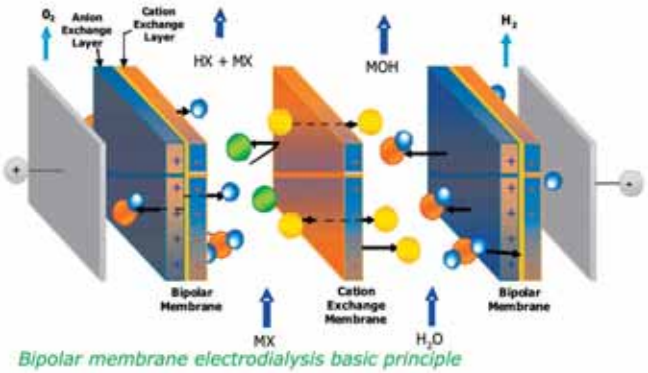
Development of large scale processes to reduce salt formation/emission

Project #: SC-00-06
Project leader: Cornald van Strien
E-mail: Cornald.vanStrien@akzonobel.com
Partners: AkzoNobel, DSM
Budget: 685 kC
Duration: Project started October 2009 and will run up to 2012

Incentive:

A large number of industrial chemical processes require a neutralization step (or pH shift) of process or waste streams. In general mineral acids or bases are used for pH adjustment, resulting in the unwanted production of large amounts of byproducts in the form of salts. BiPolar Membrane ElectroDialysis (BPM-ED) enables water splitting into protons and hydroxyl ions by means of a potential difference and thus enables neutralization of process streams without addition of undesired counter ions. This makes it possible to operate processes that need a pH adjustment without producing salt, thus reducing the amount of waste generated in processes.



Bipolar membrane electrodialysis basic principle

Objective:

Expanding the current BPM-ED operating window, through experimental work which will be performed for several industrial cases under plant conditions. The results will be supported with a model where the influence of major phenomena as water transport will be defined.

Approach:

To meet the objective of the project, the following industrial cases will be explored:

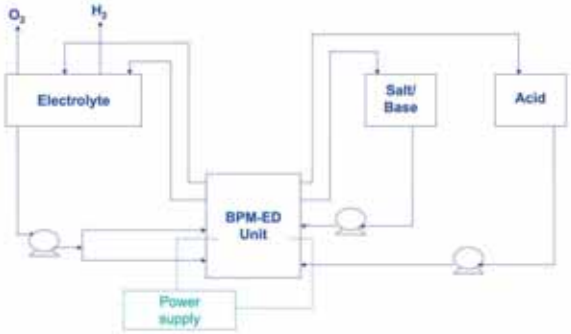
1. Change of pH of salt solutions containing oxidizing components;
2. Change of pH of viscous streams on both room and higher temperatures (25-60°C);
3. Recovery of pure acid and base from its salt at higher temperature (60-80°C).

The project receives in kind support by FuMA-Tech GmbH by supplying and if necessary modifying the membranes.

Pilot plant BPM-ED units[1)]

Results:

- The experimental setup for the first case is constructed
- Several experiments performed successfully
- Simplified general model is constructed
- 2nd and 3rd case initiated



Simplified scheme of the experimental setup

Modelling approach

Next Steps:

- Finalization of the experiments w.r.t. pH shift in concentrated electrolyte systems and overall feasibility assessed.
- Model extension and validation with results of the experimental work done and publish the results.
- Building a setup suitable for the conditions in the other cases to be explored.
- Experiments on other industrial cases.

[1)] www.fumatech.com

Removal of ions from complex streams

Pre-project: Technology scan

Project #: SC 10-07
Project leader: Peter van der Heijden
E-mail: p.vdheijden@paques.nl
Partners: DSM, Paques
Budget: 1,0 MC
Duration: Project started September 2009 and will run up to 2013

Incentive:

Many industrial, agricultural and fermentation processes result in aqueous steams high in salt content. These salts represent a certain economical value, pose problems in water treatment and are often negatively influencing the sustainability of the overall process. Separation of these salts from aqueous stream is desired.

Objective:

- Develop cost effective technologies to remove ions from large aqueous process streams or effluents
- Characteristics of the streams are:
  - High flows (~100 m^3/h)
  - Low value of the products
- Drivers:
  - Cost reduction
  - Sustainability (reuse of components)
- The focus will be on technologies that can be used at full scale within 1-2 years

Approach:

Phase 1 - Technology scan

- Carried out by Bodec, results are presented on this poster

Phase 2 Development and pilot testing

- Together with technology partners the selected technologies will be optimized and debottlenecked
- Pilot units (0.1 to 1 m^3/hr) will be build
- Long term pilot runs (~1/2 year) on actual process streams will be used to identify critical success parameters of the selected technology in this application
- Focus on application research

Results:

The technology scan resulted in a longlist with technologies (Figure 1

Figure 1, Longlist technology scan in DSTI funnel to show time to market.

Five real life industrial situations were used to evaluate the technologies on the shortlist. This evaluation led to the selection of two most promising technologies.

In phase 2 of the project the bottlenecks identified for successful application of these technologies will be addressed.

Next Steps:

- Definition of phase 2
- Expanding project with new partners (end-users and technology suppliers).

Solvent Impregnated Resins for separating enantiomeric or poorly water soluble mixtures

Project #: PH-00-01
Project leader: Rob Geertman
E-mail: rob.geertman@spcorp.com
Partners: Albemarle, DSM, Tue, Schering-Plough and Syncom
Budget: 1,1 MC
Duration: 4 years, project start 2009

Incentive:

Crystallization is the workhorse separation technique in the pharmaceutical industry. It is a very efficient, cheap and mild technique. However, there are two areas where having a backup technique would be beneficial; the inability to form crystalline material and the separation of enantiomers.
Using molecular recognition in the form of especially developed selector molecules might be an attractive alternative. The classic approach of chemically attaching the selector molecules to a carrier will not result in an acceptable specific capacity of the system. Dissolving the selector molecules in a stationary liquid phase will solve this issue – hence the choice for solvent impregnated resins.

Objective:

Develop and demonstrate the separation of a mixture of enantiomers and a mixture of poorly water soluble isomers using solvent impregnated resins.

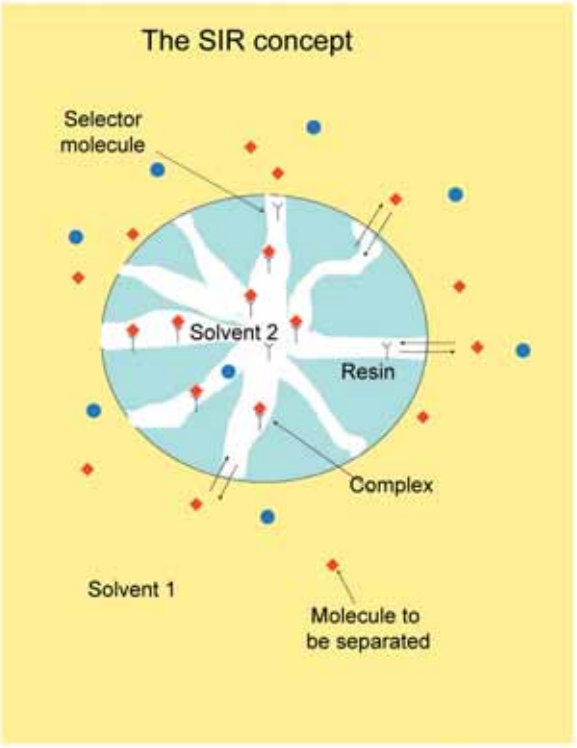
Approach:

Three model systems have been defined by the industrial partners, two enantiomeric systems and one isomeric system.

For the enantiomeric systems the classic approach will be used: water as a mobile phase and an organic liquid in the resin.

For poorly water soluble systems a completely new approach is chosen. As water cannot be used a new liquid phase must be used which does not mix with apolar solvents, but nevertheless has a reasonable dissolving power for apolar compounds. Ionic liquids meet this requirement and will be used to develop the SIR system for poorly water soluble compounds.

For all three model systems, specific selector molecules will be developed and screened by Syncom. TU Eindhoven will develop and test the SIR systems and test the selector molecules.



Schematic depiction of the SIR concept. The resin particle contains a liquid which is not miscible with the liquid outside the particle. The capacity of the resin particle for a specific molecule is increased by adding selector molecules, while other molecules are only absorbed to a small extent.

Results:

The model systems have been defined, Syncom has started working on the selector molecules

Next Steps:

Setting up the SIR system for enantiomeric separations;
Screening several selector molecules.

Pharma process design tools

Robust calculation of solubilities and separation sequences

Project #: PH-00-02
Project leader: Gerard Krooshof
E-mail: Gerard.Krooshof@dsm.com
Partners: Albemarle, Schering-Plough, DSM, SCM
TU Delft (A), TU Eindhoven (B)
Post-docs: Ana Morao, Erin McGarrity
Budget: 0.85 MC
Duration: Project started in 2009 and will run up to 2012

Incentive:

Pharmaceutical companies are increasingly forced to speed-up their process development for the production of pharmaceutical active ingredients in order to reduce the costs. On the other hand, FDA regulation requires more robust processes. To meet both conditions the sector Pharma needs tools to screen a set of possible process routes in a solid way.

Objective:

Develop a molecular computational method that gives robust prediction of solubilities or partitioning of pharmaceuticals in single or two liquid mixtures (project A), and develop a process design/synthesis tool that contains separation units, which are applied in current pharmaceutical processes (project B).

Innovative aspect:

The program will result in two tools that give Dutch process industry the ability to design a pharmaceutical process with batch reactors and separation units starting from a molecular level.

Approach:

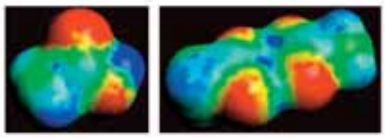
Post-doc Erin McGaritty (TU delft) under supervision of Theo de Loos is developing a new molecular modeling method to consistently predict the solubility of APIs in solvents. The ADF software (SCM) molecular modeling code is being used to make a new COSMO-RS type of model.

Post-doc Ana Morao (TU Eindhoven) under supervision of Edwin Zondervan is developing a tool to evaluate pharmaceutical process routes. The tool will be integrated with existing software and methods. The tool of project A will be used in project B.

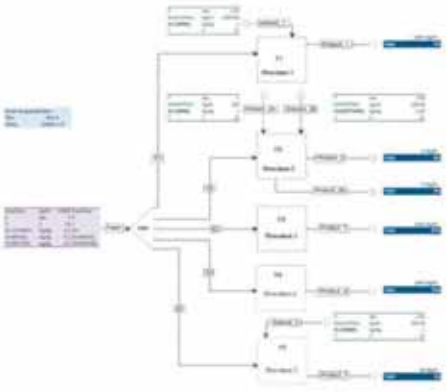
Results:

Projects B and A started in May and August 2009 respectively and kick-off meeting was held a 3 months later.

