4th Congress of the African Membrane Society (AMSIC-4)
(Addis Ababa, Ethiopia - November 2-8, 2024)

(Meeting location: Inter Luxury Hotel
https://interluxuryhotel.com/)

Address: Kazanchis area, Guinea Conakry (Tito) Street, Addis Ababa, Ethiopia.

Conference Booklet

In Memoriam

Professor Enrico DRIOLI

(1941 - 2024)

African Membrane Society 3rd International Congress, Dakar, Sénégal, November 2-5, 2021 (AMSIC-3 photos)

Pr Enrico DRIOLI (R), as Guest of Honor at AMSIC-3 with Dr Cheikh Oumar ANNE, Ministry of Higher Education & Research

Pr DRIOLI (R), with AMSIC General Secretary, Dr-Eng. Abaynesh YIHDEGO GEBREYOHANNES

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AMSIC community.

List of Sponsors

List of Plenary lectures

	Author	Topic
1	Mathias Ulbricht	Reactive coating of desalination membranes in spiral-wound modules: Increasing antifouling properties and enabling “second life” applications
2	Ivo Vankelecom	Polymer-based membranes: from fundamental understanding to upscaling
3	Suzana P Nunes	Polymer membranes for sustainable separations
4	Soraya MALINGA	Selenium and silver based antibacterial membranes: Synthesis, characterization and application
5	Ludovic Dumee	3D printing functional nanoporous membranes and separation materials
6	Lidietta Giorno	Trends in Membranes and Processes for Biotechnology and Biorefinery
7	Heidi Richards	MEMBRANE DISTILLATION CRYSTALLIZATION IN THE AFRICAN CONTEXT
8	Esayas Alemayehu	Non-liner problem solving approaches: Integrated water treatment technologies for efficient water purification and wastewater reuse
9	Loredana De Bartolo	Advances in multifunctional membrane systems for biomedical applications
10	Abaynesh Gebreyohannes	Membrane from research to product with market value – connecting the dots
11	**Stefan Panglisch**	New ways to improve the scaling behaviour of dense membranes

List of Keynote lectures

No.	Presenting author	Topic
1.	Rita Namoe Tabi	Incorporation of artificial water channels into a thin film composite membrane for nanofiltration
2.	Abdoulaye Doucoure	Adopting anotextile fabrication processes for filtration applications
3.	Adel Zrelli	Valorizing waste bricks in geopolymer membrane preparation for treating oily wastewater: effects of curing temperature and liquid/solid ratio
4.	Efrem Curcio	Membranes in mining raw materials from brine
5.	Sara Chergaoui	Membranes for solution crystallization
6.	Michael Daramola	Sodalite-based membranes for water and wastewater treatment
7.	Raja Ben Amar	Adsorption, membrane separation, and photocatalysis: sustainable water treatment with low-cost materials for addressing organic pollutants—synthesis, characterization, and application
8.	Gaetan Blandin	Towards membrane recycling: OSMO4LIVES
9.	Rhea Verbeke	Epoxide-based membranes: an emerging platform for liquid and gas separations
10	Andrea Schaefer	Membrane technology for fluoride removal: Tanzania experience
11	Frank Lipnizki	New concepts for water treatment with membrane technology: From ideas to large pilot scale tests
12	Misgina Tilahun	Membranes for alkaline water electrolysis
13	Kibrom Alebel Gebru	Desalination membrane modification toward improving antifouling performance: From lab to pilot scale
14	Joao Crespo	Ion-exchange membrane processes: Perspectives in water treatment and desalination
15	Elena Tocci	Crystallization mechanisms in Lithium salt membranes: Insights from molecular dynamics

16	Ngonye Keroletswe	Cellulose-functionalized electrospun membrane as potential membrane filter for water decontamination
17	Rosalinda Mazzei	Mimicking nature to improve membrane bioreactors: towards process intensification
18	Gideon Oron	Ultra-Filtration Membrane Flushing in Hybrid Systems of Wastewater Reclamation for Unrestricted Reuse
19	Imen Khouni	Industrial Soap wastewater improvement for sustainable reuse and recovery using a hybrid process of coagulation/flocculation and membrane filtration
20	Noreddine Ghaffour	Scaling-up the membrane distillation process: challenges and contributions
21	Saad Alami Younssi	Valorization of natural materials in development of new ceramic composite membranes
22	Soumana Gagara	Contribution to the quality assessment of purified water: a case study of the methods used by UN field operations mission in the province of South Kivu in the DRC
23	Lakshmeesha Upadhyaya	Hollow fibers for Organic gas dehydration
24	Ramato Ashu TUFA	Role of membranes in advanced electrochemical energy systems
25	Gyorgy Szekely	Machine learning for molecular sieving in organic solvents
26	Abi Taddesse Mengesha	Fe-Al nanocomposite filled dialysis membrane tubes (DMT-HFAO): a modified method for assessment of phosphate sorption-desorption from aqueous and soil solutions
27	Hern Kim	Fabrication of high-performing double-ligand ZIF-8/cellulose acetate mixed matrix membranes for selective H2/CH4 and CO2/CH4 gas separation
28	Stephan Rehlen	The dynamic development of organic cotton in the global market and in Africa
29	Abdoulaye Doucoure	Impact of Armed Conflicts on Highly Vulnerable Communities: what role for resiliency tactics, membrane technologies and networks in highly volatile environments

30	Fred M	An application of photovoltaic (PV) solar-based membrane systems for potable water production in Africa
31	Elizabeth Guyman	The XPRIZE Challenge: In Search of Breakthrough Seawater RO Desalination Technologies to Tackle Water Scarcity
32	Edward	Unique properties for carbon-based nanostructured membranes for diverse applications
33	Geoffroy Lesage	Integrating electrochemical systems in a granular anaerobic membrane bioreactor
34	Hajer Aloulou	Development of graphene oxide membrane on flat mud ceramic support for methylene blue dyes removal
35	Ludovic Dumee	Engineering functional nanofiber based membranes for air and water treatment
36	Ranil Wickramasinghe	Development of membrane based operations for emerging separations challenges

List of Oral presentations

Njabulo Sondezi, Kgabo Matabola and Thollwana Makhetha	FABRICATION OF THE PVDF/PAN ELECTROSPUN NANOFIBROUS MEMBRANES INCORPORATED WITH TIO2/Cu@NH2-MIL-125 NANOCOMPOSITE FOR WATER REMEDIATION
Khady Ndiaye, Cheikhou Kane and Codou Mar	STABILIZATION OF AQUEOUS HIBISCUS EXTRACT IN A MEMBRANE-SEPARATED TWO-COMPARTMENT ELECTROCHEMICAL CELL
Dr. Abdulrahman Babatunde Ameen and Folahan Amaoo Adekola	Leachate Plumes: Effects on Water Quality and Public Health Risks in Ilorin, Kwara State, Nigeria
Màxim Gibert-Vilas, Geoffroy Lesage, François Zaviska and Marc Heran	Study of a novel electrochemical membrane bioreactor (E-MBR): reduction of membrane fouling and electro-oxidation of poorly biodegradable organic matter
Khona Maziya, Anita Etale and Heidi Richards	High performance TFN membranes with modified CNCs for improved dye/salt removal from water
Purity Langa, Fildah Ayaa, Samuel Iwarere and Michael Daramola	Blended Polysulfone/Polyethersulfone Infused with Sodalite nanoparticles for carbamazepine removal from pharmaceutical wastewater
Wuhib Zeine Ousman, Esayas Alemayehu and Patricia Luis	Fluoride Removal and Recovery from Water Using Reverse Osmosis and Osmotic Membrane Crystallization
Afef Attia and Raja Ben Amar	Zinc-montmorillonite intercalate- based polyethyleneiminenanocomposites : Preparation and photodegradation of BB41 dye under UV light
Haftu Gebrekiros Alemayehu, Rshane Hailu and Berhane Desta	Highly water stable Ultrathin 2D Metal organic framework-based membrane for molecular separation
Pengrui Jin	Nanofiltration membrane with adsorptive effect for treatment of emerging organic pollutants
Yasamin Khanifar, Ghazaleh Baghaei, Mohammad Mirarefin, Shahrzad Esmaili, Omid Tavakoli, Geoffroy Lesage, Marc Heran and Farshid Pajoumshariati	TREATMENT OF SUGARCANE INDUSTRY WASTEWATER BY A NOVEL MEMBRANE PHOTOBIOREACTOR
Anteneh Mersha and Bilisuma Finina	Development of Cellulose Nanofiber-Scaffolded Composite Wound Dressing Film from Medicinal Plant Extract
Dr. Leta Lemma, Professor Zebene Kiflie and Dr. Shimelis Kebede Kassahun	Biopolymer Based Hydrogel for Adsorption of Heavy Metal Ions from Aqueous Solution: Experimental and Theoretical Investigation.
Phumlile Mamba, Motsa Machawe Mxolisi, Titus Msagati and Thabo Nkambule	BIOCATALYTIC HOLLOW FIBER MEMBRANE REACTOR FOR THE DEGRADATION AND FILTRATION OF NATURAL ORGANIC MATTER FROM SURFACE WATER
Gaetan Blandin, Saidou Nourou Diop, Absa Sabdou Seck, Xenia Garcia Farré, Madeleine Nguidé Sarr and Courfia Keba Diawara	ULTRA-SEN: DECENTRALISED AND GRAVITY-DRIVEN ULTRAFILTRATION MEMBRANES FOR WATER POTABILIZATION
Nompumelelo Sharol Mbali Kubheka, Edward Nxumalo and Muthumuni Mananga	THE FABRICATION OF PES/ FE3O4/ZNO MEMBRANES FOR THE EFFICIENT REMOVAL OF CONTAMINANTS FROM WASTEWATER
Karabo Concious Mashiloane, Edward Nxumalo and Machawe Motsa	Investigating the impact of hexagonal-Boron Nitride Nanosheets (h-BNNS) on the structural characteristics and the efficacy of polyvinylidene (PVDF) membranes for water-oil separation
Solomon Hailu Tela, Maria Beatriz Cristóvão, Andreia Bento Silva, Maria Rosário Bronze, Maria Teresa Barreto Crespo, João Goulão Crespo, Monica Nunes and Vanessa Jorge Pereira	OCCURRENCE OF ANTIBIOTICS IN WASTEWATER EFFLUENTS AND THEIR TREATMENT BY A PILOT SCALE NANOFILTRATION UNIT
Sawadogo Boukary, Nouhou Moussa Abdoul Wahab and Konate Yacouba	INTEGRATED COAGULATION-FLOCCULATION AND NANOFILTRATION OR REVERSE OSMOSIS MEMBRANE SYSTEM FOR TREATING SUGAR CANE INDUSTRY EFFLUENT FROM A MEMBRANE BIOREACTOR OUTLET
Ahmad Taghizadeh Damanabi and Gomotsegang Fred Molelekwa	Separation of alcoholic biofuel with two-dimensional MXene nanocomposite membrane using Pervaporation process by CFD analysis
Faizal Soyekwo and Changkun Liu	Enabling improved Lithium/Magnesium Separation using Polyamide Nanofiltration Membranes Functionalized with Clustered Multination side chains
Indira Chimanlal, Corinne Cabassud and Olivier Lorain	Could a new ultra-thin coated membrane compete with a microporous membrane in VMD?
Tewodros Taddese Tiruneh	Enhancement of mechanical property of clay ceramic water filter using 1-D TiO2 nanoparticles for water purification

Abera	Electrochemical membrane technology for future applications: Zn-MOF/g-C_3N_4 photoelectrochemical system for real-time sensors and naproxen removal in wastewater
Caroline J.	Selective water and wastewater treatment in Africa -Role and Opportunities for Advanced Materials

List of Poster presentations

Wondimagegne Mamo Mengistu	Comprehensive review on the use of Zeolite in the filtration and purification of water.
Sara Chergaoui	Removal of toxic metal ions from surface water using biopolymer chitosan/ZIF-8 mixed-matrix membranes
Haftu Alemahyehu	Mild temperature regulated highly stable graphene oxide membrane for molecular separation.
Remedan Ahmed	Advancements in Membrane Technology for Decentralized and Autonomous Water Treatment Systems
Nicolas Saganias/Gaetan Blandin	Low-cost membrane characterization setup developed in open-science for broad dissemination of membrane evaluation and research.
Bveledzani Pertunia Makhado	Evaluation of carbon nanomaterial and titanium dioxide leaching from ultrafiltration membranes in water treatment systems
Solomon Hailu Tela	Advanced process monitoring using online fluorescence in solvent resistant nanofiltration applied in olefin metathesis
Souha Harabi	Microporous activated carbon derived from peach stones :optimized synthesis by Response Surface Methodology
Lemma Teshome Tufa (	Plasmon-Enhanced Photo/Electrocatalysis in Hetero-Nanostructures for Sustainable Energy Applications
Karabo Mashiloane, (Oral presenter)	Enhancing Oil-Water Separation Efficiency Using Nano-Engineered PVDF Membranes Incorporated with Exfoliated Boron Nitride Nanosheets.
Abrham Tesfaye	Membrane Technology at the water-energy nexus: The Ethiopian prospect
Kibrom Gebru	Membrane modificaitons for RFBs
Yosef Hagos Abrha	Removal of Synthesis Methylene Blue Dye using Bottom Ash and Sewage Sludge Mixed Adsorbent Collected from Reppie Waste-to-Energy Facilities and the Kality Wastewater Treatment Plant.
Soliyana Teshome	Response surface statistical modeling for optimization of methylene blue adsorption from aqueous solution using chitosan/graphite composites: Isotherm and kinetics studies
Màxim Gibert-Vilas	Micropollutants removal from membrane bioreactor permeate using TiOx reactive electrochemical membranes (REM) and prospects for the integration of REMs as anodes in membrane bioreactors
Raja	Impact of Activated Carbon on Ceramic Flat Membrane Performance
Tizita Desalegn	Studies on the preparation of oleo-resinous wood varnish by utilizing Jatropha seed oil
Stefan P	WE-Africa: Membrane Knowledge Hub: A University-Industry Platform Towards Sustainable Water and Energy Management in Africa

List of Abstracts

[1] Wondimagegne Mamo Mengistu (Bio and Emerging Technology Institute).
Title: *Comprehensive review on the use of Zeolite in the filtration and purification of water.*
Abstract
The purpose of this thorough analysis is to examine how zeolite is used to filter and purify water. Zeolite is a natural or synthetic substance that has certain qualities that enable it to effectively filter impurities out of water. The review looks at the variables that affect how well zeolite filters work, including the kind of zeolite utilized, particle size, starting pollutant concentration, pH, temperature, and contact time. It also looks at the various zeolite filtration methods, such as adsorption, hydrolysis, and ion exchange. Zeolite filter medium provide a natural and sustainable water treatment solution. Zeolites can absorb and eliminate pollutants by adsorption because of their high pore density and vast surface area. Additionally, they are able to take positive ions from water and swap them for other ions thanks to their cation exchange capabilities. Zeolite filters don't require frequent back-washing since they are efficient at capturing and eliminating particles, including germs and insoluble contaminants. The review contrasts the capacities of synthetic and natural zeolites for water treatment. It talks about the variations in their characteristics, including pore density, cation exchange capacities, and silica-to-alumina ratio. The analysis also emphasizes how crucial it is to take into account the degree of modification in synthetic zeolites and the source of natural zeolites when evaluating their efficacy in water treatment. Overall, this comprehensive review offers insightful information about the application of zeolite in water filtration and purification. It highlights the need for more data and investigation to compare the efficacy of synthetic and natural zeolites in cleaning up water contaminants.

Keywords: Zeolite, Synthetic, Natural, Filtration, Purification, Water

[2] Vercus Lumami Kapepula (Centre de Recherche en Hydrobiologie CRH-Uvira/ DRCongo), Sara Chergaoui (UCLouvain) and Patricia Luis (UCLouvain).
Title: *Removal of toxic metal ions from surface water using biopolymer chitosan/ZIF-8 mixed-matrix membranes.*
Abstract
Biopolymer chitosan (CS)/ZIF-8 selective layers were successfully deposited on two different PAN supports, namely wet PAN (PAN-w) and dry PAN (PAN-d) to fabricate mixed-matrix membranes (MMMs). PAN-w-supported MMMs exhibited better heavy metal retention properties than PAN-d-supported MMMs. The membrane hydrophilicity varied with ZIF-8 loading. Metal ion analyses were performed by standardized ICPOES methods. The best results were obtained using a PAN-w-supported MMM with 3 wt.% CS as bio-matrix and 15 wt. % ZIF-8 as the filler, reaching a permeability of 4.6 L.m-2.h-1.bar-1 at an applied pressure of 30 bar. Significant rejections were also obtained: 13, 88, 98, 96.5, 85 and 24% for As3+, Cd2+, Cr3+, Ni2+, Pb2+ and Sb3+ respectively, from a feed solution having a total initial concentration of 90 ppm (15 ppm per ion). Single element solutions were also filtered under the same operating conditions. Compared with feed solution containing all the element ions, the rejection increased significantly for the Cd2+, Pb2+ and Ni2+ ions respectively, to 97; 96; 97% without compromising the Cr3+ rejection rate. Compared to commercial membranes, the economic profitability of the process of filtration can be guaranteed under a low driving pressure of 29 bar with an energy consumption of 2.10-3 kWh.m-3.

Keywords: 'chitosan', 'ZIF-8/CS mixed matrix membrane', 'reverse osmosis', 'toxic metal ions removal'

[3] Haftu Alemayehu (Arba Minch University), Rshane Hailu (Arba Minch University) and Paulos Taddese Shibeshi (Arba Minch University).
Title: *Mild temperature regulated highly stable graphene oxide membrane for molecular separation.*
Abstract
Graphene oxide (GO) exhibits considerable potential for addressing global water scarcity issues due to its ultrathin structure and abundance of oxygenated functional groups, making it an attractive material for nanofiltration membrane development. Nonetheless, challenges persist regarding the stability of GO membranes in aqueous environments and their sustained performance over time, posing significant hurdles to efficient mass transfer. In this study, we present a rapid fabrication method for an ultrathin GO membrane on a nylon substrate using vacuum filtration, achieving completion within 5 minutes. Our investigation reveals that drying GO/nylon membranes at 70°C significantly enhances their stability in aqueous solutions compared to those dried at room temperature. Immersion tests conducted over a 20-day period demonstrate that the GO/nylon membrane dried at room temperature becomes detached from the substrate within 12 hours, while the membrane dried at 70°C remains intact for over 20 days without any signs of deterioration, attributed to the thermally induced equilibrium in electrostatic repulsion that stabilizes the GO membrane. This optimized membrane exhibits improved operating duration, selectivity, and permeability. Specifically, it demonstrates near-complete rejection of organic dyes (~100%) and high selectivity for sulfate salts such as Na2SO4 and MgSO4 (>80%). Furthermore, the membrane sustains continuous operation for over 60 hours with only a 30% decline in water permeability and complete dye rejection. Our findings underscore

the importance of moderate temperature drying for enhancing separation performance and membrane stability, suggesting broad applicability of this drying technique across various fields.

Keywords: graphene oxide, nanofiltration desalination, membrane separation, nylon membrane

[4] Rita Namoe Tabi (Kwame Nkrumah University of Science and Technology), Frank Ofori Agyemang (Kwame Nkrumah University of Science and Technology), Patrick Boakye (Kwame Nkrumah University of Science and Technology), Sampson Oduro-Kwarteng (Kwame Nkrumah University of Science and Technology) and Mihail Barboiu (Institut Européen des Membranes (IEM), Université de Montpellier.).

Title: *Incorporation of artificial water channels into a thin film composite membrane for nanofiltration.*

Abstract

Groundwater is the main source of water for communities without access to national water supply systems. However, various groundwater sources across the globe have concentrations of fluoride, nitrate, iron, manganese beyond the recommended guidelines. Drinking such water causes diseases such as fluorosis, methemoglobinemia, and neurotoxicity. Hence, treatment is required. Conventional methods such as adsorption and oxidation-coagulation-filtration are available. But these methods have disadvantages such as low product water quality, large footprint and require highly skilled personnel. Membranes are a promising technology to overcome these challenges. However, a selectivity and permeability trade-off does exist in membrane filtration. Artificial water channels, which mimic aquaporins have been proved to help overcome this challenge in reverse osmosis membranes. In this study, the same concept will be used to develop a nanofiltration membrane and apply in the removal of some groundwater contaminants such as fluoride, iron, and nitrate.

Interfacial polymerization was used to fabricate the membrane unto a polyether sulfone support, with the incorporation of imidazole - quartet artificial water channels. Scanning electron microscope and energy dispersive x-ray analysis confirmed the formation of the nanofiltration membrane layer on the support. Fourier-transform infrared spectroscopy analysis confirmed the incorporation of artificial water channels in the membrane. A reduction of 41 % in water contact angle was obtain for the biomimetic membrane, thereby increasing the membrane's water permeability by 38 %.

Four salts, 2 g/l each, were used to study the selectivity of the membrane by crossflow filtration at 10 bars. Rejections of 94.4 %, 84.4, 58.2 % and 42.1 % were obtained for sodium sulphate, magnesium sulphate, sodium chloride and calcium chloride respectively. In the case of groundwater contaminant rejection, a total rejection of up to 6 mg/l of iron, over 90 % rejection of 12 mg/l of fluoride and about 68 % rejection of 100 mg/l of nitrate were obtained at 6 bars.

In all, the data so far obtained indicates that the fabricated membrane has a good potential for groundwater treatment and is not characterised with a significant trade-off in selectivity and permeability.

Keywords: Artificial water channels, Nanofiltration, Groundwater, Biomimetic membranes

[5] Amara Mourad (USTHB & ENSNN University).

Title: *Improvement of membrane selectivity by chelation properties of self-adsorbed compound.*

Abstract

Membrane materials are not utilized only as porous materials; they also play a significant part in the transport and separation of species due to their surface charge, hydrophilic/hydrophobic balance, texture, and many other physical and chemical properties that depend on the medium matrix. The development of selective membranes implies the adoption of a novel concept of separation, which is based on the complexes that form within the membrane material during the chelation process of transport. This gives the membrane a highly selective characteristic regarding to specific species that exist in a highly heterogeneous environment. Using this phenomenon of chelation and transport by complexation-decomplexation between feed-and-receive surfaces in the direction of transference flow became possible by polymer inclusion membranes, or PIMs. This type of membrane has been synthetized using polyethyleneneimine (PEI), which has the ability to chelate in aqueous environments. This polymer exhibits polyelectrolyte behavior in aqueous solution; the pH and ionic strength of the water determine its viscosity, protonation rate, and conformation. A structure with both amine and ammonium groups is produced when the pH is kept at or near pKa=8.8, which polarizes the membrane surface. Alcaline medium leads to the predominance of amine groups, non-binding nitrogen doublets, and complexation mechanisms as opposed to ion exchange mechanisms. Negatively-charged metal-ligand complexes are transported at higher pH levels by ion pair mechanism into the membrane bulk. Since more than 20 years, we have concentrated our efforts on the investigation of several facets of PEI's acid-base and complexing behavior in aqueous solutions, as well as inside membranes or ion exchange resins as a surface modification and ion transport facilitator through complexation. Copper is a highly studied metal that absorbs light at 630 nm in the visible spectrum and 280 nm in the ultraviolet spectrum. In addition, additional

molecules like polyvinylpyrrolidone (PVP) for cobalt, thiourea for copper and silver separation, D2EHPA for chromium transport, and other complexing agents have been utilized to complement PEI or work as substitutes.

