Membrane News Twente

News magazine of the Membrane Science and Technology Cluster **2018-Winter**

Welcome

A warm welcome to the newsletter of the Membrane Science and Technology Cluster. With the holidays coming close, it is a good time to look back and reflect on the past year. For the Membrane Science and Technology Cluster 2018 has been a very good year. We have had many new faces joining the cluster, seen many new and exciting projects starting while we have also seen the successful graduation of many PhD students. Another major theme of the last year was the search for a new staff member in the cluster. We are very happy to announce that we found the perfect candidate. Very recently, Dr. Joris de Grooth has taken up a position as an assistant professor in the cluster. Dr. de Grooth will focus on the interface between material science and process technology, and the validation of new membranes and membrane processes at larger scales. In this newsletter, you will find a more complete description of Dr. de Grooth and his plans.

We are also proud to announce that the OSN 2019 conference will be held at the University of Twente from the 28th till the 30th of October 2019. Furthermore, in this newsletter, you will find information on the PhD graduations and on the new people joining the cluster in the past 6 months. Finally, you will also find a scientific overview of the Membrane Technology and Engineering for Water Treatment research group, led by Prof. Walter van der Meer and Dr. Antoine Kemperman.

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 the Membrane Science and Technology Cluster at the University of Twente, we would like to wish you pleasant holidays!

MST Cluster wishes you Merry Christmas and a Happy New Year!

New Group in the MST Cluster! "On the Boundary"

As of November this year, Dr. Joris de Grooth, has been appointed as Assistant Professor within our Membrane Science & Technology Cluster. Dr. de Grooth will be working on combining experimental and theoretical tools for different membrane processes.

Dr. Joris de Grooth

Throughout his professional career, he has been involved in membrane technology. The different positions he fulfilled allowed him to experience a variety of topics in membrane science. During his PhD, he focused on properties of polyelectrolyte multilayers and translating these to membrane performance: "*I truly enjoyed seeing how the understanding of fundamental aspects can be used to tune the selectivity of a membrane*". At Pentair X-Flow, Dr. de Grooth worked as a researcher in multidisciplinary teams on membrane development and membrane processes. There he learned that the performance of a membrane process is not only governed by the membrane properties but also it needs to be put into context with an entire process. After his tenure at X-Flow, he spent a year as a researcher at the European Membrane Institute Twente, before becoming the Research Manager at NX Filtration in 2016.

"*I experienced how exciting it is to see fundamental and theoretical principles come to life with experiments. Here, the membrane research area has a unique position: it is on the boundary between material science and process technology*". It is at this boundary that de Grooth will focus his research within our cluster. He enjoys taking challenges and demands from an industrial scale and translating these to design criteria for a membrane: "*When you integrate the full-scale process within your membrane design, you start with different, new, and sometimes even counterintuitive criteria for that membrane and its process.*" Of course, this also means that he will work on the validation of the membrane processes on a larger scale, e.g. by means of full-scale pilots on location. He concludes: "*Taking the different models and membranes out of the lab and into the real world is an exciting step for both me and the students. Moreover, this can lead to further developments in membrane processes and membrane science.*"

Membrane Technology and Engineering for Water Treatment (MTEWT)

Being part of MST cluster, the Membrane Technology and Engineering for Water Treatment (MTEWT) group operates at the interface between material science and process technology. The main research activities extend from the design of novel membrane modules to the investigation of optimal operational regimes in combination with (new) membrane materials, membrane geometries, product water quality, energy consumption, fouling tendency, and pre-treatment requirements.

Innovations in membrane manufacturing as well as in process design and operation have led to a dramatic decrease in operational and investment costs. Consequently, membrane filtration has emerged as a cost competitive, robust, and viable alternative to conventional drinking and wastewater treatment processes. Therefore, membrane filtration processes are increasingly being applied in drinking and process water production for all kinds of water sources, e.g. sea-, ground-, waste- and surface water.

