2006 summer

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

Polymers and Ceramics Join Forces

Over the past 25 years membrane research at the University of Twente has been carried out in two different chairs: one founded by Prof. Smolders, focussing on polymer membranes, the other one run by Prof. Burggraaf investigating ceramic membranes. Although scientific questions and preparative work had very much in common, both groups operated separately. Even today, the ceramic membrane research has its own conference: ICIM, recently hold in Norway. More and more of today's exciting research however occurs at the interface of polymer science and ceramic processing and synthesis.
The problems to be solved in the areas of sustainable energy and separation processes as well as better and healthier life asks for joining forces rather than traditional co-existance as separate disciplines. Therefore, the Faculty of Science and Technology of the University of Twente has decided to transfer the activities of ceramic membrane science out of today's chair of Prof. Blank on Inorganic Material Science and transfer it to the Membrane Technology Group. The activities remain clustered as such and will be headed by a part-time professor out of industry. However, the ceramic membrane group integrates with the groups of Prof. van der Meer on Membrane Process Technology and Prof. M. Wessling on Membrane & Interface Science into the Membrane Technology Group.
Preparation of this integrative activity has been going on for the last year and has been the nucleus for new research funds in the order of 1.5 Mill Euros. Projects currently starting up focus on polymer/ceramic composite membranes for gas and liquid separations (2 Ph.D. students, 1 PostDoc), ceramic and metallic porous membrane micro-reactors (1 Ph.D student, 1 PostDoc), carbon and carbon nanotube based membranes (1 Ph.D. student, 1 PostDoc), and polymer-modified ceramic nanocomposite (1 Ph.D.student).

The future looks bright: at the end of 2007 the Membrane Technology Group moves into a new building, with new laboratories and a renewed spirit.

NWO grant for Kitty Nymeijer

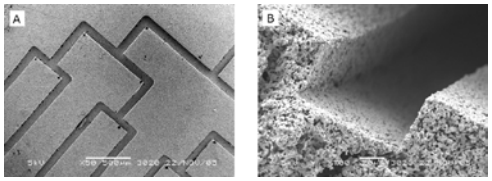
Recently the Dutch Science Foundation (NWO) rewarded Kitty Nymeijer with a grant within the framework of the MEERVOUD program.

The granted project focuses the separation of olefins and paraffins and the capture and sequestration of CO_2. Lower olefins e.g. ethylene and propylene are one of t he most important products of the chemical industry, whereas CO_2 is one of the major contributors to the green house effect. Traditional technologies are expensive and energy consuming, thus offering an incentive to develop cost effective separation technologies. Membrane processes as sustainable separation technology play an important role in this respect and significantly contribute to a reduction in energy consumption. During the last decades, the performance of membranes and membrane processes has made a major step forward. However, to further increase this performance and to make membranes attractive as sustainable technology, functionalization of polymeric membranes is required. In the present proposal, we focus on the development and application of such functionalized membranes using ionic liquids as functional additive for the removal of CO_2 from CH_4 and the separation of olefins and paraffins.

VIDI laureate for Rob Lammertink

Dr.ir. Rob Lammertink, assistant professor at the Membrane Technology Group, has received the Vidi grant from NWO for his proposal on porous microreactors.

The Vidi grant is intended for researchers with several years of postdoctoral experience, and provides the means to develop a new line of research. The proposal was submitted to the Technology Foundation STW. Out of the total 47 submissions, 8 were funded after three selection rounds. The aim of the research is to explore new concepts for gas-liquid reactions inside microreactors and economically fabricate new metallic and ceramic microreactors. Microreactors are extremely suitable for exploring and performing highly exothermic and fast reactions. Due to the reduced characteristic length scales, enhanced mass and heat transfer is obtained. The flexibility in materials choice that the new method provides, e.g. metallic and ceramic, presents optimal stability at high temperatures, pressures, and aggressive media.
One of the scientific challenges is to incorporate membrane functionality within microstructured systems, e.g. contacting purposes. This direct incorporation allows for highly integrated systems that are suitable for out-scaling towards industrial sized applications. Relevant gas-liquid reaction systems include fluorination of aromatic compounds, and heterogeneous catalyzed hydrogenations.



Scanning electron micrographs of microchannels in a porous metal structure.

