2017 summer

Membrane News Twente

Membrane Science & Technology

News magazine of the Membrane Science and Technology Cluster
MNT, p/a University of Twente - TNW/MTO
PO Box 217 , NL-7500 AE Enschede, Netherlands
membrane@utwente.nl - www.utwente.nl/tnw/mtg
Telephone: +31 (0) 53 489 2950

Welcome

A warm welcome to the newsletter of the Membrane Science and Technology Cluster. In this newsletter, we pay tribute to Prof. Ton Burggraaf, who passed away in February of this year. Ton was a pioneer in the field of inorganic membrane science, with long and distinguished academic career. As a professor in Inorganic Material Science (1969-1994), he performed ground breaking work in the field of inorganic membranes, and even after his retirement he remained active and interested in the field. On the 3rd of February of this year he even still participated in the Membrane Science and Technology open day, being very interested in the recent formation of the MST cluster. Many more details about Ton and his career can be found on the next page, but it can be clear that Ton will be sorely missed, both as a scientist and as a person.

Naturally, there is also much more positive news from the MST cluster. In a period of just two weeks' time (2-15 June) there were as many as three inaugural lectures at the University of Twente where research on membranes played a major role. This included on the 2nd of June, Prof. Willi Meulenberg, head of Gas Separation Membranes at the IEK-1 of Forschungszentrum Jülich, who was recently appointed as professor in the field of ion conducting membranes within the Membrane Science and Technology Cluster. In his inaugural lecture, Prof. Meulenberg painted a picture of the future of dense ceramic membranes, highlighting the strength and the potential of the cooperation between Jülich and Twente. On the 8th of June, Prof. Dimitrios Stamatialis, appointed as Professor of (Bio)artificial organs, held his inaugural lecture. While Prof. Stamatialis is not an official part of the MST Cluster, his work on kidney dialysis membranes is a real inspiration to our cluster and we congratulate him wholeheartedly.

And finally, on the 15th of June, Prof. Walter van der Meer held his inaugural lecture, highlighting the big role that membranes can play in the delivery of pristine drinking water.

In this newsletter, you will further find an overview of promotion ceremonies and a more in depth scientific insight into the expertise of the Soft Matter, Fluidics and Interfaces group (SFI) of Prof. Rob Lammertink.

We invite you to read this newsletter and hope you will enjoy it. In case you have additional questions or you would like to receive further information or publications, please feel free to contact us at MSTtnw@utwente.nl or +31 53 489 2950.

On behalf of all members of Membrane Science and Technology at the University of Twente, we would like to wish you pleasant holidays!

Members of the MST cluster during the safety day (Dated: 3rd July 2017).

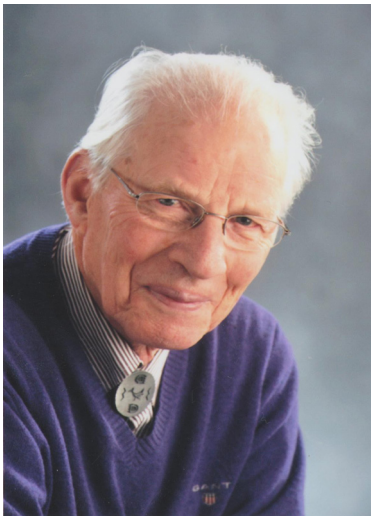
In Memory of Ton Burggraaf (1931 - 2017)

The membrane community lost a pioneer in inorganic membrane science, Professor Anthonie Jan (Ton) Burggraaf, who passed away on Saturday, February 11, 2017 in Enschede, the Netherlands.

Ton Burggraaf was a member of the World Academy of Ceramics and an honorary member of the Dutch Ceramic Society. He obtained the Leo Stuijts award in 1991 at the second conference of the European Ceramic Society (Augsburg).

