North American Membrane Society 29th Annual Meeting

Emerging Membranes, Materials, Processes and Applications

NAMS 2020

OVERVIEW OF TECHNICAL SESSIONS

CONFERENCE CO-CHAIRS

MaryLaura Lind, *Arizona State University*

Manish Kumar, *The University of Texas at Austin*

www. membranes.org

NAMS 2020
Overview of Technical Session

APPLICATIONS: BIOLOGICAL AND FOOD

Cell and Protein Purification, Harvesting, and Processing

Chairs: David Latulippe, latulid@mcmaster.ca ; Prity Bengani-Lutz, plutz@repligen.com

This session will focus on the latest advances of membrane technologies in bioprocessing and purification of peptides and proteins, including monoclonal antibodies and tagged proteins. Contributions related to topics such as membrane-based cell culture production, clarification, cell harvesting, membrane chromatography, adsorption and perfusion are welcomed. We hope that the contributions to the session will allow participants to apply and explore the use of existing and new membrane technologies in cellular bioprocessing and potential scalability.

Purification of Non-Protein Biologics

Chairs: Onur Kas, Onur.Kas@ucb.com; James McGrath, jmcgrath@bme.rochester.edu

This session will highlight and compare state-of-art strategies for non-protein biologics purification and explore the impact of their characteristics, such as affinity, size , functionality, and binding mechanism, on the performance of purification strategies. Non-protein biologics such as nucleic acid, carbohydrate, vaccine, and cell-based therapies, viral vectors and oncolytic viruses are moving through clinical studies and emerging as approved products. Similarly, there is a growing interest in non-protein biologics such as extracellular vesicles and cell-free DNA as diagnostic targets and novel therapies. We anticipate that the contributions to this session will allow the participants to discuss recent advances and approvals in therapeutic biologics and explore therapeutics strategies on manufacturing and commercialization.

APPLICATIONS : ENERGY

Carbon Capture

Chairs: Winston Ho, ho.192@osu.edu; Dave Hopkinson, David.Hopkinson@netl.doe.gov

Membrane-based carbon dioxide capture technologies face several key challenges to progress from lab scale to pilot demonstration scale. Materials must have high performance, low-cost, and simple fabrication into a thin film composite as well as robust stability in the presence of moisture and other contaminants. This session focus on, but not limited to, performance of membrane materials for both post- and pre-combustion carbon capture; flue or synthesis gas simulation and experiments; module and system designs; long-term testing; scale-up strategies and demonstrations of membranes for carbon capture; and techno-economic assessment along with CO_2 capture cost optimization.

NAMS 2020
Overview of Technical Session

APPLICATIONS: WATER TREATMENT

Brine Minimization and Zero Liquid Discharge

Chair: Kerri Hickenbottom, klh15@email.arizona.edu; Jonathan A. Brant, jbrant1@uwyo.edu

This session will highlight the applications of membrane technologies for low, medium and high salinity brines treatment to achieve zero liquid discharge. We would like to include lab-, pilot-, and full-scale studies and demonstrations with a variety of brines (i.e., reverse osmosis concentrates, brackish water, seawater, produced water, industrial effluents,) to explore innovative solutions and strategies that are unique to membrane technologies. We are soliciting contributions that address and discuss the performance and scalability of these systems as well as techno-economic analysis and comparison with other technologies.

Contaminant Removal from Surface Water, Groundwater and Wastewater

Chairs: Andre da Costa, Andre.DaCosta@hbfuller.com; Prakhar Prakash, Prakhar.Prakash@chevron.com

This session will focus on membrane separation for water purification and contaminant removal. Water sources include wastewater, surface waters (such as lakes, rivers and reservoirs), groundwater, and produced water. Contaminants may include particles, inorganic impurities, biological impurities (viruses/ bacteria), organic impurities such as natural organic matter (NOM), emerging organics such as per- and polyfluoroalkyl substances (PFAS) or oil resulting from accidental spills or production operations. Contamination may occur due to industrial pollution, solid waste landfills or pipeline corrosion. We welcome papers addressing membrane performance (permeation properties, fouling and integrity), module design, pilot studies for any of the water sources referred above.

