ISMET
International Society
for Microbial Electrochemistry
and Technology

ISMET news

Quarterly newsletter No. 5 – Jul 2014

A world full of opportunities

A world full of opportunities, awardees, networks and chances for business

Dear **ISMET news** readers,

I am very happy to spread around 2nd *ISMET news* in 2014 and hopefully it brings to you some enjoyable reads. Maybe get started with getting to know the two 2014 ISMET-Award winners Dr. Kun Guo working in Ghent and Dr. Krishna Katuri from KAUST. If you are as oriented on transfer to praxis as our both 2014 awardees, you will probably find the interview with Dr. Justin Buck, Co-founder and CTO of Cambrian Innovation, very stimulating and encouraging for starting your own business.

As in our multi-optional world a lot of things can happen virtual and virtually in parallel, I am very happy (and thankful to the authors) that the ISMET news provides conference reports on the NA-ISMET and AP-ISMET meetings. This might recall some memories of attendees and bring a good overview for those, who couldn't make it. It will bring our feet to ground when looking on the historic foundation of our profession, this time going back more than 250 years. Furthermore, you'll also find information on new projects, networks, conferences and even a new job!

Please enjoy our *ISMET news,* no matter if you use the computer screen in your office or have a print-out at your fingertips on the beach.

See some of you in Alcalá and we'll certainly meet in the next ISMET news by end of 2014

Yours,

Falk Harnisch
Editor

NA-ISMET meeting, a big success at Penn State University

The North American ISMET meeting was held at Pennsylvania State University in State College, PA on May 13th-15th. While targeted to North American researchers, the conference drew people from as far away as China to discuss all aspects of microbial electrochemistry research.

The conference started out with a great workshop on methods used in studying microbial electrochemical technologies. Dr. Roland Cusick discussed how electrochemical impedance spectroscopy could be used to tease out the different resistances encountered in electrochemical cells. Jaroslaw Syzdek from Bio-Logic explained the importance of using specially designed wires that come with commercial potentiostats to avoid noise in our experiments. Dr. Lenny Tender explained how to use gated potentials on two electrodes to measure the electron transport rates through electrochemically active biofilms grown between the two electrodes. Finally, Dr. Fang Zhang showed the importance of the placement of reference electrodes outside of the ion path in electrochemical experiments.

Keynote speakers included Dr. César Torres, Dr. Korneel Rabaey, Dr. Derek Lovley, and Dr. Mike Hickner. Dr. Torres talked about how pH and ionic gradients are major limiting factors in making efficient MXC for real applications. Dr. Rabaey demonstrated how modifying the surface chemistry of stainless steel electrodes could improve colonization and attachment. Dr. Lovely presented on autotrophic biocathode production of useful products in *Clostridium ljungdahlii*. Dr. Hickner expanded on the importance of ion flow in MXCs by showing how the membranes used can and need to be improved to increase energy efficiency.

Among the many other great presentations, Dr. Moh El-Naggar and Nathan Kirchhofer were two of the most notable for me. Dr. El-Naggar's videos of *Shewanella oneidensis* nanowires and discussion on

their lack of pilin protein opened up the door to many questions about extracellular electron transport mechanisms in *Shewanella*. Nathan showed how modification of *Shewanella* with conjugated oligoelectrolytes could improve current production without major cytotoxicity, demonstrating a novel method for chemically modifying one of our favorite microorganisms.

The poster session was very engaging, and continued even beyond the allotted time. Afterwards, Dr. Linda Chrisey gave a great talk from the Office of Naval Research on the history of METs from the point of view of the Navy who continues to support many research projects in the field. Overall, NA-ISMET was a great success with many networking opportunities. We here at Arizona State University hope to see all of you, including those who could not make it out, next year for ISMET 2015.

Joseph Miceli III, Arizona State University

AP-ISMET meeting in Singapore, exciting discussions and networking

The second Asia-Pacific ISMET meeting was organised by the Centre for Water Research (CWR) at the National University of Singapore and took place at the university campus over a two-day period. Fifty-odd delegates flocked in from all corners of East Asia, India and Australia to share their progress in MET research.