Ton had a long and distinguished career in academia. After receiving his MSc at the Delft University of Technology in 1958, he worked on glass and glass ceramics at Philips Research Laboratory for several years. In 1965 he defended his PhD dissertation at the Eindhoven University of Technology: '*The mechanical strength of alkali-aluminosilicate glasses after ion exchange*'. In 1969 he was appointed as professor in Inorganic Materials Science at the University of Twente. Ton published more than 300 scientific papers, several book chapters, and many patents in the areas of ferroelectrics, oxygen-ion and mixed conductors, ceramics with special mechanical properties, and inorganic membranes. He was one of the founding fathers of inorganic membrane science, and because of this pioneering work, inorganic membranes are now regarded as one of the major classes of membranes for separation and chemical reaction processes.

In the field of membranes, Ton performed groundbreaking work on inorganic membranes back in the 1980-1990's. He was the first to illustrate the formation mechanism as well as the structural and transport properties of sol-gel derived mesoporous alumina membranes, which are nowadays the workhorse for inorganic membrane ultrafiltration processes in industry. He was one of the pioneers in sol-gel synthesis of microporous silica membranes and hydrothermal synthesis of polycrystalline zeolite membranes for industrial gas separations. In the same period of time, Ton and his collaborators in Twente also studied gas and vapor transport through mesoporous and microporous inorganic membranes and elucidated both surface flow and capillary condensation mechanisms for gas permeation and separation by inorganic membranes. His work in this area provided the theoretical basis for characterization and applications of mesoporous and microporous membranes for gas separation. Additionally, Ton was a major pioneer in developing mixed-conducting ceramic membranes for oxygen separation and syngas production. Prior to his work, ionic conducting or mixed ionic-electronic conducting ceramics were studied mainly as electrolytes or electrodes for fuel cells or oxygen sensors. It was shown by his group that inorganic membranes, made of a one-phase mixed-conducting ceramic, or ionic-conducting ceramic/metal dual-phases, can offer 100% perm-selectivity for oxygen with high oxygen permeance. This original work led to exponential growth of research in mixed-conducting membranes for oxygen and hydrogen separations in academia as well as in several large industrial efforts on commercializing ionic transport membrane technologies for air separation and syngas production.



The scientific "drive" of Ton Burggraaf can best be summarized by what he said during his Stuijts lecture: "*My colleague and friend Leo Stuijts convinced me of the importance of microstructures and consequently of the importance of technological factors. It has influenced my career in a profound way*" (Journal of the European Ceramic Society, vol. 10, 1992, 245-250).

Ton was a true scholar with a strong interest in science. After his retirement in 1994, he remained interested in membrane science and continued to publish 50 more journal papers. Just recently, on February 3rd, he attended the Membrane Science and Technology open day in Twente, where he showed interest in the recent developments of our cluster.

Ton Burggraaf was not only a passionate scientist and educator, but also a mentor, advisor, friend, and a man of high character. He was a social person with an open, international mind. Ton will always stay in our memory with the highest regard.

(Parts of this text are also published as a Letter to the Editor of the Journal of Membrane Science, 2017).

Soft matter, Fluidics and Interfaces

Within the MST cluster, the group Soft matter, Fluidics and Interfaces (SFI) investigates transport phenomena near interfaces. Membrane processes are to a great extent influenced and often limited by these phenomena. We are approaching this by using experimental techniques that allow to quantify concentration and velocity fields, numerical modeling and theory to fundamentally understand the transport, and design transport intensification strategies.

Fundamental interfacial transport phenomena

Mass transport near interfaces, including membranes and solid catalysts, is of crucial interest concerning the overall performance of a process. We aim to study these transport phenomena on the length scale of the boundary layer itself (typically submillimeter). The use of microfluidic devices has proven to be extremely adequate in gaining knowledge on interfacial transport that is normally not acquired via overall performance parameters (pressure, flux, selectivity). The well-defined flow conditions allow one to extract true and local permeation values, by matching experiments with mass transport models.