In **project A** a list of possible improvements for COSMO-RS is being screened on impact. A new entropic term based on PC-SAFT equation of state has been tested and seems to correct the activity coefficient of large solute molecules in a solvent of small molecules, as expected. Further, the solubility of molecule complexes is under study. Acetic acid monomer (left) and dimer (right) shows different solubilty.



In **project B** some unit operation models, **crystallization, extraction and filtration**, were built in Aspen Custom Modeler (ACM). The yields of crystallization and extraction are predicted by the solid-liquid and liquid-liquid equilibrium curves, using the NRTL-SAC method to calculate the activity coefficients of API and solvents. The connection of ACM to Excel provides a friendly interface for the end user of the synthesis tool. These features make this approach promising for conceptual process design in the pharmaceutical industry.



Next Steps:

Project A: Screening of other improvements, implemenations of accepted changes.
Project B: Inclusion of new unit operations (e.g. chromatography), cost calculation and process time.

Intelligent Observer and Control for Pharmaceutical Batch Crystallization

Project #: PH-00-04
Project leader: Peter Daudey
E-mail: peter.daudey@albemarle.com
Partners: Albemarle, Bruker Optics, DSM, FrieslandCampina Domo, IPCOS, MSD, Perdix Analytical Systems, TU Delft, TU Eindhoven, Zeton
Budget: 2,4 MC
Duration: Project started October 2007 and will run up to 2013

Incentive:

Crystallization is the main purification step in the manufacturing of Active Pharmaceutical Ingredients (API's). Batch cooling crystallization is the workhorse of the industry, however, the reproducibility is far from sufficient (fig. 1).

Implementation of modern control techniques is demanded by the FDA (Food and Drug Administration). This is the so-called PAT (Process Analytical Technology) initiative.

During the last decades, measurement tools (fig. 2) and control technologies have become available, that should be able to cope with the control demands.

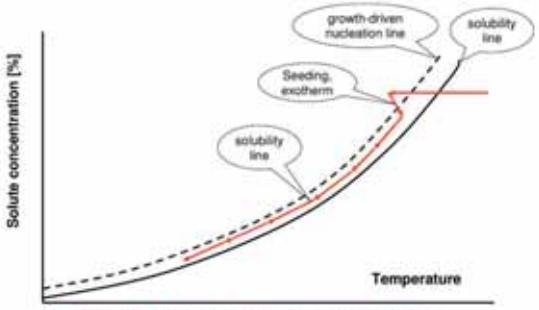


Figure 1. Cooling crystallization path

Objective:

- Tackle seeded batch cooling crystallization
- Introduce on-line measurement techniques and control software in Pharmaceutical Manufacturing
- Demonstrate Control both on crystal growth rate and on crystal size

Figure 2. On-line measurement instruments

Approach:

- Place instruments in measuring skid (fig. 3)
- Supervisory control software (IPCOS)
- Crystallization phenomena (TU Delft, P&E)
- Instrument models, seeding control (TUE)
- Batch to batch optimizer (TU Delft, DCSC)
- Test at partner sites (fig. 4)

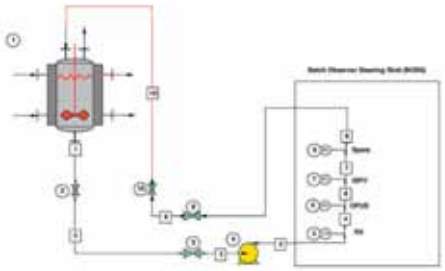


Figure 3. Measurement skid

Results:

- Three PhD's appointed, FTIR-ATR tested, software design, skid basic design completed
- IPCOS Model Predictive Control software at FrieslandCampina Domo operates in closed loop

Next Steps:

- 2010: Skid building, tests at MSD, Apeldoorn

Test at partners	2009	2010	2011	2012
FrieslandCampina (Borculo)	Bx, ISPV, FBRM			
MSD (Apeldoorn)		Skid		
Albemarle (Orangeburg)			Skid	
DSM (Delft?)				Skid

Figure 4. Testing at partner sites

Validation of In-Situ Particle Viewer

In-Situ Imaging technology for chemical / physical processes

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Project #: CS-01-04
Project leader: Fred Hugen
E-mail: Fred@perdix.nl

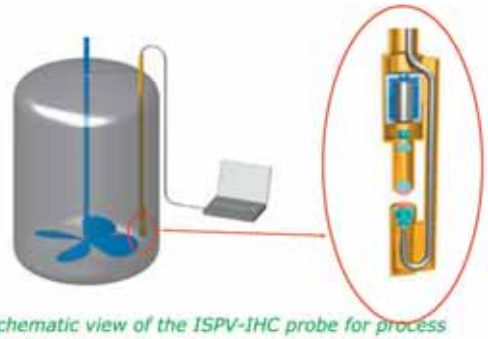
Partners: Perdix Analytical Systems, Friesland Foods Domo, Albemarle Catalysts Company, TU Delft
Budget: 50kC
Duration: Project started May 2008 and will end on June 2010

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.



Schematic view of the ISPV-IHC probe for process conditions

Approach:

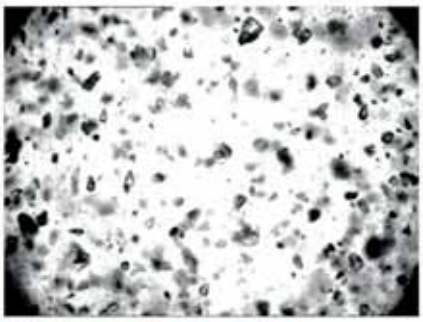
Tests have been defined in order to validate the operating conditions and accuracy of the measurements of the ISPV.

The defined tests are:
- Laboratory tests on the size distribution of Lactose crystals in ethanol and in H2O
- Monitoring the size distribution of Lactose particles in H2O in real batch crystallization in a production plant

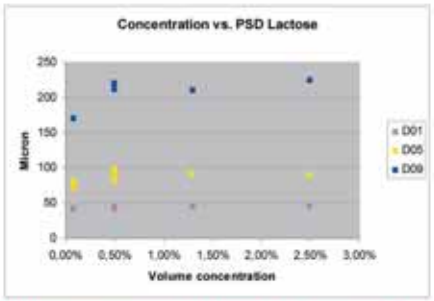
Results:

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.

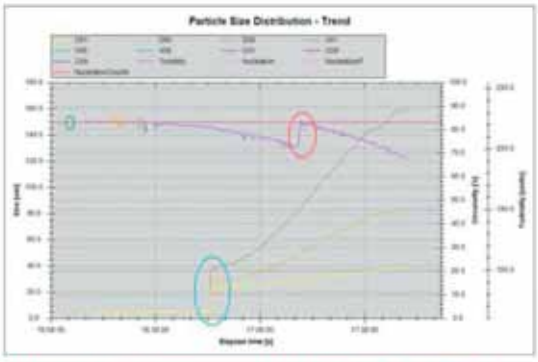
The crystallization process could easily monitor the PSD of the particles during the growth up to 5% mass. Also it was clear from the images that agglomeration already takes place in an early stage of the process.



Sample image of Lactose crystals



PSD characterisation as function of concentration (Lactose in H2O)



PSD of real bacth crystallization of lactose. The Ovals denote characteristic points in the process

Next Steps:

-Final report will be delivered on June 2010

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Technoproject Oscillating Baffled Flow Crystallizer

From batch to continuous crystallization

Project #:	**CS-01-08**
Project leader:	**Henk Akse**
E-mail:	**henk.akse@traxxys.com**
Partners:	**COSUN, PURAC, CRODA**
Budget:	**50KC**
Duration:	**April 15th - November 2010**

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

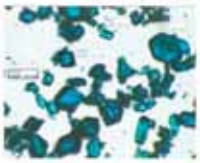
* Many design parameters to optimize crystallizer design for specific mixtures

Objective:

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

OBFC test rig

Crystals from Stirred tank Crystallizer

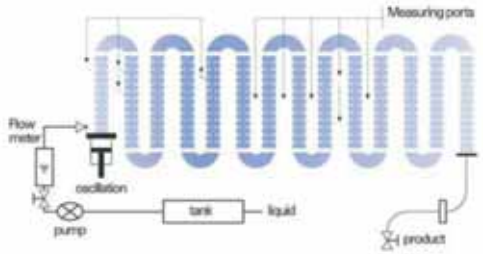


Crystals from OBFC

Approach:

In a test rig at NiTech Labs we will investigate Mixing condition, Amplitude, Frequency, Starting temperature, End temperature, Cooling profile, Seeding, Hold times
Concentration/solvent ratio/solids loading and Filtration index

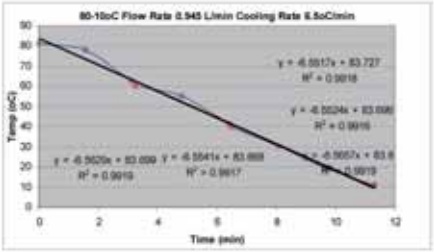
OBFC consists of a tubular crystallizer through which the mixture is pumped continuously that has to be crystallized.



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.

Next Steps:

Additional optimizing in bilateral projects.

Setup of Business Case quantifying Investment Cost, Revenues and Earning Power of OBFC-applications in customer processes.

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SME Contact group

Small and medium sized technology suppliers from within DSTI

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DUTCH SEPARATION TECHNOLOGY INSTITUTE

Account manager: Jan Koning
E-mail: jan.koning@dsti.nl

The Scale up barrier

DSTI aims at a smooth implementation of technologies in full scale applications.
However implementing new technologies takes more time than necessary. This is clearly noticeable in the transition steps from principle to small scale and from small scale to full scale.
Causes are the difference in practices of each development stage, the definition of distinct phases and the different requirements between small scale and full scale installations.
As a result certain items have to be redone in a next phase and developments from proof of principle to first application take four years and even much longer.

Our Objective:

Reduce the implementation of new technologies to first application to about two years while obtaining a better quality and avoiding rework.

Develop a modus operandi to get this done and ultimately optimise profitability.

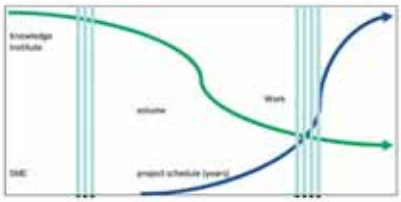

Illustration of current development practice.

Approach:

Process engineering consultants, equipment manufacturers and technology suppliers build bridges from laboratory to user.

Technologies are put into practice by several companies cooperating in a supply chain. Every technology has its own type of supply chain.

Early involvement of technology suppliers in developments enhances information exchange and early introduction of technology specific conditions.