In MTEWT, we focus on mass transport, module, full-scale plant design, and process development, in particular on the integration of new membrane materials and new module design in combination with different water sources (e.g. brackish ground water, wastewater, rainwater). Although the technology becomes more and more a reality, many fundamental questions, such as prediction of the rejection of organic micropollutants, mechanism of membrane (bio) fouling, and the integrity of membranes around the membrane separation processes for drinking and wastewater treatment, are still unsolved.

Head of the MTEWT group is Prof.dr.ir. Water van der Meer, part-time professor in the MST cluster at the University of Twente. Additionally, he is the CEO of OASEN NV water supply company based in Gouda, the Netherlands. Although some parts of his projects are carried out in Twente as part of the MST cluster, he is also (co)supervisor of several PhD projects abroad when the projects require special expertise.

One Step Reverse Osmosis (OSRO)

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.

One Step Reverse Osmosis (OSRO, Figure 1) is a pioneer state-of-the-art concept to replace old multistep conventional treatment with only a single step of RO membranes capable of removing all known and unknown pollutants from water.

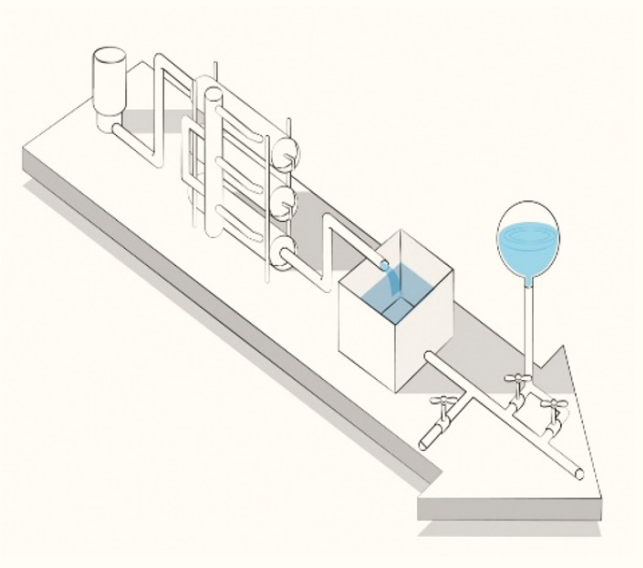


Figure 1. A schematic drawing of One Step Reverse Osmosis process for anaerobic groundwater purification

The process is currently being applied to treat anaerobic groundwater at large and pilot scale at several Oasen water treatment plants. OSRO is being further investigated at MTEWT in terms of recovery and post-treatment (remineralization).

Current research:

A Sustainable remineralization process for RO based water treatment systems (Almohanad Abusultan, UT)

Reverse osmosis (RO) membrane technology has been used for decades for seawater desalination but its contribution to groundwater purification is still quite limited. Although RO is considered a promising alternative to replace the multistep conventional groundwater treatment processes, it still has two main limitations compared to the conventional treatment: a lower recovery and the fact that a post-treatment step (i.e. remineralization) is required.

In this research, we aim to develop a sustainable remineralization process for reverse osmosis permeate by investigating and optimizing the recovery of hardness ions (Ca^{2+}, Mg^{2+}) from anaerobic groundwater using ion exchange resins (gradient elution, Figure 2) and bipolar membrane electrodialysis.

