2017 winter

# Membrane News Twente

Membrane Science & Technology

News magazine of the Membrane Science and Technology Cluster
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## Welcome

A warm welcome to the newsletter of the Membrane Science and Technology Cluster. In this year we have seen the membrane cluster grow even stronger, with many new PhD students, postdocs and technicians joining our ranks. In this newsletter, however, you will see that we are now also looking for more senior talent. We have opened a position for a new group leader within the cluster, preferably around the theme of "Membrane Process Technology". If you think that this could be you, please continue reading.

A growth in seniority within the cluster was also very apparent from the recent inaugural lecture of our Professor Nieck Benes, head of the Films in Fluids research group. Not only did the lecture showcase the strong scientific work of Prof. Benes and his group, it also highlighted some excellent discussion points related to teaching and organization within the university. The inaugural lecture of Prof. Benes was the third inaugural lecture within the MST cluster this year, with Prof. Willy Meulenberg and Prof. Walter van der Meer preceding him (see newsletter summer 2017).

We are also very proud to announce that the MST cluster will organize the 35th European Membrane Society (EMS) Summer School. It will be held from 24th - 29th June, 2018, with the overall theme: '*From Fundamental Concepts Towards Commercialization of Membranes*'. Please find more information in this newsletter, but more importantly make sure to attend this stimulating event!

In this newsletter, you will also find a full report of the MST cluster study trip to Denmark. From September 18 - 21, about 50 participants from the MST cluster visited membrane related companies and academic institutions. These visits lead to the exchange of knowledge and ideas, and for many of our younger cluster members, it was the first time to see membranes being produced and used at industrial scales. A very inspiring trip!

In this newsletter you will further find an overview of new cluster members and a more in-depth scientific insight into the expertise of the Membrane Surface Science group (MSuS) of Dr. Wiebe M. de Vos. Moreover, you will find details of an upcoming collaboration between the MST cluster and the Islamic University of Gaza (Palestine).

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 2018!

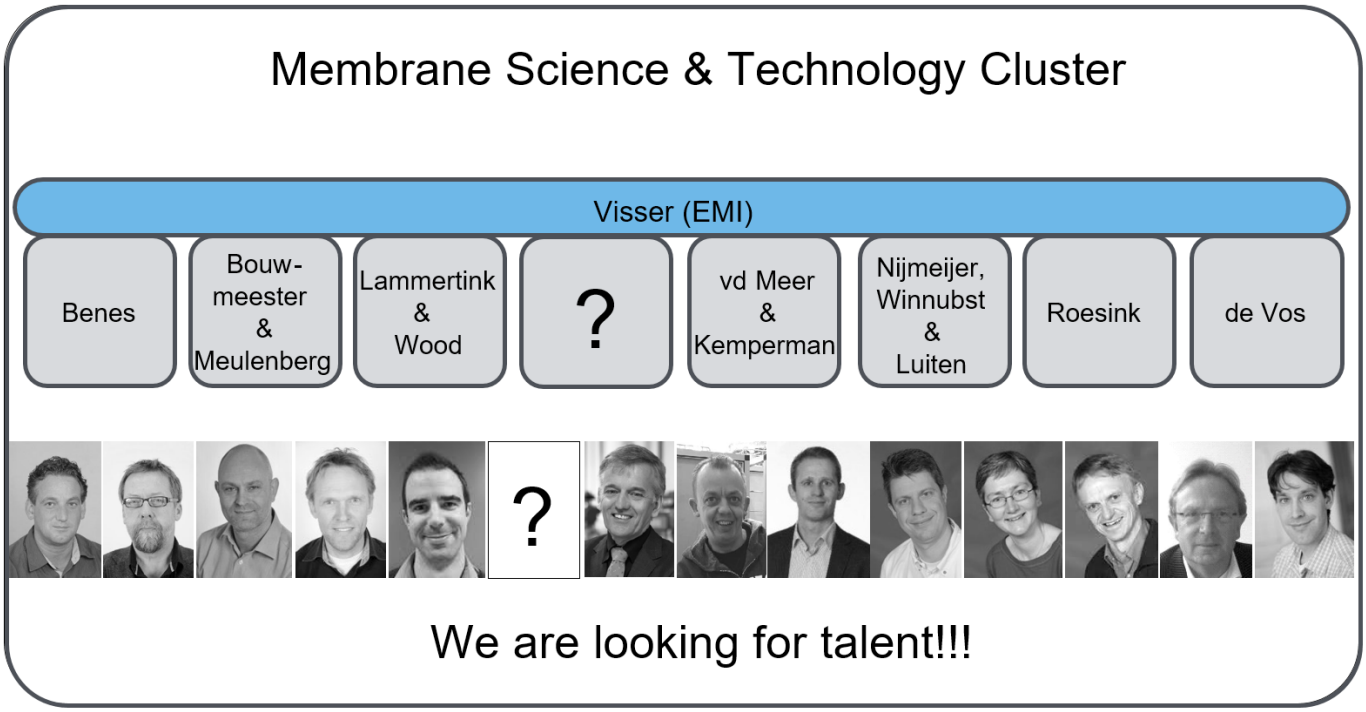
*A part of the group posing for a picture in the sunny Copenhagen.*