Early involvement of equipment manufacturers leads to focus on applicability in the first stages of development.

Innovative process engineering consultants provide balanced scale-up, feasibility and cost data enabling users to select new processes.

Illustration of DSTI development model

SME contact group and Technoprojects

The SME Contact group of DSTI comprises the companies to fulfil all links in the supply chain.
DSTI strives at involving these companies in the projects from the start, thereby enhancing continuity of information flow.

In Technoprojects technology suppliers have the opportunity to test their technology on real media from practice. This gives a quick impression of the feasibility and provides the SME with an excellent introduction to the industrial users of separation processes.

The Technoprojects and SME contact group form an additional facility for speeding up acceptance and implementation of new technologies.

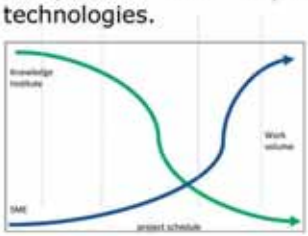

Illustration of time saving by early involvement

Next Steps:

Building upon the unique strength of the DSTI community, increase the number of applied new technologies.

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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: AKZONobel, DSM, LyondellBasell, Schering-Plough, Shell, SolSep BV
Budget: 50 kC (GUTS-DSTI Technoproject)
Duration: Project start: May 2008; end April 2009

SolSep BV

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.

SolSep spiral wound elements.

Approach

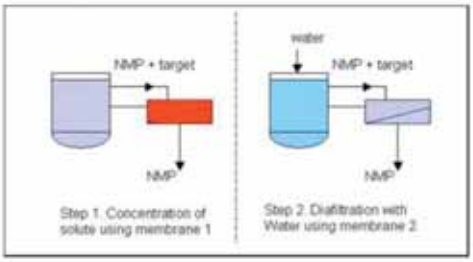
SolSep NF membranes (polymeric) were evaluated. Their performance regarding flux and retention in relation to process phenomena like fouling and concentration polarization was monitored.

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.



Tests were performed in NF and diafiltration mode.

Pilot rig for NMP.

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-SEP

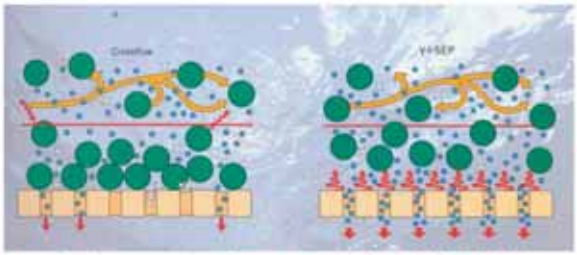
Project #: CS-01-02
Project leader: Ton Franken
E-mail: franken@mact.nl
Partners: MACT, Purac
Budget: 50KC
Duration: May 2007 - April 2009

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.



Boundary layer resistance in cross-flow (left) and V-SEP (right).

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.

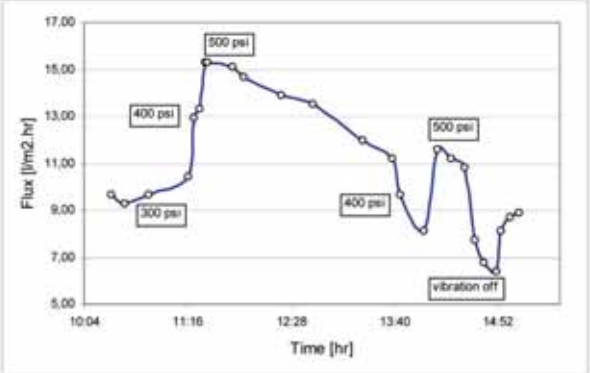
Equipment:

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.

Membrane module on torsion spring

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.



Flux as a function of time

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.

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:	**DSM, Huntsman**
Budget:	**49,8 KC**
Duration:	**Project is approved on 1 October 2009, duration 1 year**

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

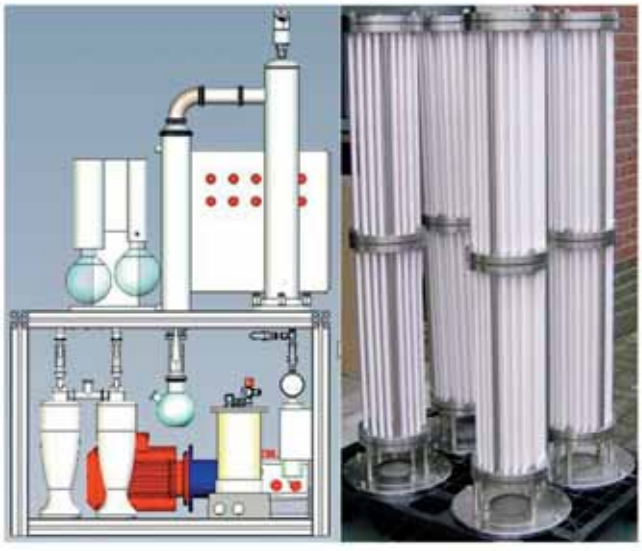
Objective:
DSM:
With organophilic pervaporation membranes the by-products of the fermentation and chemical reaction can be selectivily separated. The permeate contains water, reaction products and low molecular weight species which poison the chemical reaction. In-situ removal of those species during 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.

Next Steps:
For the dehydration testing the pervaporation system to be used has to be fully Ex-certified. The available system is being modified to fulfil this requirement, after which testing on site will commence.



Technoproject applying Evodos centrifuge

Chemical free separation using Evodos Spiral Plate Technology

Initiated by NL Guts

Project #:	**CS-01-07**
Project leader:	**Marco Brocken**
E-mail:	**marco.brocken@evodos.eu**
Partners:	**Cosun, DSM, Nedmag Industries**
Budget:	**50KC**
Duration:	**Project started Sep 2009 and completed Feb 2010**

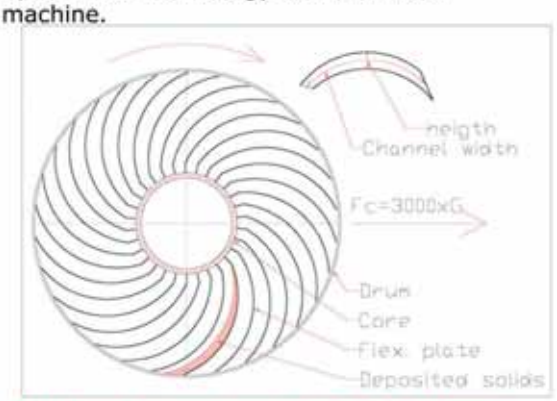
Incentive:
For the participating companies a cost improvement is the incentive, either by achieving a higher dry solid content in the discharged solids or by obtaining a more clean centrate.

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.



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

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.

Evodos SPT machine, closed and open view

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.

HYPERCATCH I

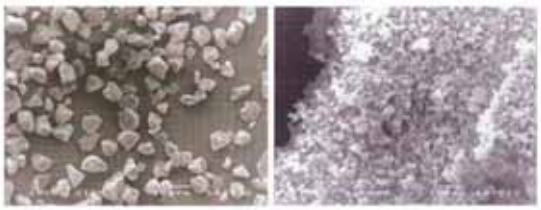
New High Performance separation platform

Efficient purification of valuable compounds at large scale

Project #: CS-02-01
Project leader: Ria Rhemrev-Boom
E-mail: rhemrev@@kpn-officedsl.nl
Partners: Schering Plough, DSM, Friesland Foods, Mosaic Systems
Budget: 50 kC
Duration: 1 year (started end 2007)

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).



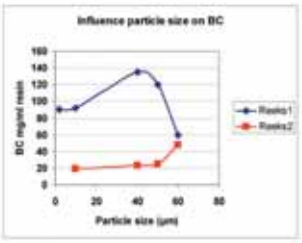
Increasing the surface area of resins by using smaller particles (left picture: 40 um silica; right picture: monodisperse 2 um polymer beads produced via dispersion polymerization).

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.

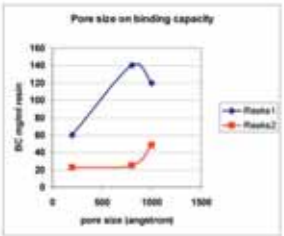
Specific resins, with appropriate characteristics (high capacity and selectivity), which allow one step downstream processing, are currently not available, nor is adequate knowledge available what the criteria are for the particular resins to obtain these high capacity separation modules.

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 resins with high capacity.



Next Steps:
To allow efficient functionalization of these small particles, it is proposed to embed these particles in mixed matrix membranes prior to functionalization.

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: Schering Plough, DSM, Friesland Foods, Mosaic Systems
Budget: 37,5 kC
Duration: 1 year (started end 2007)

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).

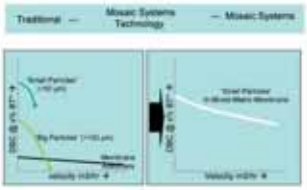
Combination of FILTRATION and ADSORPTION: MIXED MATRIX MEMBRANE fibers to form high capacity SEPARATION DEVICES.

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.

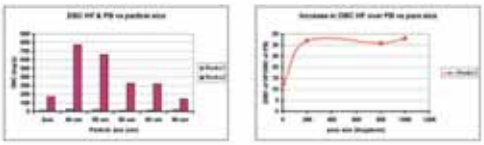
Approach:
Selective resins with high capacity (obtained from Phase I) are embedded into porous mixed matrix membrane fibers. Depending on the resin embedded, high capacity separation modules are obtained, which are selectively capturing the compound of interest (model components chosen are albumin and 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;



Advantages of Mosaic Systems platform technology schematically demonstrated.

- 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

Next Steps:
Testing of end-user applications.

Scaling up of the hollow fiber membrane modules. In this case the porosity of the membrane should be taken into consideration.

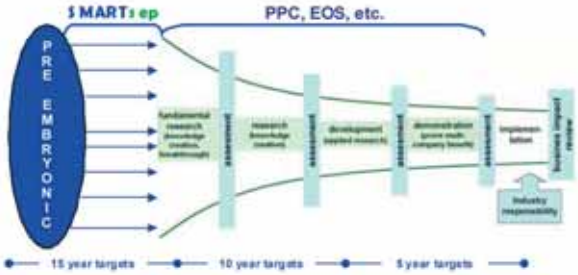
STW Perspectief Programme SMARTsep

Smart Separations for Complex Systems

Project #:	**STW Perspectief Programme**
Project leader:	**André B. de Haan, Monique Wiegel**
E-mail:	**a.b.dehaan@tue.nl, m.wiegel@stw.nl**
Partners:	**STW**
Budget:	**6 MC (incl 1 MC DSTI matching funding)**
Duration:	**Projects will start January 2011 and will run up to 2015**

Incentive:

A major part of the energy consumption and investments in processes originate from the separation of **complex systems** consisting of molecules/ particles with similar properties or complex mixtures. For these complex systems the capabilities of the existing separation principles/technologies cannot reach the Innovation Roadmap Separation Technology targets with respect to energy consumption (50-80% reduction), competitiveness (75% intensification) and value generation through increased quality in 10-15 years time. Thus, there is a clear need for the establishment of new **SMART** separations that utilize new highly **S**elective separation principles, require **M**inimal footprint, are industrially **A**pplicable, **R**esource effective and easily **T**argeted towards different complex systems.



