Dear ISMET members,

I feel honoured for editing this 2nd issue of ISMET News a few weeks before we meet all together at MFC4 meeting (Cairns, Australia). Along this summer a large number of MET-related works has been successfully presented in general scientific meetings as SIMB, AEESP and FEMS to name a few. The presence of MET-related presentations is rapidly growing, showing a definitive interest of the microbe-electrode interaction to many general scientific societies. This rise of interest is a solid consequence of the multidisciplinary nature of our discipline. Clean energy was of course the first hook ten years ago, but we knew that exoelectrogenic bacteria were way-too-cool to be just associated with MFCs. Creativity and curiosity made the rest and now we have a number of fascinating applications and a sparkling young scientific society. In that sense, we should welcome three new members of the ISMET Board of Directors. Daniel Bond (NA-ISMET), Federico Aulent (EU-ISMET) and Stephano Freguia (PA-ISMET), who will for sure spread their contagious enthusiasm in the following three years. We also have to thank Cesar Torres, Ashley Franks and Bruce Logan, who leave the Board after supporting the society from the very beginning.

It is now 10 years since Geobacter sulfurreducens was reported in AEM for breathing using graphite electrodes. We thought it would be a nice story to be told by the authors. So many unpredicted MET stories have been written since then. We will continue with this section in the following issues so a number of fascinating findings will be honoured.

METs are strongly associated with applied science and many start-up companies have bloomed in the recent years. We want to reserve space for them in our newsletter. It is our pleasure to hear from the enterprising leaders and to encourage young researcher to convert creative science into a business model. Emefcy co-founder, Eytan Levy left his testimony in the current issue, but many others will appear in our spinning-off section in the future. The multidisciplinary nature of METs is a well-accepted fact, and the integration of technological companies as part of the research consortia is becoming more common in large projects funded by Public administrations such as the European Research Council. We report in this issue some of these large projects that are now active and exploring different aspects of MET. Last but not least, I would like to point out that this newsletter is the ISMET forum, so do not hesitate to send us ideas for new sections or to participate with a written contribution or with a job offer that seek a position for working on METs.

In the meantime, prepare your luggage for travel to Queensland.

Abraham Esteve-Núñez
ISMET news editor
It is ten years since…

Daniel Bond and Derek R. Lovley’s AEM paper ‘Electricity Production by Geobacter sulfurreducens Attached To Electrodes’ was published in 2003. “Science is as much luck as anything”, they agree, but to paraphrase artist Pablo Picasso, luck has to find you working hard.

What did this discovery mean at that time?

**Derek Lovley.** This paper was a follow up to that we had published in *Science* the year before which demonstrated for the first time that microorganisms could convert organic compounds to electricity at high columbic efficiencies and that this could be a sustainable process because the microorganisms conserved energy to support their growth by direct electron transfer to electrodes.

In the earlier studies we focused on *Desulfuromonas acetoxidans* and *Geobacter metallireducens*, whereas the AEM paper reported the first detailed studies on *Geobacter sulfurreducens*. We had just developed methods for genetic manipulation of *G. sulfurreducens* and we published its genome in *Science* later the same year. This made it possible to begin to elucidate the mechanisms for electron transfer to electrodes through genome-scale gene expression and gene deletion studies.

**Daniel Bond.** I was pretty new to the idea of metal reduction and *Geobacter*. I thought about physiology, how a bacterium made a living, how fast energy went in and out, and how bacteria found a niche in the world. I started showing this stuff to Derek, he was the one who picked out one or two figures from my lab book and said: “These. It really was fundamentally a cool story, and while many had shown bacteria and electrodes shoved in boxes for decades, those one or two first figures opened a door.

A year before you published the fascinating finding that bacteria could generate electricity from mud. How did you feel about the potential implications of graphite electrodes breathing bacteria?

**D. L.** At the time it just seemed amazing that microorganisms could produce electricity via direct electrical connections with an electrode. Some potential applications in energy harvesting and bioremediation were obvious. However, we were still just growing monolayer biofilms on the anode at that time. I could not then foresee the bioelectronics aspects of it.