Emerging Materials for Liquid Separations

Chairs: Hee Jeung Oh, heejeungoh@gmail.com; Baoxia Mi, mib@berkeley.edu;
Lucy Camacho, Lucy.Camacho@tamuk.edu; Piran Kidambi, piran.kidambi@vanderbilt.edu

We invite contributions to this session that explore the development of polymeric, and mixed-matrix, ultra-thin, and nano-scale (including G and GO) membrane materials for highly selective liquid separations. Innovative polymeric, inorganic, and hybrid composite membrane materials could enable separations that have been unachievable, energetically intensive, and cost prohibitive. Applications could include, but are not limited to, desalination, nanofiltration, resource recovery, efficient organic separations, targeted contaminant removal from industrial or municipal wastewater, and biomedical separation. The emphasis will be on materials synthesis and characterization, but contributions describing practical demonstration of highly specific separations are encouraged.

APPLICATIONS: WATER TREATMENT (CONTINUED)

Osmotically Driven Processes

Chair: Tony Straub, tonystraub90@gmail.com; Andrea Achilli, achilli@email.arizona.edu; Milad Esfahani, mesfahani@eng.ua.edu

This session will highlight recent innovations in membrane separation and processes that utilize an osmotic driving force. Osmotically driven systems can be used where conventional pressure-driven or thermal systems are have limitations or undesirable side effects. Presentations included in this session will offer new concepts through the implementation of novel materials and procedures, improved system designs, and theoretical models. These developments can further expand the potential of osmotically driven membrane processes for applications such as desalination, wastewater treatment, high salinity brine treatment, food processing, chemical separations, and power generation.

Seawater Desalination

Chairs: William Phillip, wphillip@nd.edu; Eric Karp, Eric.Karp@nrel.gov

This session will focus on the application of membranes in seawater desalination. The areas of interest include membrane fouling, fouling mitigation strategies, separation efficiency, precision separations for ion recovery, integrating brine management with remineralization, and process integrity monitoring. The session includes, but is not limited to, reverse osmosis desalination, novel membrane applications in seawater desalination, hybrid thermal or solar membrane distillation, forward osmosis, and pressure-retarded osmosis processes for energy generation from seawater. We anticipate that the contributions to this session will allow the participants to explore recent advances and approaches in seawater desalination and discuss innovative strategies on fabrication and commercialization.

Water Reuse

Chairs: Vicky Karanikola, vkaranik@email.arizona.edu; Jack Gilron, jgilron@bgu.ac.il

We invite contributions to this session that apply membrane technologies to the re-use of water in many different contexts. What unites all these contexts is that they involve recovery of water which has interacted with human-impacted environments. We plan to organize the sub-sessions around different water sources, including: (1) industrial wastewater (e.g. pharmaceutical, power, food, mining, animal husbandry); (2) municipal wastewater; and (3) runoff (e.g. stormwater, agricultural runoff).

MATERIALS

Bioinspired and Biomimetic Membranes

Chair: Yuexiao Shen, yuexiao.shen@ttu.edu; Patrick Saboe, psaboe@gmail.com

This session will highlight new functional materials and scientific advancements that have potential to contribute to the field of bioinspired and biomimetic membranes. We solicit papers relating to the topics, but not limited to, (1) Design, synthesis, performance, and characterization of bioinspired/biomimetic membranes; (2) Investigation of scalable strategies of bioinspired/biomimetic membranes; (3) Demonstration of innovative sensing or separation processes using bioinspired/biomimetic membranes.

Ion Exchange and Electrofunctional Materials and Processes

Chair: Geoffrey M. Geise, gmg9j@virginia.edu; Orlando Coronell, coronell@ad.unc.edu

This session welcomes contributions that describe recent advances in both fundamental and applied understanding of membrane materials that function as ion exchange and/or electrofunctional materials. These functional membranes are becoming increasingly significant for desalination applications (membrane capacitive deionization or electrodialysis), energy technologies (batteries or reverse electrodialysis), and resource recovery. Furthermore, they traditionally have been used in other applications including water reuse, food processing, and the chloroalkali process. Contributions to this session should focus primarily on (1) Novel membrane materials and properties; (2) Investigation of membrane performance, characterization, and modeling as opposed to the electro-membrane processes where these membranes are applied.