# WANTED

## A new group leader within the cluster

Over the last year, the Membrane Science and Technology cluster has grown substantially, with many new PhD students, postdocs and technicians joining our ranks. But currently, we are advertising for something special, a new group leader within the Membrane Science and Technology cluster.

The MST cluster aims to strengthen itself with a full-time staff member in the field of “Membrane Process Technology”. The new staff member will be able to start an independent research group within the cluster and will have full access to the already established strong infrastructure of the cluster and the university. This position is open to junior and senior academics, depending on the experience and track record of the candidate.




Specifically, the MST cluster is looking for a high potential or already established leader in the field of membrane process technology. We are looking for a real innovator, with fundamentally new concepts in process engineering and design relevant to current challenges in membrane technology. Keeping in mind the career stage, the candidate should have an excellent track record in publications, funding and contributions to national and international conferences. Moreover, the candidate should possess good teaching skills and affinity, and be highly motivated to transfer knowledge to a younger generation. Preferably, the candidate utilizes both experimental and theoretical tools to study and/or design novel processes involving (but not restricted to) membrane technology. Ideally, the studied processes can be connected to applications already studied within the cluster, including wastewater treatment, drinking water production, gas separation, organic solvent nanofiltration, and membrane reactors.

For more information, please visit the UT vacancies website.

# 35th EMS Summer School (24th - 29th June, 2018)

The Membrane Science and Technology Cluster is very proud to announce that the 35th European Membrane Society (EMS) Summer School will be held at the green campus of the University of Twente in the period **Sunday 24th - Friday 29th June, 2018**. The theme of the Summer School is '*From Fundamental Concepts Towards Commercialization of Membranes*'.

Our aim for the Summer School of 2018 is to show the participants not only the broad range of academic research activities of our University in the field of membranes but also to make them aware what it takes to translate a fundamental concept into industrial reality. The program consists of five sessions all related to our current and future global challenges (e.g. availability of potable water, energy demand, healthcare) in which membrane technology could have major contributions. Each of these sessions reflects a specific range of membranes or membrane applications in which our academic researchers at the University of Twente are active, ranging from porous membranes to dense membranes, from polymeric to inorganic based membranes, membranes dealing with ion transport and membranes in the medical field (e.g. artificial (bio)organs).

Besides the various internal speakers from our University, we have invited several interesting speakers from industry who are closely connected to our research cluster. To demonstrate the process of bringing a concept towards a commercial application, we have arranged excursions to companies in the region.

For more information, please visit: https://www.utwente.nl/en/tnw/mtg/events/

*An aerial view of the beautiful and green UT campus.*

# Membrane Surface Science

Each newsletter we highlight the research within a single scientific group inside the MST cluster. In this newsletter, we take a closer look at the Membrane Surface Science (MSuS) group, headed by Dr. Wiebe M. de Vos.

For many membranes and membrane processes, it is the outer few nanometers of a membrane surface that determine critical performance parameters such as selectivity and fouling. Within MSuS, we aim to understand and control the interactions at the membrane surface for improved performance, but also to create additional functionalities. The focus is on polymeric membranes and the application of polymeric coatings for various functional enhancements. These include anti-fouling, enhanced separations, easy-to-clean membranes, and virus inactivation. Typical coatings include polymer brushes, polyelectrolyte multilayers and thin layers of self-assembled diblock-copolymer. Moreover, a strong driver for the group is the desire to make membrane technology more sustainable. Membrane materials are prepared under completely aqueous conditions, without utilizing the unsustainable and toxic organic solvents that are usually required.