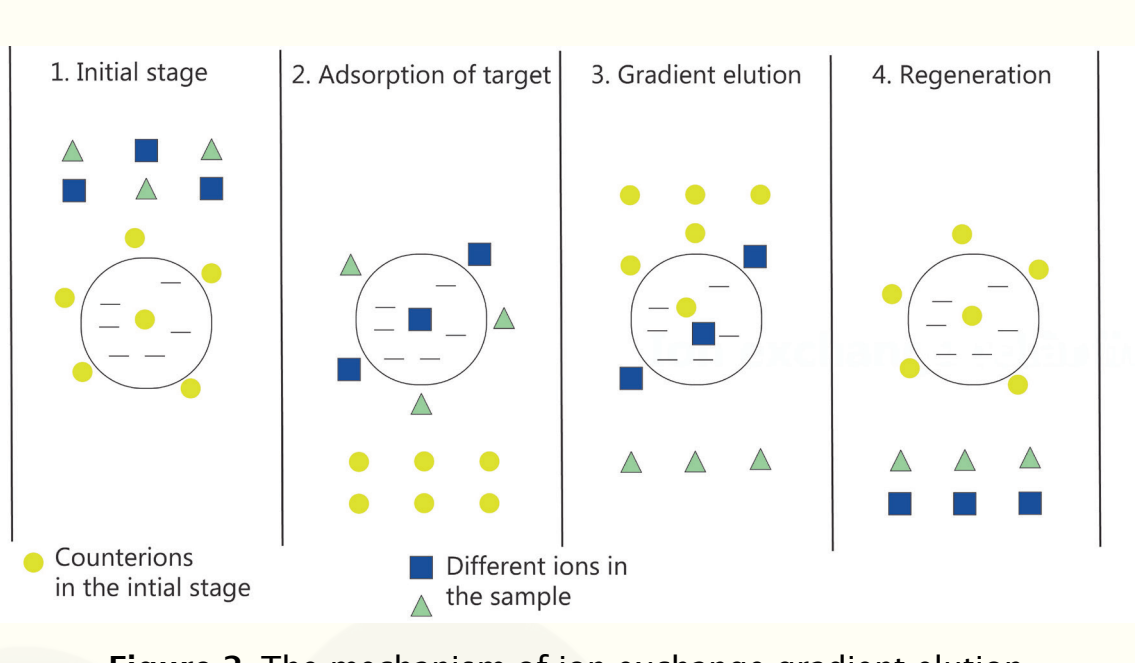


Figure 2. The mechanism of ion exchange gradient elution explained for two different cations.

Controlling calcium carbonate scaling in groundwater reverse osmosis systems: maximizing recovery and minimizing antiscalant consumption (Nasir Mangal, UNESCO-IHE/UT)

Maximizing recovery in brackish water reverse osmosis (BWRO) applications is essential. At maximum recovery, the production of brine and also the specific energy consumption (kWh/m^3) are at a minimum. However, the main obstacle to achieve high recoveries (80 - 90 %) in BWRO is scaling, particularly $CaCO_3$ scaling. Scaling has severe adverse effects on the operation and performance of BWRO processes including, but not limited to, lowering the quality of RO permeate, reducing the life expectancy of the RO membranes, and increasing the operational and maintenance cost of the system.

The aim of the study is to develop a method to efficiently determine maximum recovery and optimum antiscalant dose to prevent calcium carbonate scaling in brackish water reverse osmosis systems.

Assessing biological stability of drinking water after reverse osmosis and remineralization (Mohaned Sousi, UNESCO-IHE/UT)

Biological stability of drinking water is a vital topic due to its relevance to the public health. Drinking water is considered biologically stable when bacterial regrowth of pathogenic bacteria e.g., Legionella, in the distribution networks is limited.

The research focuses on:

- Developing and adapting the bacterial growth potential (BGP) method for low-nutrient water including lowering the limit of detection (LoD) of the method.
- Assessing the impact of RO filtration and remineralization on biological stability of drinking water as compared to the conventional water treatment processes.
- Evaluating the effect of different remineralization processes on the biological stability of the produced RO permeate.
- Identifying the factors affecting the bacterial growth, e.g. organic and inorganic nutrients availability (carbon, phosphorus and nitrogen) or other water characteristics (pH, mineral content and temperature).

Efficiency of small contaminant removal by reverse osmosis (Vittorio Albergamo, UvA/UT)

The nature of organic contaminants in raw water keeps on changing due to climate change and also the changes in societal use of chemcials. Drinking water companies may face stronger demands on removal processes as the hydrophilic compounds inherently are more difficult to remove.

The main objectives of this Ph.D. project are (i) to verify if RO is the most effective and efficient means of removing existing and newly emerging organic microcontaminants; (ii) to identify emerging organic contaminants that are not effectively removed by RO and to assess their potential threat for human and ecosystem health. The working objectives have been outlined as: (a) to identify trends in concentrations and identities of organic microcontaminants in source waters; (b) to assess the extent of removal of new emerging contaminants from water, in particular, small polar molecules, by RO; (c) to assess the toxicity, including the mixture toxicity, of the effluents of optimized RO treatments; and (d) to relate removal rates to compound properties and RO characteristics.

