

QUARTERLY NEWSLETTER

BEYOND OUR IMAGINATION

Our ISMET community continues to grow

Throughout the 8 years of ISMET and previous Microbial Fuel Cell conferences, I have seen several talks discussing the importance of developing “real world” applications if our field wants to continue its upward trend. Undoubtedly, a large volume of research in our field has led to an immense collection of important scientific information, including engineering approaches towards possible technologies. But, scale-up efforts are inherently low-paced and their results become a very small fraction of the research publications. This is the natural progression of the vetting process of a new technology, where decades might pass before a successful application is found.

Despite this apparent slow progress towards applications and scale-up, our field continues to grow at a fast pace. A search in Web of Science for “microbial fuel cell” gives nearly 500 new papers in 2016 (900 if searched without quotes), up from ~ 250 in 2010. To put this into perspective, a search for “fuel cell” yields ~ 4,000 papers in 2016 and a search for “anaerobic digestion” yields ~ 1,500 papers. Thus, while smaller, we are a significantly large group if >10% of fuel cell research comes from our field. At the same time, our local ISMET meetings saw over 450 researchers and this issue features 14 new Ph.D. graduates from our field, the most we have ever presented in ISMET News!

Microbial electrochemistry expands beyond the excitement of understanding extracellular respiration, beyond the possibilities of waste-to-energy, or the avenues to produce high-value products. Our field provides a direct interface between biology and electrochemistry, a way to interface chemical to electrical energy through complex biochemistry. This field is truly opening new engineering possibilities and expanding our knowledge of microbiology. For this reason, it continues to expand beyond what most of us imagined years ago.

César I. Torres
Editor ISMET news



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Three sunny days of excellent science at the Eternal City

The 3rd European Meeting of the International Society for Microbial Electrochemistry and Technology (EU-ISMET 2016) held this year in Rome from September 26 to 28 has testified the ever-growing interest of European researchers for Microbial Electrochemical Technologies. EU-ISMET 2016 was undoubtedly a successful event characterized by 3 sunny days of excellent science and intense social activities with the Great Beauty of the Eternal City as a backdrop. The meeting was indeed attended by over 200 registered participants from 29 different countries, which contributed with 7 keynote presentations, 62 oral presentations and 95 posters.

Thanks to the generosity of a number of commercial sponsors, the 6 best presentations were awarded during a closing ceremony. The awards for the best orals were given to Benjamin Korth (UFZ, Germany), Sarah Cotterill (Newcastle University, UK) and Christin Koch (UFZ, Germany), while the awards for the best posters were attributed to Sam Molenaar (Wageningen University, The Netherlands), Christin Koch (UFZ, Germany) and Babu Halan (UFZ, Germany). The scientific program of the meeting ended with a Roundtable on 'Future technological and scientific challenges of METs', which was admirably chaired by ISMET former President Korneel Rabaey who animated a terrific debate on prospects and current and future research directions for METs. Hopefully, future ISMET meetings will also host a similar event.

As a follow-up of the conference two Journal Special Issues are being prepared, to collect the best papers during the meeting: one to be published in the Wiley Journal Fuel Cells (submission open) and one in the Wiley Journal Microbial Biotechnology (submission will open soon).

Finally, as the Chairmen of EU-ISMET 2016, we are indebted with ISMET, the European Federation of Biotechnology (Environmental Biotechnology Section) and all the sponsors (Aqualia, BioLogic, IVIUM Technologies, METfilter, nanoelectra, PalmSens, 6TMIC, and Thasar) for their continued support to the event.

A crowded conference room during a keynote presentation



From now on, the ball of EU-ISMET is in the expert hands of Ian Head from Newcastle University who will organize the next meeting in 2018. Good luck, Ian!

EU-ISMET 2016 participants enjoying the social dinner in a typical Roman restaurant near the Spanish Steps



Authors:

Federico Aulenta & Mauro Majone
Co-chair of EU-ISMET 2016

Meeting in California



The 3rd Meeting of the North American branch of the International Society for Microbial Electrochemistry and Technology was held on October 5-7, 2016, at Stanford University, Stanford, California, USA. A total of 76 participants attended with nine invited speakers. Professor Alfred Spormann was our meeting chair, providing an excellent set of venues for this event. The meeting started with a short introduction and welcome by Professor Spormann, and was followed by the opening talks in the Clark Center Auditorium.

