2016 winter

Membrane News Twente

News magazine of the Membrane Science and Technology Cluster
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Membrane Science & Technology

Welcome

A warm welcome to the newsletter of the Membrane Science and Technology Cluster! In our previous newsletter we already informed you of the new much stronger positioning of Membrane Science and Technology (MST) within the University of Twente. The formation of a cluster between the Membrane Science and Technology group, the Inorganic Membrane group and the Soft Matter, Fluidics and Interfaces group have allowed us to share knowledge and infrastructure and to broaden our scope.

Within this new cluster we now have more than 60 people (10 staff members, 10 researchers, 35 PhD students, 3 secretaries and 7 MSc/BSc students) working on membrane materials and membrane processes using inorganic, organic and hybrid membranes. Moreover we study membrane applications ranging from drinking water production, waste water treatment, solvent resistant nanofiltration, gas separation and electrochemical membrane applications.

But don't just take our word for it! In this newsletter we will invite you to come and see this new cluster for yourself. On Friday the 3rd of February 2017, we will hold a "UTwente Membrane Science and Technology Day" were anyone who is interested in membranes is very welcome to join, free of charge. Please find more information further on in this newsletter, and sign up for this event.

But there are many more good things discussed in our newsletter. Our cluster was recently joined by a new part time Professor: Prof. Dr. Ir. Walter van der Meer. Walter, the CEO of water company Oasen, will chair the new research group "Membrane Technology and Engineering for Water Treatment". This appointment helps to strengthen the MST cluster in the field of membrane process technology, and strengthens the ties with the Dutch water drinking sector.

In this newsletter you will further find an overview of promotion ceremonies and awarded prizes, including the highly prestigious ERC starting grant, awarded to Dr. Wiebe de Vos. Furthermore you will find a more in depth scientific insight into the expertise of Prof. Nieck Benes, group leader of the new research group Films in Fluids.

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 and a great 2017!

Dr. Wiebe de Vos

The MST cluster on a visit to Wetsus and the Blue Energy pilot plant on the Afsluitdijk.

Follow MST on Facebook!

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!

An Invitation to the UTwente MST day: Friday 3 February 2017

Since the recent formation of the Membrane Science and Technology Cluster the research on membranes in Twente is intensifying again. Seven individual groups, with a combined total of 60 people, are now working closely together on essentially all major membrane related topics. The European Membrane Institute (EMI) has a new director and is now banded together with all the individual groups. We are proud to present our new cluster to you, on the first

UTwente Membrane Science and Technology Day
February 3rd 2017, University of Twente

The preliminary program of this day is:

10:00 Welcome / coffee and tea

10:30 Presentations of EMI and and principal investigators

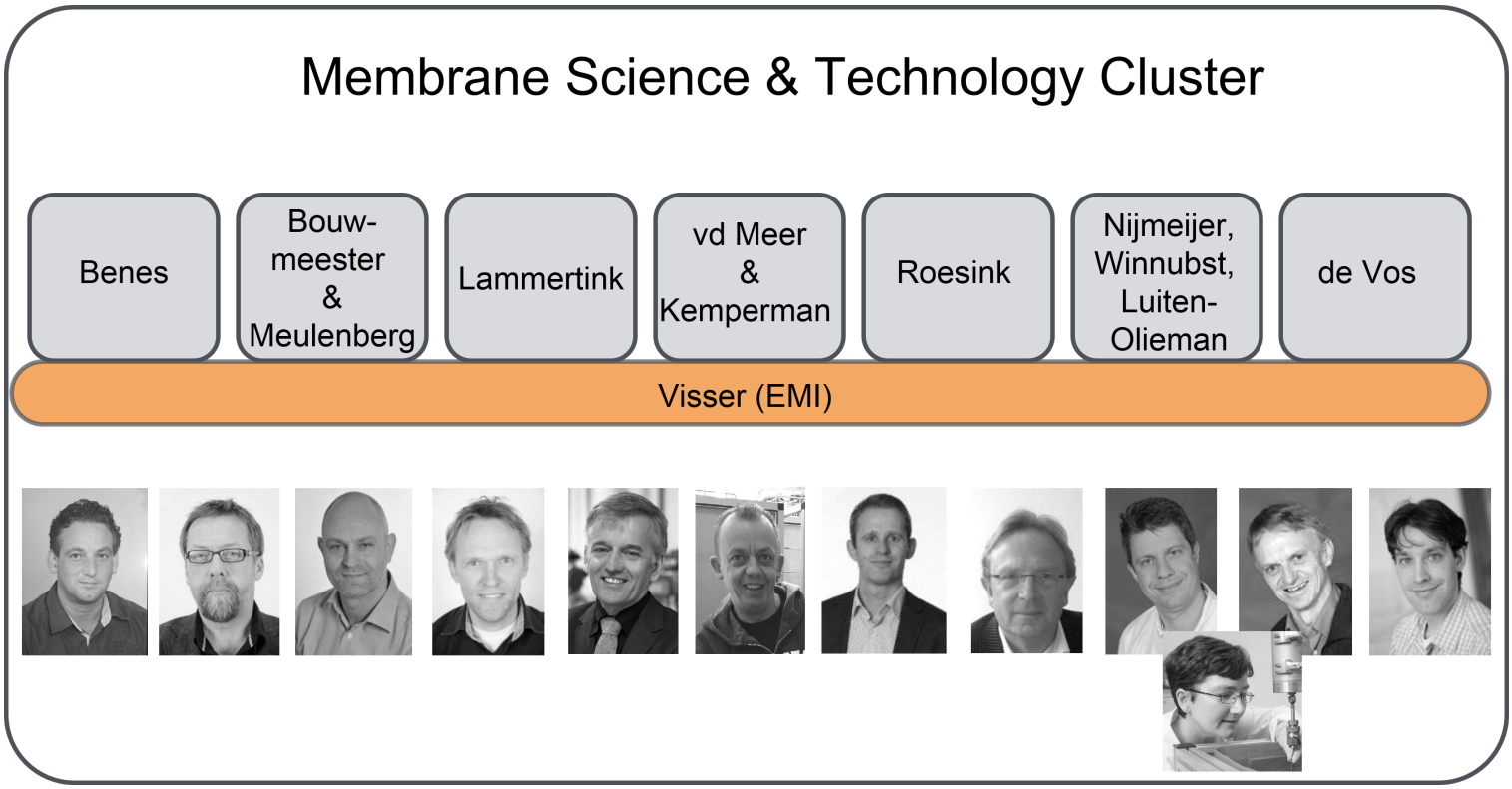
12:30 Lunch

14:00 Lab tours

15:30 Drink and bites

Everyone is welcome, and attendance is free!

For organizational purposes, it is appreciated if you register by sending an e-mail to **n.e.benes@utwente.nl**.



The current staff members of the Membrane Science and Technology Cluster:

Prof. Benes, Films in Fluids (FiF)

Prof. Bouwmeester and Prof. Meulenberg, Electrochemical Research Group (ERG)

Prof. Lammertink, Soft Matter Fluidics and Interfaces (SFI)

Prof. Van der Meer and Dr. Kemperman: Membrane Technology and Engineering for Water Treatment (MTEWT)

Prof. Roesink: Advanced Membranes for Aqueous Applications (AMAA)

Prof. Nijmeijer, Prof. Winnubst and Dr. Luiten-Olieman, Inorganic Membranes, (IM)

Dr. De Vos, Membrane Surface Science, (MSuS)

Dr. Tymen Visser, European Membrane Institute Twente, (EMI)

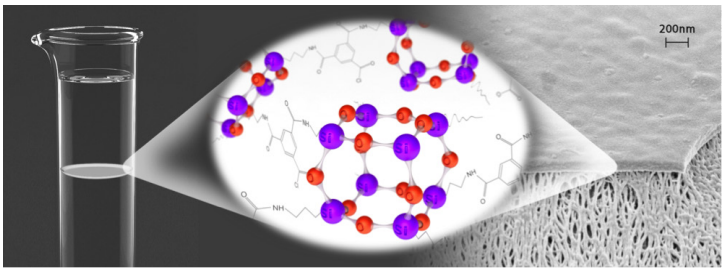
In the spotlight: Films in Fluids (PI: Prof. Nieck Benes)

Films in Fluids

The group **Films in Fluids** aspires to develop membranes for applications that involve demanding conditions. The research of the group combines Materials Science and Process Technology. The focus is on the synthesis of thin (hybrid) films by locally controlled chemistry, the in-situ characterization of thin films in fluids, and the development of multi-scale materials systems.