High Tech, Human Touch

The MTEWT group collaborates with the Islamic University of Gaza (Palestine) and has successfully acquired a grant to work together on a project titled "Enhance 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.

More than 2.0 million residents in the Gaza Strip depend on ground water aquifers for their daily water demand. However, the quality of the groundwater aquifer has deteriorated heavily over the past years due to excessive levels of over-extraction and seawater intrusion, and more than 90% of the groundwater became useless for human use. The PADUCO project introduces the One Step Reverse Osmosis (OSRO) concept to treat brackish groundwater under anaerobic conditions. The main advantages with this concept are lower total production cost and energy requirements (Figure 3).

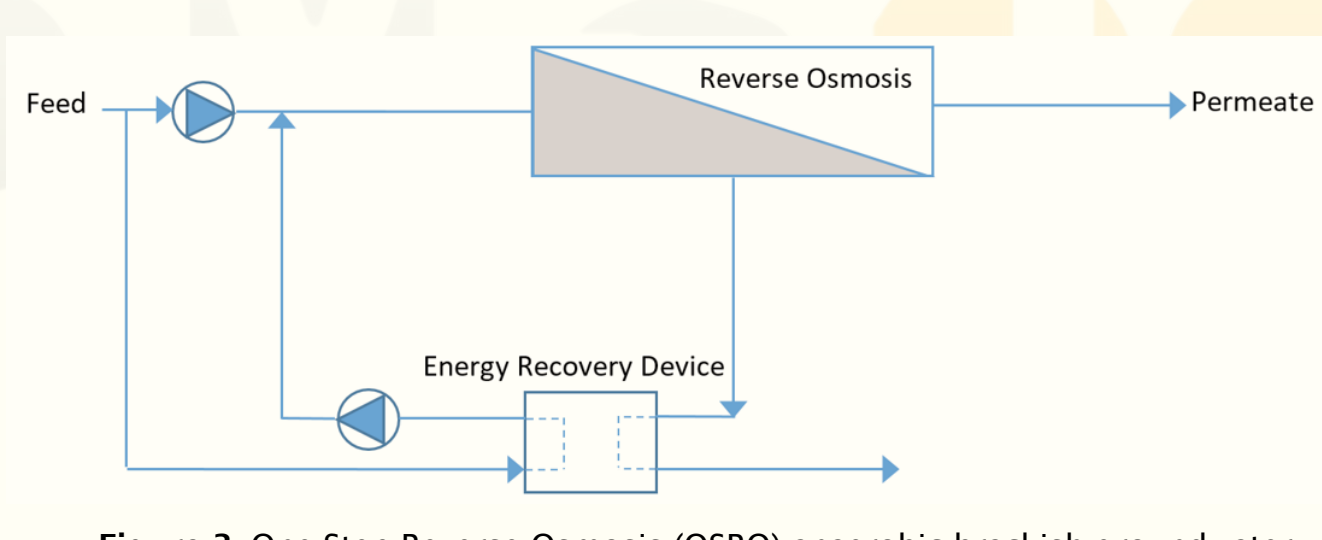


Figure 3. One Step Reverse Osmosis (OSRO) anaerobic brackish groundwater desalination scheme incorporated with energy recovery device to lower the power consumption.

More information on the MTEWT group can be found on its website at www.utwente.nl/en/tnw/mtewt/, and via Prof.dr.ir. Walter van der Meer (w.g.j.vandermeer@utwente.nl) and Dr.ir. Antoine Kemperman (a.j.b.kemperman@utwente.nl, +31-53-4892956).

PhD Graduations of the MST Cluster

Dr. Janneke Dickhout

Janneke Dickhout defended her thesis entitled "*Understanding membrane fouling in produced water treatment*" on the 1st of November 2018. Janneke performed her work in the Concentrates theme within Wetsus. She was supervised by Dr. Wiebe M. de Vos (co-promotor) and Prof. Rob Lammertink (promotor).