Programme Objective:

Provide the technology for the next generation separations by explorative research targeted at bringing new separation principles/driving forces from the stage of first discovery to a level of technological maturity that enables their utilization by initiatives that aim at shorter timescales to implementation (e.g., DSTI, Wetsus and others).

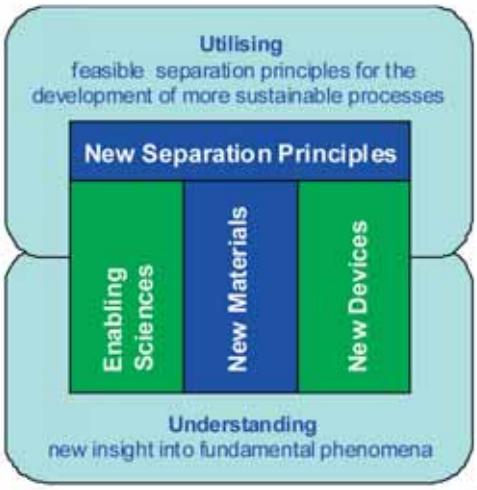
Starting point are those principles of which the concept has been published in recent scientific literature, but are not yet applied or suitable for large-scale industrial separations.

The technology should open up the door to significant improvement ('step changes') in sustainability and process efficiency.

Goals and Ambitions:

The SMARTSEP program will establish an integrated combination of **new highly selective separation principles/driving forces** for complex systems that are shown to be potentially applicable in new materials and new devices which can be applied in industrial scale separation processes.

Additionally enabling methodologies will be established to support the targeting, development and design of technologies and/or processes employing the established new principles/driving forces by advanced modelling techniques.



Current Status:

- Programme approved by STW
- Criteria for DSTI matching funding defined
- 20 pre-proposals received
- 11 pre-proposals selected for full proposal

Next Steps:

- Closure call full proposals (28 July 2010)
- Full proposal evaluation by STW procedures
- Final approval decision (November 2010)

Separating what really matters www.dsti.nl

SME Companies

SME Companies

FOYER (BASEMENT)

Foyer (Basement)

MOSAIC SYSTEMS

Contact person: **Dr. Ing. Ria Rhemrev-Boom (CEO)**
E-mail: **rhemrev@resqlab.nl**
Website: **www.mosaicsystems.nl**

The innovative and exclusive platform technology owned by Mosaic Systems, a spin-off company form the University of Twente, Membrane Technology Group, is based upon the embedding of any suitable chromatographic resin with high sorption capacity and/or related high selectivity into porous polymer membrane structures, thereby circumventing absorber related problems, which are well known during the purification of compounds of interest from complex feeds at both analytical and particular industrial scale separations.

Mosaic Systems holds two patents protecting the benefits of both technologies, i.e. high throughput in combination with high capacity. These so-called Mixed-Matrix-Membrane (**M³**) adsorbers combine a high flux and a low pressure drop with a high adsorption capacity. Because of the nondestructive conditions during the embedding of the resins, beads with various functionalities and bead sizes as low as 2 – 5 µm can be integrated while maintaining full active media functionality. As a result, depending on the selected chromatographic resin applied, **M³** adsorbers can be offered in a wide variety of modes of chromatography and relevant applications.

Next, our membrane adsorbers can be offered in several configurations, such as (stacked or wounded) flat-sheets and (full or hollow) fibers. Because membranes with a fiber geometry demonstrate clear benefits, such as the large surface per unit volume, the fact that they are self supporting and do not require additional spacers or support to separate the membranes, most of our separation modules are based upon full or hollow fibers.

Our products and services can be divided into two mainstreams:

a. Separation devices (or modules) for downstream processing for the purification of biopharmaceuticals on analytic, semipreparative and large scale, and
b. Sample preparation devices (membrane pipettips) for the diagnostic respectively analytical market.

Any type of resin, either obtained from our customers or from resins suppliers, can be incorporated into our **M³** adsorber fibers, leading to custom-made modules (service) and/or catalogue modules.

PROXCYS B.V.

Contact person: **Marcel Raedts (CEO)**
E-mail: **info@proxcys.com**
Website: **www.proxcys.com**

Proxcys B.V. is the global technology and market leader for high performance cGMP compliant high throughput Radial Flow Chromatography Downstream Processing equipment.

Foyer (Basement)

In 2010 Proxcys will launch a new line of the Prepacked Prevalidated SUPR disposable HP-RFC columns and bench-top process equipment.

Our mission

Consolidate High performance-Radial Flow Chromatography as a major process & industrial scale purification technology by Innovation, Development, Support & Training.

Our Market

We offer our products and services world-wide to blood-plasma-, bio-pharmaceutical-, biotechnology-, functional-food- and environmental industry.
Our recent Developments:

- Automatic Packing Stations
- Single Use Pilot Radial (SUPR) columns
- Pre-packed Pre-validated columns
- Laboratory Radial Mimic and prep radial columns
- Process Guard or Scavenger columns
- Automated resin conditioning vessel
- Bench top High throughput Chromatography workstation (120L/hr)

Sharing our experience and knowledge:
Chromatography and Processing expertise is applied for process improvement, process support and custom solutions regarding resin handling and Downstream Processing.

The service we offer includes:

- Standard products from lab scale to largest Industrial size available.
- High quality documentation and support
- Innovative custom solutions (for a fair price).

PERVATECH
Selective ceramic membranes
Process design

M.M. PERVATECH BV

Contact person: **Frans Velterop**
E-mail: **info@pervatech.nl**
Website: **www.pervatech.com**

Smart membranes for Pervaporation from Pervatech, separation of water from organics. Process intensification, substantial reduction in energy use, saving costs in chemical processing, with the interest of the customer in the centre. Smart membranes – the Customer – Costs savings – Flexibility are the key factors for successful implementation of our products.

Product port folio:

1. Tubular Ceramic membranes:
   a. Dehydration of organics
   b. Bio-ethanol
2. Spiral wound PDMS organophilic membranes:
   a. Pervaporation of organic compounds, like flavours and aromas
   b. Waste water treatment

Foyer (Basement)

Recently, Pervatech has acquired a license for the production, marketing, and sales of the HybSi® membrane. HybSi® membranes have an extended application temperature of up to at least 150ºC, ensuring substantial higher productivity. As a result long life time at high temperature service the membrane costs are reduced.

The cooperation with the license provided ECN, Petten, The Netherlands, ensures a successful market introduction and process operations with this superior membrane for pervaporation and vapour permeation.
We find the use for our membranes in the following industries:

- Chemical Industry
- Fine Chemical Industry
- Pharmaceutical Industry
- Food Industry

Our commercial routing goes both directly from our Head Quarters in the Netherlands as well as through OEM (equipment manufacturers) and agencies.

SOLSEP

Contact person: **Dr. Ir. F. Petrus Cuperus**
E-mail: **cuperus@solsep.com**
Website: **www.solsep.com**

SolSep BV
Robust Separation Technologies

SolSep BV develops and manufactures membrane and modules (elements) for ultra- and nanofiltration in organic solvents. Solsep's technology is fully devoted to all aspects that have to do with making a robust membrane module and profitable process. Solsep produces a range of ultra- and nanofiltration membranes and elements for use in organic solvents. On request we fabricate modules for third parties.

In a DSTI Technoproject SolSep NF membranes 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 include solvents like acetone, aromatic C8-C11 mixtures, methanol, toluene, THF, toluene, MBTE, benzene and NMP. The Solsep membranes were robust in all solvents. Successful pilot work was done in the NMP-cholesterol system for over 6 months.

RESQ LAB

Contact person: **Dr. Ing. Ria Rhemrev-Boom**
E-mail: **rhemrev@resqlab.nl**
Website: **www.resqlab.nl**

ResQ Lab BV is a private Dutch innovative analytical chemical research laboratory, owing its existence on the exclusive experience in the development and production of chromatographic resins with high selectivity and capacity, leading to the following core competences and activities.

Foyer (Basement)

- Development and manufacturing of functionalized resins with good mechanical (withstand high pressure) and chemical resistance, high capacity in combination with high selectivity and low non-selectivity;
- Manufacturing of functionalized resins based upon covalent coupled biological based ligands, such as antibodies, recombinant proteins, peptides, enzymes, etc.
- Turn-key development and validation of methods based on the above mentioned resins for application in affinity and/or immunoaffinity chromatography;
- Turn-key development and validation of protocols based on the above mentioned resins for application on both analytical and (semi-) preparative scale;
- Production and sales of a product line of resins, columns and/or assays with selective properties for applications in (commercial, governmental, R&D as well as QC) laboratories, production facilities of pharmaceutical and biotech companies.

ResQ Lab has its own patented activated resins and disposes of a fully equiped laboratory for R&D and production of these resins. Applications (as well as custom-made) with the above mentioned resins are developed and validated in-house.

FEYECON D&I B.V.

Contact persoon: **Dr. Ir. F. E. Frank Wubbolts**
E-mail: **frank@feyecon.com**
Website: **www.feyecon.com**

Goal

FeyeCon Development & Implementation B.V. strives to make the planet better by creating sustainable technologies. We specialize in developing and manufacturing novel products and processes using carbon dioxide technology. CO_2 technology is a highly versatile platform technology which opens the door to products and processes that are cheaper, faster, greener and above all innovative.
Most importantly we don't generate new CO_2 for our processes. We develop new ways to use CO_2 which has been captured from other industrial processes.

Target group

We serve customers across the globe in the food, pharmaceutical, textile, and process industries to name a few. We continue to build our customer base everyday as we develop our technology portfolio further.

Instruments

FeyeCon develops its business on several levels. We provide contract research, participate in collaborative research projects together with other knowledge institutes and companies, as well as perform own risk independent research.

Foyer (Basement)

BODEC PROCESS TECHNOLOGY

Contact person: **Marcel Geboers**
E-mail: **geboers@bodec.nl**
Website: **www.bodec.nl**

Bodec Process Technology is a consultancy and engineering firm that operates in food, chemical, and pharmaceutical industry. Founded 15 years ago Bodec has grown from a company that specializes in the optimization of dryers and drying processes into a full technological service provider for industry.