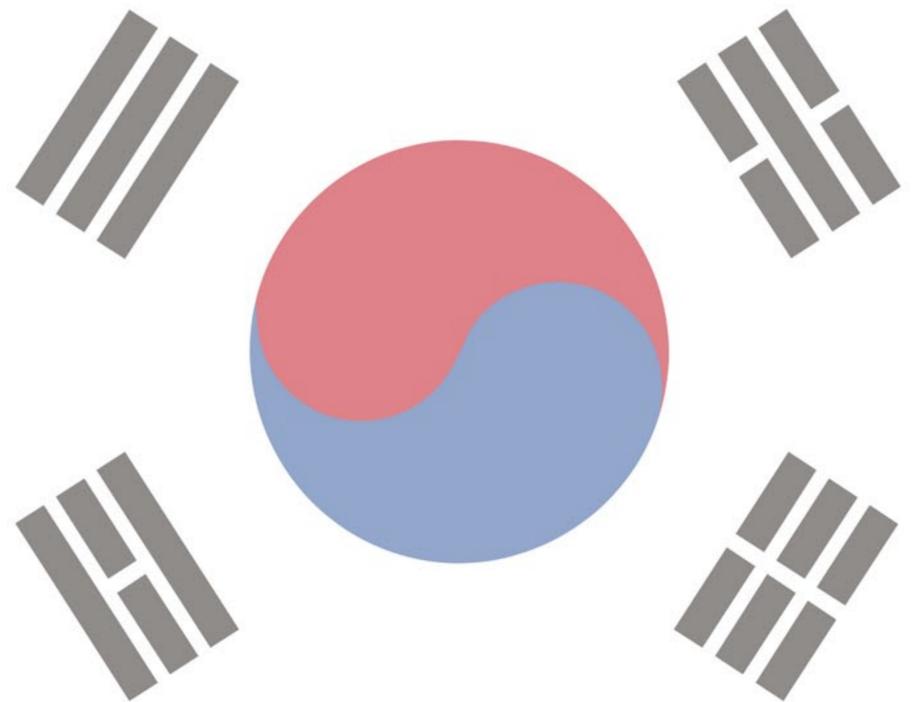
The inaugural talks were given by Moh El-Naggar from University of Southern California, Bruce Logan from Penn State University, Yasemin Yilmazel from Rochester Institute of Technology, and myself from Arizona State University. The opening talks provided an interesting combination of applied and basic research, from fundamentals of extracellular electron transfer to microbial fuel cell design. The conferences were followed by an icebreaker reception in the lawn just outside the auditorium where the meeting took place.

The following two days showcased a total of seven oral sessions and one poster session. The topics covered were quite vast, spanning from mechanistic studies on EET and microbial ecology to materials for METs, designs and scale-up, applications for wastewater treatment, and synthetic biology approaches to METs. The work of younger scientists (graduate students and postdocs) was featured throughout the meeting through oral and poster presentations. I particularly enjoyed talking to the younger generation of our field and the newer members of our ISMET community.

The meeting concluded with closing remarks by Professor Spormann. Overall, it was a successful event that strengthens our community and promotes excellent science and engineering.

Author:

César I. Torres



AP-ISMET in Korea, highlighting research across Asia

The AP-ISMET 2016 meeting took place August 31-September 2 in Busan, Korea at the BEXCO convention center. Professor Taeho Lee, Chairman of the AP-ISMET Organizing Committee, and his team hosted an incredible meeting that highlighted research across Asia in the field of bioelectrochemical systems and included invited speakers representing our global research community from countries including China, Japan, Taiwan, USA, India and across Europe. The city of Busan offered the perfect venue for the meeting. Meeting attendees could enjoy the nightlife and attractions of Korea's second largest city, including the famous fresh seafood markets, or take a stroll along the beach.

There were over 180 scientists in attendance from 12 different countries with 30 invited speakers. The meeting was co-organized by the Busan Global Water Forum, an annual meeting that attracts scientists and engineering experts in water and energy-related fields. Concurrent sessions for both meetings allowed researchers in both fields to share knowledge and introduce the use of microbial electrochemical technologies (MET) applications for wastewater treatment to those in the water treatment field.