Keywords: Membrane, complexation, selectivity

[6] Abdoulaye Doucoure (Donyatek).
Title: *ADOPTING NANOTEXTILE FABRICATION PROCESSES FOR FILTRATION APPLICATIONS* .
Abstract
This study will highlight how filters made of ultrafine fibers play a crucial role in guaranteeing the safe production of drinking water, beverage fluids, pharmaceutical drugs, and removing unwanted contaminants from air streams – e.g., respiratory masks and cleanroom HEPA filters. Technologies based on meltblown and force spinning capabilities for fabricating synthetic nanofibers will be reviewed and a special attention will be placed on electrospinning processes. They can produce nano-textiles prepared from a broad range of chemistries, comprising very uniform fibers (fiber shape and form), and a high surface area-to-volume ratio [1-3].We will comment on prior art literature that compares electrospun fiberwebs properties against those of other nano-nonwoven and standard polymeric MF/UF membranes. This presentation is meant to [4-7]
•establish a relationship between the morphological properties of ultrafine nonwoven materials and their fabrication method, discuss the properties-performance correlations – versus standard membranes, recommend some desirable nano-nonwoven structures based on filtration applications – e.g., water treatment, bio-purification, air treatment etc.

Keywords: nanofiber, nonwoven material, water treatment, biopurification, air treatment, microfiltration, ultrafiltration

[7] Adel Zrelli (Higher Institute of Applied Science and Technology of Gabes Tunisia).
Title: *Valorizing Waste Bricks in Geopolymer Membrane Preparation for Treating Oily Wastewater: Effects of Curing temperature and Liquid/Solid ratio.*
Abstract
The objective of this study is to explore the valorization potential of waste bricks through the preparation of geopolymer membranes. Specifically, we aim to investigate how curing temperatures and liquid/solid ratios influence the characteristics and performance of these geopolymer membranes, with a particular focus on their application in treating oily wastewater. After establishing the process for geopolymer membrane preparation, we characterized the membranes based on porosity, water absorption, contact angle, liquid entry pressure, and their efficiency in treating oily wastewater. The experimental results revealed that raising the curing temperature from 70 to 90 °C resulted in a significant 38% increase in porosity, leading to a 58% rise in water absorption. Additionally, the contact angle increased by 4%. Similarly, increasing the liquid/solid ratios from 0.4 to 0.5 led to a 39% increase in porosity, inducing a 22% and 8% rise in water absorption and contact angle respectively. In the case of treatment oily wastewater with an oil concentration of 125 mg L-1, the geopolymer membrane cured at 80 °C with a liquid/solid ratio of 0.4 achieved an oil rejection rate of 89%.

Keywords: Geopolymer, Membrane, Valorization, Oily wastewater, Treatment

[8] Marwa Shalaby (National Research Centre).
Title: *Hydrophilic Green Additives for Polymeric Membranes and its Effect on Sustainability and Circular Economy* .
Abstract
In this work, we will present the effect of the presence composite additives/nanostructure of metal oxides or green composites and their blends in mixed matrix membranes. The antifouling membranes are evaluated regarding reduced maintenance& cleaning facilities, and recyclability. By incorporating green additives into polymeric membranes, manufacturers can achieve several key benefits. Firstly, these additives help to increase the water permeability of membranes, which is essential for efficient water treatment processes. This, in turn, can lead to higher water productivity and reduced energy consumption. Moreover, the use of hydrophilic green additives can enhance the longevity and durability of polymeric membranes, ultimately reducing the need for frequent replacements and lowering maintenance costs. This contributes to the circular economy by promoting resource efficiency and minimizing waste generation. From a sustainability perspective, the incorporation of green additives in polymeric membranes can lead to a reduction in the overall environmental footprint of water treatment processes. These additives are often derived from renewable sources and are biodegradable, aligning with principles of sustainability and eco-friendliness. From these composites we can find cellulose nanocrystals, chitosan, chitin, zeolites, graphene oxides and tannic acid.

For instance, the main challenges in recycling RO membranes include separation of membrane layers, The different layers of the membrane need to be separated to recover the useful polymeric materials. This can be difficult due to the strong adhesion between the layers. Contaminant removal: used RO membranes may be fouled or contaminated with various substances, such as salts, organic matter, and microorganisms. Thorough cleaning and decontamination are required before the membranes can be recycled.
Polymer degradation: The polymers used in RO membranes can undergo degradation during the membrane's service life, which can affect their recyclability and the quality of the recycled material. Despite these challenges, researchers and companies are exploring various recycling methods for polymeric RO/UF/NF membranes, including:
Mechanical recycling: The used membranes are ground, shredded, or otherwise mechanically processed to recover the polymeric materials, which can then be reused in new products. Chemical recycling: The membranes are treated with chemicals to break down the polymers into their monomeric or oligomeric building blocks, which can be used to synthesize new polymers. Thermal recycling: The membranes are heated to high temperatures, causing the polymers to decompose and release valuable chemicals or fuels. Membrane reuse: Instead of recycling, some used RO membranes can be cleaned, refurbished, and reused in water treatment applications, prolonging their service life. These hydrophilic modifications can significantly improve the long-term performance and operational lifetime of RO/NF/UF membranes, ultimately reducing the frequency of membrane replacement and lowering the overall cost of water treatment systems. Maintaining the hydrophilicity of RO membranes is, therefore, a critical factor in ensuring their efficient and sustainable operation.

Keywords: Polymeric membranes, Sustainability & circular economy, Water desalination, Wastewater treatment, Hydrophilicity & antifouling behavior

[9] Njabulo Sondezi (University of Johannesburg, Doornfontein Campus, P.O. Box 17011, Doornfontein, Johannesburg, 2028, South Africa), Kgabo Matabola (DSI/Mintek NIC, Advanced Materials Division, Private Bag X3015, Randburg 2125, South Africa) and Thollwana Makhetha (University of Johannesburg, Doornfontein Campus, P.O. Box 17011, Doornfontein, Johannesburg, 2028, South Africa).
Title: *FABRICATION OF THE PVDF/PAN ELECTROSPUN NANOFIBROUS MEMBRANES INCORPORATED WITH TIO2/Cu@NH2-MIL-125 NANOCOMPOSITE FOR WATER REMEDIATION.*
Abstract
The fabrication of electrospun nanofibers has attracted more interest since the rapid advancement of nanotechnology. Electrospun fiber membranes have overcome disadvantages such as limited effectiveness and high energy consumption on conventional water treatment systems. This study outlines the fabrication of electrospun TiO2/Cu@NH2-MIL-125/PVDF/PAN nanofibrous composite membrane for point-of-use (POU) water treatment. Scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), Fourier-Transform infrared spectroscopy (FTIR) and contact angle were all used to confirm the successful incorporation of TiO2/Cu@NH2-MIL-125 onto PVDF/PAN nanofiber membranes. The SEM-EDX outcomes indicated that the electrospun nanofiber membranes possessed uniform nanofibers. The average diameter was reduced with addition of fillers. The FTIR and XRD measurements indicated features that validated the successful loading of TiO2/Cu and TiO2/Cu@NH2-MIL-125 composite fillers onto the PVDF/PAN nanofiber. The nanofiber membranes were tested against Bacillus subtilis (B. subtilis) and Escherichia coli (E. coli). The introduction of TiO2/Cu and TiO2/Cu@NH2-MIL-125 onto PVDF/PAN nanofibers resulted in insignificant inhibition and some susceptibility effects on the growth of the bacteria i.e. the colonies of bacteria were isolated. Furthermore, the nanofiber membranes had greater cadmium adsorption affinity compared to lead with 100% cadmium removal performance.

Keywords: PVDF/PAN blend, TiO2/Cu@NH2-MIL-125, nanofibrous composite membrane, antibacterial

[10] Sergio Santoro (University of Calabria), Marco Aquino (University of Calabria), Ramato Ashu Tufa (University of Calabria) and Efrem Curcio (University of Calabria).
Title: *MEMBRANES IN MINING RAW MATERIALS FROM BRINE.*
Abstract
The valorization of hypersaline brines (such as from seawater Reverse Osmosis desalination, salt lakes, geothermal water, produced water etc.) is attracting a significant attention as a potential source of water and valuable raw materials, essential for supporting a sustainable industrial growth and the green and digital transition. To strengthen Critical Raw Materials (CRM) capacities across all stages of the value chain, EU implemented the European Critical Raw Materials Act; within this action plan, a list of CRM based on their economic significance and high supply risk has been identified [1], while also promoting research on innovative mining and resource recycling, coherently with the Circular Economy concept.

Brines are a complex aqueous mixture of different metal ions with concentration ranging from g/L (e.g. Na+, K+, Mg2+, Ca2+) to mg/L (e.g. Li+, Rb+, Sr2+) or □g/L (e.g. Ga3+, Sc3+). For instance, the Mg2+/Li+ mass ratio - a key factor to the lithium recovery – typically ranges from 2-7 in salt lakes to three orders of magnitude higher in SWRO brine. Additional complications arise from presence of ions that combine into low solubility compounds (risk of scaling), presence of interfering components, high osmotic pressure of the brine which lowers the efficiency of pressure-driven membranes at high concentration.
Membranes and membrane processes, with their ability to selectively recognize and transport specific components more efficiently than traditional energy-intensive separation methods, play a key role in the design of a technological platform for the sustainable valorization of brines.
At the University of Calabria, pioneering research activities in this field, which began in the early 2000s, were focused on exploiting synergies arising from the integration of different membrane processes [2]. Currently under investigation is the hybridization of pressure-driven membrane operations, membrane contactors, and electrochemical membranes at various stages [3]: pre-fractionation (Nanofiltration), dehydration (Membrane Distillation Crystallization, potentially enhanced by the photothermal effect), and enrichment (Diffusion Dialysis, Monovalent-Selective Electrodialysis). This approach is further complemented by novel ion-selective membranes and reactive precipitation, to ascertain if brine can indeed be the mine of the future.
[1] European Commission, Study on the Critical Raw Materials for the EU 2023, Final Report
[2] E. Drioli, E. Curcio, A. Criscuoli, G. Di Profio. Integrated system for recovery of CaCO3, NaCl and MgSO4·7H2O from nanofiltration retentate. J. Membrane Sci. 239/1 (2004) 27
[3] A. Politano et al., 2024 Roadmap on membrane desalination technology at the water-energy nexus. J. Phys. Energy 6 (2024) 021502

Keywords: Brine Mining, Critical Raw Materials recovery, Membrane Processes

[11] Khady Ndiaye (ESP/UCAD), Cheikhou Kane (ESP/UCAD) and Codou Mar (ESP/UCAD).
Title: *STABILIZATION OF AQUEOUS HIBISCUS EXTRACT IN A MEMBRANE-SEPARATED TWO-COMPARTMENT ELECTROCHEMICAL CELL.*
Abstract
Until now, dissolved oxygen in juices has been treated by bubbling with an inert gas, or by adding other molecules such as preservatives, which can cause considerable damage to human health. Platinum electrode dissolved oxygen reduction is a new athermal technique using a two-compartment electrolysis cell separated by a cationic membrane. The fruit juice is stabilized by the passage of the reduction current for a set time. Oxygen reduction on the platinum/ECS electrode resulted in the retention of over 35% of anthocyanins after 4 weeks' storage at 25°C. At 4°C, a significant difference of 5% between the electro-reduced Hibiscus extract and the control was maintained until the fifth month of storage with the 1/5 (calcium/water) ratio. The activation enthalpy of the electro-reduced Hibiscus extract was around 6 J/mol/K, and that of the control 5.72 J/mol/K, showing that the electrochemical process takes place at low energy, i.e. 0.28 J/mol/K for a volume of around 250 mL. The study enabled cold electrochemical stabilization of Hibiscus sabdariffa L extract without the addition of other molecules.

Keywords: Stabilization, Anthocyanin, Oxygen, Electrochemistry, Membrane

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Title: *Membranes for Solution Crystallization.*
Abstract
Antisolvent crystallization is necessary in the development of solid organic compounds used in pharmaceutical or agrochemical applications. The crystal shape and size impact drug aspects such as flowability, compatibility, dissolution, and absorption rate. These organic compounds are commonly recovered by adding antisolvent to the solution to reach supersaturation. To fine-tune crystal properties, porous membranes can control mixing and antisolvent mass transfer.
The control of antisolvent addition avoids the formation of local supersaturations; meaning, focal points where the concentration of antisolvent is high compared to the rest of the bulk solution. The non-homogeneous mixing in the conventional crystallizer leads to crystals of ununiform crystal properties, requiring further downstream processing such as milling, that could alter the crystal properties. Membranes can be used as a physical barrier between the antisolvent and the crystallizing solution controlling the mass transfer of the antisolvent into the crystallizing solution. Besides, MAAC can easily be scaled up, it is compact and has high energy efficiency, and can be operated in

continuous mode, which goes along the objectives of Sustainable Development Goals 9 (Industry, Innovation, and Infrastructure) and 12 (Sustainable Consumption and Production).
This talk first addresses the mass transfer of the antisolvent through the porous membrane which was evaluated considering the activity difference of the antisolvent between the two sides of the membrane throughout the operation time. The possibility of reverse permeation was also assessed and linked to the stability of the mass transfer coefficient. This part is followed by the presentation of how key operating conditions and membrane characteristics impact the antisolvent mass transfer and crystal properties, using different techniques for membrane synthesis. Finally, the interactions between the membrane surface and the crystallization system are demonstrated from a molecular perspective. A comparison with the conventional stirred tank crystallizer in batch and drop-wise operation is also discussed. Glycine and L-serine amino acids served as models for crystallization in these studies given their ability to form a crystalline structure and their relevance to applications in biotechnology.
Keywords: Membrane-assisted antisolvent crystallization, Amino acids, Supersaturation control, Mass transfer

[13] Dr. Abdulrahman Babatunde Ameen (University of Ilorin) and Folahan Amaoo Adekola (University of Ilorin).
Title: *Leachate Plumes: Effects on Water Quality and Public Health Risks in Ilorin, Kwara State, Nigeria.*
Abstract
Leachate Plumes: Effects on Water Quality and Public Health Risks in Ilorin, Kwara State, Nigeria
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A physicochemical assessment of leachate was conducted at three different locations within the Ilorin metropolis: Ogundele (OG), Gbagede (GB), and the University of Ilorin dumpsites (UI). This study represents dry season sampling, utilizing standard methods. The pH of the leachate samples from these sites ranged from ultra-acidic to basic (6.6 – 8.6), with electrical conductivity measuring between 130 and 540 µS/cm. Specifically, the leachate pH at the Ilorin dumpsite varied from slightly alkaline to acidic, while electrical conductivity remained within acceptable limits. Samples were collected at distances of 2m and 5m from the central areas of these dumpsites. Notably, the pH of leachate at a 5m distance from each site was observed to be neutral. The physicochemical analysis highlighted the dangers associated with open waste dumping, revealing the presence of ammonia, calcium carbonate, nitrate, sulfate, and various heavy metals in the leachate. These contaminants pose significant risks to public health and the environment by potentially percolating into and contaminating surface and groundwater.
Keywords: Leachate, Water, Open dumpsite, Anions, Cations, Heavy Metals, Ilorin, Dumpsites

Keywords: Leachate, Water, Open dumpsite, Heavy Metal, Ilorin, Dumpsites

[14] Màxim Gibert-Vilas (Université de Montpellier, Institut Européen des Membranes), Geoffroy Lesage (Université de Montpellier, Institut Européen des Membranes), François Zaviska (Université de Montpellier, Institut Européen des Membranes) and Marc Heran (Université de Montpellier, Institut Européen des Membranes).
Title: *Study of a novel electrochemical membrane bioreactor (E-MBR): reduction of membrane fouling and electro-oxidation of poorly biodegradable organic matter.*
Abstract
INTRODUCTION
Membrane bioreactors (MBRs) are widely used throughout the world for the secondary treatment of wastewater, due to their compactness and efficiency in eliminating organic matter and nitrogen while providing particularly good physical disinfection. However, their prolonged use leads to membrane clogging, which significantly increases operating costs (Du et al., 2020). In addition, a number of organic micropollutants with harmful effects on human health cannot be eliminated by conventional MBRs. The use of an electro-active membrane bioreactor (E-MBR) would make it possible to avoid the need for tertiary treatment (Maghsoodi et al., 2019). Current approaches are essentially based on the use of external electrochemical cells, but to gain in compactness it is also possible to integrate the electrochemical cell within the MBR, by placing (i) an anode and a cathode in the bioreactor, (ii) the membrane between an anode and a cathode, or more recently (iii) by using a membrane with electro-active properties as a cathode or anode associated with a counter-electrode (Zhang et al., 2023). The advantages of using these electro-active membranes (EAMs) as both anode and microfiltration membrane are multiple: (i) the use of anode materials with a high oxygen potential, such as TiOx, favors the production of highly reactive hydroxyl radicals •OH which will contribute to the elimination of micropollutants during treatment by anodic oxidation, (ii) the forced passage of micropollutants through the EAM and more particularly in the small diameter pores of the anode material favors their conversion into CO2, (iii) EAM polarization generates electrostatic interactions and oxygen bubbles that improve biofilm permeability, aid filter cake detachment and also slow biofilm development (Trellu et al., 2018). The aim of this study is therefore to identify and characterize the phenomena associated with the fouling of electro-active

membranes and the degradation of bio-refractory organic pollutants within a E-MBR reactor on a laboratory pilot scale operated in continuous flow.

MATERIAL AND METHODS

The E-MBR is composed of a filtration/electro-oxidation module that is inserted into a six-liter bioreactor. The permeate from the membrane filtration enters an electro-oxidation cell consisting of the electro-active membrane used as an anode and a titanium cathode placed in parallel. The EAMs used in this study consist of a TiOx or titanium foam support on which a thin TiOx active layer is deposited. This active layer also forms the filter layer (microfiltration). The total geometric surface area of the 24 EAMs present on the module is 576 cm-2. Degradation and mineralisation kinetics were conducted for current densities of 1, 3 and 6 mA.cm-2 and permeate flow rates of between 20 and 100 L.m-2.h-1 in an ultrapure water matrix doped with orange 2-naphthol (15 ppm) and Na2SO4 electrolyte (50 mM). Two E-MBRs will then be operated in parallel with a 40-day SRT and variable permeation flux, one with and one without membrane polarization. The E-MBRs will be inoculated with activated sludge from a WWTP and operated with a synthetic effluent spiked with carbamazepine (300 ppb). System performance will be analyzed by monitoring pH, redox potential, total organic carbon (TOC), chemical oxygen demand (COD), biological oxygen demand (BOD5) and by tracking carbamazepine degradation by-products. Membrane fouling is measured by analyzing the transmembrane pressure over time.

RESULTS, DISCUSSIONS AND PROSPECTS

The membranes were initially characterized by analyses of porosity, permeability, and resistivity. The aim is to use the experimental device with matrices of increasing complexity: (i) ultrapure water, (ii) ultrapure water doped with 2-naphthol orange (15 ppm), (iii) model organic matter (bovine serum albumin, humic substances…) and (iv) synthetic wastewater doped with carbamazepine (300 ppb). Initial tests have begun on the ultrapure water matrix doped with orange 2-napthol. For the time being, the best conversion of organic compounds occurs at the highest current densities and lowest permeate flow rates. Subsequently, the installation and monitoring of two E-MBRs in parallel, with or without the application of a current through the EAMs, will permit the conduct of a comparative study aimed at demonstrating the effectiveness of polarized EAMs coupled with biological treatment in reducing membrane fouling and improving the elimination of organic matter.

Keywords: Electro-active membrane bioreactor, membrane fouling, electro-oxidation, biological treatment, micropollutants

[15] Olga El Kik (Mines Telecom Institute and University of Montpellier), Geoffroy Lesage (European Institue of membranes, University of Montpellier, CNRS, ENSCM), François Zaviska (European Institue of membranes, University of Montpellier, CNRS, ENSCM), Andrés Sauvêtre (Hydrosciences Montpellier, University of Montpellier, IMT Mines Ales, IRD, CNRS), Marc Heran (European Institue of membranes, University of Montpellier, CNRS, ENSCM) and François Lestremau (Hydrosciences Montpellier, University of Montpellier, IMT Mines Ales, IRD, CNRS).

Title: *COMBINING BIOLOGICAL TREATMENT AND ELECTRO-OXIDATION IN A MEMBRANE BIOREACTOR FOR AN INTEGRATED SOLUTION TO URBAN WASTEWATER TREATMENT, PARTICULARLY TARGETING MICROPOLLUTANTS.*

Abstract

The global demand for freshwater, particularly reclaimed water, underscores the urgent need to address wastewater challenges in line with the United Nations Sustainable Development Goals and the European Water Framework Directive (EU WFD). Recent revisions to the EU WFD have imposed stricter limits on nutrient releases and introduced new requirements for micropollutant removal. Concurrent research focuses on the complexities of 'emerging' micropollutants due to their uncertain effects on aquatic ecosystems and potential exposure levels (Lim et al., 2020). Anaerobic membrane processes show potential in degrading micropollutants via microfiltration/ultrafiltration (MF/UF) membranes. However, the substantial energy demands and limitations in addressing persistent hazardous micropollutants at trace concentrations due to limited anaerobic biotransformation rates remain concerns (Liu et al., 2020). This highlights the critical need for research, innovation, and advanced treatment facilities to efficiently remove organics and micropollutants while minimizing energy consumption and maximizing biogas recovery (Sanchez et al., 2022).

Current research emphasizes sustainable strategies, particularly integrating Anaerobic Membrane Bioreactors (AnMBR) with Bio-Electrochemical Systems (BES) to enhance efficiency, reduce energy consumption, and mitigate fouling using low-intensity electric fields (Liu et al., 2022). AnMBR's effectiveness in environmentally friendly organic matter and micropollutant removal aligns well with BES, known for its exceptional micropollutant degradation capabilities (Chakraborty et al., 2020). However, despite the effectiveness of most Anaerobic-BES systems, limited attention has been paid to treating wastewater containing organic micropollutants. Research has primarily focused on synthetic wastewater, with minimal exploration of industrial streams.

Furthermore, while standalone AnMBR and BES have demonstrated effectiveness for mg/L concentrations, their utility remains limited for trace concentrations in urban wastewater, ranging from ng/L to µg/L (Lim et al., 2020). Recognizing this gap, integrating AnMBR with Microbial Electrochemical Cell (MEC) technology promises improved efficiency and energy output, along with enhanced trace micropollutant removal performance. This study proposes an integrated AnMBR-MEC configuration aimed at enhancing system performance for the removal of micropollutants at low concentrations. Additionally, it enables independent optimization of biological treatment and electrooxidation, anticipating future integration with a reduced footprint and cost.
The experimental setup, constructed at the European Membrane Institute of the University of Montpellier, consists of a transparent and sealed PVC tank with a liquid volume of 6.2 L, accompanied by a gas headspace of 2.2 L, housing an AnMBR reactor. This reactor is equipped with a polyethersulfone ultrafiltration membrane (pore size of 0.04 µm) and incorporates two electrochemical systems: the external MEC system aims to enhance AnMBR performance, while the internal electro-oxidation system targets micropollutant degradation, utilizing a boron-doped diamond (or platinum-coated titanium) catalytic anode for its oxidative capabilities and stability. Inoculated with anaerobic sludge granules, the system treats a complex synthetic solution (sCOD of 224 ± 65 mg/L) with concentrations of 1 µg/L for diuron, carbamazepine, and perfluorooctanesulfonic acid. The AnMBR-MEC system operates with a hydraulic retention time of 13 hours, an organic loading rate of 0.5 kgCOD/m3.d, and variable electro-oxidation from 1 to 5 hours at 0.5-0.8 V for AnMBR-MEC and at 1.6 V for electro-oxidation. Continuous monitoring measures temperature, pH, oxidation-reduction potential, atmospheric, headspace, and transmembrane pressures. Performance evaluation, compared to a control AnMBR, includes biogas production, micropollutant degradation, toxicity, membrane fouling, and microbiology. This integrated approach offers a promising solution for sustainable wastewater treatment in compliance with evolving environmental regulations.
The reactor is designed as a decoupled system and is thoroughly evaluated using key performance indicators such as COD and micropollutant removals, biogas yield, and energy demand. These indicators demonstrate the performance improvements that the e-GAnMBR can provide compared to the control AnMBR, as evidenced in the literature. The integration of the AnMBR-electrochemical system offers a promising solution for efficient micropollutant removal and energy recovery in urban wastewater treatment. By addressing key challenges such as membrane fouling and high energy consumption, this approach provides a sustainable path to compliance with evolving environmental regulations.