A membrane interface is typically not homogeneous, although transport descriptions are often based on this assumption. During gas-liquid membrane contacting like in membrane distillation and oxygenation, the interface consists of gas bubbles and solid interfaces with liquid. This clearly heterogenic interface has direct consequences for the resulting fluid flow along this interface, and thus on the transport through this interface (Proceedings of the National Academy of Sciences, 110(21), 8422–8426 (2013), Soft Matter, 9(46), 11098 (2013)). We have studied the influence of this heterogeneity using precise micro particle imaging velocimetry and fluorescence lifetime imaging, and concluded that the presence of gas bubbles generates an effective slip velocity that enhances the mass exchange.

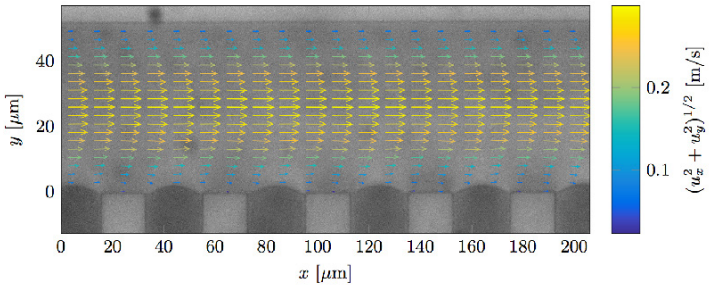


Figure 1. Typical microPIV result providing velocity profiles in a microfluidic channel with gas bubbles controlled on its channel walls.

Ion transport near ion selective interfaces

In polar media, the presence of ions crucially impact the transport phenomena, as seen in electrodialysis, Donnan dialysis, and reverse osmosis. The interplay of ion concentration and potential distribution gives rise to many interesting phenomena. Electroconvection is studied in great detail during electrodialysis processes, under conditions where severe concentration polarization occurs. During so called over-limiting currents, unsteady advective flows are generated by an inhomogeneous electric field and space charge region (Physical Review E, 92(3), 031003 (2015)). Furthermore, the strong concentration polarization phenomena can induce density driven flows as well, resulting in an intriguing interplay of fluid body forces (Physical Review Fluids, 2(3), 033701 (2017)).

We aim to obtain quantitative information regarding the velocity and ion concentration fields. At the length scale of interest, this implies the use of a microfluidic observation platform. Then the integration of a membrane becomes crucial, for which we have developed some strategies. Either use of commercial membranes or in situ fabrication of membrane functionality can be accomplished (Advanced Functional Materials, 26(47), 8685–8693 (2016)).

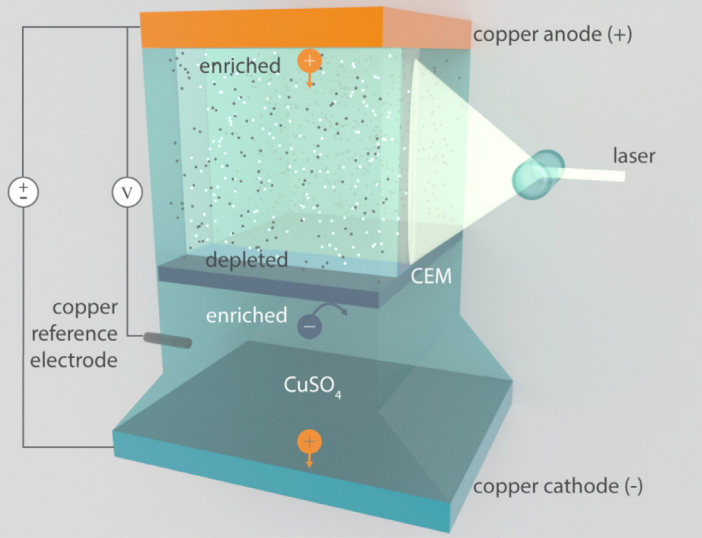


Figure 2. Experimental setup to stuydy advective flows in electrodialysis.

Towards enhanced processes

The fundamental understanding provided by the detailed studies give hints towards improving mass transport limitations via tuning of the interfacial characteristics. For instance, the inclusion of geometric features, or chemical heterogeneity may lead to interface induced transport. In a recent numerical study (https://arxiv.org/abs/1704.07420), we have predicted the flow enhancement that can be expected based on surface flux contrast. Especially in aqueous media, where charge transport plays an important role, significant flow along the interface can be induced by having interfaces of different normal transport next to one another. These flows are a result of diffusio- and electro-osmotic phenomena and give rise to additional mixing in the boundary layer.

