DESALTECH 2015

POSTER ABSTRACTS

Posters will be on display in the Mezzanine Level Lobby/West Terrace

All Day on Friday, August 28, and Until 1:00 pm on Saturday, August 29

Presentations on Friday, August 28, 2015, 5:00 PM – 7:30 PM

Mezzanine Level Lobby/West Terrace

San Diego Convention Center

Abstract # 1 - Modelling Cross Flow Microfiltration of Oil from Effluent Using Multi-channel Ceramic Membrane

Yousef Alanezi, Ph.D., College of Technical Studies (Kuwait)

Crossflow microfiltration of oil from synthetic produced water was studied experimentally under various operating conditions using a tubular multi-channel ceramic membrane. Crossflow velocities, transmembrane pressures, oil concentrations, ionic strength, ion valency, pH variation effects on critical flux and equilibrium permeate flux were investigated. An increase in crossflow velocity for oil emulsions from 1.14 to 2.28 m/s caused an increase in the critical flux. In contrast, as feed oil concentrations increased from 300 to 2400 ppm, critical fluxes were decreased. For the modelling of experimental results in this research work, the unique applications of the back transport models (such as torque balance, inertial lift, and shear-induced models) and deposition rate models such as SEM model in the area of liquid-liquid separations could be claimed a contribution to new knowledge. For the experimental critical flux results, shear-induced model showed a better prediction in comparison with the other back transport models. Particle size was used as a parameter to fit the shear-induced diffusion model to the experimental results. From the particle size distribution analysis, the number frequency of these fine droplets was less than 5 % in the poly disperse emulsions. Hence, the smaller particles are causing fouling, which is in agreement with the findings of previous studies.

Abstract # 2 - Determination of Energy Consumption in an Electrodialysis Reversal Pilot Plant

Fattaneh Naderi Behdani, Doctoral Student, New Mexico State University (USA)

Electrodialysis reversal (EDR) is an electrically driven membrane process which is primarily used to desalinate brackish water. EDR has two important advantages–high water recovery and resistance to

scaling/fouling–but the technology's relatively high operating costs limit its use and motivate efforts to increase its efficiency. Therefore, to pursue the optimization of EDR systems, this work targets the energy consumption, bringing together the expertise of GE Water & Process Technologies and the talent of New Mexico State University's IEE Institute. The current study utilizes an existing 1-stage, 7-11 gpm EDR pilot unit owned by NMSU and located at the Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, NM, and evaluates energy consumption of EDR pilot unit under a range of factors such as applied voltage, feed flowrate, and feed water salinity. The experiments were conducted at three levels of flowrate (7, 9 and 11 gpm), three levels of water salinity (1700, 3500 and 6000 (μS/cm)), and at five different voltages (30, 32.5, 35, 37.5 and 40 V). By fitting the energy consumption values against these factors, it is possible to establish a relationship between them. This information can be used to establish operating conditions that reduce energy consumption and optimize cost.

Abstract # 3 - Cross-flow Microsand Filtration as Membrane Pre-Treatment

Francis Bordeleau, M.Eng., Sonitec (Canada)

Fouling of reverse osmosis membranes can seriously affect the filtration system and a proper pre-treatment can help to not only extend the life of reverse osmosis membranes but also ensure the filtration system is operating at the designed efficiency. Common forms of pretreatment include UltraFiltration and large traditional media filters which can be either costly or require large amounts of space and water. With the recent introduction of the H2F Vortisand, cross-flow microsand filtration has been re-designed in a way that now allows for this technology to be used for larger flows as required by desalination. With up to 80% reduction in footprint, and an 80% reduction in water required for backwash (when compared to media filters), this new technology is a sustainable way to achieve membrane pre-treatment. Additionally, when compared to UltraFiltration, Cross-flow Microsand Filtration is much more cost effective. This presentation will examine 2 case studies where a brewery and a food and pharma plant both needed to reduce the incoming SDI into their RO membrane systems. By using Cross-Flow Microsand Filtration, they were able to significantly reduce SDI at the inlet of their membrane systems.