Keywords: biogas production, energy demand, membrane fouling, electro-oxidation, micropollutant removal

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Title: *New concepts for water treatment with membrane technology: From ideas to large pilot scale tests*

Abstract

Introduction
Global water scarcity requires new approaches for water treatment. Membrane technology has proven itself as key technology for water treatment from seawater desalination with reverse osmosis to wastewater treatment with membrane bioreactors. In this presentation three new water treatment concepts based on membrane technology and their development from idea to pilot scale testing will be presented. The concepts cover rainstorm water harvesting with micro-/ultrafiltration (MF/UF), direct membrane filtration (DMF) for wastewater treatment and an integrated concept of forward osmosis (FO) and membrane distillation (MD) and nanofiltration (NF) for seawater desalination.
Rain and stormwater harvesting with MF/UF
The EU-Horizon 2020 project REWAISE (Resilient Water Innovation for Smart Water Economy) aims to reduce drinking water consumption by 30%. In Sweden, where the average consumption is 140 liters per person per day, this would mean a reduction to around 100 liters [1]. About 45 liters per person per day are used for toilets and washing machines, which don't require drinking water quality. The project proposes using membrane technology to upgrade stormwater for these purposes. The initial trails of this concept were conducted at stormwater pond in Lund, Sweden, using a unit with 5 m² submerged ceramic membranes, specifically silicon carbide membranes (Liqtech, Denmark) with a 0.2 micron pore size and a 400 kDalton molecular weight cut-off. These membranes remove microplastics and micropollutants larger than 0.2 microns from stormwater. The results showed efficient removal of micropollutants, microplastics, and some heavy metals, producing water close to EU class 'A' quality for agricultural use. Based on the successful trails, a full-scale unit was then installed at the Röda Oasen apartment building in Malmö, Sweden. This unit uses 13.8 m² of ceramic silicon carbide membranes (Cembrane, Denmark) with a 0.1 micron pore size and 200 kDalton molecular weight cut-off. Operational since February 2024, it produces about

1,300 liters of water daily for 22 toilets and 4 washing machines, using stormwater from the roof and an underground tank. The installation saves the property owner approximately 40% of drinking water consumption, or 475,000 liters annually.

DMF for wastewater treatment

The DMF concept, an abiotic alternative for municipal wastewater treatment, uses coagulation, flocculation, and microsieving before membrane treatment. It has high carbon rejection, enhancing biogas production for a potentially energy-neutral or positive process. The concept was successfully tested on pilot scale in Lund, Sweden using 0.2 µm PVDF microfiltration membranes (Alfa Laval, Denmark) with coagulation, polymer addition, and 100 µm micro-screening as pre-treatment. Based on the positive results from the tests larger unit treating over 90 m3 of wastewater per day was installed in Fredrikstad, Norway, and is so far one of the largest DMF plants for wastewater treatment. The two cases show that DMF can achieve high rejection rates of carbon (COD, SS) and total phosphorus, and its high carbon rejection can boost biogas production, moving towards energy-neutral or positive wastewater treatment.

Membrane-based seawater desalination

In the EU-Horizon 2020 project DESOLINATION project (Demonstration of Concentrated Solar Power Coupled with Advanced Desalination System in the Gulf Region) the aims is to develop the efficient integration of a concentrated solar power (CSP) system with a membrane-based desalination system on a pilot-scale in a real-world setting. Waste heat from the CSP system will power the desalination process, reducing costs—a major barrier to CSP deployment. The concept is based on using a thermo-responsive polymer as FO draw solution with NF and MD plus a coalescer. A key success factor is the draw solution which needs to provide sufficient osmotic pressure to desalinate seawater with 3.5% salt and has to be compatible with the membranes as well as the modules used. Initial trials of the individual units are currently ongoing in the pilot plant hall at Lund University, Sweden and based on the results, a large scale pilot will be installed at CSP plant of King Saud University in Riyadh, Saudia Arabia.

Outlook and conclusions

These innovative water treatment concepts demonstrate the significant potential of membrane technology to address global water scarcity. By advancing from pilot studies to full-scale implementations, these projects pave the way for more sustainable and efficient water management solutions worldwide.

Acknowledgments

The research is partly funded by the REWAISE “Resilient Water Innovation for Smart Economy” (Project No. 869496) and DESOLINATION (Project No. 101022686) under the European Horizon 2020 programme.

Keywords: water treatment, rainwater, stormwater, seawater, wastewater treatment

[17] Michael Daramola (University of Pretoria).

Title: *Sodalite-based Membranes for Water and Wastewater Treatment.*

Abstract

Over 70% of our Earth's surface is covered by water. Although water is seemingly abundant, the real issue is the amount of fresh water available. About 97.5% of all water on Earth is salt water, leaving only 2.5% as fresh water. Nearly 70% of that fresh water is frozen in the icecaps of Antarctica and Greenland; most of the remainder is present as soil moisture, or lies in deep underground aquifers as groundwater not accessible to human use. However, less than 1% of the world's fresh water (~0.007% of all water on earth) is accessible for direct human uses. This is the water found in lakes, rivers, reservoirs and those underground sources that are shallow enough to be tapped at an affordable cost. Only this amount is regularly renewed by rain and snowfall, and is therefore available on a sustainable basis. Sadly, human activities, such as mining, have polluted some of the available sources of water, resulting in contaminated water (e.g. acid mining drainage (AMD)). Also the available seawater is not good for drinking and domestic use due to its high salinity. To make the fresh water available for human usage thereby contributing to realization of UN SDG 6, the seawater and the polluted water have to be treated to a specific acceptable level at which no harm is done to human life. One of the cost effective processes of doing this is the use of membrane technology [2-4]. However, current membrane-based technologies (e.g. seawater reverse osmosis (SWRO) for seawater desalination) is associated with low water recovery (50%) and high energy consumption (3-5 kWhm-3) leading to an increase in operating costs. In the same vein, effective treatment of AMD to clean potable water using membrane technology requires cascades of membrane systems in stages, translating into additional capital and operating costs. Therefore the development of affordable alternative technologies or membrane materials with high energy efficiencies for in situ water removal is inevitable for water sustainability. In view of the aforementioned statements, application of hydrophilic Hydroxy Sodalite (H-SOD) membranes for selective removal of water has been proposed. In this paper, synthesis, characterization and application of H-SO D membrane for seawater desalination and AMD treatment are presented. Results from the investigation have demonstrated the potential application of H-SOD membranes for seawater desalination and AMD treatment. However, optimization of the synthesis protocol of the membranes and of the process conditions are required to enhance their performance.

Keywords: Desalination, Acid mine drainage, Membrane, Hydroxy sodalite, Water and wastewater

[18] Khona Maziya (University of Witwatersrand), Anita Etale (University of Bristol) and Heidi Richards (University of Witwatersrand).
Title: *High performance TFN membranes with modified CNCs for improved dye/salt removal from water.*
Abstract
In this study, cellulose nanocrystals (CNCs) were derived from industrial hemp (Cannabis sativa) fibers through acid hydrolysis. Glutamic acid (GLU) brushes were grown on the surface of CNCs using surface-initiated polymerization (SIP). The synthesis of CNCs and its polymer derivatives was confirmed by Fourier Transmission Infrared (FTIR), Powder X-ray Diffraction (XRD), Transmission Electron Microscopy (TEM), Nuclear magnetic resonance (NMR) spectroscopy and Thermogravimetric Analysis (TGA). These modified CNCs were incorporated into a polyamide (PA) layer to prepare novel thin film nanocomposite (TFN) membrane for efficient removal of dyes and salt in water. The CNC-GLU/TFN membranes were characterized and evaluated in comparison with bare TFC membranes by the SEM-EDS, contact angle, permeation measurements, and dye/salt rejection studies. In comparison to the bare TFC membrane, the CNC-GLU/TFN membranes demonstrated improved permeability and dye/salt removal. These promising results prove that industrial hemp fibers are an invaluable resource for the production of CNCs with successive potential application in wastewater treatment.

Keywords: Cellulose nanocrystals, Thin film nanocomposite membranes, Dye removal, Salt rejection

[19] Purity Liaga (University of Pretoria), Fildah Ayaa (Makerere University), Samuel Iwarere (University of Pretoria) and Michael Daramola (University of Pretoria).
Title: *Blended Polysulfone/Polyethersulfone Infused with Sodalite nanoparticles for carbamazepine removal from pharmaceutical wastewater.*
Abstract
Carbamazepine (CBZ) is one of the most frequently detected pharmaceutical compounds in environmental systems and it is associated with several ecotoxicology effects on human and/or aquatic life after long-term exposure. In this study, hydroxy sodalite (HSOD) nanoparticles were successfully synthesized via hydrothermal synthesis at 413 K for 3.5 h. The morphology, phase purity and surface chemistry of the HSOD nanoparticles were checked using scanning electron microscopy (SEM), X-ray diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR), respectively. The synthesized nanoparticles were used together with a 50% / 50% blended polyethersulfone (PES)/ polysulfone (PSF) polymer to prepare nanocomposite membranes containing 10 wt % HSOD via phase inversion. The performance of the membrane was compared with that of the unblended 100% PES and 100 % PSF that contained no HSOD. The membranes were characterized using SEM for morphology and FTIR for surface chemistry. Hydrophilicity of the prepared membranes was measured via contact angle method and the mechanical strength of the membrane was also measured. The SEM images of the membranes showed that HSOD particles are embedded within the fractional free volume of the blended polymer. The 50% / 50% PES/PSF/HSOD membrane displayed the lowest contact angle of 59°, highest equilibrium water content of 50 %, highest porosity of 65 % and highest tensile strength of 11 MPa. Checking the membrane flux of the synthesized membrane via pure water permeation experiments showed highest pure water flux of 10 Lm−2 h-1 and a highest CBZ removal of 72 % was recorded for the same membrane. These results highlight the potential of blended PES/PSF polymer infused with HSOD nanoparticles for pharmaceutical wastewater treatment. However, further study on the optimisation of the synthesis protocol of the membrane is highly recommended to enhancing the separation performance of the membrane during CBZ removal in wastewater.

Keywords: Carbamazepine, Blended polymers, Sodalite, Pharmaceutical wastewater, Membranes

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Title: *Fluoride Removal and Recovery from Water Using Reverse Osmosis and Osmotic Membrane Crystallization.*
Abstract
Fluoride becomes a matter of concern for human health when present at high concentrations. To address this, the World Health Organization (WHO) has established a guideline of 1.5 milligrams per liter for fluoride in drinking water. Nevertheless, fluoride also holds significant value as a compound with multiple applications. Consequently, the development of a system that enables the removal and recovery of this valuable element from water is of great interest. The aim of this study was to evaluate the performance of an integrated process consisting of reverse osmosis (RO) and membrane crystallization to remove fluoride from water and to recover it as a pure fluoride salt. To conduct RO experiments; the Armfield FT17 filtration system was employed. This lab-scale unit utilizes flat-sheet

membranes and is designed for crossflow filtration with smaller product volumes. A commercial RO membrane known as TriSep X—20 was utilized. For osmotic membrane distillation and crystallization (OMD-Cr) setup a hollow fiber membrane contactor apparatus was employed. The RO experimental results show that; the contact angle of the commercial RO membrane was measured before and after filtration using an optical contact angle measuring and contour analysis system. Prior to filtration, the mean contact angle ranged from 10.1◦ to 15.8◦, whereas after filtration, it ranged from 27.2◦ to 58.9◦. the study also showed that the optimal transmembrane pressure strongly depends on the feed concentrations. The maximum pure water permeability of the commercial membrane was found to be 4.8 ± 0.1 Lh−1 bar−1m−2 at 40 bar. The rejection rate varied between 92.5 and 98.6. Concerning the OMD-Cr experiment result; the effect of the feed concentration on the transmembrane water flux was evaluated. The findings indicated that at lower feed concentrations the flux was not significantly influenced. However, at higher feed concentrations the transmembrane water flux was significantly influenced by the concentration. On the other hand, the concentration of the osmotic solution showed a very significant effect on both the transmembrane flux and the mass transfer coefficient due to the water activity dependence on concentration being higher. Finally, pure sodium fluoride crystals with octahedral structure and a face-centered cubic crystal system were obtained, with an average size of 160.86 ± 74.34 μm. In conclusion, the commercial membrane presented good performance for fluoride removal. In addition, the feasibility of producing sodium fluoride crystals using a membrane contactor has been confirmed.

Keywords: Fluoride removal and recovery, Reverse osmosis, Osmotic membrane crystallization

[21] Mohamed Ahmed (Department of Nanochemistry, Institute for Nanomaterials Advanced Technology and Innovation, Czech Republic), Anna Skwierawska (Faculty of Chemistry, Gdansk Technical University, Poland), Christopher Hobbs (Department of Nanochemistry, Institute for Nanomaterials Advanced Technology and Innovation, Czech Republic) and Michal Rezanka (Department of Nanochemistry, Institute for Nanomaterials Advanced Technology and Innovation, Czech Republic).

Title: *β-cyclodextrin modified polyvinylidene fluoride nanofibers for pharmaceutical removal from wastewater.*

Abstract

Cyclodextrin (CD) functionalized membranes exhibit significant potential in membrane technology due to their unique chemistry and supramolecular structure. Their torus architecture enables their known guest-host property and allows for the encapsulation of various organic molecules, thereby enhancing the membrane adsorption capabilities, particularly useful in tackling emerging pollutants such as pharmaceuticals. This work focuses on synthesizing modified polyvinylidene fluoride (PVDF) nanofibers with β-cyclodextrin (β-CD) using a radical polymerization coating method of an acrylic-β-CD (β-CD-Acr) monomer into the nanofibers. The β-CD-Acr monomer was synthesized by reacting β-CD with acryloyl chloride and subsequently polymerized into PVDF using azobisisobutyronitrile (AIBN). The synthesized products were characterized using FTIR, SEM, 1H-NMR, and 13C Solid-State NMR (SSNMR), with the latter also used to quantify the β-CD content in the nanofibers. The PVDF-β-CD-Acr nanofibers were evaluated for their adsorptive performance for pharmaceutical wastewater treatment, using pimavanserin as a model drug. The adsorption behavior was assessed in terms of kinetics, mass, pH, and concentration, demonstrating commendable adsorption capacity.

Keywords: Adsorptive membranes, Polyvinylidene fluoride, Cyclodextrin, Pharmaceutical wastewater

[22] Fatma Ellouze (INSAT), Aymen Chaaben (IEM), Jérôme Harmand (LBE) and Nihel Ben Amar (INSAT/LAMSIN).

Title: *A simple modelling approach to study the fouling in an aerobic membrane bioreactor treating urban wastewater* .

Abstract

The aim of this study is to evaluate the ability of a simple mathematical model to capture the dynamic behavior of membrane bioreactor (MBR) to fouling during municipal wastewater treatment. A pilot scale MBR was installed in Charguia WWTP (Tunisia) to treat real primary effluents with different physical cleaning operating conditions. A: 10 min filtration, 45 s backwash (BW), B: 5 min filtration, 30 s BW, C: 12 min filtration, 60 s BW and D: 9min filtration 60 s relaxation.

The model was validated using data experiments (transmembrane pressure over time) carried out for this purpose. From the fitting model, three parameters are identified: α the specific cake resistance which quantify the fouled cake layer resistance, η the physical cleaning efficiency and β the aeration shear intensity. Results highlighted that the parameters model depend on the operating parameters. Moreover, despite the bioreactor complexity the simple model could describe the dynamic of the filtration system with satisfactory coefficient regression over a filtration time of 5h.

The best fitting was observed for the experience ((A) 10 min filtration, 45 s backwash) with a R2 of 93%. We note, nevertheless, a discrepancy, principally for the last cycles which is probably due to the limited hypothesis of the model. This discrepancy does not penalize the use of this model in the development of a mathematical tool for the optimization of cleaning procedure. If the model can give a satisfactory illustration of the formed cake with precise value during the first cycles, a closed-loop control can be envisaged over longer term to rectify the parameters of the model according to the fouling degree of the membrane.

Keywords: fouling, modelling, Membrane bioreactor, Wastewater treatment

[23] Afef Attia (University of Sfax; Research unit 'Advanced Technologies for Environment and Smart Cities';Sfax; Tunisia) and Raja Ben Amar (University of Sfax; Research unit 'Advanced Technologies for Environment and Smart Cities'; Sfax; Tunisia).

Title: *Zinc-montmorillonite intercalate- based polyethyleneiminenanocomposites : Preparation and photodegradation of BB41 dye under UV light* .

Abstract

This study investigates a novel method for synthesizing a photo-catalyst using an eco-friendly and easily in-situ approach. It was focused on immobilizing zinc oxide (ZnO) on montmorillonite clay (MMT) that had been modified with polyethyleneimine (PEI).The polymer surrounding the nanocomposite plays a crucial role in photo-catalysis by facilitating contact between reacting molecules and active sites, thereby enhancing local concentration through cooperative effects.

The structure and morphology of the synthesized nanocomposites were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and Fourier transform infrared (FTIR) spectroscopy.

The photocatalytic degradation efficiency was assessed using blue Basic 41 (BB41) dye under UV light. The optimization of the UV degradation was determined thanks to the response surface methodology model, considering three input variables: catalyst loading (0.2-0.6 g/L), initial concentration (5-15 mg/L) of BB41 dye, and pH (2-10). It was found that the optimal conditions showing a degradation efficiency of 95%, were as follows: catalyst loading (0.4 g/L), initial concentration (5 mg/L), and pH (≈6). The Free radical scavenging assays confirmed that hydroxyl radicals (OH•) and holes (h+) were the components responsible for the conversion of BB41 dye. The hybrid nanocomposites exhibited high efficiency in removing dyes and showed potential for the removal of other pollutants from aqueous solutions.

Keywords: hybrid-NCs, immobilization of ZnO, Basic Bleu 41 dye, optimization of photocatalysis process, in situ synthesis

[24] Haftu Gebrekiros Alemayehu (Arba Minch University), Rshane Hailu (Arba Minch University) and Berhane Desta (Arba Minch University).

Title: *Highly water stable Ultrathin 2D Metal organic framework-based membrane for molecular separation* .

Abstract

Metal-organic frameworks (MOFs) are tiny sponges with well-defined pores, making them ideal for precise and fast separation processes. However, the creation of ultrathin MOF membranes that can withstand water is a major hurdle. This study introduces a breakthrough to overcome this challenge. Ultrathin (2D) nanosheets were successfully synthesized. These nanosheets were then used as building blocks to assemble ultrathin membranes that were remarkably stable in water. The fabricated membrane exhibited a remarkable performance in terms of solute and ion separation. Notably, a very high rejection rate (100%) was achieved for organic dyes, even for molecules with a relatively low molecular weight of 300 g/mol and alongside promising selectivity for small salt ions such as NaCl (>70%), Na2SO4 and MgSO4 (>80%). Additionally, the membrane demonstrated an impressive water permeance of 50 L/(m²·h·bar), indicating its efficient transport properties. Furthermore, the MOF membrane displayed excellent water and long-term stability. It maintained its separation efficiency for over 5 days of continuous operation without any measurable performance decay. This exceptional water stability renders the membrane suitable for applications that require long-term exposure to aqueous environments. The potential of this highly water-stable MOF membrane extends beyond molecular separation. Its exceptional properties make it a promising candidate for various applications that demand functionality under harsh conditions.

Keywords: 2D Metal organic framework, nanofiltration desalination, membrane separation, water stable

[25] Pengrui Jin (KU Leuven).
Title: *Nanofiltration membrane with adsorptive effect for treatment of emerging organic pollutants.*
Abstract
Emerging organic pollutants (EOPs) are a new category of pollutants whose effects on human and animal health are becoming a matter of public concern, even at the trace levels. Although low levels of emerging contaminants such as dyes, endocrine-disrupting compounds, pharmaceuticals in water, and polyfluorinated compounds in soils may not cause an immediate lethal effect to people, they could have chronic effects on human and animal health and the ecosystem in general. In this work, the use of polyaniline nanofibers modified a three-dimensional Kevlar hydrogel membrane as a membrane substrate to prepare nanofiltration membranes via interfacial polymerization. The acid doping chemistry of polyaniline endows the NF membrane with a tunable charge for improved selectively adsorb and separating small organic molecules from pharmaceutical and municipal wastewater. The membrane achieves > 99% removal of various EOPs (such as, bisphenol A, Tramadol) with water flux 1 order of magnitude higher than typical pressure-driven membranes of similar rejection. This work confirms the feasibility of an adsorptive nanofiltration membrane with high capacity and provides the possibility of an adsorptive nanofiltration membrane for efficient capture of EOPs.

Keywords: Nanofiltration, Adsorptive effect, Emerging organic pollutants

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Title: *TREATMENT OF SUGARCANE INDUSTRY WASTEWATER BY A NOVEL MEMBRANE PHOTOBIOREACTOR.*
Abstract
The wastewater from the sugarcane industry has complex features and challenges in terms of treatment and impact on the environment. In this research, the wastewater treatment of sugarcane industries has been investigated with the help of microalgae “Chlorella vulgaris” in two different photobioreactor (PBR). The purpose of this research is to investigate the effect of the membrane in a modified airlift photo bioreactor on the removal efficiency of sugarcane industries wastewater pollutants. All the experiments were done at ambient temperature, pH 7_7.5 and light _ dark cycle 24_0. The results showed that removal efficiency of COD, phosphate and nitrate were 51%, 47% and 27% within modified airlift photo bioreactor, on the other hand the removal efficiency of COD, phosphate and nitrate were 71%, 79% and 72% within membrane modified airlift photo bioreactor. The result shows the important role of membrane in PBR to reach the higher removal efficacy.

Keywords: sugarcane industry, microalgae, wastewater treatment, airlift photo bioreactor, membrane

[27] Raja Ben Amar (Faculty of Science of Sfax, University of Sfax, Tunisia).
Title: *Adsorption, Membrane separation, and Photocatalysis: Sustainable Water Treatment with Low-Cost Materials for addressing Organic Pollutants : Synthesis, Characterization and Application.*
Abstract
Dealing with organic pollutants in industrial wastewater requires the adoption of effective and environmentally friendly methods. Textile dyes and Pharmaceuticals, known for their toxicity and limited biodegradability, contribute to water pollution when released into the environment, thereby posing substantial health hazards to all organisms and causing harm to aquatic ecosystems. In this context, the wastewater generated by pharmaceutical and textile companies adds to the challenge of managing organic pollutants, necessitating innovative solutions to mitigate the environmental impact and protect public health.
In this study, activated carbon, sepiolite membrane, and photocatalyst were successfully synthesized for water treatment applications using cost-effective materials from industrial waste and natural clay or zeolite.
The materials were characterized, and their efficiency in water treatment was evaluated. The results demonstrated that the prepared activated carbon, sepiolite membrane, and photocatalyst showed promising performance in treating water contaminants.