The group is built on the expertise and vision of Associate Professor Wiebe M. de Vos and combines the more fundamental fields of physical chemistry, surface science and polymer science with the more applied field of membranes. The research within the group is split between three distinct but strongly related research lines: 1. Interactions at the membrane surface, 2. Membrane coatings and 3. Advanced membrane materials. Here we provide a short overview of research within these research lines.

**Interactions at the membrane interface**

In complex feed mixtures such as surface waters, biological systems, and industrial waste waters it can be very difficult to understand and predict membrane performance. A key example is produced water, that contains oil droplets, surfactants, salts, inorganic particles and dissolved organics (e.g. benzene, toluene). Membrane Technology is a very promising technique for the treatment (cleaning) of such produced water, but fouling and insufficient oil rejection

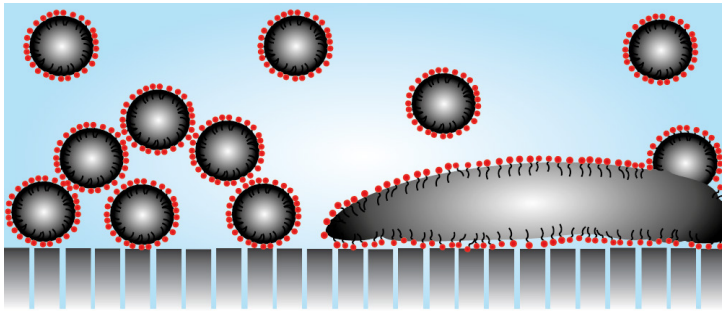


*Figure 1. Schematic picture of well stabilized (left) and poorly stabilized (right) oil droplets at the interface of an ultrafiltration membrane.*

are common problems. The complexity of such systems can be overwhelming, but by using well characterized feed streams and careful experiments, it does become possible to understand the major effects that are playing a role. For example, well stabilized oil droplets will form an open cake layer (figure 1, left side) while poorly stabilized droplets will form an oil layer blocking the porous structure (figure 1, right side). Clearly, the oil droplets are the main fouling agent, but the chemistry of the water (surfactants, salts, pH) determines the fouling severity (*Dickhout et al. 2017, JCIS, 487, 523-534*).

**Membrane coatings**

A coating can provide a membrane new separation properties and can allow an ultrafiltration membrane to become a nanofiltration membrane (*Grooth et al. 2015, JMS, 475, 311-319*), or allow a microfiltration membrane to remove viruses (https://www.utoday.nl/science/64543). But within MSuS, we always strive to create coatings that are multifunctional, for example, coatings that provide the desired separation properties while at the same time leading to anti-fouling, responsive and/or easy to clean membranes (*Ilyas et al. JCIS, 446, 386-39*). Another important driver for the group is the development of novel NF/RO type membranes specifically designed for the removal of so-called micropollutants (figure 2). These are small organic molecules (100-1000 Dalton) that stem from industrial, medicinal and agricultural waste, and that can damage the environment and human health already at very low concentrations. For these coatings, we apply self-assembly of oppositely charged polyelectrolytes at the interface of a porous support membrane. In this so-

called Layer-by-Layer assembly, the support membrane is alternatively exposed to polycations and polyanions, to build polyelectrolyte multilayer's (PEMs) of controllable thickness. A large advantage of this approach is that the properties of the PEM layer, responsible for the separation properties of the membrane, can be tuned by choice of polymer and by the employed coating conditions such as pH and ionic strength. This method thus allows the design of a membrane truly optimized towards micro-pollutant removal, while, for example, still allowing small ions to permeate (*Ilyas et al. 2016, JMS, 537, 220-228*).

