

ISMET news

Quarterly newsletter

No. 3 – Jan 2014

A maturing field of research

The range of processes has expanded enormously from energy generation to synthesis of organics

Dear ISMET member,

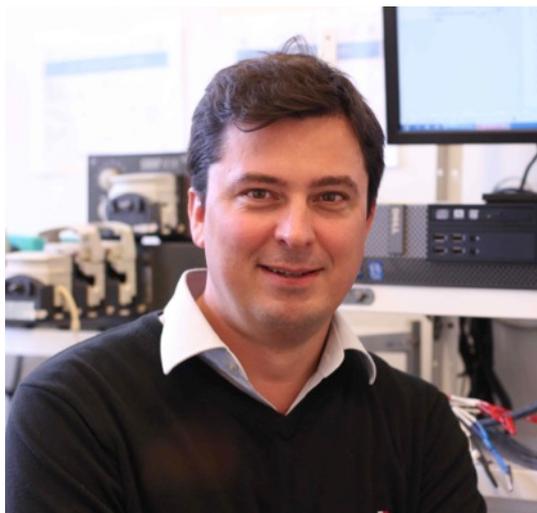
Almost exactly 10 years ago I published my first manuscript on microbial fuel cells. In those days, my endnote library comprised only about 50 references on this theme and I had no clue how my reactors worked. I did a small press release on electricity from sugar; the press headlined it as “Stinking batteries” – not the greatest success. 10 years later, we have seen a dramatic change. We now have a maturing field of research, with first full scale applications installed. The range of processes has expanded enormously, going from energy generation to synthesis of organics, from tiny implantable devices to cubic meter scale waste treatment reactors. “Microbial fuel cell” as search term now gives more than 3100 references in Web of Science, with more than 66000 citations and an H index of 114. Impressive!

Many challenges yet remain to bring the technology and processes to a mature stage, and ISMET can play a crucial role in this. It is indeed a platform for exchange of information and promotion of our work, both internally and externally. This will drive the necessary credibility with stakeholders and investors. The three conferences next year, in Singapore, State College (PA) and Madrid will constitute the next opportunity for all members to meet and exchange information. In the meantime the website committee has been busy expanding the information base on the website. I am very honoured to lead this clearly vibrant and growing grass-roots organization for the coming two years and hope to see many of you at the meetings, or interact via our website or other means.

Best wishes for 2014!



Korneel Rabaey
President



4th Microbial Fuel Cell Conference

The 4th International Microbial Fuel Cell conference was held in Cairns, Australia on September 1-4 2013. The conference program was packed with high level talks, covering all streams of the field of microbial electrochemical technology, namely microbial aspects, electrochemistry and technology.

The conference welcomed 152 delegates from the world over, one third of them students, continuing along the MFC-conference series trend of attracting primarily students and young researchers. The MFC series will now turn into the ISMET series, with ISMET 5 planned for October 1-4, 2015 in Tempe, Arizona.

The MFC4 saw a good representation from most world regions, with 61 attendants from Asia, 38 from Europe, 33 from Australia and smaller delegations from North and South America, Middle East, Oceania and Africa.

The keynote speakers were Prof. Lars Peter Nielsen and Prof. Cees Buisman. Lars intrigued the audience with a fascinating talk on cable bacteria and their “snorkels”, Cees gave an overview of a number of technological approaches that are expected to make MFCs economically feasible in the short term, including a “switch to urine”, novel copper-based cathodes, and capacitive anodes. The other invited speakers satisfied the audience’s appetite for novelty and perspective. These included Prof. Korneel Rabaey, Prof. Xia Huang, Dr. Ashley Franks, Prof. Lars Angenent, Dr. Falk Harnisch and last but not least, outgoing ISMET president Prof. Bruce Logan.

Rich poster and pitch sessions engaged the audience before and during coffee breaks. The variety of topics covered and the scientific level were remarkable, conveying the impression that the domain of microbial electrochemistry and technology is not only expanding in size, but also in depth and quality.