The meeting featured keynote presentations by Professor Helmut Kroiss (President, IWA; Vienna University of Technology Austria), Professor Bruce Logan (Pennsylvania State University), and Professor Bruce Rittmann (Arizona State University). Prof. Kroiss highlighted the challenges we face globally in planning for water utilization and treatment. Profs. Logan and Rittmann gave excellent overviews of the current state of the field for engineering microbial fuel cells (MFCs) to scale and also the engineering challenges associated with relieving proton limitations limiting power in MFCs.

Eighteen sessions spanning 3 topic areas were run concurrently on each day of the meeting that focused on MET development/scale-up and wastewater treatment, novel MET applications, and fundamental microbial process in MET, such as extracellular electron transfer (EET). The work of post-doctoral researchers and graduate students was highlighted throughout the meeting, including both oral presentations and poster presentations. Awards were given for the best student or postdoc oral presentation. Winners included Ms. Divya Naradasu (University of Tokyo, Japan) and Dr. Pablo Ledezma (The University of Queensland, Australia). There were 103 poster presentations and awards given for the best poster went to the following researchers: Mr. Ma Xiaoxiao (South China University of Technology, China), Mr. Bonyoung Koo (Chonnam National University, Korea), Ms. Manal Al Quahtani (KAUST, Saudi Arabia), Mr. Norio Matsumoto (Central Research Institute of Electric Power Industry (CRIEPI), Japan), and Mr. Ramesh Kakarla (Kyung Hee University, Korea).

Workshops were held at Pusan National University by Akihiro Okamoto (National Institute for Material Science, Japan) and Shuji Nakanishi (Osaka University, Japan) on the final day of the meeting.

The meeting was a huge success and I look forward to the next AP-ISMET meeting in 2018!

South Korea is an energetic country in various aspects such as electronics and heavy industries, pop culture, and politics. As the 8th largest energy consumer in the world, energy saving and development of alternative renewable energy sources are critical issues in South Korea which imports over 97% of its total energy from other countries.

Recently, The South Korean Ministry of Environment is promoting a plan for low-energy wastewater treatment plant to achieve 50% of energy self-sufficiency by 2030 and a carbon neutralization program for achieving 30% reduction of greenhouse gas emissions from environmental basic facilities including waste/wastewater treatment plants, landfills, and incineration plants by 2020. Many Korean researchers on microbial electrochemical technologies (METs) believe that MET can contribute to promote government's energy and carbon neutralization programs.

Since the first MET research paper on a mediator-less microbial fuel cell (MFC) was reported in 1999 by Dr. Byunghong Kim's group in Korea Institute of Science and Technology, more than 25 research groups have been actively engaging in MET research in South Korea. South Korea is currently the 2nd position in Asia-Pacific area and the 3rd position in the world in terms of publication numbers in MET research. Korean MET researchers carried out more than 20 MET related national projects since 2010.

Prof. Taeho Lee's group in Pusan National University has focused on the simultaneous organic and nitrogen removal in flat-plate MFC system for low-energy wastewater treatment and, recently, studies microbial electrochemical recovery of precious metals (Sb and Te). Prof. Inseop Chang's group in GIST firstly revealed the cause of energy loss in stacked MFC system and is studying the development of integrated MFC system for the efficient electricity production. Prof. Youngchae Song's group (Korea Maritime and Ocean University) has studied low-cost/high-efficiency materials for electrode and catalyst, and recently concentrates on MET-based anaerobic digestion. Prof. Jungrae Kim's group (Pusan National University) is focusing on the microbial electrochemical synthesis such as acetate production by CO₂ reduction and 3-hydroxypropionic acid production from glycerol. Prof. Booki Min's group (Kyounghee University) is studying nutrient removal by using an algae-based MFC. For a pilot-scale MET research, MFC R&BD center, which was co-founded with 3 companies including K-water, Hanhwa E&C and Taeyoung E&C, is operating a pilot-scale MFC system (1 m³/day) to treat a filtrate from an acidogenic sludge fermentation reactor.

Attendees in AP-ISMET2016, Busan, Korea



Korean MET researchers organized a national specialist group in 2013 and had domestic symposiums on recent MET technologies two times on March in 2014 and 2016. Korean MET researchers also have been very actively participated and largely contributed in ISMET conferences. Prof Inseop Chang organized the 2nd MFC conference at GIST (Gwangju, South Korea) on June 10 - 12, 2009 and Prof. Taeho Lee successfully organized the 3rd AP-ISMET at BEXCO (Busan, South Korea) on August 31 - September 2, 2016. Korean MET researchers are willing to cooperate with ISMET researchers for METs progress.