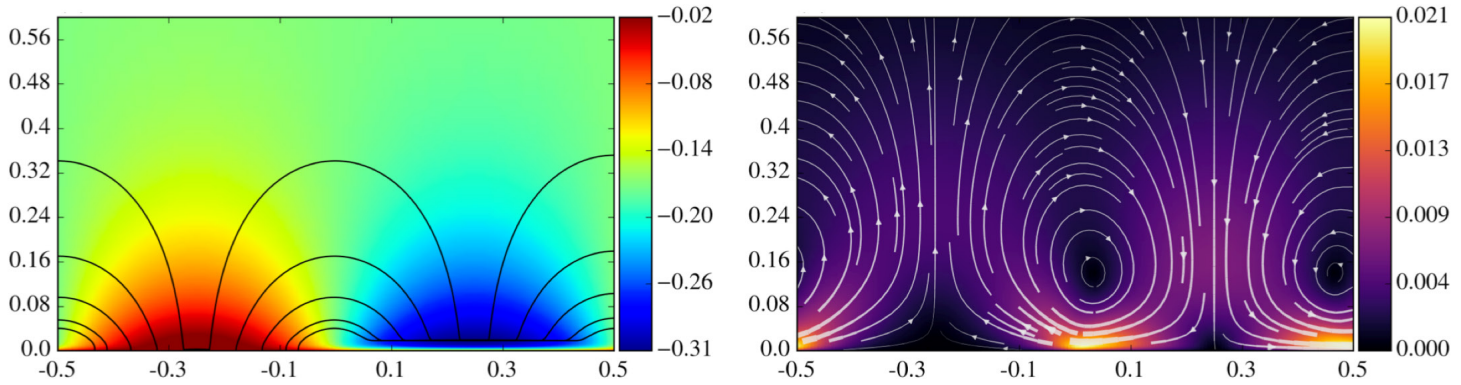


Figure 3. Resulting potential distribution (left, with electrical field lines) and velocity distribution (right, with stream lines) caused by surface flux contrast of protons.

*For more information please contact Rob Lammertink (r.g.h.lammertink@utwente.nl)

News from the Faculty Board UTwente

Prof. Dr. Nieck Benes has been appointed as a member of the Science and Technology Faculty Board.

In a restructuring of the organization of the faculties of the University of Twente, the faculties will be managed by newly formed faculty boards starting from the 1st of September. We are proud to announce that Nieck Benes, head of the Films in Fluids group of the MST cluster, will join this faculty board. In the coming four year he will be responsible for structuring the faculty's activities in teaching and education. Naturally he will also retain his duties as a group leader within the cluster.

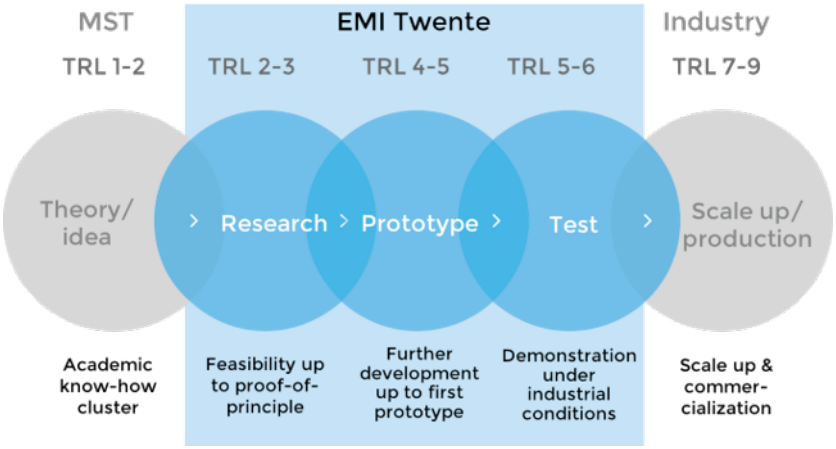
For more information:

https://www.utwente.nl/en/news/!/2017/7/92110/members-of-faculty-boards-appointed-by-executive-board

European Membrane Institute

The bridge between Science and Industry

The road towards commercialization of an innovative idea is long and challenging. How to come to a breakthrough innovation in the relatively young membrane industry? The answer is the EMI Twente! We form the crucial link between science and industry - two worlds we bring together.