The award for the best pitch presentation went to Andreas Vogl from Germany, while Cotterill, Golitsch and Nishio were awarded for best posters and were



forced back to their rooms after a rich Aussie barbecue to prepare a surprise pitch for their posters.

The CEMES Biofilm Electrochemistry Workshop sponsored by the Centre for Microbial Electrosynthesis (CEMES) that was held during the three days leading to the conference was an opportunity for about 30 young researchers in the field to have some fun together, while learning electrochemistry theory and techniques through both classroom and laboratory activities. The active learning approach was well received and stimulated the participants’ thirst for electrochemical knowledge. More than 90% of the attendants agreed that they found the workshop well organized and that they learned a lot during both classroom and laboratory sessions.

Dr. Stefano Freguia

*Advanced Water Management Centre
University of Queensland, Australia*



A big success: the CEMES Biofilm Electrochemistry Workshop

The first electrochemical highlight of MFC4 originates even before the conference had officially started. A Biofilm Electrochemistry Workshop was indeed organized Friday 30 August - Sunday 1 September 2013 by a dedicated team from the Centre for Microbial Electrosynthesis (CEMES), the Advanced Water Management Centre (AWMC), The University of Queensland and the International Society for Microbial Electrochemistry and Technology (ISMET). This workshop was definitely a success as it was "sold-out" well before the opening of the conference. It also proved to be useful as many attendants were asking basic electrochemistry questions to the conference's speakers. The attendants were given lectures at the Shangri-La Hotel and practicals at Trinity Bay on biofilm electrochemistry, and a tutorial booklet summarizing the basic concepts. Those who did not get the chance to attend can read the mini-review by Freguia and Harnisch (*Chem. Asian J.* 2008) or, to better grasp the subtleties of cyclic voltammetry applied to electroactive biofilms the recent article by Rousseau et al. (*Energy & Environmental Science* ASAP 2013). A subjective selection of electrochemistry related talks include those related to surface modification for example that of Flexer (Queensland) on plasma treatment of electrodes, Lapinsonnière (Rennes) on boronic acid functionalisation of carbon nanotube and Guo (Ghent) on the effect of surfactant deposited onto electrode surface. The talk from Bernet (INRA, Narbonne) focused on electroactive biofilms selected from salt marshes (highly conductive electrolytes) and that of Kavanagh (Galway) on the effect of the applied potential on the microbial electroactive catalyst. Knight (Sydney) presented a soil microbial fuel cell that can in principle power remote sensor networks. Few presentations were given on the coupling of electrochemistry with spectroscopic techniques. One interesting exception was by Schkolnik



(Berlin) on the use of the vibrational Stark effect to study cytochromes adsorbed at modified gold surface. Among the many interesting posters selected for a short presentation in one of the successful "pitch sessions", that of Desmond

(IRSTEA, Anthony) discussed the microbiology of oxygen reducing cathode. A copy of all these presentations and others along with the conference book of abstract were given out on a USB drive at the end of the conference. This idea allowed the attendants to scroll back through the slides of their favourite talks or to have a look at those they missed, either because of the two parallel sessions or because they sneaked out for a while to check out the tropical rain forest or the great coral reef. More news and advances in 2015 at Arizona State for ISMET5, the new name for MFC5!

Dr. Frédéric Barrière

Université de Rennes 1, France

Best MFC4 works

Postgraduated students were the stars of the busy pitch sessions and lively discussions in the coffee breaks, a unique atmosphere for networking with other colleagues.