Authors:

*Prof. Taeho Lee and Dr. Jaechul Yu in
Pusan National University, Korea*

Collaboration with artists delivers sparks of electricity and publicity

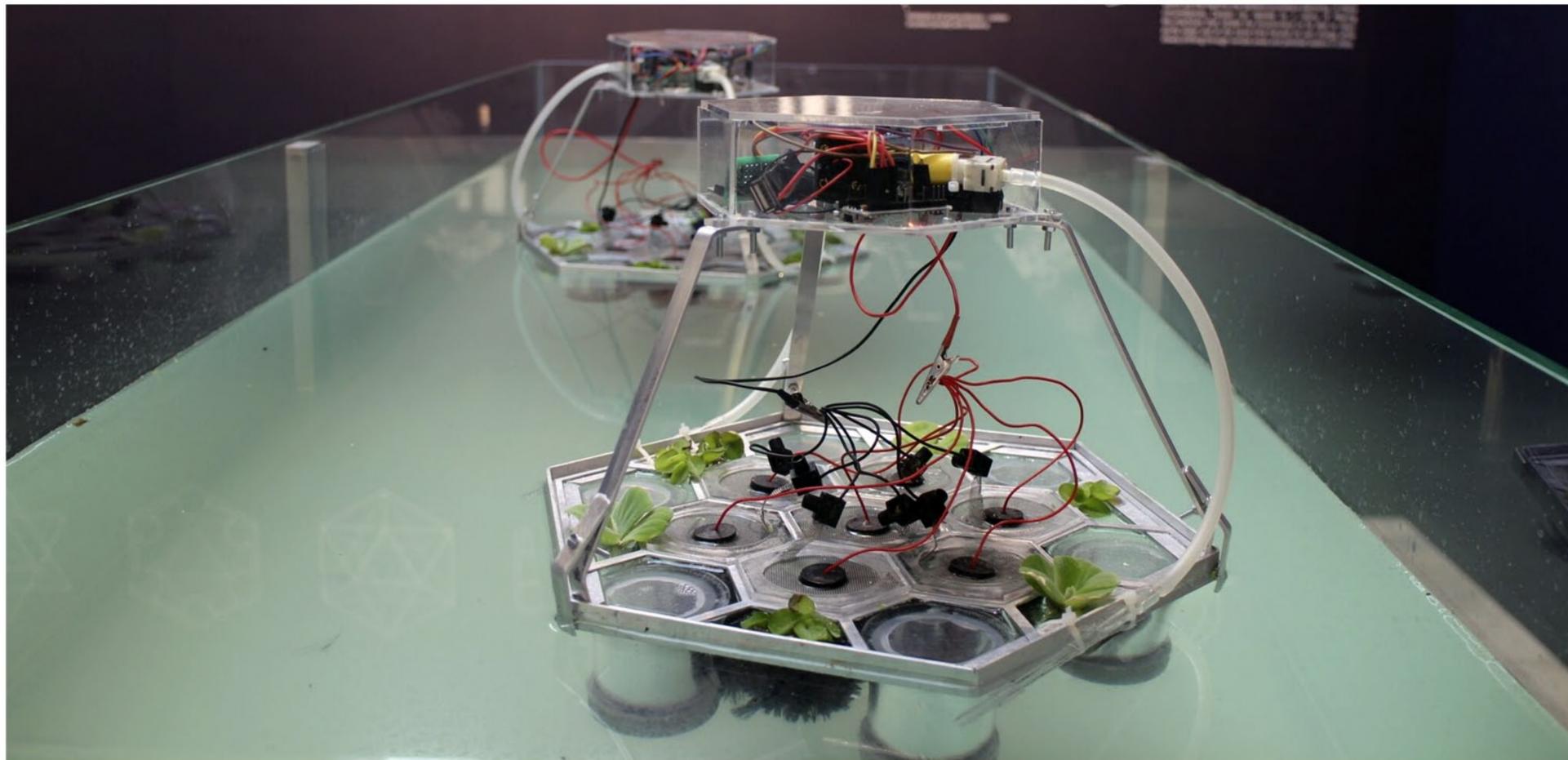
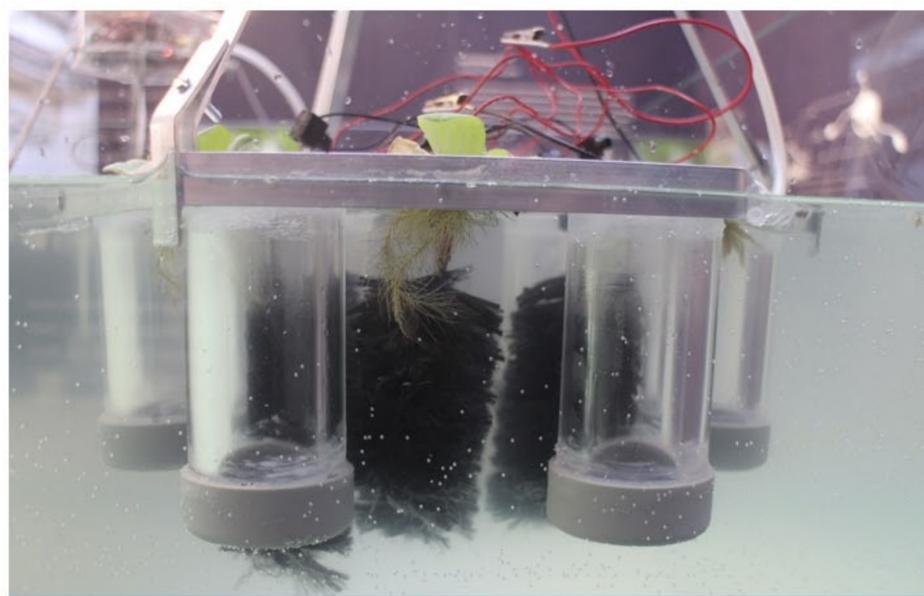