Additionally, the use of nanocomposite based low cost materials and surface treatments should improve these systems performances.
This research highlights the potential of utilizing low-cost materials to develop effective water treatment solutions, contributing to sustainable and affordable water purification technologies.
Keywords: Organic pollutants, Membrane separation, Adsorbent, Photocatalyst, Removal

[28] Remedan Ahmed (Wolkite University), Zeynu Shamil (Wolkite University) and Gebre Egnet (Wolkite University).

Title: *Advancements in Membrane Technology for Decentralized and Autonomous Water Treatment Systems.*
Abstract
Membrane technology has emerged as a vital solution for decentralized and autonomous water treatment systems, offering a sustainable and efficient approach to addressing global water scarcity and contamination challenges. This technology utilizes the selective permeability of membranes to separate contaminants from water, providing high-quality potable water even in remote and resource-limited areas. This paper reviews the current state of membrane technologies, including micro-filtration, ultra-filtration, nano-filtration, and reverse osmosis, and their application in decentralized water treatment systems. The review highlights the advantages of membrane systems, such as their compactness, modularity, and low energy consumption compared to conventional water treatment methods. Additionally, the paper examines recent advancements in membrane materials and configurations that enhance performance and reduce fouling, a common issue that impairs membrane efficiency. The integration of membrane technology with renewable energy sources, such as solar and wind, is explored, emphasizing the potential for achieving fully autonomous water treatment systems. Case studies from various regions demonstrate the successful implementation of membrane-based systems, showcasing their reliability and adaptability to different environmental and socio-economic contexts. Challenges such as initial costs, maintenance, and membrane lifespan are discussed, along with potential solutions and future research directions. The paper concludes that membrane technology offers a viable and sustainable option for decentralized water treatment, capable of providing safe drinking water to underserved populations and contributing significantly to global water security.

Keywords: 1. Membrane technology, 2. Decentralized water treatment, 3. Autonomous systems, 4. Water purification

[29] Anteneh Mersha (Assistant Professor at Addis Ababa Science and Technology University) and Bilisuma Finina (Addis Ababa Science and Technology University).
Title: *Development of Cellulose Nanofiber-Scaffolded Composite Wound Dressing Film from Medicinal Plant Extract.*
Abstract
Delayed wound healing causes various health complications, including wound chronicity. One of the factors is bacterial infection after wound formation and during clinical treatment which may result in the development of drug resistant bacteria. Hence, the use of wound dressing materials with antibacterial profile is essential to prevent wound chronicity. In recent times, numerous antibacterial wound dressings based on metal nanoparticles as an example have been commercialized, but their utilization is limited due to factors such as high cost, toxicity and development of multidrug resistant bacteria. In this context, plant biomolecules-based dressing materials have been frequently reported to overcome such problems. Accordingly, this study focused on development of antibacterial wound dressing film from Rumex abyssinicus extract (RAE) for the first time.
In this research, a biocompatible cellulose scaffolded RAE extract composite wound dressing film (CNF/PVA/RAE) was successfully developed using solution casting. The ratio of components was optimized to obtain flexible, stretchable, and transparent films with tensile strengths of 4.92 to 16.98 MPa among the basic requirements of wound dressing films. The dressing films demonstrated strong bacterial growth inhibition against the three predominant bacteria in wound site – S. aureus (11.00 to 21.33 mm), P. aeruginosa (12.66 to 16.00 mm), and E. coli (8.50 to 17.00). The degree of inhibition was proportional to the RAE loading. The film also exhibited interesting antioxidant activity against DPPH free radicals (higher than the commercial ascorbic acid antioxidant), and anti-inflammatory activity with up to 74.93% inhibition of protein denaturation.
In addition, the in vivo wound healing study demonstrated that the prepared RAE-based dressing films has shown an outstanding wound contraction rate of up to 96.8% on the 16th day of administration, which is higher than the corresponding RAE ointment (94.8%) and commercial nitrofurazone (96.1%). The developed films exhibited reduced epithelization period (faster wound closure rate of 30.28%) in comparison to a commercial antibacterial skin ointment, Nitrofurazone (32.39%).
Furthermore, the various dressing film characterizations (such as morphology, composition, thermal, mechanical, etc), and performance studies will be discussed during the presentation.

Keywords:
Wound dressing, Rumex abyssinicus, Cellulose nanofiber, Antibacterial, In vivo study, Epithelization

[30] Sabrina Morelli (National Research Council of Italy, Institute on Membrane Technology, CNR-ITM, Rende (CS)), Antonella Piscioneri (National Research Council of Italy, Institute on Membrane Technology, CNR-ITM, Rende (CS)), Simona Salerno (National Research Council of Italy, Institute on Membrane Technology, CNR-ITM, Rende (CS)) and Loredana De Bartolo (National Research Council of Italy, Institute on Membrane Technology, CNR-ITM, Rende (CS)).

Title: *ADVANCES IN MULTIFUNCTIONAL MEMBRANE SYSTEMS FOR BIOMEDICAL APPLICATIONS.*

Abstract

Membranes are widely used in bioseparation due to their selective properties and modular nature that allows upscaling and downscaling separation processes. These systems find important applications in the biomedical field and clinical treatment for the replacement of organ functions and for the separation and concentration of subcellular components such as extracellular vesicles [1–2]. Functionalized membranes designed and operated according to well-defined engineering criteria were able to provide appropriate biochemical and biophysical stimuli for the biofabrication of organs and tissues analogous because of the highly selective properties, which allow to create a fully controlled microenvironment at molecular level mimicking the specific features of in vivo environment. PLGA micropatterned membranes with surface microscale cues were developed to provide geometrical cues (channels, circular pillars, rectangular pillars, and pits) to modulate behaviour of neuronal cells, myoblasts, and stem cells [3]. Hollow fiber membrane bioreactor promoted hepatic differentiation of human mesenchymal stem cells as demonstrated by the liver specific functions and gene expression [4]. A designed approach has been utilized for the development of a neuronal membrane bioreactor consisting of poly-L-lactic acid highly aligned microtube array membranes to modulate and enhance neuronal outgrowth. The bioreactor provides a 3D low-shear stress environment fully controlled at molecular level with enhanced diffusion of nutrients and waste removal that successfully develops neuronal-like tissue. This platform was used to reproduce an in vitro model of neuroinflammation and Amyloid beta (Abeta)-induced toxicity associated to Alzheimer's disease to test the neuroprotective effect of molecules such as crocin and glycitein [5].

Biomimetic membrane systems have been developed to replicate the cell's hierarchy architecture and the interplay within the different cells as it occurs in the natural milieu of the tumor site [6]. The membrane system consists of gas permeable fluorocarbon membranes, biofunctionalized with Poly-L-lysine to mimic the extracellular matrix and to provide specific cues for modulating tissues growth. The selectivity, together with structural, physico-chemical and mechanical properties of PLL-FC membranes, allow the realization of a suitable biomimetic interface for the growth of cancer cells.

The latest developments and innovations regarding the multifunctional role of membrane systems and devices for tissue engineering applications and as in vitro platforms will be discussed.

Keywords: Membranes, bioreactors, biofunctionalization, cells, bioartificial devices

[31] Hamdy Maamoun Abdel-Ghafar (Central Metallurgical Research and Development Institute (CMRDI)).

Title: *Sustainable Photothermal Membranes for Desalination and Wastewater Purification* .

Abstract

Solar energy is the ultimate energy source of everything we have on Earth. It is without any doubt the most renewable and sustainable energy source available to us. Recently, many attempts to harness solar light and localize heat on water surface via developing photothermal membranes fabricated from different materials for steam generation and water purification have been done. However, the developed photothermal membrane faced many problems when applied for desalination or wastewater treatment like fouling and low thermal conversion efficiency. Fouling problems are due to the sun-driven evaporation technique via photothermal membrane use of the water source without any pretreatments. So, the photothermal membrane should have self-cleaning criteria and antifouling resistance to be applicable and work for a long time. In this work, we aim to develop a highly effective bio-fouling resistance photothermal membrane via decoration and doping carbon-based materials with silver nanoparticles. These synthetic nanocomposites will not only enhance the antimicrobial behavior but also increase the surface temperature of the membrane hence raising the evaporation rate due to the high illumination of silver nanoparticles. Based on previous studies, the nanocomposite strategy is facile and effective for the development of novel photothermal membranes for high-efficiency evaporation and contributes to the widespread application in the fields of desalination and wastewater treatment.

We prepared Ag-CNTs/PVDF photothermal membranes using CNTs decorated with silver (Ag) nanoparticles deposited on the hydrophilic polyvinylidene difluoride (PVDF) substrate via vacuum filtration.

The membrane showed a spontaneous evaporation rate reached 1.2 kg.m−2

.h−1 using 3.5% NaCl solution (simulated to seawater) with a solar thermal conversion efficiency of 75.6% ± 2.0. The optimized Ag-CNTs/PVDF photothermal membrane showed relative stability in the evaporation rate compared to other
membranes using 100 mg.L−1 humic acid solution for 600 min after one week under
natural evaporation with the same solution.

Keywords: Sustainable desalination, Photothermal membrane, CNTs, Anti-fouling, Humic acid

[32] Oranso Mahlangu (University of South Africa), Samkeliso Ndzimandze (University of South Africa), Mxolisi Motsa (University of South Africa) and Bhekie Mamba (University of South Africa).
Title: *LEVERAGING CALCIUM-NOM COMPLEXATION PHENOMENON AS RO FOULING MITIGATION STRATEGY DURING TREATMENT OF LAKE WATER.*
Abstract
Organic fouling during reverse osmosis (RO) is exacerbated by calcium up to a limit where extremely high calcium concentration results in lesser fouling due formation of large organic-calcium aggregates with lower cake resistance. Therefore, this work leveraged on this phenomenon and used calcium chloride as coagulant (at varying concentration) to reduce membrane fouling while enhancing NOM removal and membrane cleaning efficiency through calcium-EDTA chelation which disintegrates the fouling layers. RO fouling was performed with sodium alginate solutions and lake water. The fouled membranes were soaked in 0.1 mM EDTA (1 h) and backwashed with water to remove the fouling layer. Alginate fouling was worsened (45–85%) by increase in calcium concentration up to 5 mM but lessened at > 5 mM calcium concentration (35–15%). Similar observations were made when filtering lake water, except that lesser fouling was observed at calcium concentrations greater than 15 mM. Membrane soaking in EDTA enhanced cleaning efficiency leading to over 90% flux recovery for both alginate and late water. However, prolonged membrane exposure to 10 mM calcium resulted in slight decline in membrane salt rejection (< 2% change) and tensile stress (1.3–1.1 N/mm2), while the membrane flux increased (< 3% change) – due to chlorine attack. Finally, NOM removal improved with calcium addition (up to 90%) – key in reducing potential formation of disinfection by-products. The proposed fouling mitigation/remediation approach has potential for commercialization. However, more research must be performed for further optimization and determination of controlling factors.

Keywords: EDTA chelation, Natural organic matter, Membrane cleaning, Fouling mitigation, Fluorescence excitation-emission matrices

[33] Dr. Leta Lemma (School of Chemical and Bio Engineering, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia), Professor Zebene Kiflie (School of Chemical and Bio Engineering, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia) and Dr. Shimelis Kebede Kassahun (School of Chemical and Bio Engineering, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia).
Title: *Biopolymer Based Hydrogel for Adsorption of Heavy Metal Ions from Aqueous Solution: Experimental and Theoretical Investigation.*
Abstract
Contamination of water by heavy metal ions, in particular, hexavalent chromium (Cr6+) ion, lead (Pb2+) ion and cadmium (Cd2+) ion, has become one of the most serious issues threatening human health and thus remedial measure have to be taken. Adsorption–based research toward biodegradable polymers for heavy metal ions remediation has received much attention in recent years due to environmental concerns. Polysaccharides in this domain are interesting starting materials for the preparation of novel adsorbents.
In this work, novel type of biopolymer–based hybrid hydrogel such as PPSgCG (acrylamide–grafted native starch-chitosan-graphene oxide-PVA-PVP), and PCCFG (PVA–chitosan–cysteine functionalized graphene oxide) were designed for removal of Cr6+, Pb2+, and Cd2+ ions from aqueous solution. Physiochemical properties of freeze–dried hydrogel were characterized by FTIR, Zetasizer, SEM, EDX, XRD, and TGA. The ground state geometry optimization of modeled system were first optimized by Molecular Mechanics (MM) method with aid of Universal Force Field (UFF) followed by Hartree fock (HF) and Density Functional Theory (DFT) method, using Gaussian 09 software package. Single–point energy calculations were performed using the ωB97XD functional where basis set 6-311+G (d, p) was employed for C, N, O, S, and H atoms, and SDD basis set was employed for heavy metal ions.
The synthesized hybrid bio–hydrogels possess robust regeneration ability for further use, short adsorption processing time and better stability with good adsorption performance. Results from theoretical investigation (DFT calculation) such as Frontier molecular orbital's (FMO) analysis, natural bond orbital (NBO) result, and perturbation energy analysis as well as results from experimental investigation such as FTIR and EDX shows heavy metal adsorption onto the hydrogel were via chemical bonding/covalently bonded.

Keywords: Acrylamide, Adsorbent, Adsorption, Cd2+ ions removal, Chitosan, Cr6+ ions removal, Density Functional Theory (DFT), Graphene oxide, Hybrid hydrogel, L–cysteine, Pb2+ ions removal, PVA, PVP, Starch, Starch grafting

[34] Mihir Kumar Purkait (IIT Guwahati).

Title: *Stimuli Responsive Membranes.*

Abstract. Abstract
Separation is an integral section of various downstream operations in chemical, petrochemical, food, biochemical and several other related process industries. It is necessary to achieve the goals of purification, refining, enrichment and concentration of any desired product from a mixture. In the present era use of membranes has become increasingly important, especially in the food processing and biotechnology industry for separation, concentration and fermentation of food products with high yield and purity. Other than these industries, membranes can be efficiently used in textile, vanadium flow battery, active packaging and electrodialysis applications.
A variety of polymers such as cellulose acetate (CA), polyvinylidene fluoride (PVDF), polysulfone (PSF), polyacrylonitrile (PAN), polyethylene (PE), polypropylene (PP) and polyether sulfone (PES) are used for the preparation of commercial NF/UF/MF membranes. Among these polymers, PSF is most preferable polymer for the preparation of polymeric membranes because of its good heat resistance, physicochemical stability, resistance to chlorine, oxidation and chemical compatibility resistance over wide range of pH. In addition, solubility of PSF brings it under the category of suitable candidate for polymer blend membranes, as it is very soluble in N-methyl-2-pyrrolidone (NMP) and dimethyl acetamide (DMAc) and these solvents are further soluble in the coagulation medium which is mainly water for the preparation of asymmetric membrane. Although, PSF membrane has several advantages, these membranes are prone to be fouled because of its hydrophobicity, which can be resulted in declination of flux and life of membrane. To overcome the problem of hydrophobicity, research is going on the changing membrane surface properties using various methods such as plasma treatment, coating, UV-induced graft polymerization, redox initiated grafting, etc. However, these methods are very useful for altering the pore size and pore size distribution of the membrane without internal pore modification. At the same time these methods have the drawback of required additional complicated steps. Our current research is focused on the addition of nanoparticles (NPs) and polymers within membrane matrix to increase the membrane hydrophilicity. However, uniform distribution of NP in casting solution is actually difficult because of the agglomeration of NP and increased viscosity of the casting solution. Again, NPs were getting trapped within the pores, then the flux would have decreased with increasing concentration of the NPs. This was due to the blockage of membrane pores by agglomerated NP.
Blending of hydrophilic polymers, co-polymers, organic acids and plasticizer in the casting solution can be an important alternate to obtain different polymeric membranes with required properties and additional features. In this lecture, our recent work on the use of various water soluble polymers, co-polymers, organic acids and plasticizers for preparing hydrophilic, pH and temperature responsive smart membranes will be discussed.

Keywords: smart membranes, responsive membrane, hydrophilicity, antibacterial membrane

[35] Sirshendu De (Indian Institute of Technology Kharagpur).

Title: *Polymeric hollow fiber membranes: Spinning and their applications.*

Abstract. Hollow fiber membrane modules are becoming quite popular nowadays due to the higher filtration area in a small volume leading to a compact design. Hollow fibers are prepared through a process called spinning and that is basically extrusion of polymeric fibers through co-axial assembly, called spinneret. However, the spinnerets are difficult to fabricate and the spinning unit becomes expensive. In this talk, it is demonstrated how the spinning of hollow fibers can be done by indigenous technology making the spinning quite affordable. The fibers are spun with various grades starting from microfiltration, various cut-offs of ultrafiltration and even nanofiltration. The applications of various fibers ranging from fruit juice clarification, industrial wastewater treatment, and treatment of brackish water are presented in details.

Keywords: Polymeric hollow fiber membrane, Spinneret, Wastewater treatment, Brackish water

[36] Bianca Zappulla Sabio (LEQUiA - Universitat de Girona), Ludovic Dumée (Khalifa University), Pierre Le-Clech (University of New South Wales) and Gaetan Blandin (University of Girona).
Title: *TOWARDS MEMBRANE RECYCLING: OSMO4LIVES.*
Abstract. INTRODUCTION
Membrane processes are key elements for water reuse and desalination. Globally, in 2025 to combat water scarcity, 75 Mm3/day of water will be treated with RO membranes. At the end of their life (typically 5-10 years for seawater and brackish water desalination processes), membranes are discharged, leading the production of waste. The interest on membrane recycling has been growing in the last 20 years. Research carried out over the last decade has been focused on restoring reverse osmosis (RO) membrane performance or their recycling through transformation as other membrane types (UF, NF…). Still, how an RO membrane is affected by its previous life such as impact of compaction, oxidizing agents and/or drying is one of the topics that is still not fully understood. Apart from new alternatives for RO membrane recycling, Osmo4Lives proposes to better understand how RO membranes and especially their polyamide (PA) and polysulfone (PSf) layer are affected by oxidizing agents and drying that can occur during their usage or storage so to extend their life and favor their recycling. Current study will present current advancement regarding the impact of membrane operation and storage conditions on membrane properties and its implication for further recycling.
MATERIALS AND METHODS
New membranes coupons (BW30 and SW30) and industrial used membrane coupons (BW30 and SW30) were studied for all tests and characterized (permeability and rejection) using a high-pressure RO pilot operated at 15 bars with 2000ppm NaCl feed solution before and after treatment. Membrane surface characterization were also performed (SEM, contact angle, FTIR) to get further insight on membrane properties modification through various treatments. Chemical attack was tested by storing membrane coupons in three different solutions: H2SO4 solution (pH 1), DI water (pH 6,8) and NaOH solution (pH 13) and with/without 10 ppm of free chlorine for a long-term experiment (3 months). Membrane performances were evaluated after 4 days, 2 weeks, 1, 2 and 3 months of contact with chemical solutions. Impact of drying was assessed by placing membrane coupons in the laboratory stove at 60ºC and rehydration was tested by soaking previously dried membrane in ethanol 96%. Drying as well as rehydration kinetics was assessed by testing different drying time and solvents. Compaction was assessed by comparing permeability and rejection of new and industrially used membrane coupons. Complementary tests were performed by removing the PA layer to specifically assess impacts on PSf layer.
RESULTS AND DISCUSSION
A severe impact of compaction was observed for both BW and SW membranes with a reduction of 40% and 51% respectively, which confirm that compaction occurs at industrial scale given the large duration of operation and the pressure applied. On the other hand, rejection have been also affected with a decrease of 3,3% in BW and, an increase of 1% in SW. Impact of compaction was also observed on the PSf layer.
No impact of pH was observed on membrane characteristics for membrane stored without chlorine. This confirms the relatively high tolerance to basic and acidic pH of the PA layer. In presence of chlorine (pH + chlorine), after 720h (1 month), the membranes soaked in the solutions at pH 6.8 and 13 had increased permeability and lower rejection. This can be explained by the presence of OCl- which promotes the hydrolysis of the amide C−N bond on the PA layer at this pH.
Important loss of permeability was observed for all the membranes after drying. Especially, used membranes experienced a severe impact with a decrease of permeability of 78% for BW30 and 35% for SW30 respectively. Severity of drying proved to be dependent of the preservation solvent and its volatility. Soaking the membrane in ethanol allowed for quick and partial to full initial permeability recovery and was confirmed to be a promising option for membrane recovery. Similar tests on the membrane without PA layer demonstrated that PSf is also impacted by drying with irreversible effect.
CONCLUSION
Impact of process operation and constraints happening during membrane operational life and storage proved to have reversible and/or irreversible impact on end-of-life membrane properties especially with regards to membrane permeability and salt rejection. This study also emphasized on the respective impact on PA and PSf layers which can have a critical impact on the membrane recycling routes.

Keywords: Desalination, membrane drying, membrane oxidation, recycling, reverse osmosis

[37] Nicolas Saganias (University of Girona) and Gaetan Blandin (University of Girona).
Title: *LOW-COST MEMBRANE CHARACTERIZATION SETUP DEVELOPED IN OPEN-SCIENCE FOR BROAD DISSEMINATION OF MEMBRANE EVALUATION AND RESEARCH.*
Abstract
The emergence of new ideas and their transferability towards implementation. Such studies within research (academia or enterprise) are often limited by the availability of flexible, low-cost and portable devices that allow small configurations to be mounted, monitored and controlled. Typically, in membrane science, setups consist in a feeding pump, membrane module and instruments to measure process performances. Sensors to measure pH, conductivity, temperature, weight, pressure, flow are essential for the validation of many processes. Established sensor or device brands are traditionally high-end devices pushing their in-house developments and proposing specific sensor systems that are expensive and neither interactive nor interconnected.
The emergence of 3D printing, Arduino based environment and alternative source of supply pushed towards the Do-your-own (DYO) approach which is supported by online communities allowing for the development of cheap and interactive alternatives. The laboratory of Lequia developed an environment for membrane systems (called Flapp) aimed to be transferred to other membrane researchers based on open science approach to democratize the development of membrane setups that could be of interest for educational and research purposes. 3 systems developed in-house and daily used by membrane researchers at Lequia (forward osmosis, reverse osmosis, anaerobic membrane reactor) will be presented. The system rely on cheap sensors available globally (pH, conductivity, pressure, weight,…) connected to an Android Phone via a box through Bluetooth signal. To further cut down on price on membrane setups, 3D printing design validation were realized both for membrane cross-flow filtration cells and boxes for electronical parts. Low costs peristaltic pumps and connected balances were evaluated in order to build-up a monitored forward osmosis system below 2000€. Challenges still remain for the whole development of such technologies to further evaluate compatibility and reliability of new sensors and brands and to assure long term stability of such system.

Keywords: Membrane characterization, low-cost, Arduino, 3D printing

[38] Elizabeth Guyman (XPRIZE Water Scarcity).
Title: *XPRIZE Water Scarcity.*
Abstract
Water scarcity is an escalating global crisis that affects nearly one-fourth of the population, with predictions indicating that by 2030, demand will surpass supply by 40%. This looming crisis is predominantly impacting densely populated coastal cities and is exacerbated by the limited 0.5% of Earth's freshwater that is usable, strained further by rapid urbanization, population growth, and climate change. XPRIZE Water Scarcity, a $119 million, 5-year competition, aims to address these challenges by fostering innovative advancements in seawater desalination technology. As 70% of the planet is covered by oceans, which contain over 96% of global water resources, desalination offers a potential solution for transforming abundant seawater into a sustainable freshwater supply. However, existing desalination methods, while mature, have not seen significant innovation since the early 2000s and are often prohibitively expensive and environmentally unsustainable for widespread adoption. The competition is structured into three tracks to tackle these challenges: the development of a new desalination system capable of sustainably producing one million liters of potable water per day, the creation of novel membrane materials to enhance the efficiency and lifespan of reverse osmosis processes, and an ideas competition to reshape the global perception of water's value. Through these efforts, XPRIZE Water Scarcity seeks to catalyze a paradigm shift in desalination technology by making it more robust, affordable, and environmentally sustainable. This initiative not only aims to redefine the landscape of desalination on a global scale but also to ensure broader socio-economic equity and enhance global water management practices, creating a future where clean water is equitably and sustainably abundant.