The works were evaluated by a committee with the aim of encouraging the excitement of younger colleagues in presenting their work. The nominees were announced during the final session of the conference. The jury voted the following as the best works:

Best pitch presentation:

Vogl, A., Bischof, F. and Wichern, M. Karlsruhe Institute of Technology, Institute for Applied Biosciences (Germany). *Inter anode biofilm transfer as a strategy to shorten the start-up time of microbial fuel cells.*

Best posters:

Cotterill, S., Dolfig, J., Jones, C. and Curtis, T.P. (UK). *Pilot-scale development of a microbial electrolysis cell.*

Nishio, K., Kimoto, Y., Kato, S., Nakanishi, S., Hashimoto, K. (Japan). *Activation of polyhydroxybutyrate productivity in Ralstonia eutropha by electrochemical cultivation.*

Golitsch, F., Bücking, C., Simonte, F. And Gescher, J. (Germany). *An engineered biosensor based on Shewanella oneidensis outer membrane protein complexes – a proof of principle.*

The ISMET Awards 2012

The ISMET acknowledges outstanding work by postgraduate student and postdoctoral researcher members within the field of Microbial Electrochemical Technologies (METs) with two awards. These awards recognize the best break through discovery and the scientific manuscript published in a peer-reviewed journal that has furthered the field of Microbial Electrochemical Technologies.

Winners of the awards were announced during the opening reception at MFC4, the International Microbial Fuel Cell Conference in Cairns, Australia, last September.



The winner of the 2012 ISMET Innovation Award was Elliot Friedman from the laboratory of Lars Angenent, Cornell University (email: esf59@cornell.edu). The award is open to postgraduate students and postdoctoral researchers in all fields including, but not limited to: Microbiology; Electrochemistry; Engineering; Physics; Material Science, associated with microbial bio- electrochemical systems and technologies.

The winner of the 2012 ISMET Discovery Award was Sudeep Popat from the laboratory of César Torres, Arizona State University (email: scp@asu.edu). This award broadly encompasses new discoveries that may or may not have been published in peer review journals that are available in the public domain. The award is open to all postgraduate students and postdoctoral members who are in good standing.

References

Elliot Friedman, E. S., Rosenbaum M. A., Lee A. W., Lipson D. A., Land B. R. and Largus T. Angenent L.T. (2012). *A cost-effective and field-ready potentiostat that poises subsurface electrodes to monitor bacterial respiration*. *Biosensors and Bioelectronics*, 32(1), 309-313.

Sudeep C. Popat, Dongwon Ki, Bruce E. Rittmann, César I. Torres (2012), *Importance of OH- Transport from Cathodes in Microbial Fuel Cells* *ChemSusChem*, 5, 1071-1079

New Board of Directors

The ISMET Board was renewed last September

The outgoing members were President Bruce Logan, Vice President César Torres, and secretary Ashley Franks. During the next two years Korneel Rabaey, Lars Angenent and Abraham Esteve-Núñez will hold the positions of president, vice president and secretary, respectively.

This is the first rotation of the board of directors. Only active members are eligible for nomination and election. There are also new committee chairs: César Torres will take over the Membership committee, Miriam Rosenbaum will be in charge of the website committee and Falk Harnisch will be editing the following issues of

the newsletter. These new members will join the already existing chairs: Awards (Ashley Franks) and Conferences (Lars Angenent). The rate of turnover is expected to be high to get the entire ISMET membership a chance to get involved. The Board of Directors encourages all members to actively participate with their contributions and comments to the newsletter and the website.



Spinning-off: Plant-e, electricity from rhizodeposits

It started as a research proposal at the end of 2007 and now develops products in which living plants

How and when did you come up with the idea for Plant-e?

David Strik. The idea to start Plant-e came from two directions. It was during the preparation of a research proposal in 2007 when Bert Hamelers, Jan Snel, Cees Buisman and me discussed how to valorize the just developed Plant-Microbial Fuel Cell. We came to the conclusion that we would include in the proposal to initiate a spin-off company at the final year of the project. The postdoc of the project, which was me, approved to do his best effort in initiating this idea. Surely, at that time I was not sure how and when to start; though I do like adventures and I do like the idea that new promising technologies should be valorized. So this project started at the end of 2007 with the idea to start a company around 2011. So far so good.