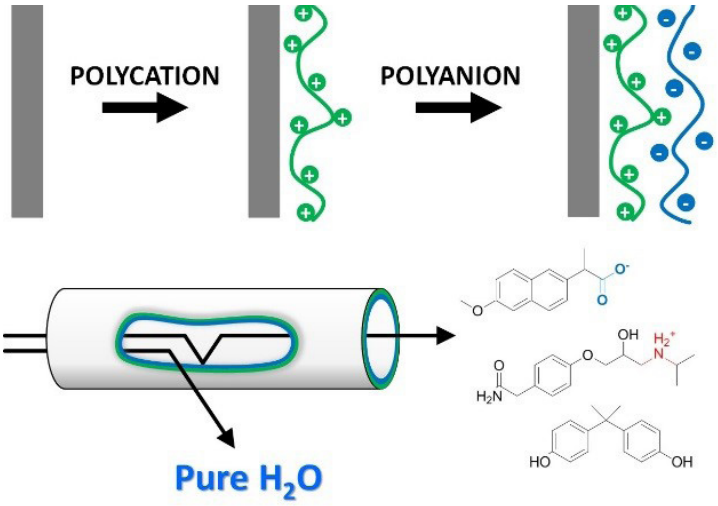



*Figure 2. A polyelectrolyte multilayer on the inside of a hollow fiber UF membrane provides it NF/RO type separation properties to remove small organic molecules.*

**Advanced membrane materials**

Under the right conditions, membrane formation and membrane functionalization can be attained in a single step. For example, the use of diblock-copolymer self-assembly for membrane fabrication not only leads to very uniform pore sizes (figure 3a), but membranes can be made responsive to pH and temperature by choice of the right block-copolymer. Control over the exact composition of the solvent during membrane casting provides further control over the membrane structure (*Vriezekolk et al. JMS, 2016, 504, 230-239*). But controlled precipitation of responsive polymers is also a highly promising method to create novel membranes completely from water. In figure 3b, we show an example of a porous membrane prepared completely under aqueous conditions. The membrane retains a responsive nature. Clearly organic solvents are not always required to obtain promising membrane structures.

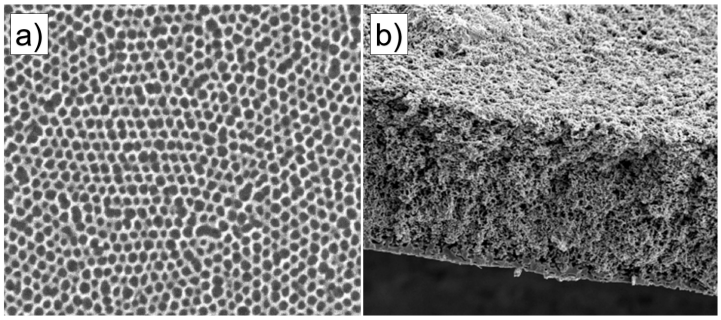
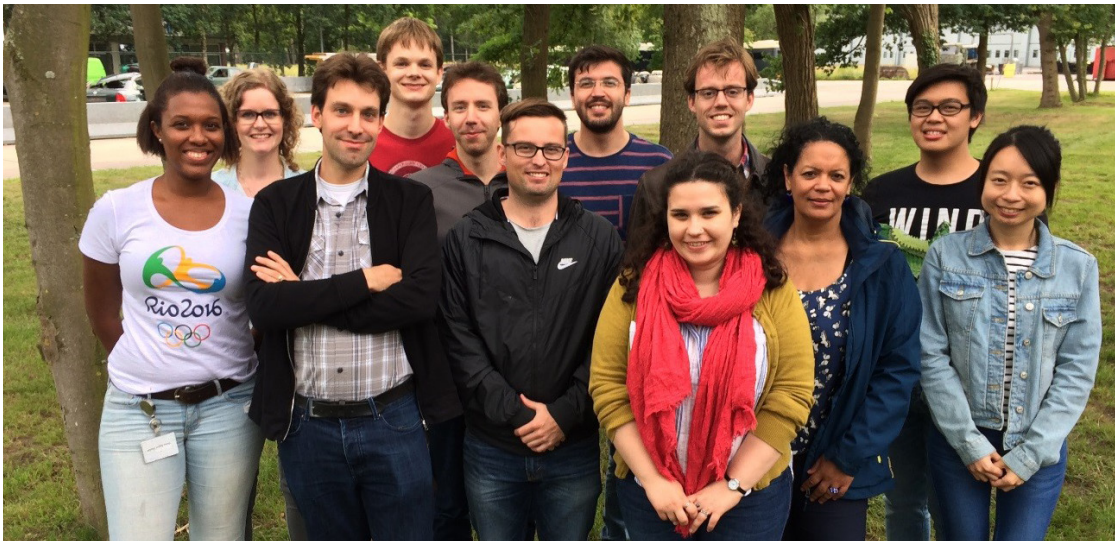



*Figure 3. SEM images of membranes. a) Uniform pore size of membrane achieved by diblock-copolymer self assembly, b) Porous membranes prepared under aqueous conditions.*

A more detailed description of the current research projects can be found at the group's website: www.utwente.nl/msus. For more information, feel free to contact w.m.devos@utwente.nl.