Figure 1: Two assembled Caravels

As a scientific society it is important to communicate our findings to the general public. In the past year, our group (Center for Microbial Ecology and Technology; CMET at UGent) has collaborated with two independent artists who were interested in exploring bioelectrochemical technology for their artworks.

The first project, by [Ivan Henriques](#), was the creation of the Caravel, which is a living machine that is self-powered by organic pollution in a waterbody (Figure 1). Exoelectrogens were pre-colonized in the lab on brush anodes (kindly provided by Bruce Logan) before being installed in the Caravel where they metabolize organic matter in polluted waters. The cathode in this system is a stainless steel mesh. Each Caravel contains 7 independent MFCs that charge a supercapacitor. During the charging process an LED blinks to indicate charging. The blinking frequency increases with increasing charge stored in the supercapacitor. When a certain setpoint is reached, the supercapacitor discharges over two little motors that are randomly, independent or simultaneous activated and blow air into the water thus creating a propulsion system. This ensures a random motion of the Caravel through the polluted area. The idea is that many Caravels i.e. a swarm, can combine and clean polluted waters in a joint effort. The Caravel also has openings to accommodate water plants that can sorb pollutants and also provide some organics to the bioanodes. The Caravel was shown at the WaterWar exhibition in Kortrijk (Belgium), the Dutch Design Week in Eindhoven (The Netherlands) and the Digital Art Festival in Taipei (Taiwan).

The second project idea came from Teresa van Dongen who aimed to show the importance of bacteria in our life and challenge energy use conventions. To achieve this, she designed [Spark of Life](#) (Figure 2) which is a lamp powered by a mixed microbial community oxidizing acetate. The lamp contains 4 separate MFCs with each containing a carbon felt anode and a tubular VITO-core gas diffusion electrode (kindly provided by Deepak Pant) as a cathode for abiotic oxygen reduction. Each MFC is a quarter of a sphere and is powering an LED by means of an electrical circuit containing a joule thief. This device was shown at the Dutch Design Week in Eindhoven (The Netherlands) where Teresa received the Keep an Eye Design Talent Grant 2016 to further develop her design.



Close-up showing the anode brushes

Flash report :: ART MEETS SCIENCE

1) *The Spark of Life* by night, 2) by day and 3) with a bottom-up view showing the LEDs. Kristof Verbeeck and Jan Arends participated in this project. Jaap Hoogerdijk designed the electrical circuit. Picture 1 & 2 were taken by Hand Boddeke.