Next, in 2008 Marjolein Helder came in the picture. She just finished her Master degree at the Sub-department of Environmental Technology – Wageningen University, and was searching for her dream. Marjolein was very interested in starting an Environmental Technology based company. While talking with Bert she found out about a new PhD position on the Plant-MFC. There she declared that she would like to fulfill this position on the condition that she could start a spin-off. So she started her PhD, and became even more enthusiastic after presenting the business case. Next, we founded Plant-e in September 2009 with great support of the *StartLife* and Wageningen University.

Since her PhD-graduation in November 2012 Marjolein is working full-time as CEO of Plant-e. Nowadays, David works as an assistant professor at Wageningen University, while supporting Plant-e's R&D one day a week.

Which are the products your company provides?

D.S. Plant-e develops products in which living plants generate electricity. The technology enables us to produce electricity with living plants at practically every site where plants can grow. The technology is based on natural processes and is safe for both the plant, and its environment. Plant-e is currently working on several types of products.

What are your competitive advantages?

M.H. To my best knowledge, there are no serious rivals in the picture. Most important advantage of the technology is that it enables a new source to produce electricity. The Plant-MFC is a unique way to produce electricity from rhizodeposits while keeping the biomass function intact. This added value of the technology may be sufficient for this unique application.

Which customers are you focused on?

We are developing different products. Green electricity roofs are aimed both at companies and individuals with a flat roof surface who want to produce their own electricity in a very sustainable way. Meanwhile we are developing a tubular system for implementation in natural areas. This system will be piloted in the field in spring/summer 2014. Customers for that system will be either land-owners (governments, nature conservation agencies, farmers etc.) or energy companies.

Where do you see Plant-e in 5 years time?

D.S. Of course, I cannot predict the future. Though I hope to see that Plant-e is enabling large-scale green electricity production from wetlands.

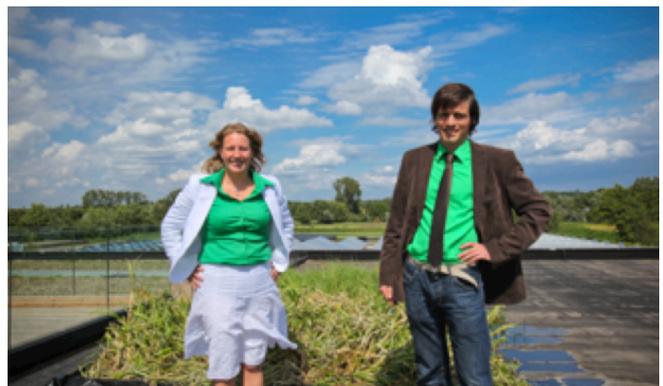
M.H. In 5 years time we hope to have fully developed the green electricity roofs and are operating worldwide. Around that time we will have implemented the first large scale system in a natural wetland as well.

What about METs in 10 years?

D.S. Fundamental knowledge, new applications and technological advancements on METs are advancing rapidly. World-wide numerous spin-off companies are starting. I am optimistic that the market for MET is existing and that within 10 years several applications are realized. It's fascinating to be part of the world of ISMET i.e. research and valorization. I am looking forward to the future!

A piece of advice to ISMET members to be starting up a business based on METs.

D.S. Numerous of (potential) MET applications exist. So grab the venture to make the world a greener place.



PhD Theses 2013

North America

Badalamenti, Jonathan

Title: Microbial Electrochemical Cells for Selective Enrichment and Characterization of Photosynthetic and Haloalkaliphilic Anode-Respiring

Host institution: Arizona State University



Forrestal, Casey

Title: Developments Towards Sustainable Microbial Electrochemical Systems for Simultaneous Deionization, Electricity Production and Wastewater Treatment

Host Institution: University of Colorado

Description: Casey's dissertation introduces multiple new reactor configurations including the Microbial Capacitive Desalination Cell (MCDC) and the Capacitive Microbial Desalination Cell (cMDC) for improved desalination. Additionally, the dissertation outlines a new reactor configuration for increased power output and an innocuous, high efficiency, low cost membrane.