*Some members of the MSuS group during the Safety Day.*

# Inauguration Ceremonies

## Prof. Dr. Nieck E. Benes

We are pleased to inform you that Prof. Dr. Ir. Nieck E. Benes has been appointed as Professor of the Films in Fluids (FiF) group at the Faculty of Science and Technology of the University of Twente on January 1st, 2017. To mark this occasion, Nieck delivered his inaugural lecture on the 2nd of November 2017, which was preceded by a visionary symposium on academic education, science, leadership, and organization.
Close friend and colleague Prof. Dr. Ir. Rob Lammertink, full professor in the Soft Matter Fluidics and Interfaces (SFI) group, opened the symposium with an inspiring talk on clustering science, taking the Membrane Science and Technology (MST) cluster as an example. He emphasized the importance of training and education to approach problems correctly and the importance of context and synergy to approach the correct problems.

*Prof. Dr. ir. Nieck Benes at his inaugural lecture on 2nd November, 2017.*

A provocative vision on education was provided by the second speaker, Drs. Berry Nijveld; consultant and designer of education and people development. In his talk, Nijveld emphasized that the intrinsic motivation of students is the key factor in the learning process and such motivation is driven by autonomy, relatedness and competence/capability. Another important factor is the drive to create things. In order to be creative and to learn, we should never stop playing. In that sense, students need a challenging playground. Nijveld feels that we can improve the learning process of our students by making sure that education becomes more thrilling!

The academic viewpoint (and view on academics) for this symposium came from Prof. Dr. Martien Cohen Stuart. He provided the audience with an overview of the motives and common assumptions regarding academic research. Furthermore, he reviewed the current funding system and pointed out his worries about the loss of collaboration and trust caused by this way of funding. At the end of his talk, Cohen Stuart stated that research should keep the society up-to-date and also should result in meaning and satisfaction for those who do the research.

The final speaker of the symposium was Prof. Dr. Mr. Rianne Letschert, rector magnificus of Maastricht University. She stressed the importance of team-based accomplishments and discussed concerns on a funding system that only rewards individual "winners". Upon winning her Vidi grant she realized that the current system, focusing on individual achievements, is not optimal. In her opinion, team contributions are crucial to research success. For this reason, she advised the introduction of a T(eam)-index as an alternative for the H-index. With this vision in mind, she accepted her job as a rector magnificus.

With these inspiring talks in mind, providing an insight into what Prof. Nieck Benes values most, the symposium came to an end and the stage was set for Nieck. During his oration, Prof. Benes presented a clear view of education, research, and collaboration. He started his oration by introducing the 'ground state' of the average student/person, using his two sons and nephew as an example. A certain amount of activation energy is needed to stimulate a student to make a transition from a passive information absorbing state (lying on the couch looking at the screen of some electronic device) to an active information absorbing state. According to him, content is available in abundance but what matters is to provide and to make a distinction between the relevant and irrelevant content. 'As a professor, you are in the first place a teacher', it is the teacher's task to educate students and to guide them to find their way in a world in which all sorts of information is available and encourage lifelong learning. As an example, Prof. Benes mentions the "Twentse Onderwijs Model" (TOM). Although

rather skeptical of the TOM education model at first, he now agrees with the benefits of this project-based learning model. Students are challenged to work together as a team and develop team skills, communication skills and to carry out a research from initial concept to a completed project. However, referring to the previous lecture of Berry Nijveld, Benes mentions that more possibilities to fail should be allowed, as failing is also a part of the learning process.

The second task of the university is research. Research in Prof. Benes' opinion is strongly connected to education and in a sense can even be considered a form of education. "After all, scientific research aims to answer questions and generate new insights, in other words, aspires to learn. Organization is a necessity to allow for good education and research." Two of Benes' inspirations in research are Josiah Gibbs and Titus Lucretius Carus. Gibbs' work provides a thermodynamic framework that allows for predicting to what extent chemical systems have the potential to undergo a change; with this, one can calculate the driving forces for diffusional transport of molecules. Lucretius was one of the first (~60 BC) to describe atoms and the importance of empty space for their motion; this explains how empty spaces inside membrane materials induce molecular separation. Driven by these two heroes, the research in his group, Films in Fluids, focuses on the development of new membranes that can be used under extreme conditions, such as high pressure, temperature or extreme pH. Furthermore, they focus on the in-situ characterization of the membranes in these extreme conditions. A third research focus is the use and fabrication of inorganic porous hollow fibers.

