2005 winter

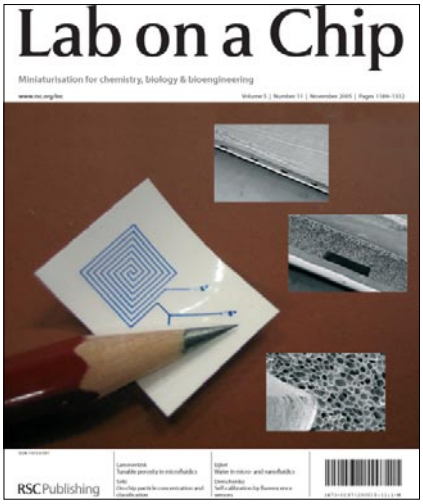
Membrane News Twente

news magazine of the Membrane Technology Group

MNT, p/a University of Twente - TNW/MTO
postbox 217 , NL-7500 AE Enschede, Netherlands
membrane@utwente.nl - www.membrane.nl
Telephone: +31 (0) 53 489 2950 - Fax: +31 (0) 53 489 4611

Membrane Technology meets microfluidics

Membrane preparation techniques are very well suited for the fabrication of microfluidic chips. This is the conclusion of Jorrit de Jong and Rob Lammertink in their recent article in 'Lab on a Chip'. The chips produced by their method, phase separation micromolding (PSμM), are featured on the cover of the November issue.



Microfluidic devices gain interest from many scientific disciplines nowadays. Due to small diffusion distances, low sample volume and controllable flow these devices are very efficient for analysis and detection. Traditional chip fabrication methods stem from semiconductor industry and are mostly based on glass and silicon.
The new technique developed at MTG is based on phase separation of a polymer solution onto a microstructured mould. During this process, a film is formed, which replicates the structure of the mould. The method is applicable to a very wide range of materials. The most interesting feature is the ability to introduce porosity into the chip. This porosity can even be tuned by controlling the conditions of the phase separation process. The resulting porous channels can be exploited for selective transport of species in- and out of the chip. It is this principle that opens up a large number of new exciting applications.
The work has been published recently in "Lab on a Chip" and awarded the cover of the November issue. The image on the cover shows a typical microfluidic chip, with the channels filled with ink. The electron microscope images show cross sections of the chip, in which the porosity is clearly visible. In their article, De Jong and Lammertink demonstrate that water in the channels can be acidified by CO_2 diffusing through this porosity. They like to see their method as a new platform technology. "Future work will be targeted at single-use applications. We aim for membrane emulsification and crystallization. But given the versatility of the method, who knows where we will end!"

Honory meeting Kees Smolders

On 28th December 2005, Kees Smolders, the founding father of membrane science and technology at the University of Twente, will reach the honorable age of 75 years. On Friday 3rd Februari 2006 we would like to celebrate this with a symposium together with old colleagues and membrane friends. The program knows a variety of technical lectures from academia and industry, but there will also be time to exchange professional and private thoughts.
Kees Smolders has inspired generations of young researchers and we hope that this event will be inspiring as well. Even though you may not have crossed his path in the past, you are cordially invited to participate.

Information

Mrs. Greet Kamminga
m.i.kamminga@utwente.nl
+31 (0) 53 489 2950

Program

3 February 2006

9.30 -10.00	**Welcome & Coffee**
10.00-12.30	**Industrial lectures** *Roesink* *Koops* *Cuperus*
12.30-14.00	**Lunch**
14.00-16.00	**Scientific lectures** *Boom* *Strathmann* *Feijen* *Wessling*
16.00-16.30	**Reminescences** *C.A. Smolders*
16.30-18.30	**Borrel & Snacks**

Every year we spend hundreds of euros on holiday wishes, of which a small part goes to Unicef. This year we have decided to send this digital card instead and donate all the money to charity.
Best Wishes, Membrane Technology Group

From Humics to Microsieves

Ronald Jansen was the first Ph.D. student to graduate from the Sustainable Technology & Membrane Technology group founded by Marcel Mulder. He studied the reduction of humic substances with the help of ozone. Ronald currently works at Fluxxion in Eindhoven