Wang, Heming

Title: New electrode materials and active energy harvesting for microbial electrochemical systems, or MXCs

Host institution: University of Colorado

Description: Heming won the Graduate School Outstanding Ph.D Dissertation Award for her Ph.D research on new MFC electrode materials, active energy harvesting, commodity chemical production from wastewater, etc.



Friedman, Elliot

Title: Bioelectrochemical systems as tools to study subsurface biogeochemical processes

Host Institution: Cornell University

Description: I developed a cost-effective and field-ready potentiostat, capable of long-term operation in remote areas with poised subsurface electrodes and measuring respiration of iron- and humic acid-reducing microbes. These systems were integrated with measurements of greenhouse gas emissions from soils and characterization of microbiome structure to study biogeochemical processes in multiple ecosystems.



TerAvest, Michaela

Title: Biological limitations of *Shewanella oneidensis* MR-1 in bioelectrochemical systems

Host institution: Cornell University

Description: *Shewanella oneidensis* is capable of transferring electrons to extracellular acceptors via both direct and mediated mechanisms, however it does so with a limited efficiency. This thesis investigated the reasons for the limited efficiency and ways to improve electron transfer rates from this organism (e.g., oxygen addition to enhance growth and mediator production).



Hussain, Abid

Title: Electricity production from carbon monoxide and synthesis gas in a microbial fuel cell (MFC).

Host institution: McGill University

Description: This study for the first time demonstrated electricity production in a MFC directly fed with carbon monoxide or synthesis gas, and elucidated the complex bio-electrochemical and transport phenomena involved in electricity production from syngas. Silicone membrane and multi-electrode MFCs were tested to increase the volumetric power output and Coulombic efficiency.

Cusick, Roland

Title: Nutrient and heat recovery from waste streams using microbial electrochemical technologies (*Received an Alumni Association Dissertation Award, 2013, from Penn State University*).

Host institution: Pennsylvania State University



Description: Two new METs were developed to enhance the sustainability of wastewater treatment. The first system coupled bioelectricity generation from wastewater organics with the recovery of nutrients via salt crystallization. The second MET was designed to enable the recovery of waste heat using thermolytic salinity gradients in microbial reverse electro dialysis cells.

Watson, Valerie

Title: Characterization and performance of activated carbon catalysts and polymer membrane layers for microbial fuel cell cathodes and an analysis of power overshoot. (*NSF Fellow, 2008-11*).

Host institution: Pennsylvania State University

Description: Examined different types of carbon for use as catalysts for oxygen reduction in microbial fuel cells. Tested different types of ion exchange materials to avoid cathode fouling while reducing impact of coatings on performance, and looked at ways to avoid power overshoot in power density curves.

Asia-Pacific

Yang, Qiao

Title: Research on Electrode Material and System Construction of Stackable Compact Bioelectrochemical System

Supervisor: Prof. Yujie Feng

Affiliation: Harbin Institute of Technology (co-cultivated with Penn State University)



Introduction: By applying heat pretreatment to anode, developing high capacitance cathode and using spacer to reduce the unnecessary distance of reactors, a compact stackable microbial fuel cell system was build up with a high performance and low cost.

Qu, Youpeng

Title: The configuration and performance of microbial



desalination cell under continuous flow

Supervisors: Prof. Bruce E. Logan and Prof. Yujie Feng

Affiliation: Harbin Institute of Technology (co-cultivated with Penn State University)

Description: We developed a recirculation microbial desalination cell (rMDC) to avoid pH imbalances and bacterial inhibition. A series of hydraulically connected MDCs was designed.