Dr. Janneke at her thesis defense.

In her thesis, Janneke studied the essential parameters that determine membrane fouling during the treatment of produced water. Produced water is a large waste stream that is generated during enhanced oil recovery. It is difficult to treat an aqueous stream that consists of stabilized oil droplets, salts, particles, and dissolved organics. Using a unique combination of a flow cell to measure oil droplet adhesion, and a membrane cross-flow setup, she successfully demonstrated the key role that the surfactant and the salt concentration play in membrane fouling. She also showed that zwitterionic surfactants are especially an interesting system for reducing membrane fouling to a very large extent.

The full thesis of Dr. Janneke Dickhout can be found at: https://doi.org/10.3990/1.9789036546379

Dr. Rian Ruhl

Dr. Rian receiving his PhD Diploma from his Promotor.

On the 8th of November 2018, Rian Ruhl successfully defended his PhD thesis entitled "*Oxygen transport membranes for power generation with CO_2 capture*". Rian performed his work within the framework of the GREEN-CC project (Graded membranes for energy efficient new generation carbon capture processes), funded by the FP7 framework of the European Union. Rian worked in the Inorganic Membranes (IM) and Electrochemistry Research groups (ECRG) under the supervision of promotors Prof. dr. Henny J.M. Bouwmeester and Prof. dr. ir. Arian Nijmeijer.

His research work revolved around the development of oxygen transport membranes (OTMs) and their implementation in power plants. In his thesis, Rian describes a new route for the synthesis of perovskite-type mixed ionic-electronic conducting membrane materials. He also studied the influence of dopant concentrations on the long-term stability of the membranes and their oxygen transport properties. In addition, he has developed novel approaches to enhance their surface exchange kinetics and to lower their vulnerability against CO_2 exposure. The thesis ends with a critical evaluation of OTMs integrated with oxyfuel combustion and pre-combustion carbon capture based processes in combined cycle power plants.

Dr. Rian is currently employed as Printing Process Researcher at Océ-Technologies BV in Venlo, The Netherlands.

The full thesis of Dr. Rian Ruhl can be found at: http://dx.doi.org/10.3990/1.9789036546560

Dr. Mohd Zamidi Ahmad

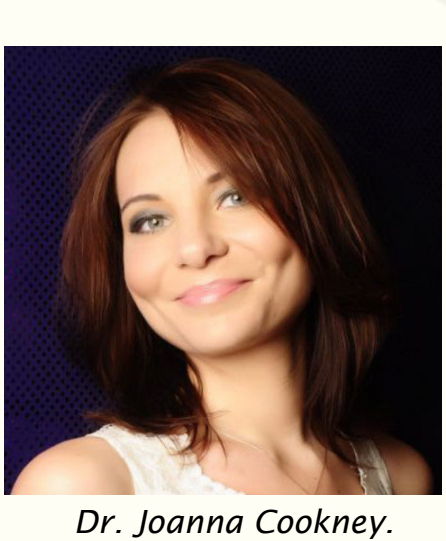
On Friday the 7th of December 2018, Mohd Zamidi Ahmad defended his thesis entitled, "*Synthesis and characterization of polyamide-based mixed matrix membranes for CO_2/CH_4 separation*". Zamidi performed his research in the framework of the Erasmus Mundus Doctorate in Membrane Engineering (EUDIME), and the project was a cooperation between 3 universities: University of Chemistry and Technology Prague, the University of Twente and Universidad Zaragoza. From the University of Twente, he was supervised by Prof. Dr. Nieck Benes (promotor) and Dr. Wiebe de Vos (co-promotor). The graduation ceremony took place in Prague.

Dr. Zamidi after his graduation.

In his research, Zamidi developed novel mixed matrix membranes based on 6FDA-based co-polyimides and zirconium-based metal-organic framework nanoparticles. The gas separation performance was evaluated with a mixed gas feed constituting of CO_2 and CH_4, at various molar concentrations, feed pressures, and temperatures. The stability of the membranes under high-pressure separation and in the presence of natural gas impurities (i.e., H_2S), was also investigated. Overall, the study demonstrates that 6FDA co-polyimide based mixed matrix membranes have a tremendous potential for CO_2/CH_4 gas separation applications.