Finally, Prof. Benes highlights the importance of working together as a team inside an organization. In Prof. Benes' opinion, collaboration is not only important in education but also crucial in research. The Membrane Science and Technology cluster has both young and more experienced researchers working together. The employees work in changing teams with overlapping research directions. By combining expertise, more is possible. With this philosophy, he also referred back to the lecture of Rianne Letschert; the accomplishments one can obtain with teamwork are far more valuable and far greater than the one achieved as an individual.

We would like to wish Prof. Dr. ir. Nieck Benes (and his team) much success.

For more information about the FiF group, please contact Prof. Dr. ir. Nieck Benes (n.e.benes@utwente.nl).

# Hoogendoorn Award - 2017

Dr. ir. Sander Haase (MST cluster PhD graduate) is the winner of the 2017 Hoogendoorn Award for his PhD thesis in Fluid Mechanics.

The jury chose Dr. ir. Sander Haase because of his outstanding PhD research in the area of Fluid Mechanics. He defended his PhD thesis cum laude on 4th November 2016 at the University of Twente. His thesis supervisor was Professor Dr. Ir. Rob Lammertink and the research was done at the Faculty of Science and Technology of the University of Twente.

The title of his PhD thesis was: Transport near Slippery Interfaces.

The Hoogendoorn Award will be awarded to Dr. ir. Sander Haase at the Burgers Symposium 2018, which will be held on 5th – 6th June 2018.

*Dr. Sander receiving his PhD Diploma in 2016.*

The Hoogendoorn Award is the award for the best PhD thesis on Fluid Mechanics in the Netherlands and is a collaboration between KIVI Mechanics and the J.M. Burgercentrum (JMBC).

For more information, please visit the website.

# MST Cluster Goes to Denmark for a Study Tour!

On an early and rainy morning on the 18th of September 2017, 50 participants of the MST-cluster started their study tour to Denmark. After leaving at 05:15 am and driving for seven hours, the group could relax a bit when the bus drove onto the boat at Puttgarden. After entering Denmark and passing a security check we headed to our first company visit, Alfa Laval in Nakskov. Alfa Laval is a membrane producing company and on the site in Nakskov they produce spiral wound membrane modules and construct complete filtration systems. After a warm welcome, we got some interesting presentations and a well-organized tour of their facilities. After some bites and a drink, we left to our first hotel in Maribo.

*A selfie moment from the MST Study Tour.*

On the second day, we headed to Copenhagen. After a smooth drive from Maribo, we could tell by the amount of traffic that we were approaching Copenhagen. The first visit of the day was the company Aquaporin in Kongens Lyngby. Aquaporin is a young company making RO and FO membranes on the basis of the Aquaporin protein. After the company showed us their vision, we got a tour which ended with a great lunch. For the second visit, we went to the Technical University of Denmark. At the university, the research group at the Department of Environmental Engineering showed us their work on membranes and their lab facilities. After leaving the university, we checked into the second hotel and walked afterwards with the whole group to the food courts in Copenhagen to have some tasty food.

*A part of the group enjoying the beer tasting in Jacobsen Brewhouse.*

On the third day, we visited Liqtech, a producer of ceramic membranes. A warm welcome was given and since we were the largest group they ever facilitated, we had to split up into three groups. Each group had a general presentation of the company, a presentation from the R&D department, and got a tour of their production facility. The whole visit was very interesting and we obtained a good insight into how ceramic membranes are produced. Next stop was the waste water treatment plant at the Herlev hospital organized by Grundfos. At this sight, hospital waste water is treated with a membrane bioreactor to levels that are not harmful anymore to the environment before disposing it to the sewage system. This was a nice visit where everybody got a good look at how membranes function in a real application. The last visit of the study tour was at Carlsberg, at their location in Copenhagen we could see the company's history in the museum and afterwards the products of their Jacobsen Brewhouse were tested.

On the fourth and last day, we traveled back by bus to Enschede. It was an intensive program, but very interesting and a lot of fun.