Cheng, Haoyi

Title: Selective reduction of nitrobenzene in bioelectrochemical system and the feasibility of energy loop compensation

Supervisor: Prof. Aijie Wang

Host institution: School of Municipal and Environmental Engineering, Harbin Institute of Technology, China

Description: Nitrobenzene was selective reduced to aniline at biocathode. The required electrons and energy were found to be partially compensated from the mineralization of the produced aniline at bioanode.



Zang, Guo-Long

Title: Complex waste treatment and photocatalytic hydrogen production based on the microbial fuel cells

Supervisors: Prof. Han-Qing Yu and Prof. Guo-Ping Sheng

Description: Plenty works were performed focusing on the conversion of lignocellulosic biomass and urine, pollutant degradation and hydrogen production using a proposed bio-photoelectrocatalytic cell with novel photoelectrocatalysis materials in MFCs.

Mao, Longfei

Title: Flux balance analysis to model microbial metabolism for electricity generation

Supervisor: Dr. Wynand Verwoerd.

Host institution: Lincoln University, New Zealand

Description: The PhD thesis employed *in silico* metabolic engineering techniques to model the optimal metabolic states and flux adjustments of the four selected microbial species (i.e., *Geobacter sulfurreducens*, *Chlamydomonas reinhardtii*, *Synechocystis* sp. PCC 6803 and *Sacharomyces cerevisiae*) for MFC electricity generation.

Europe

Uría Moltó, Naroa

Title: Microbial Fuel Cell Performance: design, operation and biological factors

Institution: Genetics and Microbiology Department, Universitat Autònoma de Barcelona, Barcelona, Spain

Supervisor: Jordi Mas Gordi

Description: The efficiency of a MFC depends on the metabolic activity of the microorganisms growing at the anode but also on a large number of factors related to the design and operation of the MFC. The purpose of this work was to contribute to the analysis and control of some of these factors as well as to throw some light on the role of different electron transfer mechanisms in MFC operation.



Escapa González, Adrián

Biocatalyzed Electrolysis for Wastewater Treatment and Hydrogen Production

Supervisor: Antonio Morán Palao

Institution: Instituto de Medio Ambiente, Recursos Naturales y Biodiversidad, Universidad de León, Spain

Description: The aim of this thesis has been studying the techno economic feasibility of Biocatalyzed Electrolysis (BE) for wastewater treatment.



Sánchez Molas, David

Title: Hybrid integration of MEMS technology and rapid - prototyping techniques: Design, fabrication and characterization of miniaturized microbial fuel cells and electrochemical devices

Institution: Institute of Microelectronics of Barcelona (IMB-CNM, CSIC, Spain

Supervisors: Francesc Xavier Muñoz y Francisco Javier del Campo (BioMEMS)

Description: The aim of this thesis is to improve the performance of miniaturized microbial fuel cells and electrochemical sensors. To achieve this goal, this thesis focuses on the development of new electrode materials and better fabrication and packaging processes.

Pastorella, Gabriele

Title: Genome shuffling of *Geobacter metallireducens* for enhanced electrochemical response

Host institution: School of Biotechnology, Dublin City University, Dublin, Ireland

Description: In this study, we improved the *G. metallireducens* electroactivity through genome shuffling. In particular, M23 mutant showed two-fold increase in electroactivity with respect to the wild type strain.

Desloover, Joachim

Title: Quantification, understanding and mitigation of nitrous oxide emissions from biological nitrogen removal processes

Supervisors: Prof. Emer. Willy Verstraete, Prof. Nico Boon and Prof. and Prof. Korneel Rabaey

Host institution: Faculty of Bioscience Engineering, Ghent University, Belgium

Description: The N₂O emission from a full-scale BNR plant was quantified, and the involved microbial reactions responsible for N₂O production were investigated. In a second phase, both curative and preventive mitigation strategies were investigated, aiming at minimizing the N₂O emission from BNR processes.