Inorganic Materials

Chairs: Jay Kniep, jay.kniep@mtrinc.com

This session will highlight inorganic materials and membranes in the view of novel synthesis, characterization, chemical and mechanical property studies, process design and molecular separations. These will include, but not limited to, microporous and dense membranes for separation of gas and liquid mixtures. We welcome submission of papers on development of advanced composite membranes and inorganic membranes as well as related membrane applications.

MATERIALS (CONTINUED)

Catalytic and Responsive Membranes

Chairs: Miao Yu, yum5@rpi.edu; Ayse Asatekin, ayse.asatekin@tufts.edu

This session will focus on innovative membrane materials that incorporate additional functions, such as catalytic activity or responsiveness to external stimulation. Catalytic membrane materials can enable combining selective permeation with chemical conversion, for example, for degrading foulants. Responsive membrane materials can enable not only the tuning and control of membrane selectivity and permeability, but also fouling prevention and removal. Research presentations addressing these topics, or other related systems that leverage these properties for membrane applications, are invited to this session.

Membrane Characterization

Chairs: Weiyi Li, liwy3@sustech.edu.cn; Santiago Romero-Vargas Castrillon, Santiago@ed.ac.uk

This session will highlight novel characterization methods and their applications to the better understanding of membrane materials and processes. This session will focus on methods that resolve the fine chemical and structural features of materials as well as tools with improved spatial or temporal resolution. Novel techniques for detailed investigation of membrane processes will also be emphasized. We plan to organize the sub-sessions around different aspects of characterization, including: (1) Membrane material and structural characterization; (2) Novel methods or tools for characterizing the kinetics of material synthesis; and (3) Process characterization (e.g. fluid dynamics, membrane fouling, integrity monitoring, etc.). We hope that the contributions to these sessions will allow the participants to gain deeper insights of different membranes and membrane processes, which aids their further development and optimization.

Membrane Synthesis and Casting

Chairs: Rachel Dorin, rachel.dorin@teraporetech.com; Christine E. Duval, ced84@case.edu

This session will be a forum for exploring novel materials and methods used in the field of membrane science and technology. Unique organic and inorganic material sets, new structures, and innovative formation pathways offer opportunities for realizing the next-generation of separation technology. Contributions to Innovations in Membrane Synthesis and Casting should contain elements that demonstrate ways to push and expand the boundaries of existing membrane platforms.

MATERIALS (CONTINUED)

Organic Solvent Separations

Chair: Ryan Lively, ryan.lively@chbe.gatech.edu; Steve White, steve.white@mtrinc.com; Michele Galizia, mgalizia@ou.edu

This session will focus broadly on liquid phase separations in organic media (organic solvent filtration, OSN/OSRO/ OSFO, etc.). We are interested in topical areas ranging from novel materials for organic solvent separations, pilot or pre-pilot experiments, organic solvent transport in membrane materials, process systems assessment, and new characterization techniques that are designed for probing membranes in organic media.

Polymeric and Mixed-Materials Materials – Gas Separations

Chairs: Benjamin J. Sundell, benjamin.sundell@aramcoservices.com; Xiaoli Ma, ma26@uwm.edu; Zachary P. Smith, zpsmith@mit.edu

We welcome contributions to this session that explore the advancements of polymeric and mixed-matrix membrane or materials for efficiently selective gas separations. Membrane-based gas separations are of interest for a variety of applications such as nitrogen generation, carbon dioxide removal from natural gas or flue gas, and olefin/paraffin separations. One approach to address these critical separation challenges is using selective polymeric or mixed-matrix membranes. The rational design of the chemical and morphological structure of polymers is one way to surpass current performance and stability limitations. In addition, incorporation of highly selective fillers, such as MOFs, ZIFs, COFs, zeolites, and carbons, can similarly enable improved performance. This session will highlight advances in the synthesis and design of polymers and inorganic materials to form pure polymeric and mixed-matrix membranes for gas separation applications as well as investigation of strategies on fabrication and commercialization.