Membrane Technology meets Tissue Engineering

Tissue engineering (TE) aims at developing living substitutes to restore maintain or improve the function of tissue or organs which can be excellent alternatives for transplantation (Fig. 1). The core of a tissue engineered replacement is an artificial 3-D matrix (scaffold) which provides temporary support for cells to grow tissue. A scaffold should be biocompatible, biodegradable, mechanical stable and porous. Cell growth can be performed in a biological active system to simulate the human body; then the cell-seeded scaffold is placed in a bioreactor.

In our group, a dynamic cluster of young scientists works on the development of such scaffolds, under the supervision of Dr. Dimitrios Stamatialis (Photo) and Prof. Matthias Wessling.

One project, entitled: Advanced microstructures for tissue engineering, focuses on the design of polymeric scaffolds and the effect of surface topography on cell behavior (PhD student: Bernke Papenburg, PostDoc: Míriam Gironès). The project belongs to the spearhead program for TE of the biomedical technology institute (BMTi) and it is performed in collaboration with the groups of Polymer Chemistry and Biomaterials, and Biophysical Engineering of the University of Twente (UT). It is also included in the Dutch Program of Tissue Engineering (DPTE).

In this project highly porous scaffolds with incorporated a micro-pattern design are fabricated. The porosity serves for nutrient transport towards the cells, where the micro-pattern align tissue formation. Phase Separation Micromolding (PSμM) is used as one-step fabrication method which is based on immersion precipitation on a micro-patterned mold; the inverse replication of the micro-pattern is imprinted in the polymer sheet during solidification

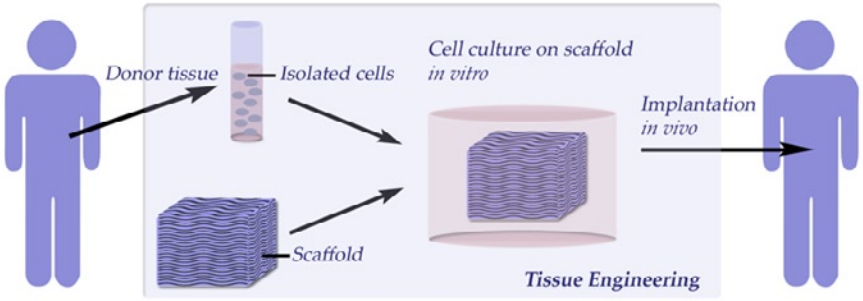


figure 1 The principle of tissue engineering

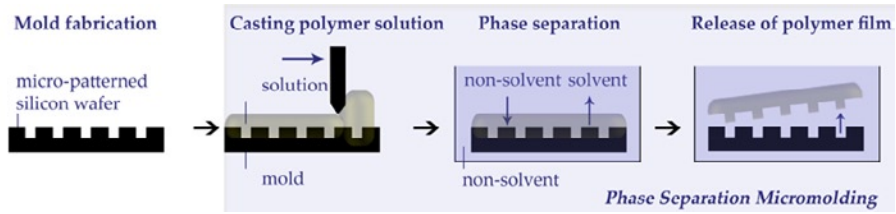


figure 2 Phase Separation Micro Molding

(Figure 2).

The influence of several parameters is studied and cell culturing experiments using HUVEC (human umbilical vein endothelial cells) and C2C12 cells (mouse myoblasts) are performed. Various polymer scaffolds (e.g. Poly(l-lactic acid) (PLLA), poly (ether imide) (PEI)) featuring various micro-patterns are designed (see the box below); the experiments confirm high nutrient transport through the sheets and alignment of the cells due to the micro-pattern can be controlled.

The second project, entitled: Biomimetic capillary networks for tissue engineering, focuses on the design of a 3-D scaffold and a bioreactor system (PhD student: Srivatsa Bettahalli).

The project is performed in collaboration with the Polymer Chemistry and Biomaterials group of UT and is funded by the Dutch organization for scientific research (STW) and other industrial partners.

A main barrier in present tissue engineering scaffolds is uniform transport of nutrients through a construct. In this project effective mass transport of nutrients is studied; maintaining the O_2 & CO_2 partial pressures and mimic the native environment of respective tissue. Porous hollow and full fibers are combined to prepare a capillary 3D network (Figure 3). The scaffolds are tested for convective mass transport within the core of the scaffold. The Influence of external mechanical stimulation is studied as well.