Ronald's Ph.D. research started in March 2000. He was the first PhD student of the late Prof. Marcel Mulder. The group was situated in Leeuwarden, located at the Van Hall Institute, but had a strong connection to the Membrane Technology Group at Twente University.
Being the first PhD student of this new group was a very exciting idea for Ronald. Despite the fact that Prof. Mulder passed away late 2003, the group expanded to 5 people after three years and merged into Wetsus, Centre for Sustainable Water Technology in 2004.
Ronald's research concerned the removal of humic substances from drinking water. The project was supported by the water division of Nuon (now called Vitens). Humic substances comprise a cocktail of organic compounds that originate from microbial decay of dead organisms in water and soil. They are the cause of the yellow color of drinking water. More stringent legislation on water quality impels water companies to actively remove color from drinking water. However, due to their low biodegradability, they are difficult to remove in conventional water treatment processes .

'Yellow water goes in, clear water comes out. Recovery: 99.9%.'

The overall strategy to solve the problem was to concentrate and treat the humic substances in a side stream biodegradation process. To enhance the biodegradability of the humic compounds an ozonation step would be deployed prior to the biodegradation process. The project was split into three main topics: Ozone mass transfer, ozonation product characterization and biodegradation. The humic substances could be very efficiently concentrated by ion-exchange adsorption: Yellow water goes in, clear water comes out. Recovery: 99.9 %.

As one of the first in the field Ronald Jansen and co-workers used a membrane contactor to study reaction kinetics, in this case of ozone with humic substances. Because of its well defined features and flow characteristics through the fibers a hollow fiber membrane contactor can be used as a model gas-liquid contactor. With this it was found that the reaction starts off as an instantaneous reaction after which it slows down but always remains fast in comparison to the transfer rate of ozone in water. Furthermore, with the same result an average diffusion coefficient of the humic substance molecules could be calculated.
With the help of size exclusion chromatography and ion-chromatography we could identify a number of products from ozonation of humic substances. One important conclusion was that under ozonation the humic substance molecules do not break up in large chunks that would in turn break up in smaller chunks and so on, but they are merely reduced according to an outside-in trimming mechanism. Only small, highly oxidized molecules are split from the large humic substance molecules.
Experiments with a small bio-filter setup proved that the small ozonation products were well biodegradable, but that the large residual molecules were still a tough cookie to crack. Complete breakdown of humic substances would imply almost complete oxidation of the humic compounds which is in practice not feasible. Ronald successfully concluded his PhD research with the public defense on May, 20, 2005.

Since March this year Ronald occupies a great job at fluXXion in Eindhoven. FluXXion is a young manufacturer of microsieves: new promising membranes that are made by semi-conductor technology. The company is situated on the High Tech Campus of Philips and uses the infrastructure of the campus. In his job he investigates applications for Fluxxion products, mainly on business demand. The job also means maintaining contact with clients, offering solutions and technical support in hardware and knowledge. A good mix of technical and commercial activities. He found that being active in a small organization means that one has to be broadly employable.

Fluxxion is growing and is always on the look-out for new enthusiastic employees!

More information

Ronald Jansen
ronald.jansen@fluxxion.com
+ 31 (0)40 274 4172

Links
www.fluxxion.com
www.wetsus.nl

Literature
R.H.S. Jansen et al. *Journal of Membrane Science 257 (2005) 48–59*

Publications & Patents

Papers

M. Gironès, A.M. Peters, D.M. Sterescu, J.H. Balster – Editors, Abstract book Network Young Membrains 7th meeting, *Print Partners Ipskamp (2005)*

M. Gironès, Z. Borneman, R.G.H. Lammertink, M. Wessling, The role of wetting on the water flux performance of microsieve membranes, *Journal of Membrane Science 259 (2005) 55-64*

A.P. Kharitonov, R. Taege, G. Ferrier, V.V. Teplyakov, D.A. Syrtsova, G.H. Koops, Direct fluorination – Useful tool to enhance commercial properties of polymer articles, *Journal of Fluorine Chemistry 126 (2005) 251-263*