# Enhanced Brackish Water Desalination Process in the Gaza Strip

The Membrane Technology and Engineering for Water Purification group (MTEWP), part of the Membrane Science and Technology cluster of the University of Twente, and the Islamic University of Gaza (Palestine) have successfully acquired a grant to work together on a project titled "*Enhanced brackish water desalination processes in Gaza strip: One Step Reverse Osmosis (OSRO)*". The project is funded by the Netherlands Initiative for Educational Research (NRO) under the Palestinian-Dutch consortium (PADUCO) second phase. The consortium gathers 6 Palestinian universities and 5 Dutch universities focusing on academic collaboration on water.

More than 2.0 million residents in the Gaza Strip depend on groundwater aquifers for their daily water demand. However, the quality of the groundwater aquifer has deteriorated heavily over the past few years due to excessive levels of over-extraction and seawater intrusion. Moreover, the groundwater is extremely contaminated by nitrate from poor sewage and fertilizers from irrigation of farmlands. These days, more than 90% of the aquifers are not safe without treatment. In addition, the Gaza Strip suffers from a consistent shortage of power supply and regular power cuts which could last for more than 18 hours a day.

Brackish water desalination seems to be the most promising and viable alternative to meet the Gaza's freshwater demands. In this project, we will introduce our One Step Reverse Osmosis (OSRO) concept to treat brackish groundwater under anaerobic conditions. The main advantage of this concept is that it requires no pretreatment before the reverse osmosis units. The project aims at evaluating the current brackish water processes in the Gaza Strip and to reduce the total treatment costs and power consumption. The project will last for 18 months and will consist of extensive testing of the concept in the Gaza Strip as well as online training workshops given by staff members of the MST cluster of the University of Twente.

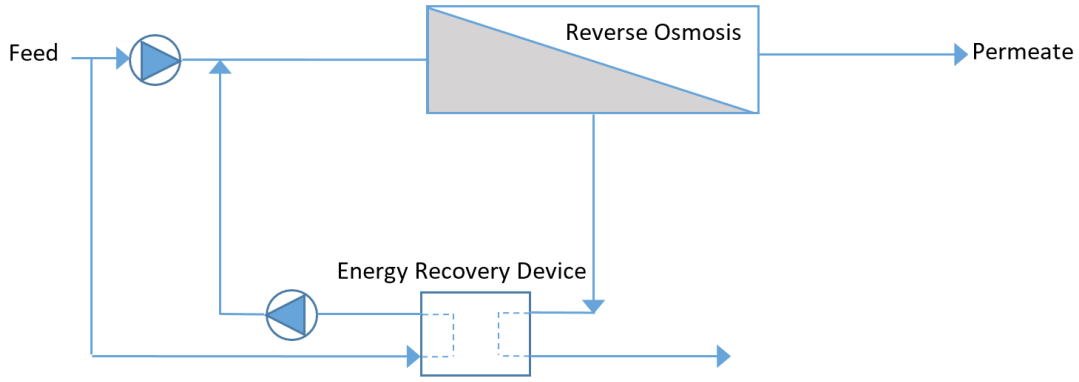



*Figure 1. One step Reverse Osmosis (OSRO) anaerobic brackish groundwater desalination scheme incorporated with energy recovery device to lower the power consumption.*

For more information about the project, please contact Prof. Dr. ir. Walter van der Meer (w.g.j.vandermeer@utwente.nl).

# New MST Members

## Technical Staff

***Iske Achterhuis***

**Association:** Membrane Surface Science

***Janieke Blom***

**Association:** European Membrane Institute

## Industrial Researcher

***Dr. Patrick de Wit***

**Association:** European Membrane Institute

## PhD Students

***Anne C. Sustronk, MSc***

**Group:** Films in Fluids

***Ettore Virga, MSc***

**Group:** Membrane Surface Science

***Jéré van Lente, MSc***

**Group:** Membrane Surface Science

***Nikos Kyriakou, MSc***

**Group:** Inorganic Membranes

***Piotr Krzywda, MSc.***

**Group:** Films in Fluids

***Shaochen Zhu, MSc.***

**Group:** Inorganic Membranes

***Shuyana Heredia, MSc***

**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 (MSTtnw@utwente.nl, www.utwente.nl/tnw/mtg).

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## Follow MST on Facebook!

Interested in the latest news of our Membrane Science and Technology Cluster? Follow 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!