Keywords: Desalination, Innovation, RO

[39] Mohamed Taky (Ibn Tofail University).
Title: *UNCONVENTIONAL WATER RESOURCES IN MOROCCO: DESALINATION AND REUSE.*
Abstract
Morocco is facing unprecedented water stress, with declining underground reserves and scarce rainfall. The new national strategy for sustainable resource management highlights, among other options, the desalination of seawater and the reuse of treated wastewater to reduce pressure on underground resources. In Morocco, the membrane-based reverse osmosis (RO) process has been adopted as a desalination technology. In addition to ensuring the availability of drinking water for the city of Agadir, the reverse osmosis seawater desalination plant (SWRO) at Chtouka Ait Baha (Agadir region) provides the region's farmers with desalinated water for irrigation. At the same time, the

national water plan 2020-2050 focuses on the reuse of treated wastewater. Until today, most of this reuse is for golf courses and green spaces. Advantages and drawbacks of desalination and reuse must be assessed in terms of costs and benefits, societal and environmental aspects, and compared to other freshwater production processes. The first aim is to review the Moroccan experience on the desalination of seawater and reuse. The second aim is to highlight challenges facing RO desalination and reuse in Morocco.

Keywords: Desalination, Seawater, Brackish water, Unconventional water, Reverse osmosis, Reclaimed water, Wastewater, Reuse

[40] Phumlile Mamba (UNISA), Motsa Machawe Mxolisi (UNISA), Titus Msagati (UNISA) and Thabo Nkambule (UNISA).

Title: *BIOCATALYTIC HOLLOW FIBER MEMBRANE REACTOR FOR THE DEGRADATION AND FILTRATION OF NATURAL ORGANIC MATTER FROM SURFACE WATER.*

Abstract

The formation of toxic disinfection by-products and biofilm accumulation in drinking water distribution pipelines is caused by the presence of natural organic matter (NOM). Various water treatment technologies are available and effective for NOM removal; however, the issue of sludge generation is a problem for disposal. This study evaluated the performance of an enzymatic-assisted membrane bioreactor for the degradation and retention of NOM in water. Porous hollow fiber ultrafiltration membranes were prepared through phase inversion and modified by infusing ligninolytic enzymes on the membrane surface. The membranes were characterized using microscopic and spectroscopic techniques. The reactor was operated in an outward-mode filtration. The permeate quality revealed that the enzyme-modified membrane achieved 99.6 % NOM removal, while the unmodified membrane removal efficiency varied from 54 to 65 % after 270 min of filtration. The improved removal efficiency could be attributed to the prolonged contact time between the enzymes and the organic matter. A 20 % decline in permeate flux was observed from the enzyme-modified membrane, however, the flux was recovered through the reverse backwash of the membrane. The enzyme-modified membrane reactor proved high stability as the performance was maintained over long-term application and repeated cleaning. These results confirmed that the enzyme-modified membrane had dual functionality of organic matter breakdown and filtration.

Keywords: Catalytic degradation, Enzyme immobilization, High retention membrane, Organic matter degradation

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Title: *ULTRA-SEN: DECENTRALISED AND GRAVITY-DRIVEN ULTRAFILTRATION MEMBRANES FOR WATER POTABILIZATION.*

Abstract

Worldwide, an estimated 785 million people lack a basic drinking-water service, including 144 million people who are dependent on surface water. As an example, the populations of several towns in Casamance (south of Senegal), in general, and Ziguinchor, in particular, experience difficulties in obtaining safe drinking water in one of the most humid regions of the country. Ziguinchor, like African cities in general and Senegalese cities in particular, continues to grow and expand. Additionally, population showed limited trust in water supplied by the state and prefers to drink water from wells due to better taste. Therefore, most households, whether in rural areas or in the city, obtain well water which is sometimes contaminated due to lack of sanitation or water treatment systems. The project Ultra-SEN aims at evaluating and implementing a decentralized water purification systems-based gravity-driven ultrafiltration technology to provide pathogens removal (viruses and bacterias). The work was funded by the University of Girona under a cooperation grant was developed in-between the Lequia laboratory of the University of Girona and the University Assane Seck de Ziguinchor and the support of its Laboratory de Analyses and Water Treatment (LATE). The program involved mobility for researchers and students participating in the project for training and teaching/dissemination, sampling and analyses of various local taps and wells water quality and implementation of decentralized modules. Two types of commercial decentralized ultrafiltration modules were used in this study, i.e. Squirt® supplied from Skyjuice (Australia) and Orisa® provided by Fonto de Vivo (France). Modules operation and performances in term of permeability, rejection and fouling were evaluated first in the laboratory. Then, 15 samples of water including tap water, untreated underground water coming from either faucets or wells available in or around the university Assane Seck de Ziguinchor were analyzed. Physico-chimico Physico-chemical parameters included conductivity, pH and turbidity. Coliforms and E. coli. Were also quantified. Comparative tests were performed on microbially contaminated water after filtration to quantify the effect of UF membranes on pathogens removal. Finally,

modules were implemented on site. Results show first that much lower conductivity is observed in underground water in comparison with the water available from the network. However, major E-coli and coliform contamination were found in open-wells; limited contamination was observed in taps. The implementation of easy-to-use decentralized UF system allowed for the complete rejection of pathogens (below detection level) to potabilize underground water even after severe pathogen contaminations. Challenges remain with regards to the full implementation and local management of such systems.

Keywords: Decentralized systems, Ultrafiltration, Gravity-driven membrane system, Water potabilization

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Title: *Reactive coating of desalination membranes in spiral-wound modules: Increasing antifouling properties and enabling "second life" applications.*

Abstract

Fouling of reverse osmosis (RO) or nanofiltration (NF) membranes in water desalination or other water treatment applications, with negative effects on process performance and efficiency as well as membrane life-time, is a challenge that is addressed by a number of different approaches. Building on prior own research [1], this study presents further developments of an in situ antifouling coating methodology for commercial RO and NF flat sheet membranes and spiral-wound modules, deploying a concentration polarization-driven reactive ("click") coating formation process [2] and results from the first phase of a project devoted to recycling of used RO modules to enable their use for certain NF applications [3]. The transfer from lab-scale cross-flow experiments with membrane coupons to successful in situ reactive filtration cum coating of full-scale spiral-wound modules will be in the focus of this presentation.

The study was performed using different commercially available polyamide thin-film composite membranes and spiral-wound modules. Upscaling to large-scale modules was deeply studied with BW30 membranes and BW30-4040 spiral-wound modules from DuPont. "Clickable" polyzwitterionic building blocks [1] and analogous new polymers that can also be covalently cross-linked into antifouling hydrogels, in particular an easily accessible polyvinylalcohol (PVA) derivative, were used. The influences of "chemical" (type of polymeric building block and complementary cross-linker to "click" into a hydrogel; surface linker; concentrations; …) and "engineering" parameters (initial flux, cross-flow velocity and feed spacer to impact the degree of concentration polarization; duration of reactive filtration; …) on coated membrane structure and separation performance were studied in detail. Correlations between the extent of flux decline during reactive coating as function of parameters and the resulting coating thickness with impact on coated membrane permeance were established. Information from such correlations was then utilized for the transfer to spiral-wound modules, for example by keeping all "chemical" and almost all "engineering" parameters constant and only varying the duration of reactive filtration, to ensure on the one hand a sufficient thickness of the coating to improve fouling resistance but on the other hand to limit the reduction of permeance to < 10%. Detailed characterizations, including autopsies of modules, yielded information about structure and homogeneity of the coating. Salt rejection was slight improved, what can be explained with the "repair" of defects in the membranes by the coating. Lab- and pilot-scale studies confirmed the improvement of overall separation performance due to the anti-fouling coatings for most investigated application scenarios. The chemical stability of the polyacrylate-based zwitterionic hydrogel coating allows the use of acid cleaning, but it also enables the removal of a used (and not anymore functional) coating under alkaline conditions, with the option to thereafter recoat the membrane to renew the antifouling functionality.

Finally, implications of the results of this work for methodologies that will enable a "second life" of the rapidly growing number of end-of-life (spiral-wound and other) membrane modules will be outlined, and first results toward recycling of used RO membranes by initially removing the polyamide layer and then applying a NF-selective layer will be presented.

Acknowledgments

This work has in parts been funded in the frames of the "WEISS_4PN" project (German Federal Ministry of Education and Research, PTKA #02WV1570) and an IGF project (German Federal Ministry of Commerce and Energy, AiF 21232 N). Financial support has also been received from funds of the European Union (EFRE) and the state Northrhine Westfalia (JTF) via the project „RORe3" (GreenEconomy.IN.NRW, IN-EC-1-018b).

Keywords: Water desalination, Membrane fouling, Hydrogel coating, Polyamide thin-film composite membrane, Spiral-wound module

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Title: *THE FABRICATION OF PES/ FE3O4/ZNO MEMBRANES FOR THE EFFICIENT REMOVAL OF CONTAMINANTS FROM WASTEWATER.*

Abstract

Over population, growth of industrialization and ongoing economic expansion contributes significantly in water contamination which is a major obstacle to achieving sustainable quality water. This study demonstrates the use of Fe3O4/ZnO nanoparticles on polyethersulfone (PES) membranes for the removal of BSA and Humic acid. PES/ Fe3O4/ZnO mixed matrix membranes were found to be highly permeable and less prone to fouling, with a high flux recovery ratio. Transmission electron microscopy images confirmed that Fe3O4/ZnO had cubic and spherical morphologies. The surface and cross-sectional images showed that ppolyvinylpyrrolidone (PVP) and the coagulation bath temperature (CBT) had a considerable influence on the morphology of the membranes and confirmed the successful addition of the different concentrations (0.25 wt.%, 0.50 wt.% and 0.75 wt%) of nanocomposites onto PES membranes. The membrane with 0.50 wt% of Fe3O4/ZnO nanoparticles was found to be the most permeable with a water flux of 682 L/m2.h, and a high flux recovery ratio (%) of 98.75% for BSA, 88.88% for HA, and wastewater samples, indicating that the modified PES membranes were less prone to fouling. In addition, this study highlighted the importance of influential phase inversion parameters in membrane fabrication.

Keywords: Polyethersulfone, mixed matrix membranes, Fouling, Fe3O4/ZnO nanoparticles, wastewater treatment

[44] Ndamulelo Phosha (Institute for Nanotechnology and Water Sustainability, University of South Africa) and Mxolisi M. Motsa (Institute for Nanotechnology and Water Sustainability, University of South Africa).
Title: *POROUS RECYCLED EXPANDED POLYSTYRENE/PDMS MEMBRANES FOR EFFICIENT VAPOUR PASSAGE DURING MEMBRANE DISTILLATION* .

Abstract

Waste valorisation can be one of the most effective approach towards the development of sustainable and affordable water treatment technologies. This work describes the fabrication of porous hydrophobic membranes from recycled packaging waste (expanded polystyrene (EPS)) for membrane distillation. The membrane's mechanical properties (tensile strength and elasticity were improved by blending EPS with varying loading of polyvinylidene fluoride (PVDF). And surface wettability was tuned using PDMS and silicone oil. The addition of silicone oil during phase inversion increases surface hydrophobicity and porosity. The contact angle increased from 98.16 (±6.37) º of the pristine membrane to 120.14 (±5.27) º for the modified membranes, demonstrating that the modification led to less surface wetting which improved vapour passage. The measured total dissolved solute and conductivity of the sampled groundwater were reduced from 1725 ppm and 2384 µS/cm to 16 ± 3.4 ppm and 23 ± 4.4 µS/cm respectively. There was complete removal of harness and the composition of the concentrated rentate was dominantly Calcium, Magnesium, Potassium, Iron, Barium and Silicate ions as well as high levels of Fluoride. Solar irradiation was used to heat the bulk feed stream to drive the distillation of hard groundwater. The highest generated feed temperature was 60 °C which induced 15 lm-2h-1. The membranes had a salt rejection of more than 95 %. Low surface scaling was observed during the evaporation cycle however, precipitants were re-dissolved into the bulk feed during the non-solar cycle. It was further demonstrated that membrane performance during distillation was an interplay between surface hydrophobicity, porosity, and crossflow velocity.

Keywords: Membrane distillation, Polystyrene, Solar irradiation, Water hardness

[45] Bveledzani Pertunia Makhado (University of South Africa), Edward Nxumalo (University of South Africa), Nozipho Gumbi (University of South Africa), Lueta-Ann De Kock (University of South Africa), Oranso Mahlangu (University of South Africa), Mary Gulumian (Noth West University) and Charlene Andraos (National Institute for Occupational Health).
Title: *EVALUATION OF CARBON NANOMATERIAL AND TITANIUM DIOXIDE LEACHING FROM ULTRAFILTRATION MEMBRANES IN WATER TREATMENT SYSTEMS.*

Abstract

Introduction: Carbon nanomaterials (CNMs) are increasingly used in various fields due to their unique properties, such as high surface area, excellent electrical conductivity, and chemical stability [1]. These materials can enhance the efficiency of water filtration membrane systems and improve the T the photocatalytic efficiency of titanium dioxide (TiO2) [2]. Additionally, CNMs have been reported to reduce leaching in ultrafiltration (UF) membranes [3,4]. However, while nanoparticles offer potential benefits for modifying water treatment membranes, they can leach from the membranes into the permeate, subsequently entering the water distribution system [5]. The leaching of these

nanomaterials can significantly decrease the membrane's hydrophilicity and mechanical strength, raising concerns about potential health and environmental impacts. This study aims to assess the leaching of CNMs and TiO2 used in water filtration membranes for wastewater treatment.
Methodology: Nanomaterials were synthesized using Hydrothermal, Sol-Gel, and Hammer's Method. The instruments used in this work include, among others, atomic force microscopy (AFM), attenuated total reflection-Fourier transform infrared spectroscopy (ATR-FTIR), contact angle analysis, scanning electron microscopy (SEM), Raman spectroscopy, and X-ray diffraction analysis (XRD). Membranes were fabricated using Nonsolvent-induced phase separation. Leaching studies were conducted during the filtration experiment and samples were analysed using Inductively coupled plasma mass spectrometry (ICP-MS) to determine the leaching extent. The nanomaterials and membranes were characterized using SEM, RAMAN, XRD, AFM and FTIR. The leached membranes were characterized using SEM cross-sectional micrographs and AFM micrographs for changes in surface morphology, and roughness and contact angles for changes in hydrophobicity.
Results: It was noted that nanomaterial exposure of the membranes to cleaning solutions resulted in nanoparticle leaching. The rate of nanoparticle leaching may be affected by the type of cleaning solution and its strength. The incorporation of GO and NGO enhanced nanoparticle-binding onto the polymer thus suppressing leaching. Nanomaterials leaching resulted in alterations in key membrane properties, including hydrophilicity, morphology, and surface roughness.
Conclusions: Understanding the leaching of nanomaterials from membranes helps determine the potential risks associated with the use of these membranes in water treatment. It is also crucial for developing regulations and guidelines for their safe use in wastewater treatment and for researchers and engineers to develop safer and more effective methods for using them in wastewater treatment.

Keywords: Carbon nanomaterial, Titanium Dioxide, Leaching, Nanostructured membranes, Membrane Stability

[46] Ghofrane Louhichi (Water Researches and Technologies Center of Borj Cedria (CERTE)), Linda Jammeli (Water Researches and Technologies Center of Borj Cedria (CERTE)), Henda Hedhli (Water Researches and Technologies Center of Borj Cedria (CERTE),) and Imen Khouni (Water Researches and Technologies Center of Borj Cedria (CERTE)).

Title: *Industrial Soap wastewater improvement for sustainable reuse and recovery using a hybrid process of coagulation/flocculation and membrane filtration.*

Abstract

The detergent manufacturing represents an industry of prime importance for developing countries such as Tunisia. Because it makes it possible to satisfy an increasingly growing demand for detergent products. This strong contribution requires significant production activities, thus generating huge volumes of effluent linked to the use of water in the process. Soap wastewater poses risks to the environment and public health due to high pollutant concentrations. These wastewaters, which are difficult to biodegrade are for many industries, discharged without prior treatment. Nowadays, several processes have been used in order to effectively treat these wastewaters such as advanced oxidation processing, adsorption, and ozonation. Unfortunately, these processes are very expensive and not effective. The general objective of this work is therefore to reduce pollution from these industrial soap wastewaters (SW) using a hybrid process based on the combination of Coagulation/Flocculation (CF) with membrane separation (MS) in order to be reused.
In the present investigation, CF experiments were conducted using the jar-test protocol. Response surface methodology (RSM) based on a three-level Box–Behnken design was employed to design the experiments and optimize the performance of this process. The parameters under investigation were coagulant concentration (X1), flocculant dosage (X2), and initial effluent pH (X3). The highest removal efficiencies (i.e., 100% turbidity and 52% COD) were achieved at an initial pH of 9.32, with Al2(SO4)3 concentration of 17.14 g·L-1 (coagulant) and a cationic flocculant dose of 182.08 mg·L-1.
Furthermore, MS was conducted using the Dead-End Filtration (DEF) mode with the objective of determining the appropriate membrane pore size for the best treated water quality. A range of different flat microfiltration (MF) membranes with pore sizes ranged from 0.22 to 5 µm and ultrafiltration (UF) membranes with molecular weight cut-offs (MWCO) in the range of 5-100 kDa were investigated.
The combination of CF with MF membrane pore size of 0.22 µm yielded excellent results for better soap industry wastewater treatment, achieving 100% and 56.34 % of turbidity and COD removals, respectively. Whereas, the proposed CF/UF hybrid process proved to be even more efficient, achieving outstanding results with maximum turbidity removal (100%) with nearly 81% COD removal using the smallest membrane MWCO of 5 kDa. Consequently, the proposed CF/UF hybrid process markedly enhanced the quality of the treated water and exhibited considerable potential for further reuse/recycle especially in the same soap production process with a salinity removal achieving 42%.

Keywords: Soap Industry wastewater, Membrane separation, Coagulation/Flocculation, Microfiltration, Ultrafiltration

[47] Linda Jammeli (Water Researches and Technologies Center of Borj Cedria (CERTE)), Ghofrane Louhichi (Water Researches and Technologies Center of Borj Cedria (CERTE)) and Imen Khouni (Water Researches and Technologies Center of Borj Cedria (CERTE)).

Title: *Comparative effectiveness of membrane filtration and evaporation-concentration for the treatment of soybean oil refining industry wastewater: improved recovery and valorization of the oily phase.*

Abstract

Protecting the environment has become a major economic and political issue, and every country in the world is concerned about safeguarding water resources. Industrial activities can have harmful impacts on the environment through the exploitation of natural resources such as water and/or the emission of polluting products. In this context, the vegetable soya oil refinery is one of the industries that uses huge quantity of water and, consequently, a major producer of wastewater heavily contaminated with organic and inorganic matter, oils and greases, volatile fatty acids, and suspended solids which are highly toxic.

The objective of the present investigation is to properly treat the soya vegetable oil refining wastewater (SVORW) in order to recover the oils lost in these effluents for safe and sustainable valorization. The selected treatment processes were membrane filtration using the microfiltration (MF) with a membrane pore size of 0.2 µm and the Evaporation/Concentration (EvC) in order to choose the most appropriate process for better oil and grease recovery to be reused.

The SVORW treatment using a crossflow MF-0.2 µm process under a TMP of 1.5 bar allows to achieve a maximum oil and grease retention of about 99.97% with 99.4% COD removal from treated water. On the other hand, the treatment of SVORW using EvC resulted in a total oil and grease (100%) recovery with a maximum COD removal of about 99.8%.

In summary, the MF and EvC processes used for SVORW treatment are effective in removing oils and fats and reducing the COD of the treated water. Therefore, the selection of the appropriate process for SVORW treatment and valorization is guided by: (i) the ability to maintain the quality and characteristics of the retained oily phase, as heat can alter these characteristics; (ii) the assurance that the treated water will meet Tunisian standards for reuse; and (iii) the efficiency of the process in minimizing costs while ensuring technical and economic viability.

Keywords: Vegetable Oil Refinery Wastewater, valorization, oil recovery, Microfiltration, Evaporation/Concentration

[48] Karabo Concious Mashiloane (University of South Africa), Edward Nxumalo (University of South Africa) and Machawe Motsa (University of South Africa).

Title: *Investigating the impact of hexagonal-Boron Nitride Nanosheets (h-BNNS) on the structural characteristics and the efficacy of polyvinylidene (PVDF) membranes for water-oil separation.*

Abstract

Hexagonal-boron nitride nanosheets/polyvinylidene fluoride (h-BNNS/PVDF) composite membranes were successfully fabricated through a facile one-step phase inversion process. The amount of h-BNNS incorporated into the PVDF membrane was varied within the mass percent range of 0 – 3%, and the influence on the membrane's structural properties and performance for water-oil separation was investigated. Surface roughness and wettability analyses (water contact angle data) showed that the membranes are hydrophilic, and the average surface roughness measurements reveal that the presence of h-BNNS enhances the wettability of the composite membranes. In addition, h-BNNS in composite membranes increased the total porosity which favoured enhanced membrane separation flux. The performance of the composite membranes for water-oil separation revealed that the addition of h-BNNS to the membrane polymeric matrix resulted in enhanced selectivity towards water with the highest flux of 384.96 L/m2h, and selectivity efficiency of 99.60% for a 3% h-BNNS/PVDF composite membrane with no transmembrane pressure applied. The preference for water as a filtrate is attributed to the superior water permeation properties of the h-BNNS and PVDF interaction. Water permeability was attributed to the presence of positively charged B atoms which pull the oxygen atoms in the water molecules. The improvement in fluxes of the investigated membranes, upon the addition of h-BNNS makes them excellent candidates for water-oil emulsion separations.

Keywords: Polyvinylidene fluoride, hexagonal Boron nitride nanosheets, Nano-enhanced membranes, Water-oil emulsions

[49] Ahmad Taghizadeh Damanabi (Faculty of Chemical and Petroleum Engineering, University of Tabriz) and Gomotsegang Fred Molelekwa (Tshwane University of Technology).
Title: *Separation of alcoholic biofuel with two-dimensional MXene nanocomposite membrane using Pervaporation process by CFD analysis.*
Abstract
Ethanol is a widely used organic substance in various industries and is considered one of the most important and strategic goods in many countries. The application of membrane technology for the purification and separation of this compound has become more preferred than other existing separation processes due to low energy consumption, diversity in the construction of modules, and the use of small-volume devices. The studies on the pervaporation process started in 1917 by Kobber. Since then, with the aim of environmental considerations, achieving fast, simple, and cost-effective processes, improving the conditions of the evaporative permeation process, and increasing the separation efficiency, scientists have been trying to achieve thin membranes and application and control of effective parameters in these processes through process modelling and simulation. In this study, the researchers simulated the evaporative percolation system using COMSOL Multiphysics® software to optimize the purification and increase the separation efficiency of the water and ethanol mixture and the performance of the MXene nanocomposite membrane. Then, the predicted model was validated with experimental data. The results of the modelling showed that flux penetration and separation efficiency increase with increasing water-ethanol feed flow rate and decrease with increasing temperature in the membrane unit. As a result, the optimal separation point was determined to be at room temperature with 95% ethanol by weight in the feed. Additionally, the highest transmission flux occurs in the area near the entrance of the feed channel and reaches zero in the upper part of the module.