Abstract # 4 - Polymer Enhanced Forward Osmosis: Exploration of the Potential of Branched Polyethyleneimine as Draw Solute

Manki Cho, Doctoral Student, Korea Advanced Institute of Science and Technology (Korea)

Forward osmosis (FO) is a promising membrane-based separation technology which has a potential to offer more energy-efficient processes than pressure-driven membrane processes (e.g., reverse osmosis) for various environmental and industrial applications including (i) water reclamation, (ii) desalination, and (iii) resource recovery (e.g. nutrient extraction/concentration from wastewater). However, a major and unresolved challenge in FO remains the availability of efficient draw solutions that can be separated and reconstituted using a low-energy separation process. This study investigates the potential use of a branched polyethyleninime (PEI) macromolecule (Mn: 10000 Da and Mw: 25000 Da) as an osmotic agent to formulate new FO draw solutions that could be separated and reconstituted utilizing low-pressure membrane filtration. To assess the potential of aqueous solutions of branched PEI as FO draw solutions, we combine (i) osmotic pressure measurements using a custom-built membrane osmometer with (ii) water flux and reverse solute permeation measurements using two commercial membranes (HTI-CTA and

HTI-TFC) in both the FO and PRO modes and (iii) ultrafiltration (UF) and nanofiltration (NF) separation/concentration experiments using a polyethersulfone UF membrane (MWCO: 5k Da) and a DOW-Filmtech NF 270 membrane. The overall results of this study suggest that branched PEI macromolecules are promising building blocks for the preparation and formulation of FO draw solutions with high osmotic pressures and very low reverse solute permeation. However new FO membranes and draw solution reconstitution processes will be required to advance the applications of polymer-based osmotic agents such as PEI.

Abstract # 5 - Evaluation of Membrane Distillation Performance Using Various Nanoparticle Porous Membrane

June-Seok Choi, Ph.D., Korea Institute of Civil Engineering and Building Technology (Korea)

Membrane distillation (MD) has been considered as a new desalination technology. However, membrane and modules for MD have developed only recently and are not being commercialized in the market. Therefore, many manufacturers have developed MD membranes and modules to improve flux and performance. The MD membrane requires more hydrophobic materials, and must be optimized for porousness and thickness to obtain better results. Nanofibers have hydrophobic characteristics, and have been adapted for industrial applications. In this study, we have tested nanofiber porous microfiltration membranes of four different pore sizes and thicknesses to measure flux and efficiency for the MD process under various conditions.

Abstract # 6 - Hybrid Electrochemical Seawater Desalination at Ambient Conditions with Energy Recovery

Divyaraj Desai, Ph.D., Palo Alto Research Center (USA)

Freshwater scarcity is one of the most severe problems of this century and desalination efforts have been increasing steadily to address this issue. Reverse osmosis (RO) is the leading technology to address this issue but is challenged by high capital cost, high pressure operation, low yield and periodic membrane replacement due to fouling. The technologies that work under ambient conditions include Electrodialysis (ED) and Capacitive Deionisation (CDI), which work in brackish water (5,000–12,000 ppm). However, there is no definitive process that works reliably for seawater (35,000 ppm). We propose an electrochemical desalination battery (EDB) that can desalinate seawater at ambient conditions. During desalination, seawater containing Na+ and Cl- ions flows through a central chamber. An applied potential causes Na+ ions to intercalate into the cathode and Cl- ions to be absorbed by the anode. EDB technology is shown to remove ~66% of TDS from simulated seawater (35000 ppm) at its initial stage of development, which can be improved further by system optimization. A hybrid EDB-CDI system can provide potable desalinated water with low cost, high energy efficiency and reduced water wastage. The hybrid EDB-CDI technology has the potential to replace commercialized RO systems by offering a higher freshwater output at a lower installation and operating cost. The technology is highly scalable from modular units that can be afforded by individuals to installations used by utility companies. Additionally, the energy retention is high and the process can be coupled with variable energy sources, including intermittent renewables.

Abstract # 7 - Omniphobic Membrane for Anti-Wetting Membrane Distillation

Shihong Lin, Ph.D., Vanderbilt University (USA)

Membrane distillation (MD) has been identified as a promising desalination technology capable of treating highly saline water with low-grade heat. As a thermal separation process, MD employs a hydrophobic membrane as a barrier for liquid water transport but the medium for vapor transport. As a result, a major challenge facing MD is the wetting or fouling by hydrophobic contaminants, which is of particular concern for application of MD in desalinating wastewater from shale gas and oil production. To overcome this problem, an omniphobic membrane has been developed by engineering both the chemistry and morphology of the membrane surface. The resulting surface nanostructure enables the membrane to effectively repel both water and oil. We compared the performance of the omniphobic membrane and a conventional hydrophobic membrane (e.g. PTFE) in MD operation in the presence of surfactants. Our results show that the hydrophobic membrane fails as an MD membrane due to wetting, whereas the omniphobic membrane can sustain robust MD operation even in the presence of surfactants.