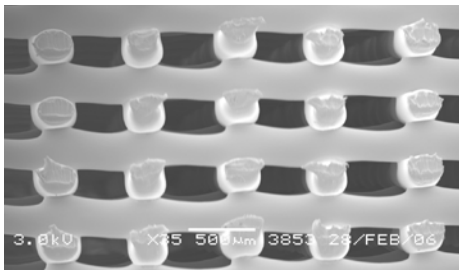
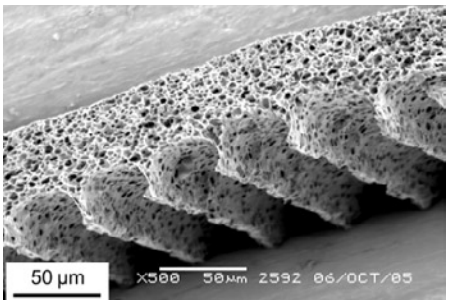


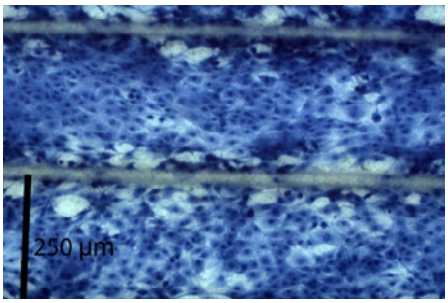
figure 3 Capillary 3D network structure

More information

Dr. Dimitrios Stamatialis
d.stamatialis@utwente.nl
+ 31 (0)53 489 4675

The tissue engineering team:
D. Stamatialis, M. Gironès,
B. Papenburg & S. Bettahalli





Cell growth on PSμM scaffolds

The micropatterned sheets prepared with PSμM can induce cell alignment on the scaffold. This is demonstrated in the photos on the left. The top one shows a typical PLLA scaffold prepared in out labs. The porosity is very high and allows the transport of nutrient to the cells. The photo at the bottom shows that the cells indeed preferentially grow in the direction of the channels. The cells (C2C12) were cultured on a scaffold featuring 250 μm wide channels for 4 days.

Publications

Papers

I. Frenzel, H. Holdik, V. Barmashenko, D.F. Stamatialis, M. Wessling, Electrochemical reduction of dilute chromate solutions on carbon felt electrodes, *Journal of Applied Electrochemistry 36 (2006) 323-332.*

M. Gironès, R.G.H. Lammertink, M. Wessling, Protein aggregate deposition and fouling reduction strategies with high-flux silicon nitride microsieves, *Journal of Membrane Science 273 (2006) 68-76.*

I. Frenzel, D.F. Stamatialis, M. Wessling, Water recycling from mixed chromic acid waste effluents by membrane technology, *Separation and Purification Technology 49 (2006) 76-83.*

L. Vogelaar, R.G.H. Lammertink, M. Wessling, Superhydrophobic Surfaces Having Two-Fold Adjustable Roughness Prepared in a Single Step, *Langmuir 22 (2006) 3125-3130.*

MTO student wins national award

On the 26th of April 2006, Master student Bouke Ankoné received the award for the best graduation thesis of 2005 from the national society of engineers KIVI-NIRIA. His work entitled "Fabrication of porous microfluidic chips" yielded him EUR 2500 and a labor contract from outsourcer United Technical Solutions.

Bouke worked in our group on the application of phase separation micromolding (PSμM) for the production of microfluidic devices with integrated membrane functionality. 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. Also fast parallel screening of reactions and reaction conditions is possible. A current focus in this field is on the integration of unit operations on-chip. For this purpose, Bouke developed a procedure to make completely porous chips, where the channel walls could be exploited for (selective) transport of species in- and out of the chip. He demonstrated a proof-of-concept by preparing a micro gas-liquid contactor.

In this device a water flow could be saturated with CO2 that was supplied through the porosity. The phase separation micromolding technology that he used as a basis is simple, cheap, and applicable to many materials. Furthermore, it is possible to tune the porosity by controlling the conditions during the phase separation process. Therefore, Bouke's procedure can be used as a platform for many exciting applications.