Despite the scorching heat and debilitating humidity, the conference participants managed to engage in exciting scientific discussions and mingled their way towards their next international collaborations. The talks were all engaging and mind-stimulating, led by example by the world-class crew of invited speakers, including plenary speakers Byung Hong Kim (Malaysia) and Bruce Logan (USA) and keynote speakers Ashley Franks (Australia), Satoshi Okabe (Japan), In Seop Chang (Korea), Booki Min (Korea), Taeho Lee (Korea), Jurg Keller (Australia), Srikanth Mutnuri (India), Korneel Rabaey (Belgium), Kazuya Watanabe (Japan), Venkata Mohan (India) and Yujie Feng (China).

The scope of the conference covered all areas of MET research, from microbial and electromicrobiological aspects, through electrode materials to applications, the latter spanning from wastewater treatment to solar cells and resource recovery: the mix of expertise areas which makes MET so unique and challenging!

The participants included academics of all levels, industry affiliates and postgraduate students. It was slightly discouraging to see that students were by a large margin outnumbered by seniors, a trend that we hope to see reversed in future AP meetings.

The keynotes

The conference started with a talk by MET forefather Prof. Byung Hong Kim, who shared his latest thoughts on oxygen biocathodes and handed out plenty of valuable technical hints to a cheering crowd. He concluded by challenging the audience with the enigma “what is the carbon source for bacteria at oxygen biocathodes?”

The second keynote speech was by MET titan Prof. Bruce Logan, who shared his group’s latest advances on electrode materials and configurations of MFCs for wastewater treatment. Bruce made everyone in the room freeze when he suddenly declared that “MFCs cannot be used for wastewater treatment”. Disconcerted faces were relieved when – a few seconds later – he amended his statement to a much milder “MFCs *alone* cannot be used for wastewater treatment”: by Logan’s vision, the way to go is the coupling of MFCs to anaerobic fluidized membrane bioreactors (AFMBRs) for complete wastewater treatment.

A special note must be made to the organising committee led by Prof. How Yong Ng, who went out of their way to keep attendees entertained during coffee and lunch breaks, and arranged for a massive multi-course feast and free flowing wine and beer at the gala dinner.

Best poster awards were conferred to Ms Jia Jia Li from Shandong University (China) and to Ms Praveena Gangadharan from Indian Institute of Technology Madras (India). As the announcement was made, they were loudly cheered by a drunken crowd. Congratulations!

Stefano Freguia, AWMC/University of Queensland

From top to bottom: awardee Praveena Gangadharan; awardee Jia Jia Li; MFCs cannot do it? “Cannot do it alone”, he says. Puhhh.

ISMET AWARDS 2014

Discovery Award winner Kun Guo and Innovation Award winner Krishna Katuri talked to our newsletter about their research and their expectations.

Kun Guo is currently a postdoctoral researcher at the Laboratory of Microbial Ecology and Technology (LabMET), Ghent University (UGent). He has been working on microbial electrochemical systems for 6 years. His main research interests are electrode materials, electrode surface modifications, and microbial electrochemical systems reactor design.

Kun earned his Bachelor of Biotechnology in 2007 from Heilongjiang University and Master of Biochemical Engineering in 2010 from Chinese Academy of Sciences (CAS). Then he worked as a Research Assistant in the Institute of Process Engineering, CAS for half a year. After that, he started his PhD in January of 2011 at Advanced Water Management Centre, The University of Queensland (UQ). In October of 2012, he moved to Belgium to conduct second half of his PhD at LabMET, UGent under a joint-PhD program.

In June of 2014, he was awarded the PhD of Environmental Engineering and PhD of Applied Biological Sciences by UQ and UGent, respectively.

What does this award mean to you?

This award is an amazing honor to me and it encourages me to dig deeper in the interaction between bacterial cell membrane and electrode surface in microbial electrochemical systems.

Where do you see the fundamental science going in the next 10 years of microbial electrochemistry?

More knowledge should be gained on electroactive bacteria in terms of strains and electron transfer mechanisms. We need to find and/or breed some “super bugs” with high electrochemical activity. Also, we still need to clarify the extracellular electron transfer mechanisms especially the direct electron transfer from electrode to bacteria. What is more, it is very interesting to investigate the impact of surface chemistry and topography on anodic/cathodic biofilm formation and electron transfer, thereby further enhancing the performance of MET.

Could you give a visionary statement about the role of microbial electrochemical technology in the future.

Nowadays, renewable electricity can be produced cheaply by solar panels and wind turbines. Thus, using MET to produce electricity is less attractive in the near future. However, it has been reported MET can be used to fix CO_2 and the electricity into valuable chemicals such as fatty acids. Hence, MET

might be a promising technology for CO_2 fixation and electricity power storage.