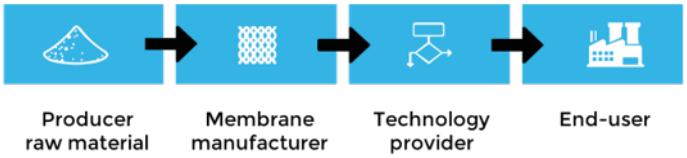


Our team of experienced membrane experts has full access to the innovative know-how, experience and state-of-art facilities belonging to the Membrane Science and Technology research cluster of the University of Twente. In addition to contract research, we can analyze and characterize a wide range of membrane properties, build customized equipment, organize trainings & workshops and have build up a broad experience in consultancy & troubleshooting.

Track record

With whom do we typically work?

We work with any organization within the membane value chain.



We offer confidential, high quality membrane research as an independent research institute and are looking forward working with you!

Did we attract your attention? - Contact us!

Dr. Tymen Visser
Director EMI
Tel.: + 31 (0)53 – 489 5387
E-mail: t.visser@utwente.nl

Inauguration Ceremonies

Prof. Dr. Wilhelm A. Meulenberg

Within the MST cluster, we are pleased to inform you that Prof. Dr. Wilhelm A. Meulenberg has been appointed by the Executive Board of the University of Twente as Professor of Ion Transport Membranes at the Faculty of Science and Technology. Prof. Meulenberg combines this function with his position as head of the division 'Gas separation membranes' at the Institute for Energy and Climate Research of the Forschungszentrum Jülich GmbH, Germany. To mark the occasion of his appointment, Prof. Meulenberg gave an inaugural lecture on the 1st of June, 2017, entitled '*Ceramic Ion conducting membranes membranes for a sustainable European energy system*.' As an experienced lecturer at the RWTH University of Aachen, Prof. Meulenberg gave an inspirational talk on how to make the future energy supply secure and environment friendly, emphasizing on the need of carbon capture in climate-disrupting applications such as power plants and cement industry, but also on the energy storage needed on implementing renewable energy sources like wind and solar power. Special attention was drawn in his inaugural lecture to the highly promising integration of oxygen-supplying Ion Transport Membranes in oxygen-fuel technology processes, and in related membrane reactors, and towards the production of these membranes by different ceramic processing technologies. The knowledge, know-how and expertise in these fields complement research activities of the MST groups Inorganic Membranes (IM) and Electrochemical Research Group (ERG). We, therefore, consider the appointment of Prof. Meulenberg, called Willi by his friends and colleagues, a matter of high privilege and we look forward to a fruitful and successful cooperation. We wish him many success in his new position.

Prof. Dr. Wilhelm Meluenberg before his inaugural lecture on 1st June 2017.

Prof. Dr. Ir. Walter van der Meer

Prof. Walter van der Meer (CEO of drinking water company Oasen) held his inauguration ceremony at the University of Twente on June 15th, 2017. He was appointed a part time professor at the University of Twente as of September 1st, 2016. Since then, he holds the newly-established chair of Membrane Technology and Engineering for Water Treatment (MTEWT). The main goal of his chair is to find better ways to purify drinking water worldwide, using membranes. His chair is part of the Membrane Science and Technology cluster.

One Step Reverse Osmosis

In his inaugural speech, Walter van der Meer introduced a new concept for drinking water treatment based on membrane filtration. The concept titled '*One Step Reverse Osmosis (OSRO)*' focuses on using only one membrane step to remove all known and unknown pollutants from water. In the Netherlands, most of the drinking water is produced using traditional treatment methods, some of them dating back to the 19th century. Although these traditional treatment plants are working fine, some of them consist of more than six steps, depending on the quality of the drinking water source. A driver of the new-established chair now is to introduce a method using only one step: one unit of membranes that removes all known but also all unknown pollutants from the water.