A.M. Urmenyi, A.A. Poot, M. Wessling, M.H.V. Mulder, Affinity membranes for hormone removal from aqueous solutions, *Journal of Membrane Science 259 (2005) 91-102*

L. Vogelaar, R.G.H. Lammertink, J.N. Barsema, W. Nijdam, L.A.M. Bolhuis-Versteeg, C.J.M. van Rijn, M. Wessling, Phase separation micromolding: A new generic approach for microstructuring various materials, *Small 1 – 6 (2005) 645-655*

I. Frenzel, H. Holdik, D.F. Stamatialis, G. Pourcelly, M. Wessling, Chromic acid recovery by electro-electrodialysis, Evaluation of anion-exchange membrane, *Journal of Membrane Science 261 (2005) 49-57.*

J. Balster, O. Krupenko, I. Pünt, D.F. Stamatialis, M. Wessling, Preparation and characterisation of monovalent ion selective cation exchange membranes based on sulphonated poly(ether ether ketone), *Journal of Membrane Science 263 (2005) 137-145.*

S.J. Metz, W.J.C. van de Ven, M.H.V. Mulder, M. Wessling, Mixed gas water vapor/N2 transport in poly(ethylene oxide) poly(butylene terephthalate) block copolymers, *Journal of Membrane Science 266 (2005) 51-61.*

G.A. Schrader, A. Zwijnenburg, M. Wessling, The effect of WWTP effluent zeta-potential on direct nanofiltration performance, *Journal of Membrane Science 266 (2005) 80-93.*

N. Stafie, D.F. Stamatialis, M. Wessling, Effect of PDMS cross-linking degree on the permeation performance of PAN/PDMS composite nanofiltration membranes, *Separation and Purification Technology 45 (2005) 220-231.*

E.M. van Voorthuizen, A. Zwijnenburg, M. Wessling, Nutrient removal by NF and RO membranes in a decentralized sanitation system, *Water Research 39 (2005) 3657-3667.*

I. Frenzel, H. Holdik, D.F. Stamatialis, G. Pourcelly, M. Wessling, Chromic acid recovery by electro-electrodialysis, II. Pilot scal process, development, and optimization, *Separation and Purification Technology 47 (2005) 27-35.*

P.A.M. Lips, I.W. Velthoen, P.J. Dijkstra, M. Wessling, J. Feijen, Gas foaming of segmented poly(ester amide) films. *Polymer 46 (2005) 9396-9403.*

J. de Jong, B. Ankoné, R.G.H. Lammertink, M. Wessling, New replication technique for the fabrication of thin polymeric microfluidic devices with tunable porosity, *Lab on a Chip 5 (2005) 1240-1247*

Patents

M. Gironès, R.G.H. Lammertink, M. Wessling,
Vibrating microsieves, *EP 05077172 (2005)*

Graduations

Ph.D.

Míriam Gironès i Nogué
Inorganic and polymeric microsieves. Strategies to reduce fouling
December 9, 2005

Bachelor/Master of Science

Bachelor:

Wilma de Groot
Characterizing block copolymer orientation by birefringence
October 10, 2005

Master

Sumbharaju Raghavendra
Asymmetric bipolar membranes for reduced salt leakages
October 10, 2005

Koray Uelger
Preparation of thin film multi-layer membranes for gas separation
September 12, 2005

Nayeli Masetto
Cellulose acetate asymmetric membranes for gas separation
September 13, 2005

Christina Leinweber
Droplet formation in microstructured porous polymeric materials
October 17, 2005

Menno Gierman
Confidential
October 21, 2005

Fuat Uyar
New membrane material for flue gas dehydration - Sulfonation of PEEK
November 11, 2005

MNT- Information

Membrane News Twente is published two times per year. The aim is to inform the membrane community about the activities of the Membrane Technology Group.

editors
M. Wessling
D.C. Nijmeijer
W.J.C. van de Ven
Piotr Długołecki

layout
W.J.C. van de Ven

email
membrane@utwente.nl

internet & MNT archive
www.membrane.nl

circulation
~500

Introducing...