We optimize, develop and design processes with specialization in separation processes, process technology and engineering services. Properties of the final product are key in all the work we do – we understand how we should (or should not) separate or process a product to arrive at the desired properties. Our projects vary from dynamic modeling of processes in agro-food industry, debottlenecking studies to the upscaling, engineering and realization of processes developed at labscale.

Through strategic alliances with equipment manufacturers from all over the world we can also deliver high quality process equipment (e.g (spray)dryers, evaporators, distillation columns, extractors) at lower investment costs.

Our customers are medium sized and multinational enterprises with whom we have long term relations and often strategic cooperation's. We tackle their technological challenges and work together with them on their future products and processes.

SCREENING DEVICES

Contact person: **René Harmsen (CEO)**
E-mail: **reneharmsen@screeningdevices.com**
Website: **www.screeningdevices.com**

Screening Devices is the Benelux specialist in Separation, Purification and Synthesis. We offer practical solutions with Silica based material for extractions and removal. Removal of a metal Catalyst like Palladium, Copper and others in just minutes! We present "Palladium removal in 2 minutes", starting from 1000 to 0.9 PPM.

AQUASTILL B.V.

Contact person: **Eric van Sonsbeek**
E-mail: **e.vansonsbeek@aquastill.nl**
Website: **www.aquastill.nl**

Company profile;
Aquastill was founded in the spring of 2008 as a spin-off company of the EET-2 TNO Memstill research program. Aquastill is the first company in the world that produce Membrane distillation modules for the market.

Foyer (Basement)

The Aquastill technology uses Membrane distillation to produce distillate out of sea-water using waste heat as a driving force. This cheap, additional energy source is used to boost pre-heated water through the membrane module.

Because the process uses hydrophobic membranes only water vapor can pass through the membrane. The temperature difference over the membrane causes water vapor to diffuse from the hot side of the membrane to the colder side of the membrane. This process of evaporation and condensation will cool down the hot side and heat up the colder side. Energy consumption is minimized by using counter-current flows. The process works at low pressures (up to maximum 1,5 bar).

Company goals;
Aquastill will sell the Membrane distillation (Aqua|cube) modules to the marked. It is the intention to sell the modules to every contractor. However to learn the contractors how to use this technology Aquastill will also sell basic engineering start-up and small plants to the marked.
Because the Aquastill system requires heat-exchangers that can deal with salt also plastic heat exchangers are developed (up to 90° C). these exchangers can either be used all own or used into Aquastill's so called Aqua|flex system.
The Aqua|flex system can be used for the following applications;

- Producing drinking water out of sea water or brine from a RO
- Producing boiler feed water out of sea water or brine from a RO
- Brine up concentrating before crystallization
- De-watering of process streams like juces/milk
- Using cooling water (hot stream) to produce boiler feed water)
- Combined with solar energy producing drinking water out of sea water.

evodos

EVODOS BV

Contact person:	**Marco Brocken (general manager)**
	Hen Boele (chief technical officer)
E-mail:	**info@evodos.eu**
Website:	**www.evodos.eu**

Evodos has decided to redesign the hydrodynamics fundamentally. By introducing the Spiral Plate Technology (SPT), Evodos by sets a new standard in the centrifugal separator industry.

The Evodos technology is effective for suspended particles in the 1 – 100—micron range. The separation sharpness is higher than industry standard. The solids do come out as a liquid free cake. The free liquid content is the drum is removed before discharging the collected solids, resulting in a dry solid content of the discharged cake which is far above industry standard.

The Evodos machines are self adjusting to changing process parameters. Evodos Self Adjusting Interface Level technology allows real time process adjustment, even on instantaneous changes in process parameters. Evodos cannot be adjusted manually.

Foyer (Basement)

There are no gravity rings, no electronics to be set. This allows many new centrifugal separation applications such as handling liquids containing soft solids, fatty, sticky and greasy solids and even abrasive solids.

All without the use of chemicals. And with a minimal energy consumption of 1.6 kWh per m^3.

Possible applications are:

- Water/oil/sludge separation
- Manure & digestate separation
- Algae harvesting
- Wine clarification
- Cleaning cooling liquids in glass/stone/metal grinding
- Pre-treatment for membrane systems
- Pre-treatment for MBR systems

ZETON

Contact person: **Rob van Dongen**
E-mail: **rob.van.dongen@zeton.nl**
Website: **www.zeton.com**

ZETON
PILOT PLANT TECHNOLOGY

Zeton is in business to provide state-of-the-art lab scale reactor systems, pilot plants, demonstration plants and small scale commercial plants as well as unequalled design/build know-how in scale-up of technologies plants for the process industries worldwide. Our unique and specialized know-how focuses totally on all important stages (process development, design, engineering and construction) from innovation through early market development. The plants are typically used in the forefront of developments in a wide spectrum of chemical industry, ranging from Oil & Gas, to Food, Polymers, Bulk Chemicals, Fine Chemicals and Active Pharmaceutical Ingredients.

Many different kind of projects have been carried out. Therefore people within Zeton have a good understanding about costs and the feasibility of certain solutions from lab scale to small scale commercial plants. Zeton has two locations to operate world wide, one location in Canada (Burlington, Ontario) and one in The Netherlands (Enschede). Both locations have equal expertise and therefore the market is split geographically. Within Zeton B.V. in Enschede we have about 50 employees, which mean that we are a relative small company and therefore efficient and cost effective.

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RATON

Contact person: Dominique van de Wiel
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Website: www.raton.nl

Raton, Leader in Process Solutions

Raton is a significant player in the national and international market of process installations for the food industry, the (petro)chemical, the pharmaceutical and the water treatment industry. Throughout the years, Raton has build a reputation of being reliable, innovative and customer oriented.

Process in Process

Raton, founded in 1980, has grown into a full-service supplier for process filtration and has the following divisions:

- Engineering
- Automation
- Piping
- Process management
- Service

With its new, modern facilitated workshop, its divers divisions all located under the same roof and its well trained and enthusiastic crew, Raton is able to find process solutions for each customer individual.

Innovation and respect for the environment

Looking into the near future, innovation and respect for the environment will become issues of great importance. With innovative power and years of experience, Raton has proven to be able to combine these important issues by designing various installations according to the latest demands of the market.

Raton, ready for the future

Because of the high speed technical development and the increasing demands of the food industry, it is of the outmost importance to keep up-to-date. By working closely with young companies with pioneering ideas and of course by Ratons highly educated staff, Raton is able to stick to its main goal.

Offer full–service, now and in the future.

MTSA TECHNOPOWER

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Website: www.mtsa.nl

Since 1994 MTSA Technopower designs and builds customer specific equipment, machines and installations. Further MTSA Technopower has become a reliable supplier of complex mechatronic (sub)systems and parts.

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Projects
Every project is different, every project is new. The challenge is to operate in a multi-disciplinary manner and see beyond the boundaries of the individual specialism's and existing technologies. What distinguishes MTSA Technopower is the ability to manage complex projects and/or pro actively add value to a project, based on expertise. Engineers are the key between customer, internal disciplines and innovation. The motto "think and act" demonstrates the corporate mentality. MTSA Technopower has all required disciplines in-house, from process, mechanics, electrical, instrumentation up to automation. In this way MTSA Technopower can cover the whole project from concept up to realisation.

System Supply
MTSA Technopower is a reliable producer of high value mechatronic parts and modules, manufactured according customer specification or co-developed with the MTSA Technopower engineering departments. We excel in developing and manufacturing complex high value parts and modules as single pieces or small series.
MTSA Technopower has advanced machinery at its disposal and several welding and assembly halls. Our workers are expert in machining difficult materials. For reaching optimal precision MTSA Technopower uses a modern acclimatised measuring chamber and clean room.

PAQUES

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Paques develops and produces cost-effective water and gas purification systems using innovative biotechnology. These purification systems offer industries and municipalities added value, such as: the re-use of and savings on water, the generation of energy and the reclamation of valuable substances from wastewater. This allows Paques clients to combine economic progress and environmental responsibility.

SYNCOM

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Company activities:
Syncom provides intellectual and practical chemistry services for the design and construction of small molecules.

Syncom is a privately owned company established in 1988. About 95% of the work carried out is for the pharmaceutical industry and the other 5% is devoted to the

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synthesis of organic molecules for other purposes. The company is involved in synthetic support for medicinal chemistry, drug discovery and chemical development. We have a good track record with big and medium sized pharma and biotech companies from both Europe and the US.

Main products and services:

- Drug Discovery Services
  Hit and lead optimization, libraries based upon original scaffolds and building blocks, reference compounds, synthesis support.

- Development and scale up
  Route scouting, GLP synthesis for tox studies, metabolites, impurities, scale up, intermediates.

- Chirality, first-time-right concept
  Integral approach: simultaneous screening of resolution, chemo- and biocatalysis and chiral pool.

- Materials for Separation Technology
  Synthesis of (modified) monomers and functionalised polymers to be used in fibres or membranes. Ionic liquids for extractions. Affinity ligands and extractants for the purification of biomolecules for instance in aqueous two phase extraction systems, reactive, micellar and super critical extraction.

Syncom in DSTI:

Syncom is participating in DSTI projects PH-00-01, SC-00-01 and FO-10-05.

Articles

Joining forces

Most new technologies fail for reasons that have nothing to do with technology. The secret for success is better cooperation between technology users and (small) technology suppliers, says **Wridzer Bakker**

WHILE the process industries, in general do a good job at staying competitive, innovation remains key if this is to continue. However, the major players often face in opposite directions and, as individual companies, do not have the manpower and resources they so badly need to make a difference.

Recognising the old adage "the whole is greater than the sum of its parts", in 2006 a number of Dutch companies with an interest in separation technologies believed that close cooperation on technology development and implementation would help them realise their future business targets. As such, they established the Dutch Separation Technology Institute (DSTI).

Four years on, DSTI has a programme budget of almost €100m ($135m), and 60 actively-involved partners from the chemicals, food, pharmaceutical, and oil and gas industries. They include:

- end users (or technology users) – multinationals like Unilever, Shell, Friesland Campina, AkzoNobel and MSD;
- (small) technology suppliers including Frames, Aker Solutions, Evodos; and
- knowledge institutes such as ECN, Vito, and Wageningen and Delft universities.

Together we form a very active technology community from different market segments that have the real will to work together. Of course, trusting each other is very important, but the wariness about exchanging potentially sensitive information with the competition is not a major issue here. Process technology is a so-called enabling technology, and so cooperation is a far less sensitive issue than

case 1: Monitoring and control of crystallisation to improve quality and reduce costs

Crystallisation is a powerful purification method. Impurities do usually not fit in the crystal structure of the base product, and so this technique has vast potential to separate the desired product from unwanted side products. However, crystallisation is inherently non-reproducible, and often leads to varying purity or unexpected particle size distributions and, ultimately, off-spec product batches.