The full thesis of Dr. Mohd Zamidi Ahmad can be found here.

Dr. Joanna Cookney



Dr. Joanna Cookney.

Dr. Joanna Cookney defended her thesis entitled, "*Design and synthesis of ZIF-8 and zinc-imidazole nanofilms*" on the 19th of October 2018. Joanna has completed her doctorate in the frame of European Union Doctorate in Membrane Engineering carried out between three universities: University of Chemistry and Technology Prague, University of Twente and Katholieke Universiteit (KU) Leuven. She was supervised by Prof. Dr. Nieck Benes from the University of Twente. The graduation ceremony took place in Prague.

Her research focused on three primary areas that include investigation of crystalline ZIF-8 thin films derived from colloidal solutions, partially-crystalline pseudo-polymorphic zinc-imidazole nanofilms, and composite zinc-imidazole/polymer nanofilms.

Synthesis of ultrathin nanofilms (<200nm) that are continuous on a microscopic level is itself a remarkable achievement. The synthesized zinc-imidazole nanofilms reveal the ability for the material to withstand up to 55 bars of pressure and prolonged exposure to CO_2 plasticizing penetrant, outperforming state-of-the-art industrial polymeric thin films.

The full thesis of Dr. Joanna Cookney can be found here.

OSN 2019 at University of Twente

Save the date!

7th International Conference on Organic Solvent Nanofiltration

28th October - 30th October, 2019

University of Twente, The Netherlands.

Keep following for more information!

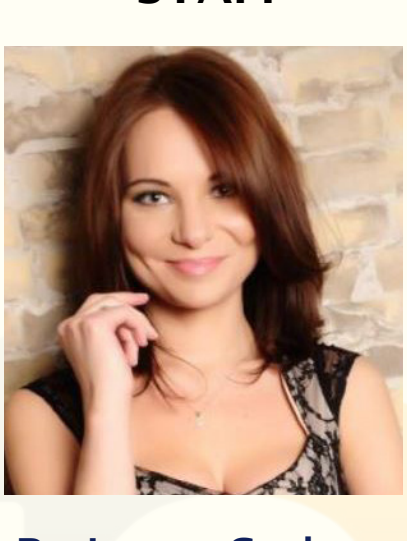
https://www.utwente.nl/en/tnw/osn-2019/

New People at the MST Cluster

SECRETARY

Brigitte Boogaard
Association: Soft Matter, Fluidics and Interfaces

POST DOCTORAL STAFF



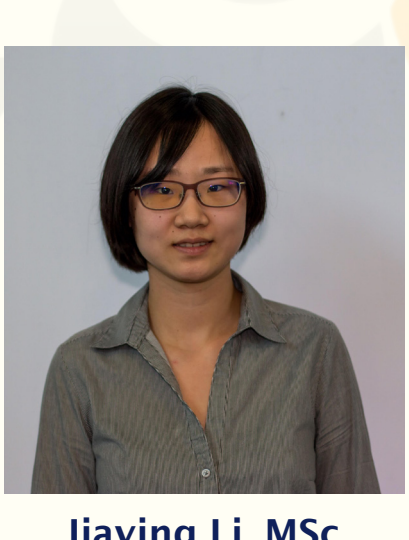
Dr. Joanna Cookney
Association: Films and Fluids

RESEARCH ASSISTANT

Youri Oude Luttikhuis
Association: European Membrane Institute

PHD STUDENTS

Farzaneh Radmanesh, MSc.
Association: Films and Fluids



Jiaying Li, MSc.
Association: Membrane Surface Science

Jürjen Regenspurg, MSc.
Association: Membrane Surface Science

Tao Wang, MSc.
Association: Membrane Surface Science

Xiuqin Wang, MSc.
Association: Soft Matter Fluidics and Interfaces

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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 (https://www.utwente.nl/en/tnw/mtg/mnt).

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