Fundamental Aspects of PSμM

Name
Matías Bikel
Origin
Argentina
Contact
www.membrane.nl
+31 (0)53-4892950
m.bikel@utwente.nl

Matías is a new Ph.D. student from Buenos Aires, Argentina.He is 25 years old and holds a Chemical Engineering degree (University of Buenos Aires) and has worked for 2 years in the R&D laboratories of Boehringer Ingelheim. He has participated in various chemistry olympiads, earning medals in Argentina, Latin America and worldwide.
In his PhD project, that started on the 1st of October, he will further explore the fundamentals and potential of PSμM (phase separation micro-moulding).

New Technician at the EMI

Name
Wika Wiratha
Origin
Indonesia
Contact
www.membrane.nl
+31 (0)53-4891116
k.w.wiratha@utwente.nl

Wika Wiratha was born in Bali, Indonesia and studied Chemical Technology at the Hogeschool Utrecht.
Since September 1, 2005, she is working as a full-time technical assistant at the European Membrane Institute (EMI) Twente, where she contributes to confidential projects with industrial partners. Before she joined the EMI she worked for 3 years at the Inorganic Materials Science Group where she was involved in the preparation and characterization of porous and dense membranes and the research for new materials.

Picture of the Month Competition
The picture of the month is chosen from all the pictures that were taken in the MTG group during the last month. The winner recieves free drinks for one night and gets to pick the winner from next month's contributions. All the winners can be found on the website www.membrane.nl

Influence of operational parameters on the nature and extent of biofouling of membranes

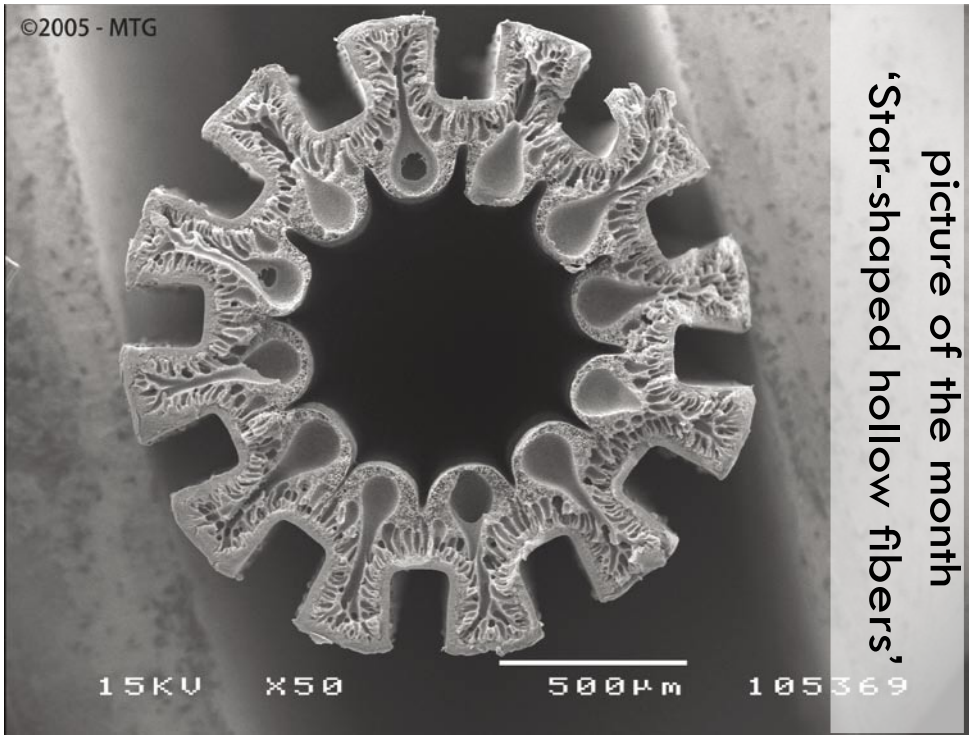
Name
Sandra Bruinenberg
Origin
Netherlands
Contact
www.wetsus.nl
+31 (0)58-2846200
Sandra.Bruinenberg@wetsus.nl