NAMS 2020
Overview of Technical Session

PROCESSES

Hybrid Processes and Process Integration

Chair: Jia Wei Chew, JCHEW@NTU.EDU.SG; Ed Sanders, ed.sanders@airliquide.com

This session will highlight papers that focus on combining two or more membrane processes or combining a membrane process with one or more non-membrane processes. Papers that explore and discuss novel hybrid processes are particularly encouraged. Specific topics to be welcome would include forward osmosis combined with distillation or extraction to regenerate the draw solution or pressure-retarded osmosis that uses membrane technology in combination with a device to convert the osmotic potential into mechanical or electrical energy.

Molecular and Process Modeling

Chairs: Shihong Lin, shihong.lin@vanderbilt.edu; David Warsinger, david.warsinger@gmail.com

Investigation of new and functional membrane materials have emerged in recent research development. Nevertheless, the practical implementation of innovative membrane technologies requires understanding properties and phenomena that span many time and length scales, as well as considering economic analysis and assessments. Computational modeling is a powerful tool combining with a real investigation and understanding of process-application economics, which can help predict useful direction for membrane researchers to pursue. This particular session will highlight the following topics: (1) Atomistic or molecular modeling of materials and fluids in the context of membranes; (2) macroscale or multiscale membrane modeling techniques (finite element modeling, numerical methods, and coarse graining methodologies; and (3) techno-economic analysis and assessments of advanced membrane-based separations, including applications for water purification, alkanes/alkenes, carbon capture, fuel cells, and more.

Membrane Distillation and Pervaporation

Chairs: Leland M. Vane, Vane.Leland@epa.gov; Alexander V. Dudchenko, avdudchenko@gmail.com

Despite showing significant technical promise, evaporation-based membrane processes are still considered emerging technologies with muted commercial success. Membrane distillation is commonly mentioned as an alternative to recover water from challenging solutions. Pervaporation, and sister technology vapor permeation, have finally made commercial inroads in bioethanol dehydration. While membrane improvements will always make a process more efficient, innovations in process design and membrane/module/system scalability may do more to advance these technologies at this stage in their evolution. Submissions covering advances in module design, process design/integration, technoeconomic analyses, real world scale-up, membrane materials, and scaling/fouling mitigation are most welcome.

PROCESSES (CONTINUED)

Membrane Fouling

Chair: Steven T. Weinman, stweinman@eng.ua.edu; Saif Rahaman, saifur.rahaman@concordia.ca
Daniel J. Miller, danieljmiller@lbl.gov

Fouling is inevitable for membrane-based processes and is one of the major challenges for further adoption of membranes in industry. This session will highlight the fundamentals and advancements of predicting and preventing membrane fouling. The topics of interests for this session include: (1) The origin, phenomena and mechanisms of membrane fouling and scaling; (2) Advanced technology to monitor fouling and evaluate foulant composition; (3) Innovative strategies and membrane module design to control and prevent membrane fouling; (4) New functional membranes materials, membrane structures and procedures to minimize fouling and scaling performance of membrane; and (5) Life cycle cost assessment of membrane fouling in real industrial applications. In addition, we anticipate that the contributions to this session will allow the participants to discuss recent innovations and advances in predicting and preventing membrane fouling and explore the energy efficiencies of possible strategies for controlling membrane fouling.

Microfiltration and Ultrafiltration

Chairs: Volodymyr Tarabara, tarabara@egr.msu.edu; William Tarpeh, wtarpeh@stanford.edu

This session will highlight recent developments and challenges in microfiltration (MF) and ultrafiltration (UF) with a strong focus on device, system, module, processing innovations and commercialization that could be leveraged across multiple application areas. Papers contributed to the following topics are welcome: (1) Advances in MF and UF device design to address challenging separations and delicate products; (2) Novel systems to enable continuous, sterile, or single-use MF, UF, and DF operations; (3) Innovative methods for integrity testing and modeling; (4) Design of MF and UF processes to control membrane fouling; and (5) Scalable and predictive systems and tools for high-throughput screening and process development of UF and MF applications. Case studies demonstrating improvements in capacity, productivity, cost of goods, or speed to manufacturing resulting from the use of these new MF and UF processing strategies are also encouraged.