Apparently not only CMET collaborated with an artist; a Plant-MFC that lights up when the plant is touched was also shown at the Dutch Design Week. This piece of bioelectrochemical art was designed by [Ermi van Oers](#) in collaboration with Plant-e and Wageningen University in the Netherlands.

All projects created local publicity for the bioelectrochemical technologies that we as ISMET community try to push forward. Therefore, I'd like to encourage all of you to interact with artists to translate (y)our findings to the general public. It is not only rewarding in terms of outreach but also on a personal level these outsiders have the possibility to challenge (y)our way of thinking.



Caravel project team left to right: Korneel Rabaey, Ivan Henriques, Way Cern Khor, Xu Zhang, Andjela Tomic (designed the electrical circuit), Jan Arends and Ramon Ganigue, E) assembling the pre-colonized brushes in the floating body.

Author:

Jan Arends,
CMet, UGent



North America

Huggins, M. Tyler



Title: Synthesis of Biomass Derived Carbon Materials for Environmental Engineering and Energy Storage Applications
Supervisors: Dr. Zhiyong Jason Ren (CU Boulder); Dr. Justin Biffinger (NRL)
Affiliation: University of Colorado Boulder
Description: I synthesized, evaluated, and compared the performance of biomass-derived carbon such as biochar and fungal char for microbial electrochemical applications such as electrodes and filter media for wastewater treatment and soil remediation, and electrodes for energy conversion and storage.

Li, Jian



Title: Challenge and Opportunities of Membrane Bioelectrochemical Reactors for Wastewater Treatment
Affiliation: Virginia Polytechnic Institute and State University (Virginia Tech.)
Supervisor: Dr. Zhen (Jason) He
Description: Integrating membrane filtration with MFCs could be a viable option for advanced wastewater treatment with a low energy input. It has more advantages over conventional membrane bioreactor or anaerobic membrane bioreactors on energy consumption and nutrients removal. Wastewater can be reclaimed and reused for fermentation use after MBER treatment.

Mahmoud, Mohamed



Title: Towards improving electron recovery and coulombic efficiency of microbial electrochemical cells fed with fermentable electron donors
Supervisors: Dr. Bruce Rittmann and Dr. César Torres
Affiliation: Biodesign Swette Center for Environmental Biotechnology at Arizona State University, USA
Description: This dissertation aimed at fundamentally understanding the main causes for low efficiency, in terms of energy recovery and treatment efficiency, of microbial electrochemical cells (MXCs) fed with complex organic matter; this knowledge will advance MXCs technology toward commercialization.

Ping, Qingyun



Title: Advancing Microbial Desalination Cell towards Practical Applications
Affiliation: Virginia Polytechnic Institute and State University (Virginia Tech.)
Supervisor: Dr. Zhen He
Description: The work examined the driving forces to remove salinity and boron in Microbial Desalination Cell through integrated approach of experiment and mathematical modeling. The ion-exchange membranes were heavily studied in terms of configuration, fouling and scaling, and back-diffusion issue.

Europe

Andersen, Stephen



Title: Membrane Electrolysis as a novel electrochemical recovery process tailored to carboxylic acid fermentation, extraction and valorisation
Supervisors: Prof Korneel Rabaey and Xochitl Dominguez Benetton
Affiliation: Ghent University, Belgium
Description: A membrane electrolysis process was demonstrated on a carboxylic acid fermentation towards mid-chain fatty acids, in which we achieved a zero-chemical input fermentation while extracting carboxylic acids and shifting production towards longer chain carboxylic acid products.

Bajracharya, Suman



Title: Microbial Electrosynthesis of Biochemicals: Innovations on Biocatalysts, Electrodes and Ion-exchange for CO₂ Supply, Chemical Production and Separation
Supervisors: Prof. Dr. Cees Buisman¹, Dr. David Strik¹, Dr. Deepak Pant²
Affiliations: ¹Wageningen University and Research (WUR), The Netherlands, ²Flemish Institute for Technological Research (VITO), Belgium
Description: This PhD was focussed on the bioelectrochemical reduction of CO₂ employing mixed-cultures. Culture enrichment with sequential acclimation and gas diffusion biocathode were adopted for effective CO₂ supply and bioelectrocatalysis. Ion-exchange resins were tested to separate the products.