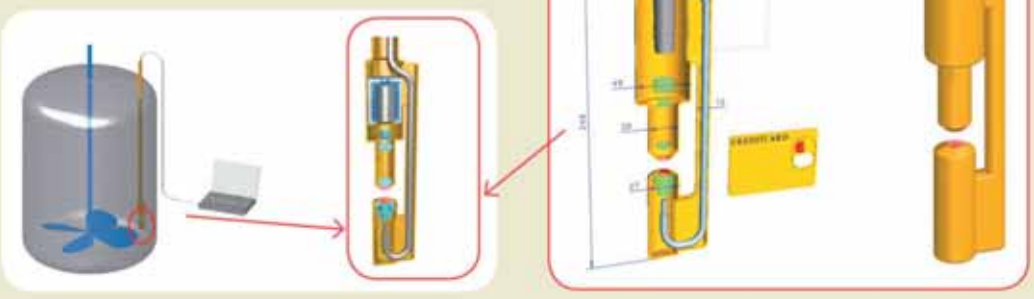
To address this problem, DSTI partners are developing a high-tech crystallisation monitoring and control system that can be implemented on existing production equipment. Several larger and smaller food and pharma companies, knowledge institutes and universities are involved in the €2.4m project, while Perdix, a small high tech supplier is playing a key role.

The project partners have developed a mobile, modular skid that can be coupled with existing crystallisation equipment in a plant. It contains an analysis system, an expert system and control software, and is currently being tested and demonstrated in a pharmaceutical and a food plant environment.

The system recognises and quantifies all kinds of crystallisation phenomena without the need to make assumptions on crystallisation kinetics – a necessity since in most cases kinetics knowledge is not available in plants. It has a unique optic probe (pictured) that is robust and can work under harsh conditions (low pH, high pressure or temperature). In combination with specially-developed software, particles can be recognised and particle size distributions calculated. With these data the process can be optimally controlled to obtain the right product.

Project leader Peter Daudey, of pharma and fine chemicals manufacturer Albermarle, believes open innovation is the way forward. "Our company's management is very enthusiastic about this open approach that was even new to a US based company," he says.

Perdix ceo Jan Willem Gerritsen is equally enthusiastic: "For us, the DSTI involvement has been very valuable. We are a small company that develops and produces video-microscopes to observe particles, but we now have access to multi-nationals – and that would normally be a closed door for us."



One of the sensors (right) is an adapted vision system from Perdix Analytical Systems.

The sensor enables direct observation of crystals by microscopy and stroboscopic backlight illumination.

it is when you are developing products. Of course we do have a good and agreed policy for the protection of intellectual property rights.

Our programme is industry-led and based on the business targets defined by the partner companies. This gives us a very clear picture of where technological developments are needed. Some of our 15-year targets include: 70% energy savings; medicines without side effects; compact and waste-free manufacturing processes; high value feed supplements from milk; process water of the required quality; doubling the amount of recoverable oil per field; and training technologists to also have R&D and business skills. The innovation programme covers all aspects from knowledge generation to technology implementation; often executed in parallel.

small meets big

We believe that if bigger players want cutting-edge process innovation in their plants, they should be prepared to invest, facilitate and protect the development and implementation and work closely together with technology suppliers and other potential users. In the development and implementation of new technologies within DSTI, small unknown high-tech technology suppliers can play a key role in the success of a project, often cooperating with big multinationals.

Most multinationals prefer buying proven technologies from big and established technology suppliers, often with the attitude of "we ask you deliver", rather than "we jointly develop". Small high-tech companies are seldom suppliers of big multinationals although many of them have very interesting new technologies, or concepts for them. They often pass under the radar of the multinationals because they are unknown, lack the track record and stability, particularly in a financial sense, that big companies require. Moreover, many of them do not know the needs of big companies nor speak the 'required language'. Banks can be reluctant to support small high-tech companies because they do not have good connections to the potential market. This 'catch 22' situation can often mean the end for a high-tech start-up company, and some of the most interesting technologies and concepts can be lost.

The two cases presented here are examples where DSTI enabled successful technology development via cooperation of multinationals with small high tech technology suppliers. **tce**

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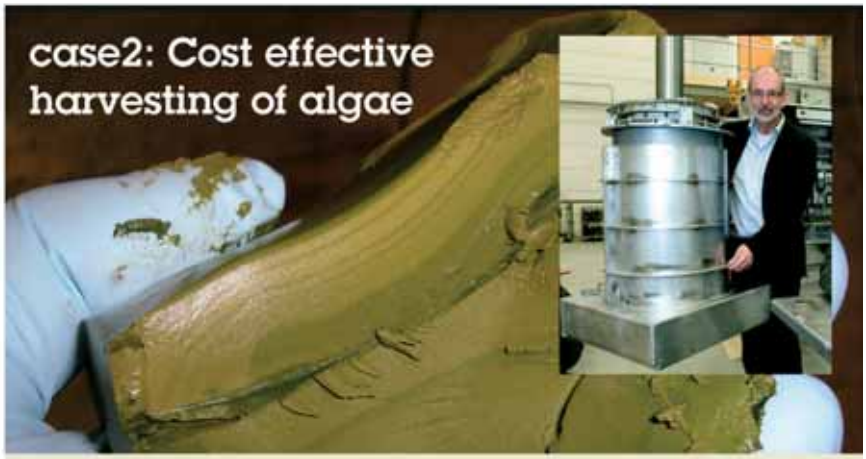
case2: Cost effective harvesting of algae



Evodos applied its technology (inset) to cost-effectively harvest algae, with no use of chemicals, algae cells completely intact, and a solids content of 30%

Several of the DSTI partners are very interested in using algae as a feedstock for their products or biofuels. Key to the business case is cost-effective 'harvesting' of the algae from the water in which they grow, which means achieving a solids content of at least 25%. Previous work with a big, established technology supplier achieved a solids content of only 7.5% and used a considerable amount of chemicals. The supplier estimated that it would take ten years to develop a technology that could reach the 25% target.

Working with some of the DSTI multinationals, Evodos, a small but high-tech DSTI partner, had shown that its spiral plate technology (SPT) centrifuge could successfully remove several other types of solids from water. Would the centrifuge also dewater the algae?

The answer was yes. Tests showed that the SPT centrifuge could concentrate the algae to 30% solids content without the addition of chemicals. Evodos is now working with several DSTI partners to further scale up and demonstrate the technology, while academic research is working on developing the second-generation technology.

Evodos joined DSTI in 2007, shortly after it started up, as an enthusiastic team of then only two people: Henk Boele, the inventor of the Evodos SPT centrifuge, and Marco Brocken, the entrepreneur who wanted to commercialise that invention.

They came to DSTI with claims that their invention would significantly improve the performance of centrifuge technologies – a very good cut off, and almost no residue water due to a fundamental change of the hydrodynamics in a centrifuge.

Boele, now Evodos' technical director, sums up his invention: "Our spiral plate technology uses vanes inside the centrifuge, which are almost perpendicular to the gravitational force, and are able to separate very small particles. This creates a 'Y-flow', heavier material moves outwards and the lighter fraction moves inwards (in the shape of a 'Y'). There is no cross flow, which not only reduces the energy consumption, but more importantly, makes the use of chemicals (such as flocculants and polymers) obsolete."

The technology also allows for automatic, very dry discharge of the solids, the basis of the company's first patent. Immediately after the process water is pumped out, the vanes can pivot and open themselves to let the accumulated solids discharge.

Within the DSTI partnership, the company was able to discharge micro algae ranging from 1.9–4 µm, with a density almost equal to the water they live in, without extracellular water.

Moreover, as potential use of algae as biofuel increases in importance, so does the energy requirement to dewater it. Evodos claims its technology is the first of its kind to harvest algae using less energy than is contained in the algae itself.

Company ceo Brocken says the DSTI involvement was invaluable: "The testing programme generated follow-up work in a market we could never have entered into on our own," he says. "We got the trust from the bank needed to get financial support, and we did it incredibly quickly – we only founded our company in 2007! Moreover, we now better know what our customers require."

Separation Institute closes gap with practice

The DSTI, a separation institute that was set up this year, wants to strengthen the position of the Dutch process industry through multidisciplinary collaboration. 'In order to stay in front, all the links in the chain, from fundamental research to the development and implementation of new technologies must be strong.'

Jacqueline van Gool

The Netherlands has a good reputation in Europe for fundamental research. However, the step to the practical application and commercialization of all the finds is performed relatively poorly. In short, there is a gap in the value chain from fundamental research to practice. And that is a threat to the competitive position of the Dutch process industry. 'There doesn't seem to be enough contact between the various parties', according to Wridzer Bakker, director of the Dutch Separation Technology Institute (DSTI).
The separation institute is trying to close the gap between research and application in the field of separation technology. 'In order to create value, the whole chain from invention, through development to application must be looked at. There must be more collaboration between the different companies themselves and between companies and knowledge institutes. Only then can we make big strides forward.'
The DSTI is a partnership between industry, universities and institutes, with the aim of improving collaboration so that innovation processes run much faster and more efficiently than has been the case up to now. Besides the development of knowledge, the institute is aiming to demonstrate and apply new and improved separation technologies. The then Minister of Economic Affairs, Brinkhorst, approved the setting up of this institute last April.

Silicon Valley

According to Bakker, there are good opportunities for extra synergy in the Netherlands by working together in the chain. There is a lot of process industry here, the education is good and the country is still the front runner in many areas of process technology. But, in view of the gap between fundamental research and application, the collaboration in the chain is not good enough to remain in front in the long term. Bakker mentions Silicon Valley as an example. 'A much larger proportion of the fundamental research there finds its way into practice and the companies work much closer together. The DSTI wants to achieve a similar situation in the

SUMMARY

The separation institute, DSTI, plans to strengthen the position of the Dutch process industry through multidisciplinary collaboration. The Netherlands occupies an excellent position in the European fundamental research field. But there is a gap in the value chain from fundamental research to practice. The separation institute is trying to close that gap by arranging a cooperation between industry, institutes and universities.
The multidisciplinary approach of the DSTI means that the best possible use is being made of the knowledge held by the different parties so that technologies can be brought to the market more quickly.

'The position of the Dutch equipment manufacturers is relatively weak', says Bakker.

Netherlands in the field of process technology in general and separation technology in particular.'