Mid-September Sandra Bruinenberg started her Ph.D. project in the "biofouling" group at Wetsus in Leeuwarden. Sandra studied Chemical Engineering at the Rijksuniversiteit Groningen. Nanofiltration and Reverse Osmosis membranes are frequently used in water purification installations. Over time, biofilms form on the surfaces of these membranes. Biofilms can give rise to a severe decrease in flux and/or increase in trans membrane pressure (TMP). This phenomenon is called biofouling.
In her research, Sandra investigates the influence of operational parameters on the nature and extent of biofouling. Examples of operational parameters are the concentration of nutrients and cells in the feed, the cross flow velocity, and the used spacer configuration. Experiments with clean RO membranes and fouled membranes are carried out in flat sheet flow cells.

Biomimetic capillary scaffold for Tissue Engineering

Name
Bettahalli Srivatsa
Origin
India
Contact
www.membrane.nl
+31 (0)53-4892961
m.s.bettahalli@tnw.utwente.nl

Srivatsa is a Ph.D. student from India and he is 28 years old. He started his work on 12th of September 2005. After his graduation as a chemical engineer (Bangalore University, India) he worked in India for about a year as software developer at Hummingbird Automations Pvt. Ltd and at the R&D laboratory of Bio-gen Extracts. He came to Europe and obtained a Masters degree in chemical engineering in Germany (FH-Muenster University)
In his PhD project he will work in the field of Tissue engineering. He aims to build 3D polymeric scaffolds to culture cells and to supply nutrients and oxygen to the growing cells.
He will model the flow limitation through the scaffold and design and develop bioreactors.



This pictures shows a star-shaped hollow fiber ultrafiltration membrane. A special insert is used in the spinneret to make these and other shapes possible. Remarkable is the regular distribution of the macrovoids in this fiber ***Picture by Peter Koel***

European Network of Excellence NanoMemPro

The membrane Technology Group of the University of Twente is one of the scientific core partners of the European Network of Excellence 'NanoMemPro' (subtitle: 'expanding membrane macroscale applications by exploring nanoscale material properties').

The main aim of this network is to coordinate and orientate the European membrane research according to the society's needs and to establish permanent interactions between membrane researchers, industries and end users. NanoMemPro intends to establish a common approach to integrate a variety of disciplines that address membrane issues, by linking the molecular and nanoscale structures and properties of knowledge-based materials to the development of more environmental friendly processes and tailor-made approaches for applications with great impact on the quality of life and European competitiveness (Figure 1).
The network consists of a core group of 13 European research centres that are highly committed to integrate and share their resources, facilities and infrastructure. The European industry is integrated in the network as a Club of Interest.
This Club of Interest advises the research centres on the industrial and citizen needs, orientates research projects and plays a major role in generating and exploiting newly developed technologies (Figure 2).

If you would like to have more information concerning NanoMemPro, please contact dr. D.C. Nymeijer (d.c.nijmeijer@utwente.nl)

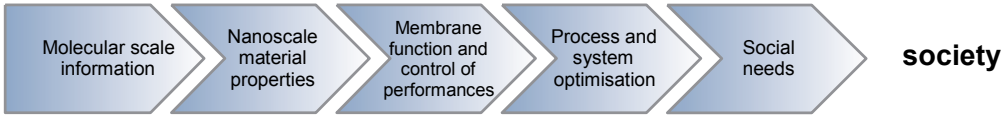


Figure 1: Common research approach to link nanoscale material properties to macroscale process applications