Currently the high capital cost prevents the scale-up for wastewater treatment, which makes microbial electrochemical systems less competitive than traditional wastewater treatment technologies such as anaerobic digestion. However, we might combine this systems with other technologies to take advantage of the synergies. For example, we could use MET to produce NaOH and H_2O_2 which can be used for pH maintaining of anaerobic digestors and disinfection of wastewater, respectively.

What area of research would you recommend to newcomers to the field?

I would recommend the newcomers the following research areas: 1) high-performance and scalable electrode materials; 2) Microbial electrosynthesis of high valuable fuels and chemicals; 3) Integration with other wastewater treatment technologies.

Krishna Katuri received his Ph.D. in 2005 from the Indian Institute of Chemical Technology. He was awarded the Marie Curie postdoctoral fellowship twice, and carried out research on bio-electrochemical systems at Newcastle University (2006 - 2008) and the National University of Ireland (2008 - 2011). His research focused on the principles of electromicrobiology for renewable energy generation using bioelectrochemical systems. He joined King Abdullah University of Science and Technology (KAUST), Saudi Arabia in 2012 as SABIC postdoctoral fellow and in 2014, he was promoted to a Research Scientist. Krishna's research at KAUST focusses on the development of energy self-sufficient anaerobic bio-electrochemical membrane bioreactors for domestic wastewater treatment. He has published 40 peer-reviewed journal articles and holds 4 patents on various aspects of electromicrobiology, microbiology of electroactive biofilms, biological wastewater treatment and fermentation technology.

What does this award mean to you?

I am grateful to the ISMET Award Committee for this recognition which gives me confidence in the research I am undertaking. Most importantly, I feel it's a reward of the hard work I have put into this field since 2006. This award also highlights the

contribution that our research group is making to the field of MET.

Look forward to watching the ISMET society grow in its efforts to promote BES research as an alternative sustainable technology to meet future global water-energy demands.

Where do you see the fundamental science going in the next 10 years of microbial electrochemistry?

I believe there will be more focus on the following fundamental areas in the coming next years: Interspecies electron transfer; Identification and isolation of novel exoelectrogens from extreme environments for niche applications such as hypersaline wastewater treatment or thermophilic wastewater treatment; I see a more role of methanogens (e.g. electromethanogenesis) in electromicrobiology in the near future.

More work on understanding the ecophysiology of organisms with extracellular electron transfer capability using various omic tools (genomics, transcriptomics, proteomics and metabolomics).

Could you give a visionary statement about the role of microbial electrochemical technology in the future.

Based on current knowledge, I see a great potential to use METs for domestic wastewater treatment. The microbial electrolysis cell (MEC) is a unique platform to develop a low-energy or energy positive and sustainable biotechnology for the treatment of low-organic strength wastewaters. Integrating METs with porous membranes, enables wastewater treatment and water reuse applications, while integration with nutrient removal bioprocesses, such as anammox, achieves a tailored effluent for discharge to the environment. The concept of METs integration to membrane processes opened a door to address the water-energy-food nexus, a global challenge facing society today.

What area of research would you recommend to newcomers to the field?

Since MET is multidisciplinary, both fundamental as well as applied scientific insights are needed in each discipline to advance the field. Since I'm a microbiologist, I think a better insight of the microbial ecology of anodic and cathodic communities and their ecophysiology is crucial to further develop METs. Integrating cutting-edge molecular biology tools with bioprocess engineering will allow us to explore the interactions of mixed microbial cultures (bacteria and archaea) involved in the microbial transformation reactions of real wastewaters. These new approaches also provide information on the community structure and function.

The development of isolation, enrichment and identification techniques to search for novel microorganisms with extracellular electron transfer capabilities may yield enhanced performance. These are areas that newcomers would find exciting and would be of benefit to the research community.

Engineering and materials research areas that newcomers can venture into include the development of biocompatible, engineered electrode materials to accommodate high biomass on the electrode surface (anode and cathode), novel electrode architectures to increase electrode surface areas and the development of earth abundant cheap cathode catalysts. Leveraging the advances in materials science will aid in a paradigm shift in current thinking on the future application of METs for maximizing resource recovery from wastewaters as well as for other specific applications.

Cambrian Innovation: advanced environmental solutions using biotechnology

Cambrian Innovation develops advanced environmental solutions using biotechnology, focused on the intersection of energy and water. Dr. Justin Buck, Co-founder and CTO talked to ISMET News member Dr. Deepak Pant (VITO) about EcoVolt, Cambrian Innovation and their technology platform.