Battle Vilanova, Pau



Title: Bioelectrochemical transformation of carbon dioxide to target compounds through microbial electrosynthesis
Supervisors: Dr. Jesús Colprim, Dr. Sebastià Puig, Dr. Rafael Gonzalez-Olmos
Affiliation: LEQUIA. Institute of the Environment. University of Girona, Spain
Description: This thesis proposes the use of bioelectrochemical systems to transform CO₂ into valuable products through microbial electrosynthesis. The results show that the production of hydrogen as intermediate is key to allow further CO₂ reduction to methane and organic liquid compounds of two (acetic acid) and four (butyric acid) carbons.

Borjas, Zulema



Title: Physiological and Operation Strategies for Optimizing Geobacter-based Electrochemical Systems.
Supervisor: Dr. Abraham Esteve-Núñez
Affiliation: University of Alcalá, Spain
Summary: Zulema explored new strategies for enhancing Microbial Electrochemical Technologies capacities by analysing parameters operating at both micro-scale and pre-pilot scale.

Cerrillo, Míriam



Title: Anaerobic digestion and bioelectrochemical systems combination for energy and nitrogen recovery optimisation
Supervisors: Dr. August Bonmatí and Dr. Marc Viñas
Affiliation: IRTA. GIRO Joint Research Unit IRTA-UPC, Spain
Description: The combination of anaerobic digestion and bioelectrochemical systems technology has been studied with the aim of improving anaerobic digestion operation and increasing energy and nitrogen recovery from a complex waste stream such as pig slurry.

Europe (cont.)

Domínguez-Garay, Ainara



Title: Bioelectrochemically-assisted remediation: a novel strategy for cleaning-up polluted soils
Supervisor: Dr. Abraham Esteve-Núñez
Affiliation: University of Alcalá, Spain
Summary: This thesis shows the improvement of pollutants biodegradation and soil detoxification by Microbial Electrochemical Systems.

Gildemyn, Sylvia



Title: Technology and tools for bioelectrochemical production of short- and medium-chain carboxylic acids from CO₂
Supervisor: Prof. Korneel Rabaey
Affiliation: Ghent University, Belgium
Description: The aim was to develop a reactor platform for the production of biochemicals from CO₂. The main focus was the design and operation of a reactor system for simultaneous production and extraction of acetic acid via microbial electrosynthesis.

Moreno Gutiérrez, Rubén



Title: Bioprocesses for Wastewater Treatment: Integration of Bioelectrochemical Systems and Other Technologies
Supervisors: Dr. Adrián Escapa González, Dra. Xiomar Arleth Gómez Barrios and Dr. Antonio Morán Palao
Description: The main objective of my PhD thesis was to evaluate the integration of BESs and other processes (such as anaerobic digestion or dark fermentation) as a technology for industrial (cheese whey) and domestic wastewater treatment.

Tejedor-Sanz, Sara



Title: Merging microbial electrochemical systems with conventional reactor designs for treating wastewater
Supervisor: Dr. Abraham Esteve-Núñez
Affiliation: University of Alcalá, Spain
Summary: Sara focused on the exploration of fluidized anodes and hybrid systems for performing microbial electrode-mediated reactions.

Asia-Pacific

Kracke, Frauke



Title: Understanding extracellular electron transport of industrial microorganisms and optimization for production application
Supervisors: Dr Jens O. Krömer, Dr Bernardino Viridis
Affiliations: Centre for Microbial Electrochemical Systems, Advanced Water Management Centre, The University of Queensland, Brisbane, Australia
Description: This thesis uses a combined approach of in silico and in vivo strategies to understand the fundamentals of microbe-electrode interaction in systems for production of chemicals and fuels.

IBERIMET celebrates its first workshop at the University of Alcalá

IBERIMET, the national network of excellence that brings together the main Spanish groups in the field of Microbial Electrochemical Technologies (MET), held its first workshop at the University of Alcalá, Spain, early December. Abraham Esteve's Bioe-, coordinator of the project, was in charge of organizing the meeting. More than 40 researchers from the University of León, University of Castilla-La Mancha, Universitat Autònoma de Barcelona, Universitat de Girona, IRTA-GIRO, Universidad Politécnica de Cartagena and CSIC met to show case their lines of research and the latest advances in the field with the aim of encouraging the exchange of experiences and collaboration. Attendees also participated in a practical seminar on microbialelectrochemistry. The IBERIMET network of excellence is financed by the Spanish Ministry of Economy and Competitiveness (reference CTM2015-71982-REDT).



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