Designing this system that removes all pollutants in one simple step is the professor's primary focus at the UT. "*Now we keep adding new steps to old techniques, some of which date back to the 19th century. We don't use appliances that old in our*

homes, so surely there is a better method for water purification" said Prof. Van der Meer.

While membranes only require pressure (energy) for operation - which can be gained from sustainable resources - traditional methods consume a lot of chemicals and space. Therefore, Walter van der Meer believes that it is the time to move to more advanced and more sustainable membrane based treatment methods.

Prof. Dr. Ir. Walter van der Meer during his inaugural lecture on 15th June 2017.

At this occasion, Prof. Van der Meer expressed, "*I'd like to emphasize that our drinking water now is of very high quality, especially in the Netherlands. However, we might deal with a different situation in the future due to global developments, such as population growth, salinization of drinking water sources, and contamination of our drinking water sources due to intensive agriculture and industrial activities.*" He mentioned that by applying membranes, we will be able to cope with these new threats. *"These membranes work for all types of water: ground water, sea water, surface water and even waste water," explains Van der Meer. "They can remove everything, and so this technology can maintain high quality of water in the upcoming decades. Our cluster at the UT (Membrane Science and Technology) is, therefore, improving existing concepts of water treatment based on membrane filtration, using their fundamental knowledge of membrane materials, processes and applications.*"

Organic Solvent Nanofiltration (OSN): Past and Upcoming Events

5th Organic Solvent Nanofiltration Conference 2015 - Antwerp

6th Organic Solvent Nanofiltration Conference 2017 - Saint Petersburg

7th Organic Solvent Nanofiltration Conference Enschede, May - June 2019

PhD Graduations of the MST Cluster

Dr. Shazia Ilyas

On Thursday the 16th of February 2017, Shazia Ilyas defended her thesis "*Multifunctional Weak Polyelectrolyte Multilayers for Membrane Applications*". Shazia performed her research in the framework of the Erasmus Mundus Doctorate in Membrane Engineering (EUDIME), and her project was a cooperation between 3 universities: The University of Twente, KU Leuven and Université Toulouse III. From the University of Twente she was supervised by Dr. Wiebe de Vos (co-promotor, PI) and Prof. Dr. Erik Roesink (promotor).

During her research, Shazia studied polyelectrolyte multilayers (PEMs) with various functionalities. At the University of Twente, she developed PEM based membranes with a high micro-pollutant retention and a low fouling propensity, that could also be sacrificed to instantaneously clean the membrane. At the KU Leuven, with Prof. Ivo Vankelecom, she tested these same membranes for their performance in solvent resistant nanofiltration applications, showing good performance and high stability in difficult organic solvents. At Université Toulouse III, with Jean-François Lahitte and Pierre Aimar, she studied how to apply PEM layers at module level using an active coating approach. Very impressive is that Shazia managed to perform all her research in just three short years.

Dr. Shazia Ilyas in a taditional Pakistani dress just before her graduation.

The full thesis of Dr. Shazia Ilyas can be found at:
http://dx.doi.org/10.3990/1.9789036542814

Dr. Roberto Floris


Dr. Roberto Floris, relaxing just before his PhD graduation.

Roberto Floris defended his thesis entitled "*Removal of Engineered nanoparticles in drinking water treatment processes*" on the 3rd of March 2017. Roberto performed the work in the Clean Water theme of the NanoNextNL program. His work was mainly performed at water cycle research institute KWR. He was supervised by Dr. Emile Cornelissen (co-promotor) and Prof. Kitty Nijmeijer (promotor).

In his thesis, Roberto investigates the removal and removal mechanisms of engineered nanomaterials and nanoparticles by techniques used in waste water and drinking water treatment, including membrane technology and coagulation-flocculation-sedimentation processes. For this, he made use of nC_{60} fullerene nanoparticles that allowed studies at the required low concentrations of nanoparticles present in the water cycle.