According to the jury,"[...] his work is highly relevant to our society. The chip fabrication technology is a leap forwards in chip development. Furthermore, the structure of the thesis was far better than that of the other contributions." Meanwhile, supervisors Jorrit de Jong and Rob Lammertink have published an article in the international journal Lab on a Chip, based on his work .

Bouke currently works at Akzo Nobel in Herkenbosch.

Prize winner Bouke Ankone (left) and supervisor Jorrit de Jong (right)

More information

Rob Lammertink
r.g.h.lammertink@utwente.nl
+ 31 (0)53 489 2063

Literature
J. de Jong et al, *Lab on a Chip 5 (2005) 1240-1247*

Graduations

Ph.D.

Guillo Schrader
Direct nanofiltration of waste water treatment plant effluent,
March 31, 2006

Maik Geerken
Membrane emulsification,
November 9, 2006

Zandrie Borneman
Membrane adsorbers
November 15, 2006

Tymen Visser
Transport phenomena in asymmetric gas separation membranes
November 24, 2006

Jörg Balster
Bipolar membranes
December 13, 2006

Master of Science

Edwin Berends
Confidential
January 21, 2006

Koen van 't Sant
Confidential
February 15, 2006

Joost van Bennekom
Microstructured thin film composite membranes
April 1, 2006

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

layout
W.J.C. van de Ven

email
membrane@utwente.nl

internet & MNT archive
www.membrane.nl

circulation
~500

Introducing...

Microfluidic filtration

Name
Ikenna Ngene
Origin
Nigeria
Contact
www.membrane.nl
+31 (0)53-4892869
j.s.ngene@utwente.nl

Ikenna was born in Enugu, Nigeria. He is 27 years old and a graduate of Microbiology from the University of Nigeria, Nsukka. He holds an MSc. in Biotechnology from Wageningen University.
He worked in the quality control department of Roxy and Park Pharmaceuticals for 2 years and also in the relationship management department of Continental Trust Bank for 1 year.
Ikenna started his PhD. in January, 2006 and will be working on applying the principles of microfluidics in membrane filtration.

Development and scale-up of capillary electrochromatography

Name
Karina Kopeć
Origin
Poland
Contact
www.membrane.nl
+31 (0)53-4893474
k.k.kopec@utwente.nl

Karina is a new 25-years old PhD student from Poland. She started her studies in Poland, Cracow and finished in Germany, Muenster, obtaining double German-Polish diploma and degree M.Sc. in Chemical Engineering. As a Masterstudent she worked for half a year in the R&D laboratories of Gambro Dialysatoren, Germany. Her PhD project, which started in January 2006, relates to Capillary ElectroChromatography (CEC). She aims to fabricate polymer fibers with fine porosity, which can be applied in CEC and then to scale-up this separation technique developing a massive CEC.

NanoMembranes against Global Warming

Name
Sander Reijerkerk
Origin
The Netherlands
Contact|
www.membrane.nl
31 (0)53 4892957
s.r.reijerkerk@tnw.utwente.nl