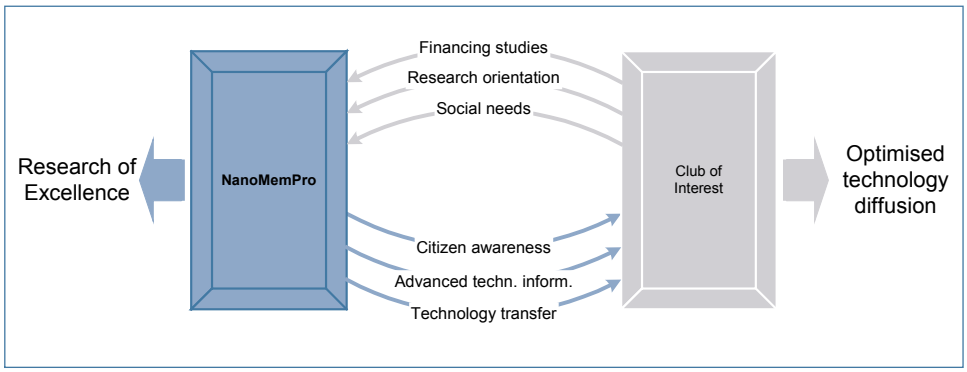


Figure 2: Structure of NanoMemPro, showing the relationship between the core partners of NanoMemPro and the Club of Interest

Upcoming Events

February 2 and 3, 2006 – Membrane Technology Group, University of Twente
Honory meeting for the 75th birthday of Prof. C.A. Smolders

March 31, 2006 – Membrane Technology Group, University of Twente
Ph.D. defence Guillo Schrader
Nanofiltration of municipal wastewater treatment plant effluent

April 22, 2006 – Enschede/Nijmegen
34th edition of the Batavierenrace

Prizes for MTG Ph.D. students at ICOM 2005

Two Ph.D. students from the Membrane Technology Group won a poster and a lecture prize at last summer's ICOM in Seoul.

Tymen Visser was one of the in total five prize winners of the oral student paper contest. From over 250 initial contributions by PhD-students, 25 were selected from various countries to compete in a special student paper contest session. In a lecture of fifteen minutes including a five-minute discussion, the students presented their PhD-work, carefully observed by a jury formed by several professors.

Tymen's lecture dealt with transport phenomena in gas separation membranes. He discovered that there is a subtle balance between competitive gas sorption in the glassy polymer and plasticization effects in the mixed gas permeation behavior, when assymmetric gas separation membranes are used. Although evidence of swelling induced by CO_2-plasticization was found, the separation was hardly affected. With higher CO_2-content in the feed mixture higher separation factors were achieved. This is in contrast to the commonly found loss in selectivity with increasing partial pressure of CO_2.

From the 125 posters on display, the poster of Hylke Sybesma was selected with 12 others for a poster prize. Hylke's poster describes the dehydration of gas streams (especially flue gas) with highly selective materials. The jury was especially impressed by the combination of multiple disciplines in the work. The composite membrane was prepared and tested in the lab followed by the preparation of pilot scale modules and onsite field testing at a power plant.

ICOM 2005 prizewinners

Literature

Visser, T., G.H. Koops, and M. Wessling,
Journal of Membrane Science, 252 (2005) 265-277

The Membrane Technology Group

Multidisciplinary approach in membrane science and technology

The Membrane Technology Group focuses on the multi-disciplinary topic of membrane science and technology. We consider our expertise as a multi-disciplinary knowledge chain ranging from molecule to process. The knowledge chain comprises the following elements:

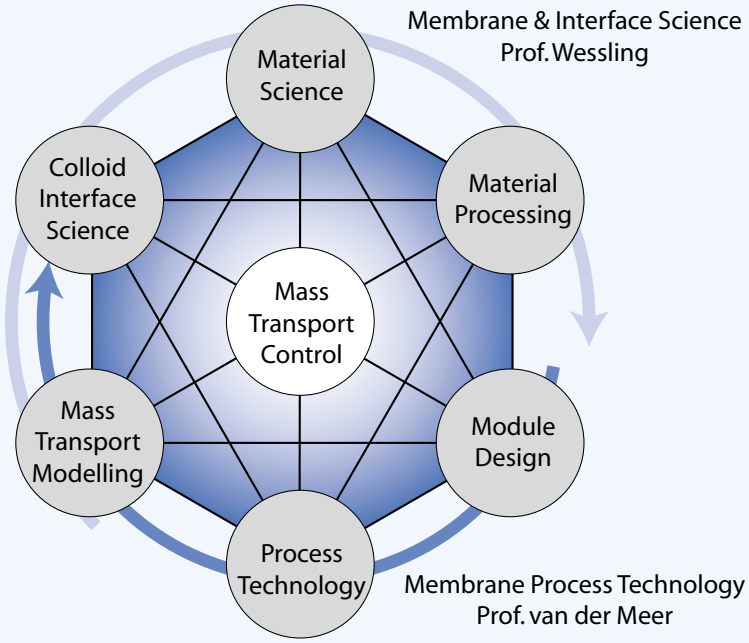
- Colloid and interface science
- Macroscopic mass transport characterization and modeling
- Material Science
- Material Processing
- Module and system design
- Process technology