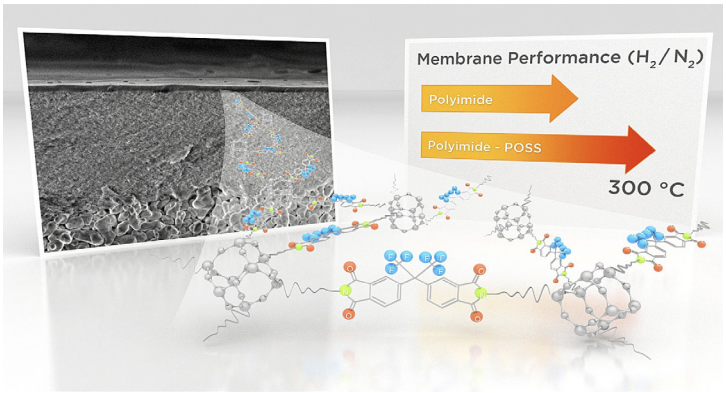
Facile synthesis of thin hybrid (membrane) films by interfacially controlled chemistry

Thin films of advanced materials can be made by localized reactions, typically at the interface between two immiscible liquids. We aim to prepare thin film membranes that outperform existing membranes, via facile and economically viable methods that are compatible with existing technology for large-scale membrane fabrication.



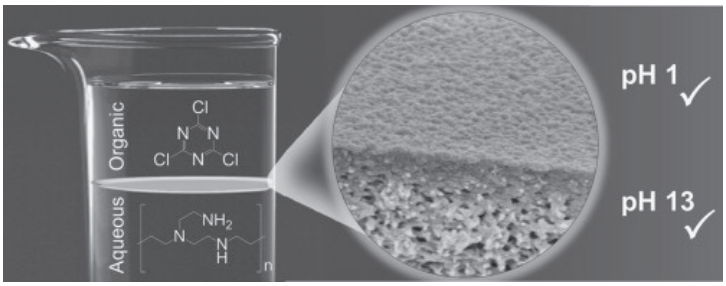
Inorganic-organic hybrid film synthesis via interfacial polymerization.

Examples include inorganic-organic hybrid films that have unique sorption and/or sieving characteristics at extremely high temperature and pressure (*JACS* **136,** 330 (2014), *Chem. Mat.* **26** 3660 (2014)), biological-organic hybrid films that combine catalytic activity with molecular separation (*Angewandte Chem. Int.* **54** 5910 (2015)), highly-dense continuous films of molecular organic frameworks with distinct carbon dioxide sorption behavior (*Chem. Commun.* **50** 11698 (2014)), and polyamine membranes that are exceptionally stable in alkaline conditions (*J. Mem. Sci.* **478,** 75 (2015) / **523,** 487 (2017)).



PolyPOSSimine films that can sieve hydrogen from nitrogen at temperatures up to 300 °C.