**D.B.** I really don't think I saw the implications like Derek did right away. I was aware this idea of biological batteries been done for decades, and fizzled each time. The other thing was, in those earlier waves of microbial fuel cells, dissimilatory metal reducing bacteria were unknown.

To this day, making power from mud, is one of the coolest things I've ever seen. It doesn't get old. I think it makes anyone dream of implications. I walk into the lab in the morning, and often the first thing I do is go over to the bank of potentiostats and just look at the traces. What I remember seeing back then, and I still believe now, is that electrodes provide a window into metabolism that doesn't exist anywhere else.

What did it mean this paper to your scientific career?

**D. L.** It seems like every couple of years *Geobacter* surprises us with a new, unexpected property. It was an incredible bit of luck that the organism that we had already been studying for some time for other reasons started turning up on electrodes harvesting electricity. The resulting studies on microbe-electrode interactions eventually led to many spin-off concepts. One of these is microbial electrosynthesis that has the potential to make a major contribution to sustainability as we move from a petroleum-based economy to an electric economy.

**D. B.** I was incredibly lucky to be in the right place at the right time. Derek was getting the molecular biology of *Geobacter* started, the genomics, tons of other discoveries were happening, and it was just exploding. Being involved in this research at such an early stage gave me a shot at finding my own small niche in the world. It's not lost on me that our AEM paper describing how to grow Geobacter was always more cited than any other paper I've ever published. Hands down, I think it has been more useful than any other paper-- I think a lot about that fact when we publish
now; about including full medium recipes, methods, replicates and methodology data.

Could you share a story related to those experiments?

D.L. The unsung hero in these experiments is Linda Chrisey at the Office of Naval Research. Linda came to me with the idea of investigating how microorganisms might be contributing to the current production of sediment microbial fuel cells. I seriously doubt that the ONR proposal that Daniel and I wrote to follow up on Linda's suggestion would have ever made it through the proposal peer-review system at other funding agencies, which has become so conservative it stifles most high-risk, innovative research. It has been Linda's continued vision of the possibilities of microbe-electrode interactions that has made possible many of the advancements in the field of electromicrobiology.

Microbial Electrochemical Techniques are a young field of research, but have experienced a boom in recent years. Did you think then that in a decade there would be so much interest in this research area?

D.L. The same week we published in Science on microbial current production we published a paper in Nature on a completely different topic, a deep subsurface microbial community fuelled by hydrogen. At the time there was at least as much press interest in the deep subsurface study, but if you go back and compare the number of citations it is clear which topic captured the imagination of the research community.

D.B. All this work was pre 'energy crisis', so the only people who cared about this for power back then was the Navy -- the mud battery was an idea that came out of an ONR meeting with Lenny Tender and Claire Reimers. So it took gas going to four bucks a gallon for microbial microwatts to seem so important all of a sudden, and produce such a community that then discovered all kinds of other ways to apply it.

Where do you see METs in 10 years?

D.L. Lessons learned from the study of how microorganisms interact with anodes and cathodes are likely to make important contributions to the emerging fields of bio-electronics and bio-computing. Application of microbe-electrode interactions for the development of environmental biosensors and bioremediation of soil and groundwater is likely to blossom. Microbial electrosynthesis of fuels and other organic commodities from carbon dioxide could become the technology with the biggest economic impact.

D.B. I still see through the eyes of a scientist who wants to understand bacteria, figure out how they work. If someone knows how to make money at this, have at it, but I remain excited by all the new ways electrochemistry can be used to study biofilms, to study electron transfer, and to add a level of control to anaerobic growth that wasn't possible before. I look forward to a day where, like chemostats or biofilm flow chambers, protein film voltammetry, or other new lab tools, things become more standardized. That's just the natural flow of science, but it's why organizations like ISMET are so important, to speed up that flow.