The full thesis of Dr. Roberto Floris can be found at:
http://dx.doi.org/10.3990/1.9783659043217

Dr. Charu Chawla

On March 3rd, 2017, Charu Chawla successfully defended her PhD thesis entitled "*Biofouling in low pressure ultrafiltration modules for Point-of-Use applications*". Charu was supervised by Prof. Dr. Ir. Rob Lammertink (promotor), Prof. Dr. Ir. Kitty Nijmeijer (co-promotor) and Dr. Ir. Antoine Kemperman (co-promotor, daily supervisor).

Dr. Charu Chawla with her proud mother after successfully defending her PhD thesis.

Access to clean and safe drinking water is still a luxury for millions of people, especially in developing countries. Point-of-use (PoU) systems are small membrane based purification units at individual or community level. Like their larger counterparts, also the small units might suffer from (bio)fouling phenomena. Since PoU systems usually are operated discontinuously and at low pressures, the fouling development is fundamentally different from that at continuous, high pressure systems. Charu studied long term fouling development in hollow fiber based ultrafiltration modules, simulating PoU treatment systems. Fouling of the PoU systems is affected by three major factors: operational conditions, feed water quality and membrane properties. Charu looked deeply into these three factors and the consequences for the effectiveness of PoU systems. Amongst others, she found very interesting predator-prey interactions between nematodes and the microbial community on the membrane surface when using secondary wastewater as feed. Despite the presence of biofouling, the hydraulic resistance decreased periodically over time. This could be explained by the presence of nematodes inside the biofouling layer, which used the microbial community as nutrients. As a result, the biofouling layer became heterogeneous and more open.

The full thesis of Dr. Charu Chawla can be found at: http://doc.utwente.nl/103342/

Dr. Joeri de Valença

Dr. Joeri with the promotion committee at the joyous moment of his graduation.

On March 10th, Joeri de Valença defended successfully his thesis entitled "*Overlimiting current properties at ion exchange membranes*". His promotor was Prof. Rob Lammertink from the SFI group and the co-promotor was Dr. Martijn Wagterveld from the Wetsus centre of sustainable water technology in Leeuwarden. The defense had a special and festive atmosphere since it was held at a location in Leeuwarden and was very well attended.

The work presented in this thesis provides the observation and determination of ion concentration polarization (ICP) near ion exchange membranes using simultaneous electrochemical and optical measurements. With fluorescence lifetime image microscopy (FLIM) the local ion concentration was quantified, while with particle tracking and particle image velocimetry (PIV) the local fluid dynamics was quantified. This latter technique was also used for proving that electroconvection supports overlimiting current (OLC) at cation exchange membranes. A new regime of chaotic motion in the electroconvective mixing layer has been observed complementing what was previously described by other researchers. Another new aspect of this work is the observation and classification of the coupling between electroconvection and Rayleigh-Bénard (density driven) convection. Furthermore, the work presented in this thesis quantifies the behavior of the electroconvective vortices at geometrically structured membranes. The fluid motion within the mixing layer is altered due to the surface structures which reduces the electrical resistance within the layer significantly.

The full thesis of Dr. Joeri de Valença can be found at: http://doc.utwente.nl/103679/

Dr. Patrick de Wit

On 30th of June 2017, Patrick de Wit successfully defended his PhD thesis titled "*Funky Inorganic Fibers*". His promotors were Prof. Nieck Benes and Prof. Arian Nijmeijer of the MST cluster. At this occasion, Patrick's family joined him and congratulated him on earning his Doctorate degree from the University of Twente.

His work describes the fabrication and applications of various types of Inorganic Porous Hollow Fibers (IPHF). IPHFs are interesting for various applications that benefit from a high surface-area-to-volume ratio, such as membranes, catalysts, electrodes, or a combination of these. His research outlines a detailed description of the fabrication of highly permeable and mechanically robust silicon carbide IPHF via non-solvent induced phase separation, followed by an intricate thermal treatment at elevated temperatures. Furthermore, he discusses production methods for IPHF that circumvent the use of organic solvents.