Abstract # 8 - Clathrate Freeze Desalination using Cyclopentane as the Clathrate Former

Richard McCormack, HydroFreeze, a Division of Ramco Consulting Company (USA)

The purpose of this presentation is to provide an overview of the recent advances and research related to clathrate desalination. Clathrate-based desalination holds the promise of producing fresh water at a lower cost and lower energy use than that achieved from Reverse Osmosis or Multi-Stage Flash Distillation. Significant progress has been made since the fruitful pilot BUREC desalination project in Hawaii had to be scrapped due to the banning of R141B as part of the Montreal Protocols. Since then, replacement clathrate formers have been identified and research by government and educational institutions has shown that achieving potable water is possible. Clathrate desalination is based on mixing clathrate formers with sea water to create a "freshwater ice," which when melted and separated, results in purified water. Recent developments using Cyclopentane and other "pairs" make for a compelling argument to invest more resources in hydrate desalination. A discussion of the technology will include a short history of clathrate desalination, results of recent projects and research and current advances and insights. Various clathrate formers will be discussed. Educational and governmental research projects will be highlighted. With the ongoing quest to produce freshwater at lower energy costs combined with the increasing demands of the human population on freshwater sources, it is time we take a closer look at a compelling emerging technology.

Abstract # 9 - Benefits of Chemically-Enhanced Seeded Precipitation and Ozone as Pre-Treatments of Nanofiltration Brine in Reducing Fouling Propensity

Minkyu Park, Doctoral Student, University of Arizona (USA)

Membrane technologies have been used for decades in water treatment due to high rejection rate of organic and inorganic contaminants, facile operation, and comparatively low operational cost. Despite these benefits, however, membrane technologies inherently produce a highly concentrated brine stream which needs to be treated before being discharged back into a water body or reused for land application. As brines contain high concentrations of both inorganic constituents and organic matter, treatment is a major challenge and often the main inhibitor in implementation of membrane treatments. A feasible method of brine treatment can be to use additional stages of membranes such as nanofiltration (NF) and reverse osmosis (RO). However, significant fouling is still most likely to occur on these membranes, thereby requiring pre-treatment. In this study, chemically-enhanced seeded precipitation (CESP) and ozonation were tested individually and synergistically as pretreatments for NF brine treatment. CESP is a two-step process: alkaline treatment to remove calcium carbonate which scavenges antiscalant and seeded precipitation for additional removal of multivalent ions such as barium and sulfate which provokes scaling. Ozone can oxidize recalcitrant natural organic matter (NOM) such as humic acid and fulvic acid, hence reducing organic fouling. With the combination of CESP and ozone treatment, it was found that fouling propensity of NF membrane was significantly reduced. The alleviated fouling propensity was found to be due to the reduction in divalent cations such as calcium and barium and aromaticity of organic matter. In addition, no scaling was observed for the given operating time.

Abstract # 10 - The Next Generation of the Energy Recovery PX Pressure Exchanger

Juan Miguel Pinto, Energy Recovery Inc. (USA)

This presentation will cover new innovations to the performance of energy recovery devices for seawater reverse osmosis. In particular, the session will focus on enhancements to Energy Recovery's PX Pressure Exchanger (PX), the most widely used energy recovery device on the global water market. The PX recovers pressure energy through a fluid-to-fluid exchange from a high-pressure to a low-pressure flow. The energy transfer occurs within the product's rotor, the single moving part in the device, which is made from aluminum oxide, more than three times more abrasion-resistant than steel. Over two decades, Energy Recovery has earned a leading position in the global water market for the PX, with more than 15,000 devices operating on six continents. The company is releasing the first new PX product since it introduced the Q-series of Pressure Exchangers in 2011. In the forthcoming version of the device, Energy Recovery has improved performance across a variety of factors, including fluid mixing, energy efficiency, back pressure requirements, capacity, turndown, noise, and starting torque. During the session, a senior leader of Energy Recovery's engineering team will walk through how improvements were made, and what the impact of this technology will be to operations in desalination plants.