There are obviously so many other organisms out there that can interact with electrodes, that we haven't studied, someone's going to come along and surprise us all. There is so much undiscovered diversity, and while I enjoy a good metagenomic sequence as much as the next person, it's still new isolates that really wake us up.
METs under the European Commission 7th Framework Programme

Some collaborative projects relevant in the field are funded under this research scheme

The Seventh Framework Programme (FP7) for Research and Technological Development (http://www.cordis.europa.eu/fp7/home_en.html), the EU's main instrument for funding research in Europe, is running out at the end of 2013, giving the way to Horizon 2020 (i.e., the new funding Programme).

This note aims to highlight some of the collaborative projects relevant to microbial electrochemical technologies funded under this research scheme. Among them, there are BioElectroMET, ROUTES, MINOTAURUS, ModelPROBE, and KILL•SPILL.

Federico Aulenta, Water Research Institute (IRSA), National Research Council (CNR), Italy
Mauro Majone & Marianna Villano, Sapienza University of Rome, Italy

ModelPROBE

Model driven Soil Probing, Site Assessment and Evaluation (ModelPROBE) (www.ufz.de/modelprobe) is a collaborative project coordinated by the Helmholtz Centre for Environmental Research UFZ (Germany). The strategy of ModelPROBE is to provide an integrative toolbox for cost effective site screening, site characterization, and forensics to aid the soil thematic strategy and to be applicable in a future Soil Framework Directive. In this context, one of the tasks of MODELPROBE is the development innovative bioelectrochemical sensors and in-situ microcosms, which could be employed as survey systems for assessing contamination levels, extension of contamination sources, and for real-time monitoring biodegradation processes. These tools are expected to provide a sound basis for risk assessment and to decide on the most appropriate sustainable remediation strategy.

Integrated Biotechnological Solutions for Combating Marine Oil Spills (www.killspill.eu) is a collaborative project, led by the Technical University of Crete (Greece), focusing on novel biotechnological approaches to degrade petroleum hydrocarbons in the marine environment including marine sediments. KILL•SPILL is expected to develop biotechnologies adapted for the remediation of anoxic/anaerobic, fresh and chronically polluted, sediments. Among the diverse remediation approaches being pursued is the application of electrodes and microbial electrocatalysis to drive biodegradation processes within the contaminated sediments. For example, hydrocarbon biodegradation is achieved by electrochemical oxygen generation at the surface of carbon-based electrodes deployed in the contaminated sediments or sediment caps. Another example comprises electrodes behaving passively (i.e., with no external input of electrical power) and being employed to exploit the natural redox gradient existing between the anaerobic contaminated sediment and the overlying aerobic water. Such situation allows microorganisms to oxidize hydrocarbons using the electrode as terminal electron acceptor in their metabolism. Also being developed is a self-powered roaming bioelectrochemical system that creates an advective flow towards first a microbial fuel cell for power generation, and then subsequently to a microbial electrolysis cell for hydrocarbon degradation.
Bioelectrochemical Systems for Metal recovery (www.bioelectromet.eu) is a collaborative project led by Wetsus Centre of Excellence for Sustainable Water Technology (Netherlands). The project aims to develop innovative extraction techniques to increase mining sustainability, increase revenues and lower impacts on the environment. In this project, bioelectrochemical technology is proposed as an entirely new method for metal processing with the aim to produce marketable metal-containing (intermediate) products with low environmental impact compared to state-of-the-art technologies. The proposed approach can be used to recover (as biocathodic products) the base metals copper, nickel, iron, zinc, cobalt and lead, which are presently mined, processed and used in large quantities. These metals are ubiquitous in process- and waste streams from the mining and metallurgical industry and therefore application of bioelectrochemistry for these metals has a high impact. Compared to traditional techniques, the use of bio-electrochemical technology allows high recovery efficiencies, increased metal selectivity and reduced use of energy with in some cases (e.g. copper reduction) electricity production.