Arends, Jan

Title: Optimizing the plant microbial fuel cell: diversifying applications and product outputs

Supervisors: Prof. Nico Boon, Prof. and Prof. Korneel Rabaey and Prof. Emer. Willy Verstraete

Host institution: Faculty of Bioscience Engineering, Ghent University, Belgium

Description: In this work, different components and designs of the plant-MFC were investigated in order to optimize electrical power output, find new niches for application or new products other than electrical power.



Save the date: future regional meetings

The ISMET Local committees are already organizing the regional meetings to be held this year. Researchers and students are invited to participate to stay connected with the most recent developments in microbial electrochemistry and its technological advances.

The meeting dates are as follows:

2nd NA-ISMET: May 13-15, 2014 at PennState University, University Park, USA. Call for abstracts. Further details at www.engr.psu.edu/naismet2014

2nd AP-ISMET: July 21-24, 2014, Singapore

2nd EU-ISMET: September 3-5, 2014 at University of Alcalá, Spain

If you are not already an ISMET member, please consider joining us at www.is-met.org.

Stay tuned for updates and more information!

Job opportunities

Faculty Position in Environmental Engineering - University of Nevada, Reno

The Department of Civil and Environmental Engineering at the University of Nevada invites applications for a tenured faculty position in the area of environmental engineering. The position is expected to be filled at either the full or associate professor level with a start date of July 1, 2014.

Candidates must have a Ph.D. in environmental engineering, civil engineering, or a closely related field of study. The selected candidate must have a strong research background in environmental engineering and have demonstrated leadership ability with proven interpersonal skills. In accordance with the University's mission as a land grant institution, the candidate is expected to continue a sustained and dynamic externally funded research program, to supervise Ph.D. and M.S. students, to teach undergraduate and graduate courses, and to participate in university and professional service and outreach. To be considered for the rank of full professor, applicants must have an exceptional research record and be widely considered as a distinguished scholar and teacher, while for the rank of associate professor, applicants must have a documented record of funded, quality research, and excellent teaching. Applicants should submit their curriculum vitae,

statement of research interest, teaching philosophy and contact information for five references electronically at: <https://www.unrsearch.com/postings/12960>

Postdoctoral research fellow position – La Trobe University, Australia

The Department of Microbiology at La Trobe University offers a research fellow position. Candidates are sought who have completed or recently submitted a PhD in Microbiology, Biochemistry, Molecular Biology or a related discipline. For further details please contact Dr. Ashley Franks (a.franks@latrobe.edu.au).

Two postdoctoral fellows positions – SCELSE, Singapore

The Singapore Centre on Environmental Life Sciences Engineering (SCELSE) is a unique interdisciplinary Research Centre of Excellence (RCE), funded by National Research Foundation, Singapore Ministry of Education, Nanyang Technological University (NTU) and National University of Singapore. Applications for two postdoctoral fellows positions are being evaluated within a two-year MFC-related project, which aims to develop a novel bioelectrochemical sensor for wastewater. Applicants should have a PhD in bioelectrochemistry/MFC or molecular microbiology. For further information, please contact Enrico Marsili at SCELSE (emarsili@ntu.edu.sg).

Newsletter editorial board members

Editor Dr. Abraham Esteve-Núñez, University of Alcalá

Contributors to this issue Dr. Korneel Rabaey, Ghent University; Dr. David Strik, Wageningen University; Dr. Frédéric Barrière, Université de Rennes 1; Dr. Stefano Freguia, University of Queensland; Dr. Federico Aulenta, Water Research Institute, Italy; Dr. Enrico Marsili, Dublin City University; Dr. Ashley Franks, La Trobe University; Dr. Tristano Bacchetti de Gregoris, IMDEA Water, Spain; Dr. Xin Wang, Nankai University

Publishing coordinator Belén Barroeta, University of Alcalá

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