Keywords: MXene membrane, Pervaporation, Computational fluid dynamic, Alcoholic biofuel

[50] Chloe Gabrielle Hahn (University of Johannesburg), Thollwana Makhetha (University of Johannesburg) and Soraya Malinga (University of Johannesburg).
Title: *NOVEL MOF@COF COMPOSITE PAN UF MEMBRANE FOR THE DEGRADATION OF ORGANIC POLLUTANTS AND EDCs IN WATER.*
Abstract
Clean and safe drinking water has become an increasingly precious resource in many parts of the modern world owing to the widespread occurrence of persistent organic pollutants, such as Bisphenol A (BPA). BPA is a potent endocrine disrupting chemical (EDC) and also possesses carcinogenic and genotoxic properties at concentrations as low as 1 μg L-1 (1). Moreover, it is a prevalent pollutant within freshwater bodies due to its widespread occurrence in common synthetic polymers (2). Membrane separation technology has recently made many advances, however, the need for efficient membrane separation techniques with improved antifouling has emerged in order to target trace-level quantities of BPA. This study proposes the use of a MOF@COF hybrid (MIL-101-NH2@TpMA) formed via solvothermal methods as an efficient catalytic unit to form a novel composite PAN ultrafiltration (UF) membrane. Utilising hydroxide or superoxide radical generation (depending on reaction media) for visible light-driven degradation of BPA, MIL-101-NH2@TpMA is hypothesised to reach an efficiency of 99%. It is also reported to degrade other organic pollutants such as methyl orange and methylene blue. Anchoring the composite within a PAN UF membrane (formed via phase inversion) will produce self-cleaning membranes, improving their reusability, anti-fouling capacities, and prolonging the lifespan of the PAN UF membranes. Additionally, it will eliminate the need for a recovery filtration step to retrieve the photocatalytic composite.

Keywords: Antifouling, Endocrine disrupting chemicals, MOF@COFs, PAN ultrafiltration membranes, Photocatalytic degradation

[51] Rhea Verbeke (KU Leuven), Daan Van Havere (KU Leuven), Nathalie Lenaerts (KU Leuven), Caroline Bogaerts (KU Leuven), Zahra Bozorgmehr (KU Leuven), Irian Baert (KU Leuven), Doug Davenport (KU Leuven), Maarten Bastin (KU Leuven), Abdelhakim El Fadil (KU Leuven) and Ivo Vankelecom (KU Leuven).
Title: *EPOXIDE-BASED MEMBRANES: AN EMERGING PLATFORM FOR LIQUID AND GAS SEPARATIONS.*
Abstract
Epoxide chemistry has been applied for many decades in a variety of industries owing to their excellent chemical, physical, and thermal resistance, and the simple tunability of their chemical composition. However, in membrane technology, the use of epoxides for membrane synthesis has only recently been demonstrated by our group. In this presentation, an overview of our research on epoxide-based membranes is presented to demonstrate that it can serve as a novel membrane platform for liquid and gas separations. The different membrane synthesis techniques that can be used to make epoxide-based membranes, such as non-solvent induced phase separation and interfacial initiation of polymerization, will be highlighted. To underline the versatility of epoxide chemistry and the available polymerization mechanisms, membranes with vastly different performances and physicochemical properties will be

shown. To improve salt rejection for desalination applications and achieve CO2/N2 selectivity for gas separations, further densification of the interfacially polymerized thin film by inducing additional cross-links is required. Besides desalination and CO2/N2 separations, the epoxide-based membranes could also be applied for solvent-resistant nanofiltration (SRNF) and organic solvent nanofiltration (OSN) as stability tests for 5 days in organic solvents and solvent filtrations showed no performance degradation nor changes in the physicochemical properties of the robust membranes. The epoxide-based membranes are also intrinsically stable in oxidizing, caustic and acid environments as demonstrated by their full stability in sodium hypochlorite, NaOH (pH 14) and HCl (pH 0), respectively. Due to their intrinsic high robustness and high degree of tunability, the epoxy-based membranes may therefore lay the foundation for a new generation of stable membranes for nanofiltration, SRNF/OSN and gas separations.

Keywords: epoxide chemistry, TFC membranes, phase inversion, robust membranes

[52] Andrea Schaefer (Karlsruhe Institute of Technology - Institute for Advanced Membrane Technology).
Title: *Membrane Technology for Fluoride Removal: Tanzania Experience.*
Abstract
Tanzania shows some of the world's highest fluoride concentrations in natural ground- and surface waters. Located in the East African Rift Valley fluoride is abundant and contaminants water sources to an extent where regular dental and skeletal fluorosis are observed. The development of bone char technology has been able to contribute greatly to providing safe water from the less polluted sources, while the national drinking water guideline has been elevated, compared to WHO, to be able to provide access to drinking water. Nevertheless, many water sources show very high fluoride concentrations that result in a rapid saturation of adsorption materials such as bone char.
In 2012 to 2014 extensive field work was carried out in Tanzania to i) investigate a large number of water sources for fluoride and organic matter concentrations; ii) carry out fundamental studies into the removal mechanisms of nanofiltration, and iii) carry out pilot studies with directly coupled photovoltaic powered nanofiltration to treat such waters and demonstrate the technology to a select number of communities.
Highlights of these extensive results will be presented together with an outlook on the implementation of autonomous decentralized treatment systems with a focus on rural African communities.

Keywords: Nanofiltration, Ultrafiltration, Organic Matter, Decentralized Water Supply, Renewable Energy

[53] Soumana Gagara (AMSIC).
Title: *CONTRIBUTION TO THE QUALITY ASSESSMENT OF PURIFIED WATER: A CASE STUDY OF THE METHODS USED BY UN FIELD OPERATIONS MISSION IN THE PROVINCE OF SOUTH KIVU IN THE DRC.*
Abstract
The study entitled " Contribution to the quality assessment of purified water: a case study of the methods used by MONUSCO in the province of South Kivu in the DRC" is intended to contribute to the quality enhancement of water purification by reverse osmosis and microfiltration systems. A comparison was made between these two processes' outputs and those from the filtration method under the same conditions of sampling and laboratory analysis. Some recommendations were considered regarding the treatment of water through both reverse osmosis and microfiltration systems. Thus, the final comparison outputs between the two mentioned processes have allowed us to ascertain that the superficial water of Kivu Lake is not salty - in the part of its peninsula in Bukavu. It is low in micronutrients; its pH is relatively neutral, and its turbidity complies with the WHO standards. Moreover, this filtered water contains total coliform, but its analysis revealed there is no Escherichia coli in the samples.

Keywords: Purified water, MONUSCO, Reverse osmosis, Microfiltration, Lake Kivu.

[54] Asim Khan (Islamic University of Madinah).
Title: *INNOVATIVE SUSTAINABLE MEMBRANES FROM WASTE POLYMERS: ADVANCEMENTS IN WATER PURIFICATION AND BIOFUEL UPGRADATION.*
Abstract
The imperative for sustainable development necessitates the innovation of green technologies in various sectors, including membrane technology. This study discusses the development of green and sustainable membranes derived from waste polymeric materials. By transforming waste into valuable membrane materials, our approach addressed the critical issue of plastic waste while reducing reliance on fossil fuel-derived synthetic polymers. The fabrication process employed greener solvents, notably deep eutectic solvents, further enhancing the sustainability of the membranes. These newly developed membranes exhibit remarkable performance in two key applications: water purification through nanofiltration and the upgradation of biofuels via pervaporation. In water purification, the membranes demonstrated high efficiency in removing contaminants, ensuring access to clean water. In the case of biofuels, the membranes effectively upgraded bioethanol to fuel-grade quality, showcasing their potential in

supporting renewable energy initiatives. The integration of waste polymeric materials and green solvents in membrane fabrication not only contributes to environmental sustainability but also offers a viable solution to the waste management crisis. This innovative approach aligns with global efforts to promote circular economy principles and reduce environmental footprints.

Keywords: Sustainable membranes, waste polymers, green solvents, water purification, biofuels upgradation

[55] Elena Tocci (Institute on Membrane Technology–National Research Council of Italy (CNR-ITM)), Giuseppe Prenesti (Institute on Membrane Technology–National Research Council of Italy (CNR-ITM) and University of Calabria), Alessio Caravella (University of Calabria) and Alfredo Cassano (Institute on Membrane Technology–National Research Council of Italy (CNR-ITM)).

Title: *Crystallization Mechanisms in Lithium Salt Membranes: Insights from Molecular Dynamics.*

Abstract

The urgent need to fight climate change and reduce greenhouse gas (GHG) emissions is driving a global shift towards renewable energy sources. However, these energy sources often face challenges due to their periodic and variable availability, necessitating effective storage solutions [1,2]. Batteries are a key solution to this problem, but their widespread use significantly increases waste and pollution. This has heightened interest in battery recycling, particularly for recovering valuable metals like lithium and cobalt through reactive crystallization processes [3,4].

Our research aims to explore the efficacy of membrane crystallization processes involving various lithium salts, with the goal of establishing a viable method for lithium recovery from spent Li-based batteries. This process utilizes hydrophobic polymeric membranes, such as polypropylene (PP) and polyvinylidene fluoride (PVDF), which act as selective barriers for water vapor while retaining lithium salts. The selective transport mechanism of these membranes is crucial for the crystallization of lithium salts, a key factor in developing an efficient industrial recycling process for lithium batteries.

All-atom unbiased molecular dynamics simulations explored Li-salt crystal nucleation and growth using GROMACS 5.1.4 [4] and VMD 1.9.3 [5] for visualization. Water was modeled with SPC/E, and ions with the OPLS force field. Systems were equilibrated in NVT and NPT ensembles for 2 ns, followed by a 200 ns production run at 300 K and 1 atm, using a 1 fs timestep.

This paper presents a comprehensive computational study on the nucleation and growth of lithium salt crystals in the presence of hydrophobic polymer surfaces under conditions of salt supersaturation. We investigate how different polymeric membrane surfaces uniquely influence crystal formation mechanisms and crystallization rates by monitoring the evolution of nuclei over time. Additionally, we explore the intricate relationship between the properties of these materials and the morphology and purity of the resultant crystals, offering new insights into the impact of membrane assisted crystallization.

Acknowledgments

This work was funded by the Next Generation EU - Italian NRRP, Mission 4, Component 2, Investment 1.5, call for the creation and strengthening of ‘Innovation Ecosystems', building ‘Territorial R&D Leaders' (Directorial Decree n. 2021/3277) - project Tech4You - Technologies for climate change adaptation and quality of life improvement, n. ECS0000009.

Keywords: Batteries, Lithium, Membrane, Crystallization, Molecular Dynamics

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Title: *CELLULOSE-FUNCTIONALIZED ELECTROSPUN MEMBRANE AS POTENTIAL MEMBRANE FILTER FOR WATER DECONTAMINATION.*

Abstract

One of the major challenges facing mankind is access to clean safe water. This is despite the fact that about 71% of the earth`s surface is covered by water. These waters contain different solutes such as toxic heavy metals, anions, drug metabolites, salinity, microplastics, nanoparticles, etc., which make the water unsafe for human consumption. In our pursuit to develop affordable and sustainable materials for application in water filtration, and to increase people`s access to clean safe water, we set out to extract cellulose from locally available invasive plant species and use the cellulose to functionalize electrospun membranes for decontamination of drinking water. Agave sisalana or sisal (English) is a plant native to Mexico and has naturalised into many countries across the glove, Botswana included. The plant grows and thrives with little or no care at all. It is cultivated for its strong leaf fibres which are used to make furniture, hats, bags and sometimes it is grown as an ornamental plant especially in Botswana. However, the plant propagates itself through suckering and seeds. It is known to exclude and outcompete native plant species

(ISSG, 2010). For that reason, sisal plant is considered invasive, and it is listed as such in countries like Australia, Madagascar, South Africa, the United States and on multiple islands in the Pacific (ISSG, 2010). The electrospun cellulose functionalized membranes exhibited relatively high particulate and microbe removal abilities in synthetic waters.

Keywords: Functionalized membrane, membrane filter, water decontamination, invasive plant species

[57] Solomon Hailu Tela (NOVA School of Science and Technology, Universidade NOVA de Lisboa), Maria Beatriz Cristóvão (iBET, Instituto de Biologia Experimental e Tecnológica), Andreia Bento Silva (iBET, Instituto de Biologia Experimental e Tecnológica), Maria Rosário Bronze (Faculdade de Farmácia Universidade de Lisboa), Maria Teresa Barreto Crespo (iBET, Instituto de Biologia Experimental e Tecnológica), João Goulão Crespo (NOVA School of Science and Technology, Universidade NOVA de Lisboa), Monica Nunes (iBET, Instituto de Biologia Experimental e Tecnológica) and Vanessa Jorge Pereira (iBET, Instituto de Biologia Experimental e Tecnológica).
Title: *OCCURRENCE OF ANTIBIOTICS IN WASTEWATER EFFLUENTS AND THEIR TREATMENT BY A PILOT SCALE NANOFILTRATION UNIT.*
Abstract
Crop irrigation accounts for approximately 70% of global freshwater withdrawals. Projections indicate that climate change and population growth will intensify demands on water resources for food production. The reuse of domestic wastewater effluents presents a potential solution to supplement agricultural water supply. However, before implementing wastewater reuse for irrigation, a comprehensive evaluation is required to quantify the presence of micropollutants in the effluents and define the best treatment processes.
Antibiotics are highly valuable in clinical settings, but their ongoing presence in aquatic environments, even at trace levels, along with their effects on both the environment and human health, has led to their classification as emerging contaminants. Therefore, analyzing their occurrence and developing effective treatment processes is necessary to prevent their release into the aquatic environment.
In this work, broad-spectrum antibiotics like fluoroquinolones (ciprofloxacin and levofloxacin) and carbapenems (ertapenem, imipenem, and meropenem) were studied. Their environmental partition and wastewater removal were predicted based on their structures and physicochemical properties. The prediction results showed that ciprofloxacin and levofloxacin are expected to present in wastewater effluents to a higher extent compared to the target carbapenems.
The recoveries of an analytical method that involves solid phase extraction to concentrate the target compounds followed by separation and detection using ultra-high-performance liquid chromatography with tandem mass spectrometry (UPLC-MS/MS) were evaluated. Nevertheless, as predicted, only ciprofloxacin and levofloxacin were found to occur in all sampling events of wastewater effluents performed throughout a year. Experimental results indicated that the occurrence levels of ciprofloxacin and levofloxacin in wastewater effluents were in the range of 584-2056 ng.L-1 and 126-1118 ng.L-1, respectively.
The removal of ciprofloxacin and levofloxacin from the real wastewater effluents was then tested using a Desal 5DK nanofiltration membrane in several pilot-scale assays. The concentration of ciprofloxacin and levofloxacin was not detected in any of the permeated samples. Considering the limits of detection, the rejection performance of Desal 5DK was higher than 93% for levofloxacin and 97 % for ciprofloxacin in all experiments, and size exclusion was identified as the dominant rejection mechanism. The consistent and high rejection rates observed with the Desal 5DK membrane is expected to guarantee an effective removal of ciprofloxacin and levofloxacin from wastewater effluents.
A long-term nanofiltration pilot scale experiment carried out with a transmembrane pressure of 6 bar and recovery rate of 72%, revealed a low membrane fouling resistance and permeability variation (6.3%) [1,2].
Hence, nanofiltration using the Desal 5DK membrane is considered to be a promising treatment to cope with antibiotics present in wastewater effluents. Ongoing work includes assessing the use of the nanofiltration permeate for raspberry irrigation and evaluating of the potential uptake of antibiotics by this crop after irrigation. Additionally, strategies for concentrate management, such as low-pressure UV photolysis are under investigation.

Keywords: Antibiotics, Partition in environment, Wastewater effluent, Occurrence, Pilot scale Nanofiltration treatment

[58] Sawadogo Boukary (Institut International d'ingenierie de l'Eau et de l'Environnement (2iE)), Nouhou Moussa Abdoul Wahab (Institut International d'ingenierie de l'Eau et de l'Environnement (2iE)) and Konate Yacouba (Institut International d'ingenierie de l'Eau et de l'Environnement (2iE)).
Title: *INTEGRATED COAGULATION-FLOCCULATION AND NANOFILTRATION OR REVERSE OSMOSIS MEMBRANE SYSTEM FOR TREATING SUGAR CANE INDUSTRY EFFLUENT FROM A MEMBRANE BIOREACTOR OUTLET.*
Abstract

Sugarcane industries, like other agro-food industries, generate significant volumes of wastewater containing high concentrations of organic and inorganic pollutants. Among the proposed treatment solutions, the membrane bioreactor (MBR) has proven highly effective in degrading organic pollutants but has limitations in removing color and inorganic pollutants. To address this gap, integrating other technologies with MBR is necessary. In this study, we propose coupling MBR with either Coagulation-flocculation followed by Nanofiltration or Reverse Osmosis for treating wastewater from sugar industries after initial MBR treatment. The wastewater treated by an anaerobic MBR pilot plant, fed with wastewater from a sugar cane production unit, was used for the tests. Various formulations of Moringa oleifera were tested, including its defatting and dehulling products with hexane and ethanol. For nanofiltration and reverse osmosis, pressures of 4 and 8 bars respectively were applied.. For the coagulation-flocculation phase, granular alum and powdered moringa oleifera seeds were compared as coagulants. Thus, the coupling of the coagulation-flocculation system with nanofiltration and reverse osmosis membranes effectively reduced both organic and inorganic matter. The use of aluminum sulfate proved more effective at high pollution concentrations, while Moringa oleifera extracted with hexane achieved removal rates exceeding 70% for heavy metals. Purification efficiencies of over 90% were obtained after filtration with the reverse osmosis membrane, while the nanofiltration membrane showed retention rates of 90% for color, but less than 50% for monovalent ions. The treated effluent at the outlet of the nanofiltration and reverse osmosis systems complies with Burkina Faso's discharge standards, with superior quality allowing for direct reuse in the industry.

Keywords: industrial wastewater, coagulation-flocculation, membrane bioreactor

[59] Getachew Teklay Gebreslassie (Institute of Porous Materials (IMAP), ENS, ESPCI, Paris, France).
Title: *PROTON CONDUCTIVE MOF-BASED MIXED MATRIX MEMBRANES FOR FUEL CELL APPLICATIONS.*
Abstract
Proton Exchange Membrane Fuel Cells (PEMFCs) hold immense promise as clean energy sources, directly converting hydrogen into electricity. However, their widespread adoption hinges on overcoming the limitations of current membrane materials. Nafion, the state-of-the-art proton exchange membrane, suffers from high cost, gas leakage, environmental concerns during production, an unclear proton conduction mechanism, and a strong reliance on high relative humidity and temperature conditions[1]. To address these challenges, Metal-Organic Frameworks (MOFs) have emerged as potential replacements due to their customizable structures, large surface area, and superior proton conductivity[2]. Nevertheless, their fragility necessitates integration into a polymer matrix, forming Mixed-Matrix Membranes (MMMs). By combining MOFs' advantages with polymers' mechanical strength, flexibility, and gas control, MMMs offer a compelling pathway to next-generation, high-performance PEMFCs[3].
Water-stable nano-MOFs, renowned for their high proton conductivity, were synthesized using environmentally friendly and scalable methods[4]. These MOFs were subsequently integrated into biodegradable polymers such as polyvinyl alcohol, chitosan, and carboxymethylcellulose. A comprehensive study explored the influence of MOF content, MOF-polymer interactions, and polymer composition on the resulting MMMs. The membranes' structural properties were meticulously characterized using X-ray diffraction (XRD), dynamic scanning calorimetry (DSC), thermogravimetric analysis (TGA), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), and mechanical measurements. Their proton conductivity was assessed through electrochemical impedance spectroscopy (EIS).
Through careful optimization of filler ratio, casting thickness, and polymer concentration, stable and smooth composite membranes were prepared. These eco-friendly MMMs showcased superior proton conductivity relative to their pure polymer counterparts. This improvement highlights the synergistic interplay between MOF and polymer, likely attributed to a beneficial interfacial structure that promotes proton mobility. Collectively, these results underscore the immense potential of MOF-based MMMs constructed from biodegradable polymers as cutting-edge PEMs for fuel cell technology. The superior performance of these MMMs offers a compelling solution to the challenges posed by traditional PEMs, paving the way for more sustainable and efficient fuel cell systems.

Keywords: MOFs, Mixed Matrix Membrane, Proton Exchange Membrane, Fuel Cells

[60] Rosalinda Mazzei (Institute on membrane technology CNR-ITM).
Title: *Mimicking nature to improve membrane bioreactors: towards process intensification.*
Abstract
ABSTRACT: The idea of imitating nature to solve problems is apparently as old as mankind. There are different ways of imitating nature and developing new processes, the two main ones being based on direct mimicry (biomimetic systems) or direct and indirect mimicry (bioinspired). In the latter case, the meaning is more flexible. In recent years, learning from nature has also been the strategy for developing sustainable systems that take advantage of nature's optimisation and use biological molecules, which are by definition green materials.

Biomimetic synthesis of materials is an important branch of biomimetics and has recently been divided into functional biomimetic synthesis (FBS), which is more related to reproducing the structure of natural systems to build artificial systems (e.g. artificial bones), and process biomimetic synthesis (PBS), where the main aim is to simulate the synthesis route of a natural process.
Biocatalytic membranes (BM) can already be considered as a biomimetic system, as they can compartmentalize biological molecules in the same way as a biological membrane.
They can also be implemented in a membrane bioreactor (MBR) regulated by controlled fluid dynamic conditions that allow the control of the biocatalytic reactions that promote the development of PBS. Particularly in recent years, there has been a strong interest in the use of biocatalytic membrane processes for multiple enzyme compartmentalization and enzymatic cascade reactions in different application fields such as: biomedical, pharmaceutical and more recently in biorefinery.
Despite the advantages of simulating nature through BM and MBR, there are several issues that need to be addressed in order to achieve the development of such systems on a large scale. The main problems are related to both biomolecule stability/storage and membrane cleaning and reuse.
In this presentation, the innovative strategies of compartmentalization and enzymatic cascade reaction carried out by membranes will be presented, which try to overcome the main limitations associated with the above-mentioned systems.

Keywords: membrane bioreactor, biocatalytic membrane, enzyme compartmentalization by membrane processes, enzymatic cascade reaction

[61] João Crespo (NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal), Sylwin Pawlowski (NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal) and Svetlozar Velizarov (NOVA School of Science and Technology, Universidade NOVA de Lisboa, Portugal).
Title: *Ion-Exchange Membrane Processes: Perspectives in Water Treatment and Desalination.*
Abstract
In this lecture, the original concept of ion-exchange membrane (bio)reactor and its design and use for the removal of ionic inorganic pollutants from drinking water supplies will be presented and discussed [1]. The target pollutants include nitrate, nitrite, perchlorate, arsenate and ionic mercury. The mechanism of ionic transport will be discussed as well as the methodology for process optimization.
Additionally, the concept of capacitive deionization will be presented as well as the recently proposed flow capacitive deionization (FCDI) using flow electrodes. Different applications will be discussed, including the recovery of lithium from brines [2]. The impact of fluid rheology on the design of the FCDI cell will be emphasized [3].
Perspectives and research needs for the implementation of ion-exchange membrane processes in water treatment and desalination will be discussed.