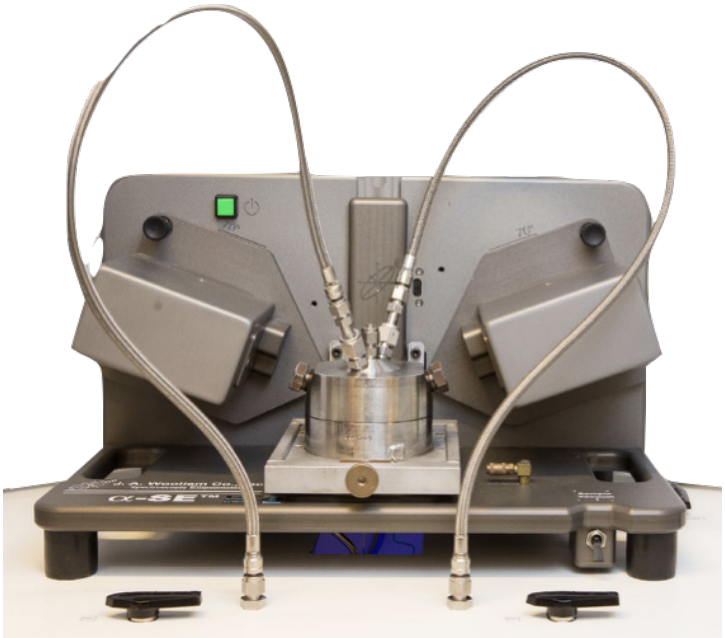
The anticipated application landscape of these membranes characteristically involves conditions that are considered demanding with respect to membrane stability, e.g., high pressure or temperature, and the presence of organic solvents or aggressive chemicals. The current activities are aimed at non-crystalline organic framework thin films, further extending the chemistry of the interfacial polymerization reactions (*Prog. Polymer Sci.* **63,** 86 (2016), assessing separation performance characterization for representative and relevant applications, and bringing selected successful membranes to the market via collaborations with industry. For example, recently the alkaline-stable polyamine membranes developed within FiF have been added to the portfolio of the membrane company SolSep B.V. (The Netherlands).



Interfacial polymerization chemistry for polyamiNe films without the hydrolysis-susceptible carbonyl group of the classical polyamiDe.

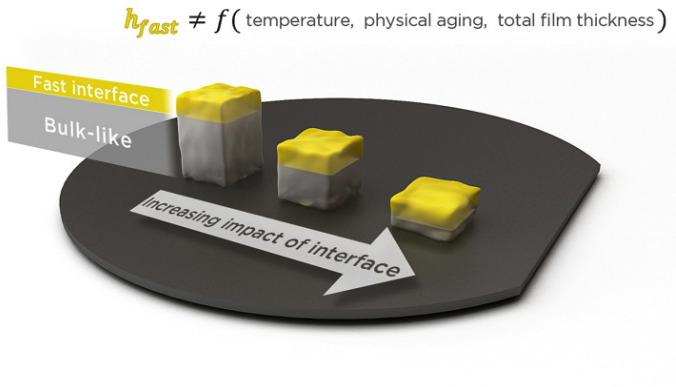
In-situ/operando characterization of thin films in fluids

The properties of (membrane) films substantially change upon exposure to high pressure or temperature, or chemically aggressive environments. Examples of the consequences include swelling and plasticization, chemical degradation, and enhanced physical aging. These effects are manifested by changes in membrane performance. Often the underlying physical and chemical phenomena are derived from these changes in performance. We aspire to, in addition to the general phenomenological approach, investigate the behavior of thin films in fluids *in-situ/operando*. That is, we measure film properties directly under relevant application conditions.



Ellipsometry set-up for in-situ/operando characterization of thin film swelling at temperature up to 200 °C and pressure (differences) up to 2 MPa.

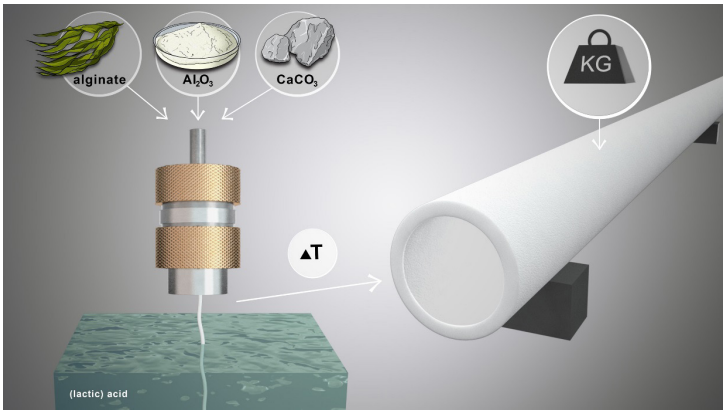
We use a unique collection of techniques, including spectroscopic ellipsometry (SE, 4 dedicated devices), quartz crystal micro-balance (combined with SE) and broadband dielectric spectroscopy to directly study the properties of films in at realistic membrane systems conditions to obtain data that cannot be readily obtained in another manner. (*e.g.*, *Prog. Polym. Sci.* **42,** 42 (2015), *ACS Appl. Mat. & Int.* **7,** 26977 (2015)). This theme has evolved from the PhD thesis work of the chair and was further re-initiated within a VIDI project. Present activities within FiF are focused in particular on organic solvent nanofiltration.