Abstract # 11 - Laminar Flow in Magnetic Labyrinth

Jorge Sarmiento, M.E., Del Sur Development LLC (USA)

BLUE FIN Water Desalinization. The new technology for water desalinization has the following advantages: (1) Lower Energy usage than Reverse Osmosis (RO). Water is not pushed thru layers and layers of membranes. But flows thru a magnetized labyrinth. (2) Lower Initial Investment. It does not require ultra filtration and costly water backwash, Simpler design using modified standard flow process technology. (3) Highest Water usage. NO refuse water. The system is back washed with high velocity air. This new technology for water desalination from BLUE FIN water is based in laminar flow in magnetic labyrinth and cleansed with high velocity air from vacuum pumps. Trying to solve the problem of wash downs on R.O. systems, where almost the same amount of treated water is required to clean, or wash down the system. From the initial point we decided that water shall not be used. Since we had seen high pressure fans and vacuum pumps used in other parts of the water processing system, such as aeration; Blue Fin water also optimizes resources and uses high velocity air compressors, or fans, or vacuum pumps to clean the labyrinth when they are saturated. A concert of valves and PLC's –Process Logical Controllers- coordinate the closing and opening of valves to allow water flow during the desalinization process, and reverses them to convert to the regeneration cycle. The system uses modified plate heat exchangers at the core of the units, and water speed, in Ft/min, is controlled by means of pumps and valves.

Abstract # 12 - Improved Desalination Using Bubble Column Evaporator Method

Muhammad Shahid, Doctoral Student, University of New South Wales, Canberra (Australia)

A simple bubble column evaporator can be used to evaporate water from concentrated salt solutions without boiling. The process is made more effective by the inhibition of bubble coalescence caused by the presence of some concentrated salts, such as NaCl. This work examines the effects of high bubble temperatures on this coalescence inhibition and its effects on the efficiency of water vapour collection. A continuous flow of hot dry air, at 275°C, produced about 10% higher rate of water vaporization than that expected from the equilibrium vapour pressures. Also, the use of a non-ionic surfactant monolayer bubble coating further improved the evaporation efficiency, by up to 18%, apparently due to supersaturation. In addition, the steady state temperature of the bubble column evaporator can be used to estimate the latent heat of vaporization even for inlet air temperatures of up to 275°C.

Abstract # 13 - Anode Doped Poly(3,4-ethylenedioxythiophene) Asymmetric Carbon Electrodes for Capacitive Deionization

Xia Shang, Doctoral Student, University of Illinois at Urbana-Champaign (USA)

The performance of a capacitive deionization (CDI) system consisting of conventional film electrodes is limited by the insulating properties of predominantly used fluorinated polymeric binders. Poly(3,4-ethylenedioxythiophene) (PEDOT) based material is known as one of the most important conductive polymers with high electrical conductivity, pseudocpacitance, and chemical stability. In this study, PEDOT is coated on an activated carbon powder based electrode by electropolymerization. The effects of PEDOT enhanced ionic and electronic mobility on salt removal and electrochemical performance are investigated when different aqueous counter ions are used in the electrochemical polymerization process. Moreover, the composition, morphology, and salt incorporation mechanism are characterized by X-ray photoelectron spectroscopy (XPS), scanning electron microscopy, and Fourier transform infrared spectroscopy. After characterization, asymmetric CDI systems are assembled with selected cathode material and the salt removal rate and overall energy efficiency are compared. This study provides in-depth understanding of the pseudocpacitance behavior of PEDOT in CDI and the incorporation of different counterions in the tailored CDI electrodes.

Abstract # 14 - High Recovery Forward Osmosis for Dewatering High Salinity Wastewaters

Jayraj Shethji, Ph.D., Hydration Technology Innovations, LLC (USA)

Hydration Technology Innovations (HTI) is at the forefront of commercializing the forward osmosis (FO) wastewater filtration technology for a wide range of markets including Oil and Gas, Food and Beverage, Industrial Process Water, and Municipal Wastewater. Besides designing and engineering multistage closed loop hybrid FO/RO wastewater systems, HTI manufactures commercial flat sheet FO membrane products on a 40 inch wide line – an asymmetric cellulose triacetate (CTA) membrane, and a family of next generation thin film composite (TFC) membranes. In this study, we present proof-of-concept testing results using HTI's CTA and TFC FO membranes for dewatering several challenging wastewaters such as high salinity oil and gas produced water, high salinity magnesium/ammonium sulfate wastewaters, landfill leachate, and different greywaters by mimicking actual field operating conditions employed in spiral-wound FO modules. We use a 9-14% sodium chloride salt solution as the draw solution, diluted by FO to 5-10% (depending on the type of wastewater) which can be polished and reconcentrated by a high pressure RO/NF system. The parameters included for performance evaluation are: FO flux, rejection, fouling, and efficiency of cleaning methods. We will also show that the membranes can be easily cleaned by simple osmotic backwashing or characteristic chemical cleaning techniques, and that the flux decline due to scaling of inorganics or organic fouling is largely reversible. Feed water recovery of 75-90% was obtained depending on the initial salinity and fouling propensity of the wastewater. A systemic assessment of the effect of FO operating parameters on the overall membrane performance will also be presented.