Keywords: Ion-exchange, Water treatment, Water desalination, Donnan Dialysis, Capacitive deionization

[62] Heidi Richards (University of the Witwatersrand) and Lebea Nthunya (University of the Witwatersrand).
Title: *MEMBRANE DISTILLATION CRYSTALLIZATION IN THE AFRICAN CONTEXT.*
Abstract
Currently, most municipal wastewater plants still employ the traditional, natural biological process for wastewater treatment. Such a process depends heavily on the biodegradability of the aquatic waste content, particle weight for faster rate of sedimentation, bacterial activity, and microorganisms. In the past centuries, wastewater treatment dealt with “simple domestic waste”, where the conventional biological treatment adequately recycled wastewater to acceptable permissible limits as regulated by relevant legislation. Biological nutrient removal treatment plants are designed to remove carbon, nitrogen, phosphorous and trace inorganics. Industrial influent may contain heavy metals, high ammonia, high salt contents and complex organics and carbon. These compounds pose additional strain on the biological process and may inhibit it when concentrations of salts are high enough. In South Africa, a study conducted by the Water Research Commission on the production of saline waste in 2009, showed that the major producers of saline waste were: Mining sector (33.1%), Petroleum (28.4%), Power generation (15%), Paper & pulp (7.6%) and Steel/metals processing industries (6.8%). This saline waste is a problem for the landfills as it affects the integrity of the landfill liners. Major producers of saline waste do not take it to landfill, but rather opt to invest in their own saline waste management facilities such as lagoons, evaporation ponds and marine outfalls. These are all high footprint treatment solutions however, with space being a limiting factor in industries where big volumes are produced on a daily basis. An alternative treatment regime is therefore becoming a matter of urgency.
In this presentation, the application of membrane crystallization is discussed as an alternative treatment method. The working principle of MCr is based on a vapour pressure gradient (mainly induced through temperature) across a microporous hydrophobic membrane. The advantage of MCr is that it produces a high quality permeate stream (fresh

water) independent of feed characteristics. Other advantages of MCr includes operation at low temperature and ambient pressure (solar powered or waste grade heat), simple configuration and potential to treat highly concentrated solution. In this paper, membrane distillation crystallization (MDC) is evaluated towards resource recovery from acid mine drainage (AMD), sugar cane effluent and Moringa oleifera powder.
AMD remains an environmental concern due to its acidic nature and presence of various concentrations of heavy metals. To ensure high process performance, process polyvinylidene fluoride (PVDF) membranes were modified using hydrophobic nanoparticle additives and compared with PTFE-20 reference membranes. Based on single crystal x-ray diffraction and scanning electron microscopy analysis, MDC predominantly produced monoclinic gypsum ($CaSO4{\cdot}2H2O$) with the C2/c space group. The synthesised membranes were able to produce both single gypsum crystals and a mixture of powdered crystals from AMD solution, demonstrating the use of this technology to treat environmental samples.
In another study, sugar water was treated with the MDC technique to recover high-quality water and sugar crystals with uniform sizes and good crystal growth. The effect of temperature on the permeate water flux, growth and morphology, and particle size distribution was investigated by varying the feed temperatures. At 80ºC feed temperature, high quality water was determined to have a flux of 0.9 Kg m-2 h-1 and a recovery rate of 95%. A higher growth rate resulted as well at the highest feed temperature, 80ºC, but also suffered from agglomeration, seen from the particle size distribution plots and the optical microscope images. The study grows the understanding and development of the MDC technique towards the recovery of high-quality water and sugar crystals.
Moringa oleifera has found interest in the food industry because of the dietary nutrients it possesses. The plant is characterized by flavonoids, isothiocyanates, phenolic acids, and tannins. Based on previous studies, bioactive molecules from moringa act as microbial agents, and antioxidants, thus demonstrating their potential use in the food industry. The current study evaluates membrane distillation crystallization (MDC) towards the recovery of crystals from moringa flower extract for use in the food industry. Initial outcomes from this study will be shared in this presentation.

Keywords: membrane distillation, crystallization, saturation, recovery, industrial application

[63] Ludovic Dumee (Khalifa University, Department of Chemical Engineering) and Harikrishnan Balakrishnan (Khalifa University, Department of Chemical Engineering).
Title: *3D printing functional nanoporous membranes and separation materials.*
Abstract
Over the past 20 years, 3D printing technologies have emerged as innovative tools to generate macro-porous materials, with potential in complex structures impossible to otherwise develop by traditional manufacturing. More recently, advanced composite materials have been developed at the mili and micro scale following progress in new polymers and resins formulations as well as greater resolution control for both Fused Deposition Modelling (FDM) and Dynamic Light Polymerisation (DLP). Breaching the micron-scale barrier, to generate nano-porous materials has however remained to date a major challenge, due to either rheological limitations or minimum printable pixel size achievable. New strategies arising from polymer monoliths development have however emerged to generate ultra-porous materials, with macron-sized thicknesses and yet nanoscale pores. Our team has developed innovative strategies based on advanced resins formulations to print nano-porous membranes, and nano-textured catalysts as well as adsorbents. In this presentation, the feasibility to develop complex 3D membrane architectures as well as functional 2D nanomaterials composites with this novel process at scale will be demonstrated for a range of chemistries and applications. Nanocomposite structures with excellent nano-load distributions and incorporation into porous polymeric matrixes are critical to achieving scale of production and roll-to-roll 3DP functional films production will also be demonstrated.

Keywords: Ultrafiltration membranes, isoporous membranes, 3D printing

[64] Soraya Malinga (University of Johannesburg).
Title: *Efficient antibacterial membranes based on nanomaterials for water treatment.*
Abstract
Most South African communities rely on untreated water from rivers, streams, and dams that are constantly contaminated with pathogenic bacteria. Ingestion of water containing pathogenic bacteria such as V. cholera, E. coli, Salmonella, and S. aureus results in many diseases such as diarrhoea and shigellosis. The use of nanocomposite membranes has been well received since it addresses the limitations of traditional methods. Thus, this talk will give an overview of the development and application of antibacterial membranes targeted for the removal of prevalent bacteria in water. The role of these membranes as a promising technology for water treatment due to their antibacterial properties will be highlighted.

Keywords: Antibacterial properties, membranes, silver nanoparticles, selenium nanoparticles, water treatment

[65] Kibrom Alebel Gebru (University of Duisburg-Essen).
Title: *Desalination membrane modification toward improving antifouling performance: From lab to pilot scale.*
Abstract
Membrane fouling is still one of the main problems in membrane applications, and reverse osmosis (RO) membranes are highly vulnerable to foulants. This work aims to overcome the membrane fouling problem using a reactive coating of the membrane surface using an acrylate-based cross-linkable zwitterionic copolymer (ZCO) and a complementary cross-linker, enabled by the concentration polarization effect. Parameters for in-situ polyzwitterionic hydrogel coating of commercial BW30 membranes were investigated using a crossflow filtration setup (membrane area = 0.0084 m2), and optimum conditions in terms of ZCO concentration, initial flux, cross-flow velocity, and coating duration were identified. Clear correlations between the relative end permeance change (REPC) during filtration of the coating solution, and the relative permeance change (RPC) for pure water due to the resistance of the coating on the obtained modified membrane were established. With the target of functional antifouling coatings at minimal reduction of pure water permeance (RPC < 10%), flux during filtration cum reactive coating was monitored, and the modification was terminated when an appropriate REPC value had been reached. The coating on the membranes was also characterized using scanning electron microscopy, Fourier-transform infrared spectroscopy, and zeta potential. Antifouling performance evaluation with industrial wastewater revealed a clear difference between the pristine membrane that displayed a 42 % flux drop after 72 hours, while only an 11 % flux drop was observed for the ZCO-coated membrane under the same RO conditions. Lab scale experiments confirmed the acid stability of the coating (at pH 2) and the coating removal (for subsequent recoating) under alkaline conditions (at pH 12). The in-situ hydrogel coating of the BW30 membrane was transferred to a four-inch spiral-wound module (membrane area = 7.2 m2) using a pilot scale system and the conditions were derived from the lab scale studies. Monitoring the flux and adjusting the coating with the help of the REPC value was successful; RPC values of 5 % were obtained for the BW30 spiral-wound modules, which are now tested in pilot-scale RO experiments with industrial wastewater.

Keywords: Zwitterionic copolymer, membrane hydrogel coating, concentration polarization, antifouling

[66] Solomon Hailu Tela (NOVA School of Science and Technology, Universidade NOVA de Lisboa), Anthony. Szymczyk (CNRS, ISCR (Institut des Sciences Chimiques de Rennes) - UMR 6226, Univ Rennes, 35000, Rennes, France), João G. Crespo (NOVA School of Science and Technology, Universidade NOVA de Lisboa) and Carla Portugal (NOVA School of Science and Technology, Universidade NOVA de Lisboa).
Title: *ADVANCED PROCESS MONITORING USING ONLINE FLUORESCENCE IN SOLVENT RESISTANT NANOFILTRATION APPLIED IN OLEFIN METATHESIS.*
Abstract
Olefin metathesis has revolutionized the way chemists design and synthesize molecules, mostly due to the development of well-defined Ru-based catalysts with high O2, moisture, and functional-group tolerance. However, the recovery and recycling of these metal catalysts often rely on energy-intensive and solvent-consuming techniques, such as distillation and chromatography. Solvent-resistant nanofiltration membranes offer a promising, low-cost, and environmentally friendly approach for catalyst recovery and recycling.
This research employs real-time fluorescence monitoring to enhance the efficiency of catalytic reactions integrated with the solvent resistant nanofiltration separation process. Specifically, monitoring of the operating conditions for catalyst recovery and product purification in a ring-closing metathesis reaction using PDMS-based solvent-resistant nanofiltration membranes will be conducted. The ring closing metathesis reaction will be tested using two substrates, diethyl diallyl malonate (DEDAM) and diallyl tosylamine (DATA) in dimethyl carbonate/toluene catalyzed with a ruthenium-based catalyst. The real-time monitoring is expected to provide critical insights on substrate consumption, maximum conversion, catalyst recovery, and the efficient extraction of target cyclic products (c-DEDAM and c-DATA).

Keywords: Ru-based catalyst, Olefin metathesis, Solvent resistant nanofiltration, Online fluorescence

[67] Noreddine Ghaffour (KAUST).
Title: *SCALING-UP THE MEMBRANE DISTILLATION PROCESS: CHALLENGES AND CONTRIBUTIONS.*
Abstract
Membrane distillation (MD) is still considered as an attractive emerging desalination process combining the advantages of conventional thermal-based and membrane-based desalination processes. However, although the process has been successfully demonstrated for treating challenging feed water quality, such as hypersaline brines and produced water, its technology readiness has not reached the required level to penetrate the desalination and water treatment market. The process scale-up remains hindered by several limiting factors related to MD-specific

membrane properties, process conditions and module design, which result in severe temperature polarization and significant heat losses. This talk addresses these interlinked effects with a focus on proposed novel concepts for flat sheet and hollow fibre modules that aim to significantly reduce temperature polarization, improve energy efficiency and maximize the overall process performance. Specific case studies demonstrated experimentally and validated numerically will be presented for different module scales.

Keywords: MD scaleup, brine treatment, efficiency, heat recovery, temperature polarization, localized heating

[68] Faizal Soyekwo (SHENZHEN UNIVERSITY) and Changkun Liu (SHENZHEN UNIVERSITY).
Title: *Enabling improved Lithium/Magnesium Separation using Polyamide Nanofiltration Membranes Functionalized with Clustered Multination side chains.*
Abstract
Selective recovery of lithium from Salt Lake brines using environmentally friendly technologies is increasingly demanded to overcome the lithium supply shortage resulting from a heightened demand in the energy sector. However, satisfying precise ion separation for lithium extraction from concentrated Mg/Li mixtures is highly challenging for most polymer nanofiltration membranes due to the miniaturized pore structures and weak and unstable positive surface charges. Besides, bestowing high permeance together with improved membrane fouling remains a challenge for the widespread implementation of membrane processes.
Herein, a series of new quaternary ammonium-based ionic liquid (IL) monomers are synthesized and utilized for the surface modification of nascent polyamide selective layers to fabricate IL-modified polyamide nanofiltration (NF) membrane for lithium separation from Mg/Li mixtures. Experimental studies and Molecular dynamics simulations confirm that the IL modification creates nanoscale structural heterogeneity leading to enhanced surface hydrophilicity, enlarged membrane pore structure, reduced internal resistance through the membrane selective layers and reinforced Donnan exclusion effects. Subsequently, the modified membranes exhibited enhanced water permeance compared to the unmodified membrane, outperforming the reported state-of-the-art positively charged membranes. it was also found that the Li+/Mg2+ selectivity for the separation Mg/Li mixtures greatly improved suggesting the membranes' potential for lithium recovery. The length of the alkyl chain and the number of cations located in the flexible alkyl-spacers was found to significantly influence the structural properties of the membrane and the separation performance, which provides theoretical guidance for selecting suitable multication chains to optimize the separation performance. Moreover, the membranes showed efficient antibacterial activity and fouling resistance, demonstrating that the modification approach is advantageous to facilitate the inhibition of biofilm formation on the membrane surface and reduce membrane fouling.
Due to the advantages of straightforward surface functionalization, multifunctional ion selectivity, antibacterial and anti-biofilm formation properties, we established that functionalization of polyamide composite film with ionic liquids containing multication side chains could be a promising approach to develop multifunctional polymeric NF membranes with improved and sustainable permselectivity for potential recovery of metal resources contributing to a circular economy and environmental water remediation.

Keywords: nanofiltration, polyamide nanofilms, quaternization, ionic liquids, resource recovery

[69] Souha Harabi (Applied Thermodynamics Research Laboratory, National Engineering School of Gabes, Gabes 6029, Tunisia), Sami Guiza (Applied Thermodynamics Research Laboratory, National Engineering School of Gabes, Gabes 6029, Tunisia), Afef Attia (Research unit "Advanced Technologies for Environment and Smart cities", Faculty of Science of Sfax, Sfax 3000, Tunisia) and Raja Ben Amar (Research unit "Advanced Technologies for Environment and Smart cities", Faculty of Science of Sfax, Sfax 3000, Tunisia).
Title: *Microporous activated carbon derived from peach stones :optimized synthesis by Response Surface Methodology.*
Abstract
The aim of this research is to produce an activated carbon derived from peach
stones with high capacity of adsorption and large specific surface area. The Central
Composite Design (CCD) under Response Surface Methodology (RSM) was applied for the
optimization of the synthesis conditions. The influences of impregnation ratio, activation temperature, carbonization time and carbonization temperature, on the yield and specific surface area, were investigated. The findings highlight that the largest specific surface area was achieved for the following conditions: impregnation ratio equal to 3.5 for a duration of five hours and carbonization time of 4h30 min at 400°C. The variable of highest significance was the pyrolysis temperature. The suitable features of the biomass coupled with the precisely chosen parameters contribute to the development of an effective adsorbent with a high yield and important specific surface area.

Keywords: Activated Carbon, Optimization, Central Composite Design, Response Surface Methodology, Specific Surface Area

[70] Lakshmeesha Upadhyaya (King Abdullah University of Science and Technology (KAUST), Thuwal).
Title: *Hollow fibers for Organic solvent nanofiltration.*
Abstract
Poly(ether ketone ketone) (PEKK) and poly(ether ether ketone) (PEEK) are exceptional thermoplastics known for their high resistance to extreme conditions, making them ideal candidates for solvent-resistant nanofiltration. However, fabricating hollow fibers from these polymers requires strong acids for solubilization, which presents a significant challenge due to the potential corrosion of metallic components during spinning, making the process impractical for long-term use.
To address this issue, we propose the development and application of acid-resistant spinnerets made from Rigid Resin and High-Temperature Resin V1 through stereolithography. Hollow fibers were successfully spun using an in-house acid-resistant spinning line, with the dope solution with Poly(ether ketone ketone) (PEKK) or poly(ether ether ketone) (PEEK) in sulfuric or methane sulfonic acid. Water was utilized as the bore fluid. This technique effectively overcomes the limitations associated with spinning under acidic conditions. The waste produced is limited to a diluted aqueous acidic solution, eliminating the need for toxic organic solvents.
The resulting hollow fibers demonstrated a N,N-dimethylformamide (DMF) permeance ranging from 1.4 to 2.7 L m-2 h-2 bar-1, with over 90% rejection of 1,3,5-tri-tert-butyl benzene (TTBB) with a molecular weight of 246.4 g mol-1. The fibers were further tested at elevated temperatures up to 83.3°C, resulting in an increased DMF flux of 3.8 L m-2 h-2 bar-1. Additionally, the fibers were tested at 65 ± 2°C for 57 hours, exhibiting stable flux over time, with no structural changes observed in the membrane during autopsy. This work successfully addresses the challenge of spinning polymer solutions that require harsh conditions for solubilization, thereby simplifying and making the upscaling of polyketone fiber fabrication more competitive. The result is membranes with stable performance in solvent-based filtration applications.

Keywords: Hollow fibers, Organic Solvent Nanofiltration, Acid-resistant spinneret, Poly(ether ether ketone)

[71] Abi Taddesse Mengesha (Haramaya University), Kassim Ahmed (Hawssa Teachers Education), Isabel Diaz (CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS) and Nigussie Dechassa (Haramaya University).
Title: *Fe-Al NANOCOMPOSITE FILLED DIALYSIS MEMBRANE TUBES (DMT-HFAO): A MODIFIED METHOD FOR ASSESSMENT OF PHOSPHATE SORPTION-DESORPTION FROM AQUEOUS AND SOIL SOLUTIONS.*
Abstract
In this work, a binary sorbent system filled in a dialysis membrane tube was developed. Accordingly, calcined (CPS) and amorphous (APS) Fe-Al binary mixed oxides (phosphate sinks) were synthesized by gel-evaporation method and characterized by XRD, FTIR, TGA-DTG, SEM-EDX and BET techniques. The single system hydrated ferric oxide filled in dialysis membrane tubes (DMT-HFO) was used as a benchmark. For the aqueous system, the sorption capacity of the crystalline binary suspension (DMT-HFAO) was found to be 260% where as the amorphous congener was approximately 200% times that of DMT-HFO during the 24 h equilibration. For the soil solution system, the phosphate desorbed by the DMT-HFAO was about 520% compared with a single system, DMT-HFO, in 168 h. For the desorption experiment carried out under soil solution, the data fitted fairly well with first order kinetics for both sorbents (R2=0.946-0.998), the amount sorped by DMT-HFAO being greater than DMT-HFO. The soil data fitted intra-particle diffusion model fairly well for both sorbents (R2= 0.98-0.992) with rate constants, kp, following the order: DMT-HFAO>DMT-HAFAO>DMT-HFO. The DMT-HFAO approach also showed better fit to the two component first order model (R2=0.994 & 0.997) indicating that the modified method has promising potential for long-term phosphate desorption kinetics study from soil, the implication of which is important both from agricultural and environmental perspectives. However, correlation of the P sorbed by this sink method with actual plant P uptake in various soils should be carried out to validate the universality of this technique

Keywords: Phospate sorption, Dialysis membrane tubes, Desorption Kinetics, Analytical tool, Nanocomposites

[72] Gyorgy Szekely (KAUST).
Title: *Machine learning for molecular sieving in organic solvents.*
Abstract
Organic solvents are extensively used across numerous industrial sectors. Membranes offer an energy-efficient way for separations in organic solvents. However, many applications are untapped due to the lack of predictability of separation performance. Methods for determining solute rejection in organic solvent nanofiltration (OSN) are time-consuming and expensive and still rely on wet-lab measurements, resulting in the slow development of membrane

processes. Molecular level understanding is important for the future advancement of OSN. To effectively examine these molecular level interactions, digitalization of collected data, miniaturization of testing methods, and automation considerations for material deployment must be co-developed alongside new material design. Two prediction methods based on the quantitative structure–activity relationship (QSAR) using traditional machine learning (ML) and deep learning (DL) models will be presented. Visualization of the effect of different solute functional groups on rejection provides a new platform for a more in-depth investigation into the membrane–solute interactions, potentially enabling the design of membranes with improved selectivity. Our database and models are freely accessible on the OSN Database website (www.OSNdatabase.com).

Keywords: nanofiltration, machine learning, database, quantitative structure–activity relationship

[74] Manoj Rajpure (Myongji University), Rajendra Mujmule (Myongji University) and Hern Kim (Myongji University).
Title: *Fabrication of high-performing double-ligand ZIF-8/cellulose acetate mixed matrix membranes for selective H2/CH4 and CO2/CH4 gas separation.*
Abstract
ZIF-8 based mixed matrix membranes with obvious molecular sieving properties have great potential for gas separation. However, their application remains challenging due to their incompatibility with polymer matrix. In this study, we introduced the AZIF-8 nanoparticles synthesized via partial substitution of 2-Mim ligand by Atz to finely tune the aperture and increase gas separation properties of MMMs. The incorporation of Atz ligand significantly enhances particle dispersion and compatibility with polymer. Different ligand substitution times and loadings were applied to investigate the gas separation properties. The experimental results reveal that the Atz modified ZIF-8 (AZIF-8) blended CA MMMs with 1 wt.% loading showed the best separation activity. The A8ZIF-8/CA enable to achieve high H2 and CO2 permeability values of 183.5 and 135.0 Barrer, respectively, with selectivity of 49.1 and 36.1 for H2/CH4 and CO2/CH4, respectively, under the 0.4 MPa feed pressure. Remarkably, the gas separation performance of Atz modified ZIF-8 MMMs lies very close to the Robeson upper bound 2008, signifying the effectiveness of this modification strategy.

Keywords: Mixed matrix membrane, ZIF-8, Cellulose, nanoparticle, H2, CO2, CH4, Gas separation

[75] Lemma Teshome Tufa (Adama Science and Technology University).
Title: *Plasmon-Enhanced Photo/Electrocatalysis in Hetero-Nanostructures for Sustainable Energy Applications.*
Abstract
Enhancing the efficiency and selectivity of photo/electrocatalytic reactions through plasmon-enhanced catalysis using hetero-nanostructures has become increasingly promising. Plasmonic nanostructures (PNSs), known for their localized surface plasmon resonance (LSPR) properties, play a pivotal role in boosting catalytic activity. The unique characteristics of LSPR allow PNSs to focus incident light, promote charge separation, and drive surface reactions, thereby improving overall catalytic performance. This study presents the preparation of plasmonic core-shell Au@Pd nanoparticles (NPs) and Au@FexOy nanorods (NRs) for plasmon-enhanced photo- and electrocatalysis, focusing on the rational design and synthesis of hetero-nanostructures. The research highlights the optimization of composition, size, shape, and interface properties to maximize performance. Additionally, it explores various combinations of plasmonic materials with semiconductors of different morphologies to enhance photocatalytic activity. Applications include water splitting, organic pollutant degradation, and energy conversion. Addressing key challenges such as material optimization, reproducibility, stability, band alignment, and a deeper understanding of plasmon-material interactions in hetero-nanostructures is crucial for progress in the field. The synergistic integration of plasmonics and nanotechnology holds immense potential for advancing sustainable technologies and tackling global challenges.

Keywords: Photoelectrocatalysis, Plasmonics, Au@Pd NPs, Au@FexOy NRs, LSPR

[76] Indira Chimanlal (Toulouse Biotechnology Insititute), Corinne Cabassud (Toulouse Biotechnology Institute) and Olivier Lorain (Polymem).
Title: *Could a new ultra-thin coated membrane compete with a microporous membrane in VMD?*
Abstract
By definition vacuum membrane distillation (VMD) uses microporous hydrophobic membranes. It behaves as a support for the liquid/vapor interface during vaporisation controlled by a partial pressure gradient between two membrane sides. VMD is of high interest for many applications such as desalination or brine concentration/valorisation. High permeate fluxes can be achieved with polyvinylidene fluoride (PVDF) hollow fibre (HF) membranes. However, these membranes might suffer from wetting which limits their sustainability.