Phase transitions

Separation processes form an important part of the Dutch process industry. All sectors of the process industry, including pharmaceuticals, foodstuffs, bulk chemicals, fine chemicals, and the oil, gas and water sectors, use them. The different sectors in the process industry often have to deal with the same problems. A significant percentage of the total energy used in the Netherlands is consumed by separation processes. The largest share of the process industry's investment budget is spent on separation equipment. Companies participating in the DSTI hope to be able to lower their costs. They would like to do this by, among other things, dramatically reducing their energy consumption and investment costs. They also want to minimize waste streams. At the same time, they want to raise the value of their products by, for example, increasing the purity of these products. Companies often integrate an extra item of equipment in the process to obtain a purer product. However, an extra unit operation usually means higher energy consumption and higher investment costs. 'If you want to make dramatic energy savings, you have to avoid phase transitions. Phase transitions are usually the reason for high energy consumption. That means that you have to come up with a couple of good tricks and fundamentally change the whole process.' The process industry wants to reduce its energy consumption by around eighty percent. 'In order to meet the targets, all the links in the chain, from fundamental research through development to the implementation of new technologies must be strong and collaborate.'

Compartmentalization

The multidisciplinary approach of the DSTI means that the best possible use is being made of the knowledge held by the different parties. As an example, Bakker mentions the separation of low concentration components from aqueous streams. That is a problem in the foodstuffs industry, for example when extracting a valuable component from milk. But also, for example, in the pharmaceutical industry when removing a substance that causes side effects. Or in the oil and gas industry, when stripping unwanted components from water. 'The collaboration in the DSTI crosses over the boundaries between the different industrial market sectors. So, while still being market oriented, the projects are not compartmentalized into a specific market.'

Parallel approach

The DSTI aims to form a community in which all the parties for whom process technology is important are participating. Companies of all sizes, as well as institutes such as ECN and universities are participating. The DSTI is giving just that bit of encouragement needed to get the collaboration going. 'In fact, our most important role is that of mediator.' There is a lot of interaction between representatives of the different industrial sectors themselves and with the knowledge institutes during meetings organized by the Institute. People from pharmaceuticals talk to people from the oil world. This promotes knowledge transfer. Techniques known for years in one sector can also turn out to be useful in a totally different market, for an application different from the one for which they were originally developed. 'This parallel approach enables steps to be made quickly. In some cases, many stages of the research and development process can even be skipped altogether because the technology only needs to be adapted for application in another industrial sector.'

Not a PhD factory

In contrast to many initiatives, the research is being steered directly by the industry. The companies are also carrying out work themselves. An extensive Separation Technology Roadmap was drawn up for this purpose before the DSTI was set up. This increases the relevance of the university research. 'Universities are going to do more work on things that really matter. That will also make it more interesting for students to study chemistry or chemical engineering.' Working like this also gives PhD students an opportunity to gain experience in working with companies. Conversely, companies will have better access to the knowledge developed by knowledge institutes and other companies and will be able to employ trained technologists more easily.
All parties are involved in setting up and carrying out research programs. As a rule, the project manager comes from industry. 'We're not a PhD factory', emphasizes Bakker. 'Experienced, permanent staff from the different partners will work together in a project with temporary, often less experienced, staff. Only temporary

The Netherlands occupies position two or three in European fundamental research. However, by no means all the research also finds its way into practical application in the market. At a European level, the Netherlands is in seventeenth place. The DSTI is trying to close the gap for the process industry.

staff carrying out the fundamental part of a project will be PhD students. Working in this way will make as much use as possible of the research facilities and knowledge of all the partners. The possibility of using the people and facilities of the business community is particularly interesting because around eighty percent of the process technology researchers and research facilities are in the companies.'

Equipment manufacturers

A culture change is needed to close the gap between fundamental research and application and that will take time. 'You also have to take a look at the human processes. In a manner of speaking, you have to modify the design of the "motor block" that we're now using. Walls have to be broken down.' It takes at least two years to change a mind set.' That is one of the reasons why the partners also find it very important that the DSTI becomes an innovation forum that lasts for at least ten years. 'It cannot be that government support for the research depends on the cabinet that happens to be in office.' So, one of Bakker's challenges is to ensure that the institute survives through the cabinet period. It is important that the government is a partner for the long term. A financial contribution from the government helps to make it attractive for companies to participate in the institute, but subsidy must not be the only reason for participating. The institute's budget for the first year is ten million euros, half of which has been contributed by the Ministry of Economic Affairs. The intention is to double the budget in the near future.
Companies from all sectors of the process industry can participate in the DSTI. At the moment, some 35 companies and eight knowledge institutes have joined the institute. 'Having a large number of participants is not a goal in itself. They must add value', says Bakker. There are a number of specific parties that the DSTI director would like to see more strongly represented in the institute. 'I'm thinking particularly of companies from the food and pharmaceuticals sectors. But I'd also like an extra accent on the oil and gas sector. I'd also like to see more equipment manufacturers joining the DSTI. The position of the Dutch equipment manufacturers is relatively weak. And if there are no equipment manufacturers there will be no new equipment.' The DSTI may therefore be extended over the border. 'The position of that sector is much stronger in Germany and Switzerland.' Bakker sees no reason why the DSTI shouldn't become an international initiative. 'The participating companies are mostly multinationals, so that of course already takes us over the borders. There is not yet a European separation institute. The next step could be to raise the DSTI to a European level.'

Advantages

Besides a so-called in-cash contribution, companies can also provide an in-kind contribution. The latter means making man-hours, installations or R&D facilities available.
By purchasing one or more 'tickets', a company can help to steer the program. A ticket costs fifty thousand euros per year. Small and medium sized businesses can participate for a reduced fee. Special measures have been taken to ensure that small companies can also recognize themselves in the program. Knowledge institutes, including universities work for reduced fees and so contribute in-kind. 'The DSTI serves all partners.
For the companies, the advantages of participating are clear', according to Bakker. Through collaboration, new technologies can be developed and tested more quickly, with more impact and with less risk for the individual parties. Participants share not only knowledge but also the risks and the costs. An additional advantage is that equipment manufacturers and suppliers sit around the same table with potential customers. The non-university knowledge institutes gain a stronger client base. The level of the staff rises because of the knowledge that is developed. The DSTI programs result in more PhDs and publications for the universities. Furthermore, rejuvenation in the sector will make the profession more attractive, which will ultimately result in more students. 'If things go well for the companies in the process industry, they will also go well for the knowledge institutes.'
At the moment, 25 projects have been selected, of which 13 are ready to start. 'The project managers have already been appointed. In principle someone only needs to blow the whistle and we can make a start.'

"At the end of the session there was team spirit and real understanding of the common goals"

Kick-off meetings in DSTI projects: an instrument to align project teams

"If you ask individual members of a starting project team to describe the key elements of their project, their answers often represent a 'starry sky' of opinions". Wridzer Bakker of the Dutch Separation Technology Institute DSTI states. Besides the selection of the right projects a common understanding of the goals and approach at the beginning of the project is key for success. This especially applies to the DSTI's projects as they are relatively large and have diverse project teams. The project members come from industry and knowledge institutes and have different levels of experience. To ensure excellent project execution several DSTI projects have therefore started with a guided kick-off meeting of one and a half day. The people involved are enthusiastic about these meetings and find them very useful.

Gert Poppe, working at Altran, has led several DSTI kick-offs. He notes that young academic researchers are not always aware of the industry's wish to translate scientific development to industrial solutions. "The first kick-off we did, we saw the PhD students getting more and more silent. During the discussions with the industry, they became nervous of the 'hard' targets set and how they had to perform to fulfill these. But the tension released as the industrial participants stimulated the young scientists to frankly pose all questions and they had, and offered all support in order to meet the high challenges."

drs. Gert Poppe, Altran

Mr. Poppe's kick-off helps to clarify burdens to a common spirit. It contains, among others, a game that shows that if people let prevail their own interest above a common goal, all individuals lose in the end. Also, there is a close look at the widest possible goal the group is working on. From there, all zoom in on what work they will do and what they will not, and on the hurdles they may face. Social interaction is an important aspect: all people are invited the evening before the meeting and preferable stay in a hotel together.

Kitty Nijmeijer, assistant professor at the Membrane Technology Group of the University of Twente, is the leader of a DSTI project on trace impurity removal in process streams. Her team consists of people from 3 universities and 6 companies. Five team members are young PhD students, whose task is to identify and develop a specific separation solution for 6 industrial problem cases. "Sometimes you see quite emotional discussions in a kick-off, and the group seems to diverge. But at the end of the meeting, you realize that common understanding has grown and you can have lunch together!"

dr. ir. Kitty Nijmijer, Twente University

In the kick-off, Mrs. Nijmeijers group was asked by Gert Poppe to specify its goals. Some reacted a bit irritated: weren't the goals well described in the project plan? But a second look revealed that the apparently accurate goals were subject to personal interpretation even among the industry participants. One of the issues popping up was the question as to what was of main importance: the problem cases brought in by the industry, or the technologies that might resolve them. If the cases are all resolved with standard technology, does that mean that the project was a success? Or is it OK if a splendid new technology is found but not all cases resolved? After ample discussion, the team agreed that the technology to be developed should be leading, as you cannot expect a new technology to be the solution for all trace removal challenges in industry.

"Even today, some months after the start, we feel the good effect of the kick-off", Mrs. Nijmeijer says, "from a 'we vs. them feeling', we developed into a real team, able to focus on technology and having fun while discussing it".

After the kick-off meeting a diverse project team is united to separate what really matters.

p² ontwikkeling

CuinQ Consulting



Anna van Dinther Milja Milicevic Mark Jongmans

Training 'Working in Projects': starting point for managing and valorizing research projects within DSTI

How do you connect the scientific world of academics with the more pragmatic view of industry?

The current DSTI project portfolio consists of 40 projects in which multi-disciplinary project teams with representatives from industry, universities and contract research organizations, work closely together. Within these projects it's important to combine scientific expertise with managerial and entrepreneurial skills. This is why DSTI developed a project management training called 'Working in Projects'. This training – organized for junior and senior researchers from DSTI – had a twofold focus: the DSTI approach for managing projects and the development of personal skills (e.g. communication, motivation and collaboration).

Training participants come out with a broader understanding of project management principles and how research activities can lead to market value by cooperating with industrial firms. Milja Milicevic, a full-time postdoctoral researcher, says: "As a researcher, I am primarily focused on my field of research – the application of bipolar membrane technology on reduction of salt formation. I wanted to gain more knowledge about the way research project can be managed more effectively in cooperation with industrial parties, in my case AkzoNobel and DSM. Besides this, the training pointed out communication and presentation qualities and pitfalls. It was very inspiring, useful and fun!"

Twelve DSTI researchers took part in the two-day course organized by 'p2ontwikkeling' and 'CuinQ Consulting'. The course started with the highlights of the DSTI project approach. Characteristics of projects, governance roles, management control, work breakdown, golden rules and differences between objective and deliverable were discussed. "Especially the work breakdown structure and description of different roles helps to structure your project," says Anna van Dinther, who is a researcher in the field of the prevention of fouling of membranes and also participated in the training. "Because industrial firms are involved in your research project you need to keep them informed of the progress and discuss the practical translation of findings. This is why the focus on communication and presentation skills was very useful. Also the interplay between theory and practice helped to get a better understanding of the project management principles."