With a core competence in microbial energy conversion, electrochemistry, and bioelectrochemical systems, their product pipeline helps industrial, government, and agricultural customers monitor their operations and recover energy, resources, and clean water from process water and wastewater streams, maximizing return on investment and minimizing environmental impact. Recently they introduced EcoVolt, which they describe as the world's first bioelectrically enhanced wastewater treatment system.

How was Cambrian Innovation established? How is it doing currently?

Cambrian Innovation was started as a spin off from MIT in 2006 by the current CEO, Dr. Matthew Silver, me and few other colleagues. We were particularly interested by the idea of bacteria producing electricity, which was being reported very frequently at that time. Our initial funding came from a NASA grant to explore how recent advances in bioelectricity can enhance water management in space. In the following years, we have acquired funding from private investors, as well as other sources such as Environmental Protection Agency (US EPA), US Department of Defense (US DoD), US Army, National Science Foundation (NSF) etc., and transitioned our focus to wastewater treatment projects for terrestrial applications. We've had a slow and steady growth.

Currently, we are marketing a technology platform for wastewater treatment using bioelectrochemistry. We came out with our first product, EcoVolt, recently and are developing other products that we plan to bring to market.

Tell us something about EcoVolt? How long did it take to develop and bring to market? What is the price of individual unit?

The concept of EcoVolt was initiated in 2009 and the first grant to develop it came in 2010 from NSF. In 2011, Cambrian began operating multiple pilot EcoVolt systems. In 2012, a small demonstration plant was installed in a winery and in early 2014, the first commercial system was launched.

EcoVolt uses a particular kind of bioelectricity, called electromethanogenesis, in which biologically coated electrodes in the reactor rapidly convert organic pollutants into electricity and secondary electrodes subsequently convert electricity into methane fuel. The methane produced by EcoVolt is high quality and can be used in a combined heat and power system to generate clean heat and power at a facility. The net result is clean water and renewable methane, from wastewater.

The price of an individual unit depends on the size as well as the application for which it is built. Even though the units being built are more or less standard, it is possible to adapt them based on application.

How many EcoVolt units sold till now?

As mentioned two units have been placed so far, one in a brewery and another one at a winery, both in the US. One has been in operation for 16 months, while the other has been running for 6 months now. EcoVolt is available in three specifications: EcoVolt Mini (100-600 KG BOD/Day), EcoVolt (100-9500 KG BOD/Day) and EcoVolt XL (2000+ KG BOD/Day).

What has been the response from the clients who bought EcoVolt? Do you get feedback from clients like operational data to improve the future units?

Cambrian provides full support system to clients who buy EcoVolt. This includes a full operation package and remote monitoring as well. Using these monitoring capabilities, we can gather the data from an EcoVolt remotely. EcoVolt installations are prefabricated and modular, reducing the non-recurring engineering costs along with a great reduction in installation time and cost.

What new developments can we except from Cambrian in coming months/years?

Even though the EcoVolt system incorporates our bioelectrochemistry, we are still working on a full-scale commercial microbial fuel cell (MFC) system for wastewater treatment. We are developing it with the US Department of Defense (DoD). Besides that, another potential application we are currently developing is the denitrification and sensing systems, such as nitrate sensor technology for detecting nitrate in surface or ground water.

Who are your research collaborators? We are aware of Prof. Bruce Logan (Penn State) and Dr. Jeffrey Hoffman (MIT). Any others who inspire the guys at Cambrian? Does Cambrian collaborate with other universities/research institutes?

We always have a lot of communications with academics and researchers all over the world. We have been in contact with Prof. Korneel Rabaey from Ghent University and current president of ISMET since we started the company. We have also been communicating with Prof. Lars Angenent. We often go to conferences and workshop and meet fellow researchers.

Any plans to get into the microbial electrosynthesis business or you want to consolidate things in the wastewater treatment sector first?

We are very excited about this new application of bioelectrochemistry and we are at the moment carefully evaluating the developments in this area. In the future, depending on the research advancements this could be a potential area of interest for us but at the moment we want to consolidate our focus on the wastewater related applications. We feel we have made a headstart there, and that it is the area where we can come up with innovative solutions that can make an impact in the near future.

Are you aware of any other company with a product based on bioelectrochemistry in market? How do you keep ahead of the competition?

No, none that I know of. We are very proud of the fact that EcoVolt is thus far the first commercial product based on the bioelectrochemical technology to come out in the market.