Conversely, dense membranes have a lower propensity for wetting but demonstrate a low permeate flux (limited mass transfer due to the dense layer) for desalination applications.
The objective of this work, done within the EXBRINER European project, was to investigate if a newly developed microporous HF membrane coated with an ultra-thin dense layer could be used in VMD. Consequently, characteristics and performances were compared with those of a porous PVDF HF membrane. The potential interests of thin-film coated membranes are i) reduced vulnerability for membrane wetting in comparison with a microporous membrane and ii) a reduced resistance to mass transfer and higher flux in comparison with a dense membrane due to low film thickness.
Herein, two HF membranes developed by Polymem are comparatively investigated: microporous PVDF membrane A and membrane B with polysulfone support (PS) and polydimethyl siloxane (PDS) surface coating. These membranes are for outside/in operation whereby the surface in contact with the liquid phase is on the exterior surface of the fibre. The two membranes were characterised in terms of physico-chemical properties and performances for the VMD process:
Morphological and structural properties: surface morphology (SEM), fibre and coating layer thickness, pore size distribution (PSD) obtained by ImageJ and Origin, average pore size, and surface roughness (AFM)
Mechanical resistance measured by tensile testing
VMD performances with pure water: Knudsen permeability with pure water (Km) by varying temperature and sensitivity to temperature polarisation (TP) studied by varying feed flowrates at constant temperature and vacuum pressure.
Wetting risk indicator: membrane surface hydrophobicity characterised by water contact angle (WCA) and liquid entry pressure (LEP).
Additionally, thermal aging of the fibres was studied by submerging them in hot water for 2 weeks at 70 °C. Km and fibre shrinkage were measured before and after thermal aging.
Notably, SEM micrographs showed an asymmetric porous structure with a porous exterior for A which contrasted a very thin (0.516 ± 0.03 µm) coated layer without detectable pores and smoother surface for B. This was corroborated by a higher surface roughness for A compared to B. Membrane A had a lower fibre thickness with an average pore size of 1.25 ± 0.02 µm, while B had a larger fibre thickness. A greater hydrophobicity was experienced with B (110 ° WCA) compared to A (90 ° WCA).
VMD experiments allowed to obtain a linear relationship between permeate flux and the driving force for membrane B, which indicated that it behaved like a VMD membrane. Thus, mass transfer resistance of the thin coated layer was probably negligible. It was also found that B was less sensitive to the limiting effects of TP. In addition, the Km for membrane B was found to be 2.3 times greater than that of A
Thermal aging induced a decrease of Km coefficient for both membranes, however, B had a lower reduction rate (6%) than A (48%). Fibre shrinkage was more significant for A (4%) compared to B (no shrinkage). This implies that B was not severely affected by temperature as opposed to A for the aging conditions used in this study.
These results support the interest of this newly developed ultra-thin film coated membrane that can be used in a VMD process. Benefits include an enhanced permeate flux and better thermal stability while avoiding wetting risks in comparison with a microporous PVDF membrane. Currently, further tests are being conducted and the results in combination with those above will be used to rationalise an appropriate choice for an integrated module for VMD.

Keywords: microporous membrane, thin film coated membrane, hydrophobic membrane, wetting, vacuum membrane distillation

[77] Zouhair Salah (University of sfax), Hajer Aloulou (University of sfax) and Raja Ben Amar (University of Sfax).
Title: *Development of graphene oxide membrane on flat mud ceramic support for methylene blue dyes removal.*
Abstract
Nowadays, various pollutants present in water exhibit detrimental effects on both ecosystems and human health causing serious environmental problems. In this study, flat mud supports, sintered at different sintering temperatures (900-1050 °C), were prepared via dry uniaxial pressing process. The SEM analysis evidenced that the supports were free of defects and present homogeneous surface structure with evenly distributed pores of similar sizes. Sintering at 950 °C results in a low shrinkage of 9%, 32% of porosity, 1.4 µm of pore size, 20 MPa of mechanical strength, and water permeability of 168.21 L.h-1.m-2.bar-1. This temperature was chosen as optimum sintering temperature for the mud support. The low-cost prepared support was coated with graphene oxide (GO) by dip coating method for the fabrication of ceramic membrane GO/Mud. The adhesion of GO powder on membrane surface was checked by SEM analysis demonstrating homogeneous and defect free coating layer over porous support. The GO/Mud membrane presents an average pore diameter of 0.63 µm and a water permeability of 69.49 L.h-1.m-2.bar-1. The efficiency of the prepared membrane was explored for methylene blue (MB) removal. A high removal of color (96%) and chemical oxygen demand (COD) (92%) was observed. After filtration operation, the initial membrane permeability was recovered by chemical regeneration using acidic-basic solution alternatively. The study of the decrease of

permeate flux with time shows that membrane fouling follows the standard pore blocking model which was in accordance with the results obtained from the mass balance between inlet and outlet of the membrane during filtration, presenting an error less to 1 %.

Keywords: Graphene oxide, Mud, Ceramic support, Membrane, Dyes removal

[78] Abdoulaye Doucoure (Donyatek).

Title: *Impact of Armed Conflicts on Highly Vulnerable Communities: what role for resiliency tactics, membrane technologies and networks in highly volatile environments?* .

Abstract

In 2023, the number of armed conflicts across the globe reached a record with nearly 60 cases. Sadly, the latest development indicates no sign of reversal [1]. This intensification of military activities has proven deeply destabilizing for civilian communities, especially in low-income countries, and has generated a vast carbon footprint – i.e., falling between that of India and Russia based on emitted tons of carbon dioxide (2). In terms of regional ranking, Africa has been more prone to non-state conflicts than all other continents over the past eight decades, and considering the current geopolitical climate, no change is expected in the foreseeable future.

Against the backdrop of rising instabilities, such as pandemics, environmental catastrophes, food crisis, extreme ethnic/religious tensions etc., it is increasingly relevant to address societal challenges by adopting resilient solutions – i.e., outcomes that exhibit robustness and sustainability over the long run (3). In contrast, when decisive weaponized "solutions" are sought, highly vulnerable communities suffer severe trauma and losses, consistent with recent civilian tragedies affecting Eastern Africa and the Middle East (1). Africa's struggle to solve conflicts through peaceful means is cause for concerns considering that nearly 450 million of citizens (35% of continental population) live under extreme poverty [4].

Our initiative envisions resilient tactics that the African Membrane Society and other knowledge-based groups can leverage to foster growth initiatives in highly volatile regions. More specifically, AMSIC can seek to enhance long term regional stability by performing tasks such as

•Bringing together regional stakeholders (e.g., countries) to tackle shared local challenges;

• Screening local pain points that membrane technologies can efficiently solve (job creation, environmental causes);

•Upgrading AMSIC organizational leadership to integrate conflict response capacities;

•Developing and sharing key resources/information with local government officials to foster cooperation and create resilient growth plans for the region – aimed at water, health, food, energy and infrastructure development policies.

Through this investigation, we consider the merits of leveraging a diversity of viewpoints and competencies – i.e. embracing a multidisciplinary strategy, not just membrane science and technology- to achieve resilient outcomes, specifically when instabilities are on the rise.

Keywords: Armed conflicts, Vulnerable groups, Extreme poverty, global instabilities, climate justice, Military footprints, Knowledge-based networks, Resiliency, Sustainable development

[79] Ranil Wickramasinghe (University of Arkansas).

Title: *Development of Membrane Based Operations for Emerging Separations Challenges* .

Abstract

Membrane based separations are attractive for a number of reasons such as easy scale up, lower operating cost and the potential for significant process intensification. For applications in bioseparations linear scale up is important given the regulatory approvals needed for a manufacturing process. Integrated membrane processes could enable the recovery and reuse of highly impaired wastewater streams such as hydraulic fracturing flowback and coproduced water. Catalytic membranes provide the possibility of combining reaction and separation into one unit operation which leads to significant process intensification. In this presentation the potential for membranes in each of these areas will be discussed.

Biopharmaceutical manufacturing processes make use of cell lines to produce therapeutics such as monoclonal antibodies, fusion proteins etc. Membrane based processes such as membrane adsorbers, ultrafiltration and virus filtration are routinely used in the purification of the products. Here the focus will be on virus clearance, which is a major challenge in the manufacture of biopharmaceuticals. Today, biopharmaceutical manufacturing processes are typically run in batch mode. Further there is growing interest in complex therapeutics, e.g., live attenuated virus vaccines, viral vectors for delivery of gene therapy, VLPs, plasmid DNA, cell-based therapies. These more complex therapeutics create additional challenges when attempting to validate virus clearance. Some of these challenges will be discussed. In addition, there is a great deal of interest in developing continuous biomanufacturing processes in order to minimize batch to batch variation.

Electrocoagulation as a feed pretreatment operation prior to membrane distillation will be described. Today highly impaired hydraulic fracturing flow back water is typically reinjected into a geologically isolated formation in the

Earth's crust. However, treating this highly impaired water for beneficial uses will promote a circular economy. The advantages of an integrated electrocoagulation, microfiltration and membrane distillation process for maximizing water recovery from hydraulic fracturing produced water will further highlight the potential for process intensification through integrated membrane based separation processes.
The overall agricultural industry contributes more than 25% to world greenhouse gas emissions.
Agricultural residues represent an abundant source of fuels and chemical intermediates. Here lignocellulosic biomass hydrolysis and dehydration has been conducted using a synthetic polymeric solid acid catalyst consisting of dual polymer chains grafted from the surface of a ceramic membrane. By using a catalytic membrane, reaction and separation can be combined into a single unit operation leading to an intensified process. Here the focus is on production of sugars and levulinic from lignocellulosic biomass.

Keywords: Bioseparations, biomass, catalytic membrane, virus purification, water treatment

[80] Yosef Hagos Abrha (Ministry of Industry).
Title: *"Removal of Synthesis Methylene Blue Dye using Bottom Ash and Sewage Sludge Mixed Adsorbent Collected from Reppie Waste-to-Energy Facilities and the Kality Wastewater Treatment Plant."* .
Abstract
This paper focuses on the Removal of synthesis Methylene Blue Dye using Bottom Ash and Sewage Sludge mixed adsorbent collected from Reppie Waste to Energy Facilities and the Kality Wastewater Treatment Plant. The collected adsorbent materials were air dried before using a Jaw crusher and sized to a wide range of particles then thermal activation was used in Electric Furnace at a temperature of 500 o C for 1 hour. The activated raw materials surface characteristics were characterized using Fourier-transform Infrared spectroscopy (FTIR), X-Ray Fluorescence (XRF), and Emmett and Teller (BET) surface area analyses. Several aspects impacted the adsorption process including the initial concentration of the dye, the adsorbent dose, and the bottom ash to sewage sludge ratio. The initial concentration of the dye was adjusted to 5 mg/L, 10 mg/L, and 15 mg/L levels to study its impact on the adsorption efficiency. The adsorbent dose, referring to the amount of activated material used, was varied at levels of 1 g/L, 2 g/L, and 3 g/L. The ratio of bottom ash to sewage sludge was manipulated at levels of 25%, 50%, and 75% to investigate its influence on the adsorption.
Results showed that the textural characterization was 43.344 m^2/g and 553.868 m^2/g (specific surface area) for bottom ash and sewage sludge respectively. Furthermore, analysis of variance (ANOVA) was used to analyze the color removal efficiency and determine the appropriate model regression equation; a coefficient of determination (R2) 0.9884 was achieved for dye removal. The optimized removal efficiencies were obtained using 2hr of the reaction process, 2.261g/L dose, 10mg/L, and 55.622 ratios, which resulted in 94.167% of color removal. Moreover, the adsorption kinetics was determined using a pseudo first order of -0.0014 and 0.38895 for (K1 and R2 values) and pseudo-second-order models 0.014946948 and 0.99413 for (K2 and R2 values). The Freundlich and Langmuir isothermal model for both bottom ash and sewage sludge values of R2 were 0.89664 and 0.97929 respectively. Moreover, the maximum color removal obtained from bottom ash and sewage sludge adsorbents prepared at higher doses and ratio absorbent has good potential to remove the dyes from wastewater.

Keywords: Bottom Ash, Sewage Sludge, mixed adsorbent, methylene Blue, RSM, BBD

[81] Soliyana Teshome (Merit Engineering plc) and Yosef Hagos Abrha (Ministry of Industry).
Title: *Response surface statistical modeling for optimization of methylene blue adsorption from aqueous solution using chitosan/graphite composites: Isotherm and kinetics studies.*
Abstract
The study aimed to create a chitosan/graphite composite (CGC) using the impregnation method to optimize its adsorptive efficiency for methylene blue dye from synthetic wastewater. The composite adsorbent material was synthesized using a chitosan to expand graphite ratio of 5% and acetic acid and glutaraldehyde. Expanded graphite was prepared by reacting it with H2SO4 and H2O2 for 90 minutes at room temperature. The specific surface area of graphite increased from 1193.75 m2/g to 1223.648 m2/g. The composite adsorbent material was synthesized using the impregnation method, with chitosan to expanded graphite ratio of 75:25. The CGC was characterized using FTIR, XRD, BET, SEM, and point of zero charge analysis. The adsorption of methylene blue
dye onto CGC was optimized by response surface statistical experimental design method to achieve a removal efficiency of 98.61% at 5.24 initial concentration, pH of 9.98, and 95.43-minute contact time. The Langmuir isotherm best fitted the adsorption process, with an R2 value of 0.9974 and adsorption capacity of 98 mg/g. The kinetics of adsorption were best fitted to pseudo-second order with K value 0.0378. The composite was found to be the best alternative adsorbent for removing methylene blue dye from textile wastewater.

Keywords: Optimization, chitosan, graphite, composite, methylene blue

Ivo Vankelecom (Membrane Technology Group, KU Leuven Belgium)
Title: Polymer-based membranes: from fundamental understanding to upscaling
Abstract
An overview will be given of the membrane development work performed at the Membrane Technology Group of KU Leuven. It will start from attempts to deeper understand membrane formation processes using microfluidics and confocal fluorescence microscopy. At the other side of the spectrum, pilot-scale upscaling will be discussed and all hurdles met on that way. Case-studies will involve PVDF-crosslinked and UV-cured PSf membranes for solvent-resistant and solvent-tolerant NF, as well as corrugated PSF and PVDF membranes for vibrating membrane bioreactors for water treatment and algae harvesting.
Epoxide-chemistry will be introduced as a new platform chemistry to prepare NF-membranes with exceptional pH and hypochlorite stability. For CO2-selective gas separations, record-performing novel mixed matrix membranes will be presented that largely surpass the Robeson-limits for removal form CH4 and N2, while keeping mechanical stability and thermal resistance.

S. Panglisch (Chair of Water Technology, University of Duisburg-Essen), M. Futterlieb, M. Patel and I. Elsherbiny (Chair of Water Technology, University of Duisburg-Essen)
Title: *NEW WAYS TO IMPROVE THE SCALING BEHAVIOUR OF DENSE MEMBRANES*
Abstract
Scaling in inland membrane desalination plants presents several significant challenges beyond limiting recovery rates. One primary issue is the reduction in membrane efficiency. As scaling occurs, it decreases the effective surface area of the membrane, leading to lower water permeability and decreased permeate flux. To maintain desired production rates, higher pressures become necessary, which in turn increases energy consumption and operational costs.
Another problem is the increased operational costs associated with scaling. More frequent cleaning cycles and maintenance are required to manage the buildup of scale, leading to higher labor and material expenses. Additionally, persistent scaling can damage membranes, shortening their lifespan and necessitating costly replacements.
Lastly, there are environmental concerns associated with scaling and the methods used to mitigate it. The discharge of antiscalant-laden concentrates into receiving water bodies raises environmental issues, as these chemicals can have detrimental effects on aquatic ecosystems. Moreover, the presence of antiscalants can promote bio-fouling on membranes and potentially lead to the formation of harmful disinfection byproduct precursors in the permeate since they cannot be completely removed by the membrane.
To address the challenge of scaling in membrane desalination plants, two innovative approaches are being explored: surface patterning of membranes and process optimization through Closed Circuit Reverse Osmosis (CCRO).
Recent publications have highlighted the potential advantages of surface-patterned thin-film composite (TFC) membranes in water desalination. The imprinted microstructures on the membrane surface can induce specific mixing effects in the immediate vicinity of the membrane, which have been shown to mitigate organic and bio-foulant deposition. Under certain conditions, these microstructures can also reduce the boundary layer thickness, thereby increasing the membrane's active surface area and enhancing pure water permeability compared to flat counterparts. However, current studies have not extensively examined the performance of surface-patterned TFC membranes in conjunction with feed spacers, a typical component in spiral-wound modules (SWM).
Feed spacers play a crucial role in determining fluid dynamics and pressure drop in the feed-retentate channel but are prone to particulate fouling and bio-fouling due to localized regions with poor fluid mixing. Enhancing fluid characteristics through the combination of membrane surface patterning and feed spacer design could potentially address these issues. A systematic study has been conducted to examine the synergistic effects of surface-patterned TFC membranes and typical diamond-shaped feed spacers. Initial results from lab-scale experiments using a mini-plant RO testing unit indicate that surface-patterned TFC membranes show better antifouling and antiscaling performance without feed spacers. However, when combined with feed spacers, the performance was relatively worse, suggesting that the hydrodynamic effects generated by the feed spacers might
disrupt the beneficial mixing effects induced by the membrane surface patterns. Further detailed studies, including simulations and real-time measurements using Tomographic Particle Image Velocimetry (Tomo-PIV), are ongoing to better understand these interactions and optimize the design for industrial applications.
The second approach involves the optimization of the desalination process through CCRO. This method operates RO and nanofiltration (NF) systems in a semi-batch, discontinuous manner, offering potential advantages such as higher resistance to scaling and fouling. Unlike conventional Plug Flow RO (PFRO), CCRO has shown promising results in reducing the propensity for calcium carbonate (CaCO3) scaling. Comparative studies conducted on pilot and bench scales using natural water matrices revealed that CCRO either completely prevented scaling or significantly delayed its onset compared to PFRO. The CCRO system allows for the optimization of alternating modes of closed-circuit filtration and flushing, adjusting parameters such as the duration of each mode, flux, and recovery rate to minimize

scaling risks. The research also found that higher dissolved organic carbon (DOC) levels in the feed water reduced the tendency for scaling, possibly due to the complexing of humic substances at higher DOC concentrations. Additionally, monitoring the concentrate pH was identified as an effective early detection tool for CaCO3 scaling, enabling timely countermeasures to prevent irreversible scaling layers or optimize chemical cleaning processes.
Both surface patterning of membranes and CCRO process optimization represent promising strategies to mitigate scaling in membrane desalination plants, potentially enhancing efficiency, reducing operational costs, and improving overall water quality.

Keywords: Scaling, Membrane desalination, Surface patterning, Closed Circuit Reverse Osmosis (CCRO), Early scaling detection

Gideon Oron (Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev), Lieonid Gillerman (Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev), Yossi Manor (Central Virological Lab., Sheba Medical Centre) and Amos Bick (Bick Associates, Harey Jerusalem 7)
Title: *Ultra-Filtration Membrane Flushing in Hybrid Systems of Wastewater Reclamation for Unrestricted Reuse*
Abstract
Water shortage forced the national authorities to reuse treated urban wastewater. However, treated wastewater contains elevated concentrations of dissolved solids (high salinity). The high saline water is associated with reductions in agricultural yields and soil salination.
A two-stage pilot membrane system consisting of an UltraFiltration (UF) stage and a subsequent Reverse Osmosis (RO) stage is in operation for upgrading secondary effluent for unrestricted irrigation. The UF stage actually serves as a pre-treatment for the RO stage. The UF stage is accounts for the solids and virus removal and the RO for r the elimination of the dissolved solids. The main confronted problem in such a system configuration is that of permeate flow decline, due to membrane fouling at the UF treatment stage. In order to let the UF system operated well it was flushed once a while to prevent fouling. Fouling is one of the major drawbacks of membrane systems operation, primarily during upgrading of secondary effluent for unrestricted reuse.
Field experiments were conducted in order to minimize the permeate flow decline at the UF membrane stage. It requires characterizing the required frequency of flushing and the related expenses per flush. These total costs are based on energy and clean water consumptions per flush. It is concluded, according to the field results and related economic assessments that frequent flushing, for every 20 to 30 minutes, is the preferable alternative to maintain minimal permeate flow decline.

Keywords: Ultrafiltration; Fouling; Wastewater; Spiral wound membranes; Flushing strategy; Economic assessment.

Saad Alami Younssi (University of Hassan II- Casablanca), Mohamed Ouammou (University of Hassan II-Casablanca) ,Brahim Achiou (University of Hassan II- Casablanca), Dounia Beqqoura (University of Hassan II-Casablanca)
Title: *VALORIZATION OF NATURAL MATERIALS IN DEVELOPMENT OF NEW CERAMIC COMPOSITE MEMBRANES*
Abstract
In recent years, various methods have been developed for the treatment of pollutants in wastewater, including chemical precipitation, membrane filtration, adsorption, and dialysis/electrodialysis. Among these methods, ceramic microfiltration and ultrafiltration membranes made from natural materials such as phosphate and clays are particularly promising due to their abundance in Morocco [1-4].
Filtration tests of salt solutions, performed with different ultrafiltration ceramic membranes, show that salt rejection depends on the charge of the ions, pH, salt nature, and concentration. The rejection mechanism depends on the relative ratios of coulombic, dielectric, and hydration interactions between the material and the ionic species [1].
This presentation will focus on the development and characterization of microfiltration and ultrafiltration ceramic composite membranes and their application in removing salts and textile dyes from water.

L. Giorno, F. Bazzarelli, R. Mazzei, E. Piacentini, T. Poerio, S. Regina, G. Vitola (National Research Council of Italy, Institute on Membrane Technology, CNR-ITM)
Title: TRENDS IN MEMBRANES AND PROCESSES FOR BIOTECHNOLOGY AND BIOREFINERY
Abstract
Artificial membranes and membrane-based processes are recognized as significant contributions to sustainable and environmentally friendly growth. Biotechnology and biorefinery, which transform biomass into chemicals and fuels by biocatalysis, can benefit tremendously from membrane technology. Separation is among the steps that most influence the production costs in these sectors. Stabilizing biocatalysts (such as enzymes) through heterogenization is also important to extend the production systems' lifetime. The lecture will analyze the properties of membranes required to host enzymes and allow

reaction at the membrane level and product separation simultaneously, such as in biocatalytic membrane reactors. Here, different ways to attach the enzyme to membranes will be highlighted. Cases in which the production of valuable components is obtained in a bioreactor (such as a fermentor) and the membrane serves as a separation step combined with the bioreactor will also be discussed. The brakes and drivers of each configuration will be outlined.
The lecture will also illustrate the potentiality of integrated membrane processes to refine biomasses, such as agri-food residues, processing waters, and microalgae, underlying the capability of membrane processes to separate, fractionate, and purify bioderived components while preserving their native bioactivity as well as stabilizing labile molecules in emulsified formulations. The critical issue of removing micropollutants of emerging concern from complex matrices will be pointed out. The need and challenges for membranes resistant to fouling based on sustainable materials and fabrication processes will be discussed.

Keywords: Polymeric membranes, enzyme-loaded membranes, integrated membrane processes, membrane biotechnology, membrane biorefinery