Stratified swelling dynamics of a thin film in an organic solvent; the presence of a 14 nm thick ultra-fast interface has major impact on the swelling behavior of thin films.

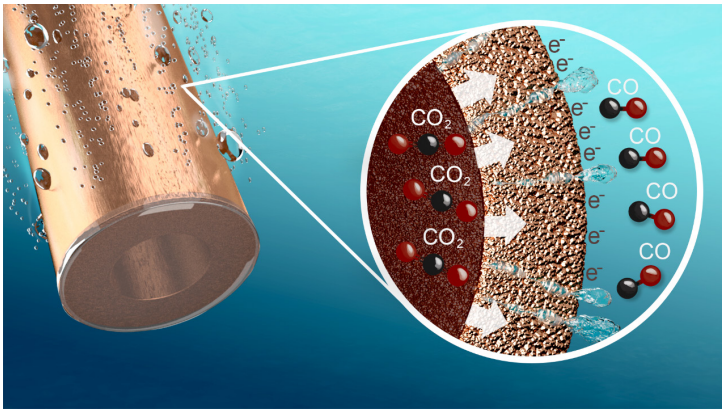
Multi-scale materials systems

We have developed a generic route for large scale production of porous inorganic fibers, consisting of almost any ceramic or metal, with very small (~200 micrometer = world-record) radial dimensions (*J. Mem. Sci* **407,** 155 (2012)), and alternative routes for fabrication of inorganic hollow fibers without the use of organic solvents (*ChemSusChem* **8,** 251 (2015), *ACS Sust. Chem. Eng.* **3,** 3454 (2015)).



Organic-solvent-free route for the fabrication of inorganic hollow fibers, based on bio0ionic gelation of an alginate.

At present, we consider the methods for the fabrication of these fibers as more or less established and now focus our activities on the development of systems and processes that incorporate them. Examples of this include their application as filters, membrane supports, catalytic supports, and microreactors (*J. Mem. Sci.* **381,** 244 (2011)). In a recent study we have demonstrated the high efficiency of copper hollow fibers as electrode in the electro catalytic reduction of carbon dioxide to carbon monoxide (*Nature Comm.* **7,** 10748 (2016)). The next step is to scale this concept up to multi-fiber systems and to evaluate the actual efficiency and economic potential of such systems.



Highly efficient (Faradaic efficience up to 80%, minor hydrogen evolution) electro catalytic reduction of carbon dioxide to carbon monoxide, using porous copper hollow fiber electrodes

For more information, please feel free to contact Nieck Benes (n.e.benes@utwente.nl)

Walter van der Meer part-time professor of membrane technology

Prof Walter van der Meer (57), PhD MSc, CEO of drinking water company Oasen, has been appointed part-time professor at the University of Twente from 1 September 2016. He will hold the newly-established chair of Membrane Technology and Engineering for Water Treatment.

The part-time professorship at the UT means Walter van der Meer works as a professor one day per week, while he works in his position as CEO of drinking water company, Oasen, the rest of the week. Since 2011, he has been professor of Innovative Water Processes at the Delft University of Technology, a position he will discontinue.

Research on membranes

The new chair is part of the research cluster Membrane Science and Technology. In the Netherlands, the research cluster is a leader in the field of fundamental and applied research into the development process and technological applications of membranes in, for example, the water sector.

Drinking water sector

Van der Meer: "The University of Twente offers new opportunities and fits well with the technological challenges associated with the drinking water sector. The drinking water sector is facing major challenges such as climate change, threats to the abstraction of drinking water due to, for example, salination, and the customer's desire to receive pure drinking water out of the tap. Water companies must prepare for these developments. For example, by using modern purification techniques such as membrane filtration."