The quality of the Dutch economy depends on the ability to acquire, protect, translate, combine and apply knowledge. This knowledge is needed to solve today's problems and to prepare the ground for solving tomorrow's. Without new knowledge and new combinations of knowledge, there will be no innovation. If we want to keep up with the rapid evolving markets we need strong university – industrial

dsti
DUTCH SEPARATION TECHNOLOGY INSTITUTE

relations. The valorization of shared initiatives starts with a structured approach for managing projects. “Universities are more scientific driven whereas industrial firms are more pragmatic. You need to have a common understanding of the objective, deliverables and scope of your project. If you fail to do so it can lead to improvisation and frustration,” says Mark Jongmans. His project, the removal of impurities or (by) products from organic bulk chemical streams, addresses one of the main application domains of separation technology in the bulk chemical sector. In order to meet the needs of both industry and science Mark Jongmans determined short-term and long-term goals. “Short-term goals I discuss with my research supervisor, long-term goals with involved companies to prevent that I wander from the subject,” he says.

The ‘Working in Projects’ training helps to increase professional skills for handling university – industry partnerships and the valorization of research projects. It is one of the building-blocks to exploit opportunities. After all, the future will never happen by itself, it will have to be created!

Top-level Researchers for DSTI projects

General DSTI

The Dutch Separation Technology Institute (DSTI) is a partnership in which industry, universities and knowledge institutes work closely together to develop breakthrough separation technologies for application in different sectors of the Process Industry. "Together we can take bigger steps, have more impact, and share the risks". So far, 39 companies from the Food, Pharmaceutical, Oil and Gas, Chemical and Process Water Industries, together with 8 knowledge centers, have joined DSTI. The budget is EUR 30 million for the next 4 years and DSTI has plans in place to double this in the near future.

Activities

Separating what really matters!

High-value components from milk, clean process water, medicines without side effects, energy savings of up to 80%, compact and waste-free production processes. DSTI offers the best of the scientific and industrial world. You will be working in a project team with top level researchers from universities, industry and knowledge institutes on the cutting edge of Separation Technology. Joining the DSTI research program is exploring the multi-disciplinary network of the Food, (Bio)Chemical, Pharmaceutical, and Oil and Gas Industries. The research program covers all aspects from (fundamental) knowledge generation to technology implementation.

We seek:

DSTI is continuously looking for enthusiastic junior and experienced researchers who are interested in a challenging position at DSTI, with a strong career opportunity at one of its partners. Occasionally, we also have positions for technicians and lab assistants. Currently there are about 35 job openings. Visit our website at www.dsti.nl for a list of vacancies.

Functional requirements

- At least a Master's Degree in: (Bio)Chemical Engineering, (Bio)Chemistry, Mechanical Engineering, Fluid Mechanics, Materials Science, Applied Physics, Food Technology, or a related field.

Attitude and skills

- Flexible and result-oriented
- Interested in working in a multi-disciplinary team
- Out-of-the-box thinking
- Entrepreneurial spirit
- Hands-on mentality
- Fluent in English.

We offer:

- Flexible temporary contracts at DSTI, with the prospect of a permanent position with one of the DSTI partners;
- Work in a multi-disciplinary project team with experienced R&D colleagues from industry, universities, and knowledge institutes;
- Work on site at various DSTI partners;
- Ample opportunities to follow courses and attend conferences to improve your technical competences;
- Personal and business skills development support through:
  - A mentor from industry;
  - Participation in business simulations;
  - Training in project management and communication.
- Active support toward your next career step within the DSTI network.

Are you interested in a R&D position within the DSTI program or would you like to have more information please contact us. See for contact information last page.

DUTCH SEPARATION TECHNOLOGY INSTITUTE

VAN UITVINDING NAAR INNOVATIE

Bij de oprichting in 2006 kreeg DSTI als opdracht mee versnelde ontwikkeling, demonstratie en implementatie van doorbraak-scheidingstechnologie. Oftewel, uitvindingen omzetten in innovaties. Onder die titel – Transforming inventions into innovations – organiseerde DSTI begin juni haar eerste congres voor partners en directe relaties.

DSTI-directeur Wridzer Bakker: 'Je moet bedrijven actief laten deelnemen en sturen, wil je nieuwe technologie ontwikkeld en geïmplementeerd krijgen.'
Foto's: Sjoerd van der Hucht

Het congres besloeg twee dagen met in totaal 330 deelnemers. De eerste dag was voor executives en de tweede dag voor de deelnemers aan DSTI-projecten. Het feit dat ruim de helft van de uitgenodigde executives op de eerste congresdag aanwezig was, ziet directeur Wridzer Bakker als een teken dat het nog jonge DSTI inmiddels als een belangrijk gevestigd instituut wordt beschouwd. De inhoudelijke focus en de wijze van samenwerken vinden blijkbaar weerklank, getuige ook de positieve beoordelingen van de Commissie van Wijzen en het CPB, het groeiende aantal partners en een programmabudget van inmiddels tachtig miljoen euro.

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Technologie-ontwikkelplatform

Ter verklaring van het succes wijst Bakker op de rol van DSTI als facilitator van een actief technologie-ontwikkelplatform. 'Draagvlak voor ontwikkeling en implementatie van nieuwe technologieën bij bedrijven ontstaat alleen als de benodigde kennis in de hoofden van de mensen komt. Dit gebeurt alleen als bedrijven actief deelnemen en sturen in de definitie en uitvoering van de projecten. Het onderzoek is daarom vraaggestuurd en de projectmanagers zijn uit de industrie afkomstig. Potentiële leveranciers en eindgebruikers worden er vroegtijdig bij betrokken en er ligt echt 'ownership' bij de industrie.' DSTI bouwt zeer actief aan duurzaam vertrouwen tussen partners in en om de procesindustrie, onder het motto 'samen kunnen we grotere stappen zetten met meer impact en gedeelde risico's'.
'Maar samenwerking kóst ook tijd en geld', weet Bakker, 'en dat moet je goed organiseren om er echt voordeel uit te halen. Verwacht niet dat grote projecten met verschillende uitvoerders en stakeholders zo maar goed lopen. Erg belangrijk bij de samenwerking zijn bijvoorbeeld een gedeelde urgentie en prioriteitsstelling, een goed gefaciliteerde projectstart en de bereidheid van de partners om op een andere manier te werken en kennis te delen.'

(Nieuwe) aandachtsgebieden

Zeventig procent energiebesparing, medicijnen zonder bijwerkingen, compacte en afvalvrije productieprocessen, hoogwaardige voedingssupplementen uit melk, proceswater van de gewenste kwaliteit, verdubbeling van de hoeveelheid winbare olie per veld, en technologen met R&D- én businessvaardigheden. Dat zijn enkele van de doelen uit de roadmap Scheidingstechnologie. Inhoudelijk blijft DSTI werken aan doorbraaktechnologieën die moeten resulteren in goedkopere, schonere en zuinigere processen en producten met een hoge toegevoegde waarde. Onder die brede noemer komen dankzij recente financiële injecties nieuwe aandachtsgebieden binnen bereik. Enkele daarvan stonden centraal op het DSTI congres, zoals biorefining, de omzetting van biomassa naar een scala van componenten en materialen met een zo hoog mogelijk toegevoegde waarde, miniaturisering en procesintensificatie, technologieën om stoffen in lage concentraties uit grote vloeistofstromen te halen. Ook wordt er gewerkt aan een 'zwavelplatform': ontzwaveling van olie en gas wordt urgent nu de 'goede' (zwavelarme) voorraad grotendeels is gewonnen en de zwavelrijkere velden geëxploiteerd gaan worden. Een ander aandachtspunt in DSTI's lopende R&D-plan is 'unshelving', het van de plank halen bij bedrijven en in een project onderbrengen van technologie die zij ooit hebben ontwikkeld. Oftewel, meer waarde halen uit reeds uitgevoerd onderzoek.

Impressie van het goedbezochte DSTI congres.

Budget naar tachtig miljoen euro

De cruciale positie van de scheidingstechnologie in de procesindustrie, een motor van de Nederlandse economie, gaf in 2006 de aanstoot tot de oprichting van het Dutch Separation Technology Institute. DSTI kreeg als missie mee de sterke Nederlandse positie duurzaam te versterken door proces-industrie en kennisinstellingen samen te laten werken aan doorbraak-scheidingstechnologieën.
Als partners in DSTI dienden zich aan universiteiten en contractresearch-organisaties, grote bedrijven uit de olie en gas, (petro)chemie, farma en food, en hightech mkb'ers, alles bij elkaar nu al bijna zestig.
Op grond van de roadmap Scheidingstechnologie werd voor het programma 35 miljoen euro beschikbaar gesteld, door het ministerie van EZ en de DSTI-partners. Door aanvullende bijdragen van onder meer EZ en de partners is het programmabudget inmiddels gegroeid naar tachtig miljoen. Bij de uitvoering van de projecten zijn meer dan 300 mensen van de verschillende partners actief betrokken. DSTI zal voor het in oprichting zijnde instituut voor duurzame procestechnologie (ISPT) één van de belangrijkste pijlers vormen.

DSTI a career opportunity

DSTI is a Technology Development and Implementation Platform for the Process Industry. Industry and knowledge institutes work closely together under the motto: "Together we can take bigger steps, have more impact, and share the risks".
So far, 50 companies from the Food, Pharmaceutical, Oil and Gas, Chemical and Process Water Industries, and 10 knowledge institutes, have joined DSTI. The total size of the program is almost 100 million Euro and over 300 (ca. 100fte) people are involved in the project execution.

Developing what really matters

Seventy percent energy savings, medicines with reduced side effects, compact and waste-free manufacturing processes, high value feed supplements from milk, process water of the required quality, a doubling of the amount of recoverable oil per field, and technologists with R&D and business skills. These are some of the targets our partners have defined.

DSTI offers the best of the scientific and industrial world. You will be working in a project team with top level researchers from universities, industry and contract research organisations on the cutting edge of Process Technology. Joining the DSTI means exploring the multi-disciplinary network of the Food, (Bio)Chemical, Pharmaceutical and Oil & Gas industries. The R&D program covers all aspects from (fundamental) knowledge generation to technology implementation.

DSTI a career opportunity for you?

DSTI is continuously looking for enthusiastic junior and experienced researchers. Are you interested in a challenging position at DSTI than please visit **www.dsti.nl** for our vacancies.

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Notes

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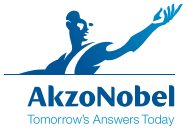
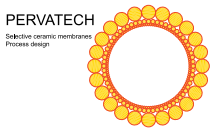
Solid partner base is key to succes







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