The research team is assembled such that permanent staff members cover one or more of the disciplines involved. The proposers cover in particular the scientific and technological questions on membrane and interface science.
The majority of the research deals with separation of molecular mixtures and selective mass transport. Our research program distinguishes four application clusters:

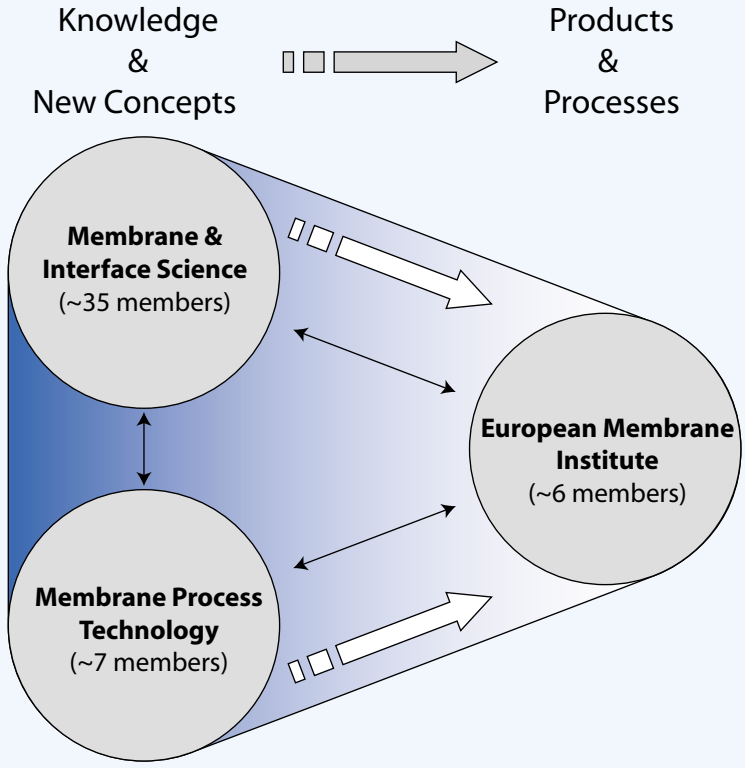
- Energy and Sustainability
- Water
- Life Science
- Micro Systems Technology

Knowledge transfer and utilization

Over the past years, our group has focused especially on knowledge utilization and transfer. Over the past decade, we experienced that the time scales of research are extremely different in industry and academia. Even within industry a significant difference exists in time-scales between small and medium enterprises and multi-national cooperations. We have adjusted our organization structure such that we can distinguish between long-term scientific activities and short-term technology transfer. We have established the European Membrane Institute (EMI) Twente for this purpose.
The EMI performs research and development work on new membrane products and processes. The work often focuses on the production of a tangible deliverable.



Total mass transport control by a multisdicplinary approach. The membrane & Interface science group together with the Membrane Process Technology group cover the full spectrum of mass transfer phenomena in membrane separation.. From the very small scale to module and process design the combined knowledge of the groups can handle any membrane related problem.



Bringing new knowledge and concepts to the market. The traditional discrepency between the needs of the industry and the research performed within universities is bridged by the establishment of the Europen Membrane Institute.