PROCESSES (CONTINUED)

Module Modeling and Design

Chair: David Ladner, ladner@clemson.edu; Nils Tilton, (ntilton@mines.edu)

This session will address recent developments and advancements in understanding the hydrodynamics and mass transport in membrane modules and systems. Both analytical and computational modeling – coupled with experimental verification – has yielded insight into fluid and solute flow. This insight has enabled the creation of new module designs and process configurations that allow greater water/solvent recoveries and lower energy costs. Examples include computational fluid dynamics (CFD) modeling of spacers and membrane morphologies (patterns) for reduced membrane fouling in reverse osmosis, two-phase (gas and liquid) flow for scouring in membrane bioreactors, and minimizing pressure drop through design of modules tailored to gas separations.

Process intensification, Scale up and Technoeconomic Analysis

Chairs: Mahdi Malmali, mahdi.malmali@ttu.edu; Albert S. Kim, AlbertSK@hawaii.edu; Hannah Murnen, hmurnen@compactmembrane.com

Scientific breakthroughs of fundamental mechanisms and novel materials are utilized through realistic, cost-effective processes for long-term, and stable operations. This session focuses on, but not limited to, optimization of pre-existing processes with low-energy consumption rates and low capex merits, new hybrid membrane separations to combine multiple processes, and proof-of-concept approaches to developing novel industrial processes. We seek modeling and combined experimental/modeling studies that can range from micro- to macro-scale analyses including quantum mechanics, molecular dynamics, particle hydrodynamics. computational fluid dynamics (CFD), and industrial cost assessments. This session will be organized around the following topics: (1) Holistic modeling and data-driven approaches from material design to economic analysis, (2) Fundamental scientific issues such as new statistical mechanics for membrane phenomena and non-equilibrium thermodynamics coupled with CFD, (3) Seamless coupling of osmotically and thermally driven processes, and (4) Industrial-scale cost-analyses as originated from technological aspects of specific membrane processes. All other new experimental, theoretical and computational approaches for academic advances are also highly welcome.

PROCESSES (CONTINUED)

Industrial Applications of Membranes

Chairs: Dibakar Bhattacharya, db@uky.edu; CJ Kurth, cj.kurth@solectamembranes.com; Evan Hatakeyama, EHatakeyama@chevron.com

This will be an invited-only session from leaders and innovators in industry. Results from new industrial processes and pilots can provide key insight on the advancement of a technology area. This session will focus on the learnings from industrial field pilots, and new or modified full scale processes. This section will have papers describing new industrial processes and fields pilots, their results, and key learnings. Presentations will be selected to cover all applications and membrane technology areas.

Membranes for Electrochemical Applications

Chairs: Shudipto Dishari, sdishari2@unl.edu; Christopher G. Arges, carges@lsu.edu

The immediate need to combat climate disruption with renewable energy sources has led to scientific breakthroughs and innovations in membrane technology used in electrochemical energy storage and conversion. Renewable energy sources, such as wind and solar, are intermittent and their proliferation hinges on the maturation of energy storage and conversion processes. Not only has progress in electrochemical membranes impacted the field of energy storage and conversion, but it has also made an indelible impact on electrolyzers, which are used in the production of commodity chemicals, and electrochemical separations, such as water remediation. This session will highlight the latest trends in molecular science and engineering of membranes for electrochemical applications. Topics include: i.) the latest developments in molecular thermodynamics and transport phenomena of these membranes under a diverse range of environments, ii.) new insights as to how nanoscale architectures and confinement govern membrane properties at interfaces and in the bulk, and iii.) how newly engineered membrane materials impact electrochemical device performance.