Do you have any suggestions for ISMET members/researchers who might have an entreprenurial streak in them?

The main point I would suggest is to find a key platform technology and find a great entry point for the product that you develop. Another important message is to continue the research and try to be at the forefront of the technology market you are developing. Also important is to build up a decent IP

portfolio. Building up a company needs blood, sweat and tears and one should be ready for all of them. Be very prudent with your finances as that will determine the survival of your company especially during the lean periods. The main thing is to be in business, so timely and adequate funding is very crucial.

Also regardless of the technology, your drive, dedication, persistence and ability to face the ups and downs will determine your success. Last but not the least is the team with which you grow and develop. You can't build a successful company without having a good team and we at Cambrian Innovation are fortunate to have one.

How do you see the MET/BES field in a decade?

We are pretty excited about the technologies that are coming out of the bioelectrochemical platform. The previous decade was a time of understanding the principles and mechanisms and now the results are coming out in terms of applied products. In the future, we expect a better understanding and control of electroactive biofilms. Also more elegant solutions especially in the wastewater treatment sector can be foreseen. There will be more developments and interaction among the biology, material science and electrochemistry that will lead to new avenues in treatment.

Announcements

The **'In Situ Remediation 14'** conference will take place from 2 to 4 September in London, UK.

More information at

http://theadvocateproject.eu/conference/main.html

2nd EU-ISMET: September 3-5, 2014 in Alcalá de Henares, Spain.

There are still vacancies in the *Electroactive-biofilm workshop*. More details at www.eu-ismet2014.org

Foundation of the New German Workgroup of Electro-Biotechnology at the DECHEMA

In April 2014 the workgroup of electro-biotechnology (Elektrobiotechnologie) was founded at the DECHEMA, Frankfurt. The aim of DECHEMA (Society for Chemical Engineering and Biotechnology) is to bring experts from science, business and the authorities together. One core activity is the organization topical work groups – here already of about 20 established in biotechnology alone. Due to the fact that the development of efficient electro-biotechnological process requires the expertise from a wide range of disciplines – electrochemistry, biochemical engineering, materials science, and molecular biology – that are already organized in DECHEMA, the electro-biotechnology work group is embedded in an ideal environment.

The work group electro-biotechnology covers a wide range of topics, e.g. energy conversion in microbial and enzymatic fuel cells, microbial and enzymatic production processes, the application of electro-biotechnological processes in re-mediation and bio-mining as well as in downstream processing. During their first meeting the participants decided to prepare a position paper on the trends and prospects of electro-biotechnology aiming to bring the field more in focus of the (German) authorities and industry. This paper is expected to be published in June 2015 at the ACHEMA. For further information and if you want to join, please contact Dirk Holtmann (DECHEMA Research Institute, holtmann@dechema.de).

Dirk Holtmann & Falk Harnisch

ISMET jobs: Technology corner administrator

The ISMET website committee is looking for a highly motivated volunteer to join the team for serving as technology corner administrator. You will contribute to the development of the ISMET website and certainly benefit of getting first-rate involvement in the ISMET website development as well as the ISMET community as a whole.

Please contact the committee chair: miriam.rosenbaum@rwth-aachen.de

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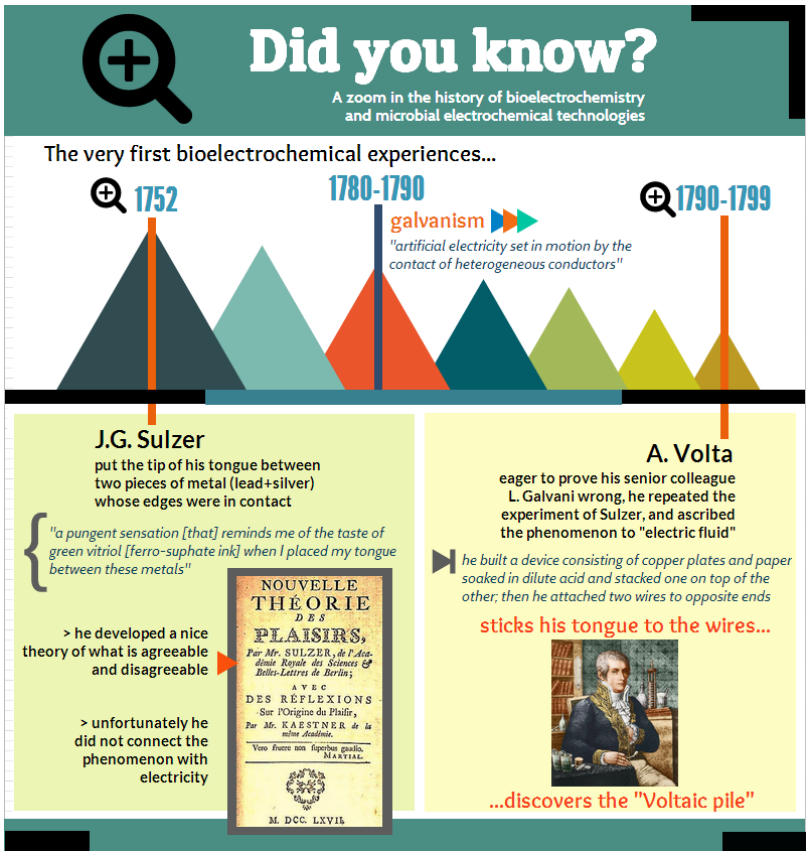