Walter van der Meer studied Chemical Engineering at the Delft University of Technology. In 2003, he obtained his doctoral degree in Civil Engineering Course at this university. From 2005 to 2011, he was taught as a professor of Membrane Process Technology at the University of Twente. From 2011, he worked as a part-time professor for Innovative Water Processes at the Delft University of Technology. He has been CEO of the drinking water company, Oasen, since 2012.

Prof. Dr. Ir. Walter van der Meer joins the MST cluster. His appointment brings in important expertise in the field of membrane process technology, and helps to strengthen the ties with the Dutch drinking water sector.

Promotions from the MST cluster

Dr. Mustafa Al-Furaiji en Dr. Basma Waisi

September 16th 2016 was an extra special day for the Iraqi couple Mustafa Al-Furaiji en Basma Waisi. On that day both husband and wife received their PhD diploma's for their research into the treatment of produced water. In the recovery of oil a lot of waste water is produced, containing high salt concentrations and small stabilized oil droplets. Here Al-Furaiji focused on the removal of the remaining oil, while Waisi focused on the removal of salts. Their work was performed partly in the Inorganic Membrane group of Prof. Arian Nijmeijer and partly in the Water engineering and Management group of Prof. Suzanne Hulscher, while they also spending time at the University of Conneticut, working with Prof. J. McCutcheon. Mustafa Al-Furaiji en Basma Waisi have now returned to Iraq to continue their research there.

The full thesis of Dr. Basma Waisi can be found under: http://doc.utwente.nl/101035/

The full thesis of Dr. Mustafa Al-Furaiji can be found under: http://doc.utwente.nl/101036/

Dr. Mustafa Al-Furaiji en Dr. Basma Waisi at the UT campus.

Dr. Sander Haase recieves his cum laude PhD diploma.

Dr. Sander Haase

On October 4th, Sander Haase defended successfully his thesis entitled "Transport near Slippery Interfaces" (SFI group, promotor Prof. Rob Lammertink, co-promotor Dr. Jeff Wood). The work described in this thesis involved theoretical, numerical and experimental investigations related to transport phenomena near heterogeneous interfaces. A significant part of the research considered mass, momentum and heat transport in systems containing fixed gas bubbles on surfaces, which act as "slippery" interfaces with little or no friction. Such interfaces can be encountered in, for example, gas-liquid contacting, membrane distillation, and membrane reactors. Sander explored the effect of surface heterogeneity and microscopic geometry on the extent of drag reduction and enhanced mass transport. Using microfluidic experiments, the details of the fluid flow were explored as well, as concentration profiles. This was done by dedicated techniques such as micro particle image velocimetry (microPIV), supported by numerical simulations (COMSOL) and theoretical analysis of the underlying transport phenomena. Sander also carried out studies ranging from the very fundamental to more application oriented: the Graetz-Nusselt problem extended to homogeneous and heterogeneous slip conditions, investigation of the effect of wall slip on the flow of non-Newtonian fluids and collaborating on studies of desalination at the microscale.

The thesis and defense were judged by the committee to deserve the "cum laude", which is strictly reserved for only the top 5% of all theses. *A digital copy of the thesis can be found at: http://doc.utwente.nl/101592/*

Dr. Marcel ter Hove

On November 23, 2016, Marcel ten Hove defended his PhD thesis entitled "Metal doped hybrid silica for hydrothermally stable hydrogen separation membranes". Marcel was supervised by Prof. Louis Winnubst and Prof. Arian Nijmeijer.

The research was carried out within the cluster "Catalysis, Membranes and Separations" (CMS) of ADEM (A green Deal in Energy Materials), which was funded by the Dutch ministry of Economic Affairs. The focus of the project of Marcel was on the development of hydrothermally stable microporous ceramic membranes that can be used in a water gas shift membrane reactor concept. Marcel investigated how gas permselectivity properties of 1,2-bis(triethoxysilyl)ethane (BTESE) solgel-derived membranes could be improved by using metal dopants. Specifically an increased H_2/CO_2 selectivity was observed when a metal-doped hybrid silica membrane is operated under hydrothermal conditions.