Abstract # 15 - Impacts of Fouling on Capacitive Deionization and Membrane Capacitive Deionization Systems

Laura Southworth, M.S. Student, University of Illinois at Urbana-Champaign (USA)

Capacitive deionization (CDI) and membrane capacitive deionization (MCDI) systems have the potential to lower the energetic demand of freshwater production from unconventional sources like brackish water and reclaimed wastewater through direct treatment or by treating brine generated by existing pressure-driven systems like reverse osmosis (RO). Organic fouling at filtration interfaces significantly increases energy consumption and adversely impacts freshwater production rates by obstructing water flux through the membrane. While RO fouling has been well characterized, little is known about the impact of organic foulants on ion adsorption in CDI and MCDI systems. In these systems, fouling layers could accumulate on the ion exchange membrane or the electrode itself, impeding flux and adsorbtion of ions out of bulk solution and onto the charged electrodes. Electrode potential could also impact foulant accumulation, producing fouling mechanisms distinct from those of RO fouling. Synthetic saline solutions containing model organic foulants will be used to evaluate CDI and MCDI fouling potential. Feed solutions will run through lab-scale CDI and MCDI systems separately, and the extent of fouling and scaling will be evaluated by observed changes in desalination performance and flow path pressure drops. Scanning electron microscopy and energy-dispersive X-ray spectroscopy will be used to characterize the electrode structure before and after fouling to evaluate the extent of structural changes. Atomic force microscopy (AFM) will be used to measure the interaction forces between a charged colloidal AFM tip and polarized electrodes under different set potentials and solution conditions.

Abstract # 16 - Withdrawn

Abstract # 17 - Forward Osmosis: A Promising Technology

Coimbat Veda, P.E., Enterpreneur in Membrane Systems (India)

Forward Osmosis (FO) has been established as a promising versatile solution for the treatment and desalination of complex industrial streams, primarily production wastewaters and O & G -produced water industry. This paper addresses current challenges in FO technology such as draw solutes/solution with their recovery methods, energy savings, and fouling limitations. FO is a process normally occurring in nature when harnessed for water filtration and liquid transfer requires little or no electricity or external power source. FO is known to feature a patented membrane-based desalination platform which can transform wastewater with up to five times the salinity of seawater into fresh water. In contrast to RO, FO operates at very low pressure which is adequate to circulate the fluids, and the natural osmotic pressure in the draw solution pulls water through the membrane, leaving solids and foulants behind in the concentrated feed solution. Energy-efficient FO piloting is one of the on-going four test plants at the Masdar City, UAE, as an alternate to energy-intensive desalination. Looking to the future, shortcomings into the membrane configurations, pH range, permeability and studies on organic draw solutions need to be addressed. FO offers an impressive list of industrial applications: algae biofuels, landfills, chlor-alkali, food processing, methane digesters, nuclear wastewater, bio-reactor.

Abstract # 18 - Performance Evaluation of HTI's Latest High‒Flux Thin-Film Composite Forward Osmosis Membrane for Municipal and Industrial Applications

Daniel Wandera, Ph.D., Hydration Technology Innovations LLC (USA)

Over the last decade, tightened wastewater treatment and discharge regulation standards coupled with increased complexity of municipal and industrial wastewater challenges plus increasing energy and other costs of treatment operations have resulted in heightened focus on Forward Osmosis (FO) for a variety of applications. For many years, the only commercially available FO membranes were produced by Hydration Technology Innovations (HTI) in the form of an asymmetric membrane based on cellulose triacetate (CTA). Since 2012, HTI has also produced a next generation thin film composite (TFC) FO membrane family. The TFC FO membrane was designed, developed, and commercialized by HTI to overcome some of the limitations of commercial CTA FO membrane, such as its moderate water flux and susceptibility to hydrolysis. TFC FO membrane enables higher water flux, lower salt transfer values, and an improved tolerance to a wide pH range. Through a continuous product enhancement process, HTI's newest high-flux TFC FO membranes demonstrate water flux values exceeding 35 LMH with less than 200mg/L of reverse salt transfer, which qualifies them as the leading FO membranes available today. The basic design of this TFC FO membrane inherits the embedded backing design structure from the CTA membrane and gives HTI the versatility to tailor the membrane design for a wider range of waste water applications. This presentation focuses on test results of several applicable waste water streams, such as municipal grey waste water and oil/gas exploration waste water to highlight the wide applicability of this high-flux TFC FO membrane.