Job opportunities

Up to 4 Postdoctoral Research Associate Positions available in the UK

We are seeking PDRAs to work on a multicentre, interdisciplinary research programme on the development of bioelectrochemical systems (BES) for the recovery of resources from wastewaters. The project brings together teams from Newcastle University, Manchester University, The University of South Wales and the University of Surrey along with a range of industrial and international collaborators.

Ideally the positions will commence in August/September 2014 but there may be some flexibility in start dates.

Applicants with interests in cathodic metal recovery or microbial electrosynthesis should contact Prof. Ian M. Head at Newcastle University (ian.head@newcastle.ac.uk).

Applicants with interests in cathodic production of functional nanomaterials should contact Prof. Jon R. Lloyd at Manchester University (jon.lloyd@manchester.ac.uk)

Applicants with interests in scale up of bioelectrochemical systems should contact Prof. Guiliano Premier at the University of South Wales for further information (iano.premier@southwales.ac.uk).

PhD scholarship – AWCM/CEMES, Australia

The Centre for Microbial Electrochemical Systems (CEMES) at the University of Queensland is seeking a highly motivated candidate to undertake a PhD within the project *Microbial fuel cells for nutrient recovery from source-separated urine*. This project aims to develop a bioelectrochemical system for the sustainable recovery of nutrients from source-separated human urine. The successful candidate will undertake lab and pilot work. Award of scholarship will be based on academic merit. For more information contact Dr. Stefano Freguia at s.freguia@uq.edu.au

Post-doctoral researcher – Portugal

The inorganic biochemistry and NMR group is looking for a post-doctoral researcher with background in (bio)electrochemistry to join the team in 2015. We seek a post-doctoral researcher to reinforce the work on MFCs and related devices in order to translate our basic biochemical knowledge into improved operational characteristics of bioelectrochemical devices. The group provides a multidisciplinary environment for biochemical and biophysical research with opportunities for training in complementary techniques.

More info on our activities, interests and publications can be found in the group's web page www.itqb.unl.pt/~louro.

Interested candidates please contact Dr. Ricardo O. Louro indicating their motivation, a brief CV (2 pages) and names of up to two researchers that may provide references.

Unfunded candidates will be supported in the application for Post-Doctoral fellowships by the Portuguese Science Funding Agency.

PhD vacancy – (Bio)electrochemical recovery of critical metals from aqueous solutions - VITO, Belgium

Candidates should have an outstanding CV and demonstrable excellence in electrochemical engineering (computational modeling skills are sought). Previous experience in metal recovery is valued. Applicants should send their CV and research proposal highlights to Xochitl Dominguez-Benetton (xoch@vito.be). Suitable candidates will prepare an extended proposal to be defended with a jury. Funding and regulations detailed at https://www.vito.be/ Deadline for application: 15th September 2014

Postdoctoral or sabatical vacancy for outstanding Mexicans – VITO, Belgium

Mexican candidates are invited to apply with VITO as hosting institution for CONACyT postdoctoral grants. Candidates should have an outstanding CV and demonstrable excellence in bioelectrochemistry. Previous experience in biofilm-metal interactions will be valued. Applicants should send their CV and to Xochitl Dominguez-Benetton (xoch@vito.be). Suitable candidates will prepare an extended proposal to be submitted via CONACyT. http://www.conacyt.mx/index.php/becas-y-posgrados/becas-en-el-extranjero

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