The full thesis of Dr. Marcel ten Hove can be found under:
http://doc.utwente.nl/101915/

Dr. Marcel ten Hove

Innovation vouchers for Akvoregia and CoorsTek

Last year the University of Twente launched the Innovation Voucher program, in which 50 vouchers will be awarded in tranches to 50 different SMEs. They are intended to further stimulate collaboration between the knowledge-intensive SMEs and the University. The vouchers have a value of €10K and can be used for necessary training, consulting, facility use or contract research at one of the seven Centers of expertise. The European Membrane Institute Twente (EMI) is one of these Centers of expertise.

In the first two rounds in total 17 vouchers were awarded of which WhiteFox Technologies and BLUE-tec worked together with the EMI. The third round of vouchers closed last October. Within this round two new SMEs working in the field of membrane science and technology received a €10K voucher to work together with the EMI: Capra Ibex Akvoregia BV and CoorsTek Netherlands BV. Akvoregia develops and sells compact smart water treatment installations using polymeric hollow fiber membranes, whereas CoorsTek's key expertise is the fabrication of ceramic porous fibers.

Interested in the innovation voucher program? For more information please contact: Tymen Visser (t.visser@utwente.nl)

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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!

ERC Starting Grant for Dr. Wiebe de Vos

Dr. Wiebe M. de Vos, associate professor Membrane Surface Science at the University of Twente, will receive an ERC Starting Grant to pursue his groundbreaking research in the field of membrane technology.

The researcher of the Membrane Science & Technology cluster of MESA+ will receive a grant of 1.5 million Euro from the European Research Council in order to undertake research into new capabilities of in membranes prepared in water and the new processes that become possible as a result.

The next generation of membranes

The next generation of membranes are created without the use of toxic or harmful solvents, but are prepared completely in water. This not only leads to a more environmentally friendly approach, but it also opens the door to new applications. By varying the properties of the water, such as its pH value, and the used materials, new membrane structures and properties can be achieved.

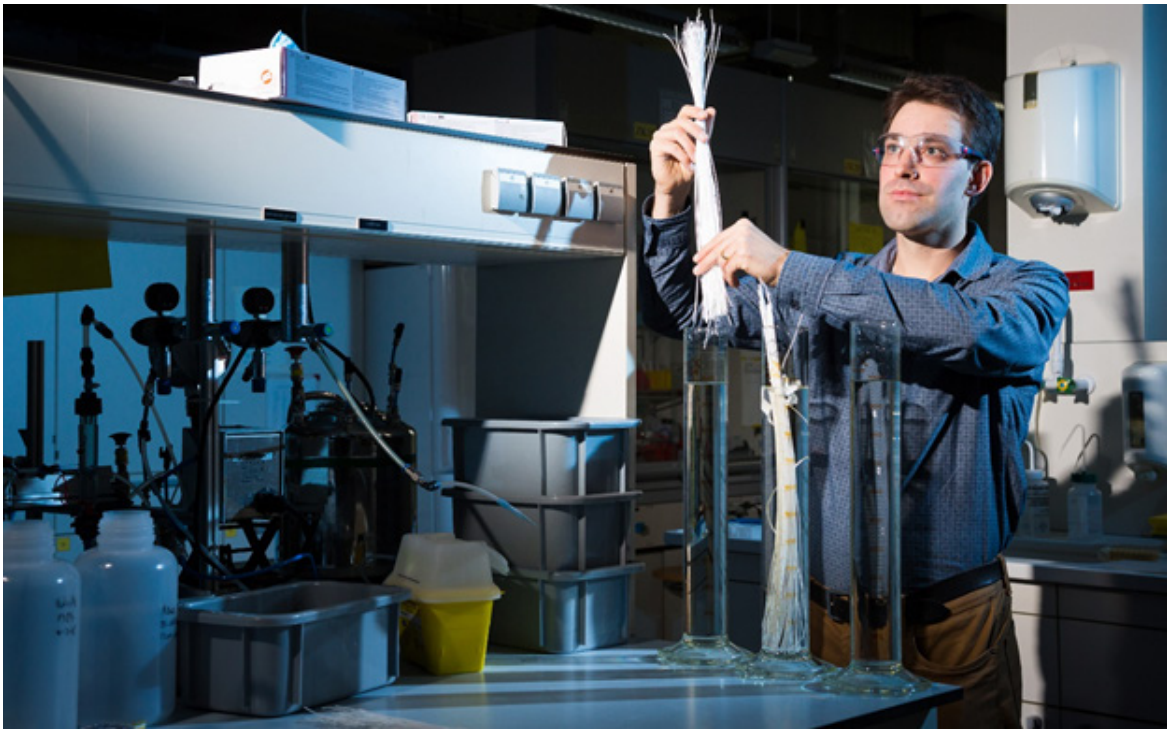
New fields of application are for instance foreseen in the cleaning of waste water, separation of gasses or the desalination of water. “The membranes that we make will show stable performance in organic solvents, which makes it possible to, for example, fractionate light oils”, says De Vos.