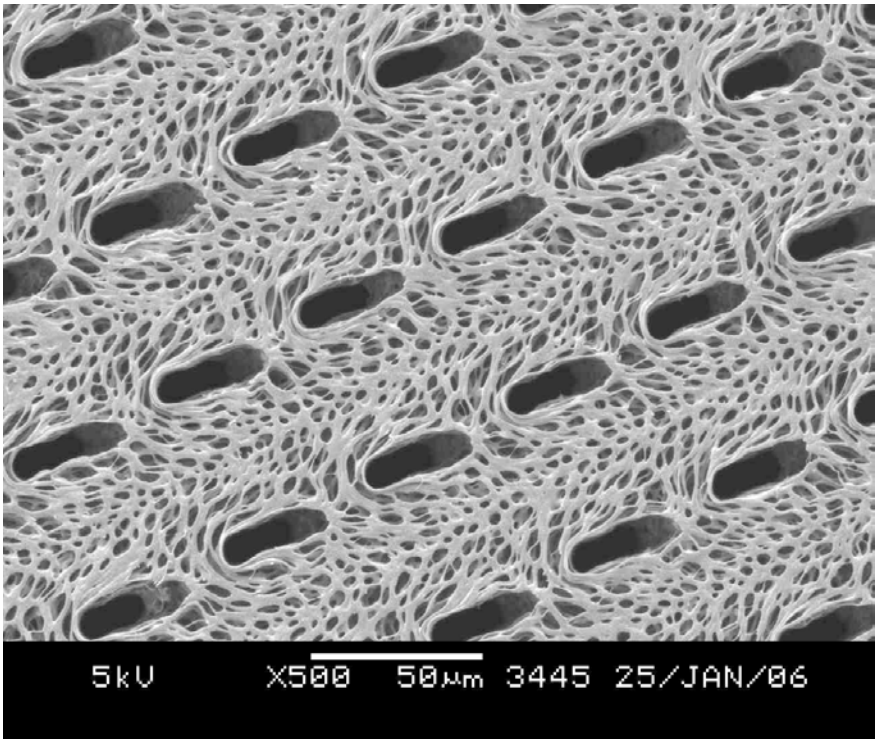
On the 15th of June Sander Reijerkerk joined the membrane technology group to start his PhD. He studied Chemical Engineering at the University of Twente. In his project he will work on gas separation membranes for the reduction of CO_2 greenhouse gas from flue gas. His aim is to develop and prepare cheap, high flux, polymeric diffusion transport membranes that selectively remove CO_2 or CO_2 and water by nanofunctionalization of cheap base materials.

Gas separation in a membrane contactor with ionic liquids

Name
Katja Fischbein
Origin
Germany
Contact
www.membrane.nl
+31 (0)53-4892961
k.fischbein@utwente.nl

Katja is a new PhD-student from Germany. She is 25 years old an d she studied Chemical Engineering/Chemical Processing at the University of Applied Science in Münster, Germany. After graduating she started in the middle of March her PhD project, dealing with the separation of CO_2/CH_4 and olefin/paraffin in a gas/liquid membrane contactor with ionic liquids.

picture of the month 'Slit shaped perforations'



Slit shaped perforations with pores around it showing great respect for their big brother. This happens when the membrane is not easily released from a mold, and only by force we can lift off the film. *Picture by Antoine Kemperman and Erik Rolevink*

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

Batavierenrace 2006

The membrane technology group has again participated in the world's longest relay race from Nijmegen to Enschede.

The first Batavierenrace was organized in 1972 by a group of students from the University of Nijmegen. The name of the race refers to the route the Batavians took in 50 b.C. They sailed down the river Rhine from Nijmegen to Rotterdam. The first race followed the original route. However, for infrastructural reasons, the route was changed for the second edition and has remained basically the same for the next races. The starting point is still Nijmegen, the finish however is on the campus of the university of Twente. The 185 km long trail follows a diverse route through the hills around Nijmegen and then moves through Germany to finish in Enschede. The race is divided in 25 stages, ranging from 3.6 to 12 km. This year marked the largest amount of participants in the history of the race: 321 teams and 7,500 runners participated in the race. The membrane technology group has a history of participation. It is one of the few research groups that has its own team. Although the Membrane Runners never end-up high in the rankings, few people are trained athletes, the combined effort of the group shows the unity of the group and the ability of membranes to promote people's health in a very direcy way.!

Before the race, the team of 25 runners is split into three groups. The three groups, the night, morning and afternoon team, travel in minibuses to the starting point of the different stages. For safety reasons, the runner is always accompanied by one other person of the team on a bike.The biker is responsible for the right directions, water and mental support.
This year's edition of the race had a rough start. Shortly after the starting signal of the race, at midnight in Nijmegen, an accident took place on the route. No one of the participants was involved in this, but it delayed the race for a few hours and the first two stages were left out of the ranking. The night team finished at about 7 in the morning, where the morning team took over. At around noon, the afternoon team started for the final stages.

Overall, the membrane technology grouped finished on the 227th position. Our fastest runners were Rob Lammertink and Alisia Peters.

After the race, the accomplishment was celebrated with a very nice barbecue at Greet's place!

This event would not have been possible without the aid of our sponsors. The Membrane Runners would like to express their gratitude to E. Roesink of X-Flow B.V., B. Krause of Gambro Dialysatoren GmbH, and K. Nijmeijer and A. Kemperman of the European Membrane Institute for making this event possible!