A part of his thesis is dedicated to characterization of the mechanical strength of IPHF. His thesis also explores the applications of these fibers, starting with direct electric heating of silicon carbide-carbon fibers that have been functionalized with thermo-responsive poly(N-vinylcaprolactam) (P-VCL) microgels. The permeability and selectivity of these membranes can be adjusted reversibly by controlling the applied electrical power. He also demonstrates the use of alumina IPHF as support material for thin films prepared by interfacial polymerization. Also, suggestions are given for possible routes for further research, focusing on functional fibers and the application thereof.

The full thesis of Dr. Patrick de Wit can be found at: http://dx.doi.org/10.3990/1.9789036543279

Announcements from the MST Cluster

Dr. Nieck Benes's Inauguration Ceremony

Save the date!

You are all invited to the inauguration ceremony of Dr. Nieck Benes on **November 2nd 2017**.

The ceremony will be held on the campus of University of Twente, in building De Waaijer (W2). The program starts at 13:00 hr with a symposium at which four speakers will deliver visionary addresses on academic education, science, leadership, and organization:

- **Rob Lammertink** (https://www.utwente.nl/en/tnw/sfi/people/scientific-staff/lammertink)
- **Berry Nijveld** (http://www.educationandlearning.nl/people/berry-nijveld)
- **Martien Cohen-Stuart** (https://www.knaw.nl/nl/leden/leden/7963)
- **Rianne Letschert** (https://www.maastrichtuniversity.nl/nl/over-de-um/organisatie/college-van-bestuur/prof-dr-rianne-letschert)

At 16:00 hr Nieck will deliver the inaugural lecture with the title "***Content, indeed…***", followed by drinks and bites, and the opportunity to discuss, congratulate, and celebrate.

Please sign up at: https://www.utwente.nl/en/academic-ceremonies/inaugurallectures/registration-2016/benes-sign-up-form/

New MST Members

Industrial Researchers

Dr. Nora Konnertz

Project: Testing and evaluation of organic solvent nanofiltration membranes in industrial processes

Association: Films in Fluids/ European Membrane Institute

Dr. Denys Pavlenko

Project: Investigating commercially available membranes for novel applications

Association: European Membrane Institute

Post Doctoral Staff

Dr. Esra te Brinke

Project: Polyelectrolyte multilayer membranes for micro-pollutant removal

Group: Membrane Surface Science

Dr. Joshua Willott

Project: Advanced membranes by aqueous phase separation

Group: Membrane Surface Science

PhD Students

Elif Nur Durmaz, MSc

Project: "Polyelectrolyte complexation induced phase separation"

Group: Membrane Surface Science

Muhammad Irshad Baig, MSc

Project: "Polyelectrolyte complexation induced phase separation"

Group: Membrane Surface Science

Wouter Nielen, MSc

Project: "Aqueous phase separation for advanced and sustainable membranes"

Group: Membrane Surface Science

Abimbola Ashaju, MSc.

Project: "Stirring boundary layer"

Group: Soft Matter, Fluidics and Interfaces

Arputha Paul, MSc

Project: "Stirring boundary layer"

Group: Soft Matter, Fluidics and Interfaces

MNT- Information

Membrane News Twente is published two times per year and aims to inform the membrane community about the activities of the Membrane Science and Technology cluster of the University of Twente (membrane@utwente.nl www.utwente.nl/tnw/mtg).

Editors
Wiebe de Vos
Elif Nur Durmaz, Muhammad Irshad Baig

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Interested in the latest news of our Membrane Science and Technology Cluster? Follow us and like us on Facebook (www.facebook.com/membranetechnology). There you will find all our most recent publications, PhD defenses, and MSc colloquia, as well as the more social aspects of our cluster. Enjoy!

Follow MST on Twitter!

The Membrane Science and Technology Cluster has its own Twitter account!
Follow @MST_UTwente for the latest news of the MST cluster in a nutshell!