Scientific excellence

The ERC Grants are awarded each year by the European Union to researchers who undertake groundbreaking research with a firm base in fundamental research and, at the same time, research with an expected societal relevance. The grant can be used to set up an own research team or programme. Only European researchers who received their PhD a maximum of seven years ago qualify for the grant. There is a strong competition: just ten to fifteen per cent of the applicants for an ERC Starting Grant are successful.

VIDI grant

For De Vos, this is the second large research grant for his membrane research within a short period of time. In May, a VIDI grant was announced by NWO, the Dutch national research organization. “It is a great acknowledgement of the quality of our research and has a great impact on our possibilities for the coming years. It will allow us to make significant progress, both regarding fundamental research and application in practice” says de Vos.



Dr. Wiebe M. de Vos, coating hollow fiber membranes.

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Prizes

Janneke Dickhout wins Business and Development Prize at MESA+ day

At the 2016 MESA+ day Janneke Dickhout was awarded the Business and Development Prize for her poster 'Understanding membrane fouling in produced water treatment'. This award is given to the group or individual that has best represented the impact of their research in the poster. On her poster Janneke describes her research to obtain more efficient separation of water and oil using membrane technology.

For more information: https://www.utwente.nl/mesaplus/archive/!/2016/9/192960/prizes-awarded-at-mesa-meeting

Jordi Moreno at the prize ceremony

Jordi Moreno wins Marcel Mulder special award for partnership

On the recently held Wetsus external conference (3-4 October 2016), Jordi Moreno was awarded the Professor Marcel Mulder special prize for excellent partnership. Jordi won his price for the efforts he does for advancing real life Blue Energy. Jordi Moreno is a fourth year PhD student of MST on Blue Energy, the technology to harvest electrical energy from mixing salt and sweet water (salinity gradient power, or 'Reverse Electrodialysis', RED). After several years of research in laboratory and at pilot conditions, the first full-scale RED plant has been constructed at the Afsluitdijk, where the water from the IJsselmeer and the Wadden Sea meet each other. Jordi is working with the industrial partners in his project to tackle problems like membrane fouling and the negative effects of multivalent ions present in natural feed waters.

Janneke Dickhout with prize

Krzysztof Trzaskus wins 'Best PhD paper of the year 2016' award of the Twente Water Centre.

During the 2016 Twente Water Week Krzysztof Trzaskus was awarded for his paper 'Towards controlled fouling and rejection in dead-end microfiltration of nanoparticles – Role of electrostatic interactions' in the Journal of Membrane Science. A jury choose the winning paper among four nominated papers. The other nominees were Cesar Casiano Flores, Joep van der Zanden, and Abebe Chukulla. Though the jury observed that all papers could have won the price, in the end they awarded Krzysztof Trzaskus for his paper and inspiring presentation.

The Twente Water Centre 'Best PhD paper of the year' aims to promote interest in PhD research in water. Additionally it emphasizes the importance of publishing research findings in early stages of the academic careers of PhD candidates.

The process of pre-selecting nominees and papers is taken care of by the Scientific Program Committee of the Twente Water Centre.

The winning paper can be found at the UT publications Website or via Science Direct at dx.doi.org/10.1016/j.memsci.2015.06.047.

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).

Editor
Wiebe M. de Vos