Concluding remarks

Despite the increasing involvement of scientists and stakeholders throughout European Institutions, no concerted actions have been done so far by the European Commission to boost research on microbial electrochemical technologies under FP7. Indeed, while fragmented research tasks/activities have been included in a number of projects, only a very limited number of projects entirely focusing on this topic have been funded. In view of the forthcoming release of Horizon 2020, there is an urgent need to push the European Commission to consider MET in future application calls. Only the financial support from EU will enable surmounting the interdisciplinary challenges that MET research is now facing and bringing the envisaged processes and technologies to the market.
The latest addition to the MFC4 conference program is a workshop on biofilm electrochemistry. This workshop is endorsed by ISMET and fully sponsored and organised by the Centre for Microbial Electrosynthesis (CEMES) at the University of Queensland, Australia.

One of the missions of ISMET and CEMES is to encourage the sharing of knowledge in the microbial electrochemical technology field. This is done via regional and global conferences, but also through continuing education. In such a multi-disciplinary field, we (students and academics alike) must strive to continuously learn to stay afloat in each of the key disciplines which microbial electrochemical technology builds upon. Is there someone in the field who claims to possess solid knowledge from electrochemistry to microbial ecology, and from microscopy to pilot scale reactor design? While we can gain some understanding of aspects of any of these disciplines by attending relevant presentations, long-lasting learning can occur just through education programs that are designed to provide scientists the knowledge and skills that are relevant in the laboratory setting. In this way, they can take their research to a truly multi-disciplinary level.

**Active and cooperative learning**

The CEMES Biofilm Electrochemistry Workshop is designed with this mission in mind. The teaching team comprises three early-career scholars who have used electrochemistry throughout their research career to understand the underlying principles of microbe-electrode electrochemical interactions in biofilms. The teaching team believes that learning electrochemistry cannot be achieved in short term through knowledge transmission via traditional lecturing or through hands-on workshops that are based on ‘cookbook recipes’. The teaching team instead embraces the spreading concepts of active learning and cooperative learning, whereby the learners construct knowledge in their minds while trying to solve real problems in a team. This mode of workshop delivery is typically more engaging for the learners, who will strive to ‘dig-out’ the truth, and by doing so they will acquire knowledge that they will not forget easily.

This style of electrochemistry workshop was piloted at the University of Queensland in 2012 with encouraging results. The CEMES Biofilm Electrochemistry workshop will be the first delivery in this mode at international level, which was made possible by ISMET and CEMES support to continuing education and life-long learning.

**Cyclic voltammetry**

Specifically, this Biofilm Electrochemistry workshop will focus on cyclic voltammetry (CV) as the key electrochemical technique to obtain essential information about your electroactive biofilm. By the end of the 2.5-day workshop, participants will be able to describe the working principles of CV; design and debug CV experiments; extract and analyse useful data from CV.


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**MFC4 updates**

The organization of the ISMET-MFC4 conference in Cairns is well underway, with abstracts currently under review by the international scientific committee. Exciting invited talks will include a bird’s eye view by Prof. Bruce Logan, keynote speeches by Prof. Lars Peter Nielsen and Prof. Cees Buisman, and additional invited presentations from Prof. Lars Angenent, Dr. Falk Harnisch, Prof. Korneel Rabaey and Prof. Xia Huang.

This conference is the 4th of the series, with themes accommodating the progressively diversifying nature of microbial electrochemical technologies. It is a must-attend conference for postgraduate students who want to put their own research in the perspective of the whole domain, as well as for seasoned academics that are curious about the most recent findings in the new “hot topics” in microbial electrochemistry. And after the conference, everyone should treat themselves for a few days between the rainforest and reef!

Spinning-off: Emefcy, wastewater treatment solutions

Founded in 2008 by experienced entrepreneurs in the field, the vision of Emefcy is to provide energy efficient wastewater treatment

Emefcy is a startup company with a vision to provide energy efficient wastewater treatment solutions. Most specifically: to commercialize electrogenic bioreactors (EBR), more commonly known as MFC. The company currently holds 25 employees and operates out of 3 sites: the offices and labs in Caesarea, Israel, a pilot site at a Wastewater Treatment Plant on the Carmel Coast and a production facility nearby.

CEO and Co-Founder Eytan Levy talked to ISMET news about his company.

How did you come up with the idea for Emefcy?

My partner, Ronen Shechter and I are experienced entrepreneurs in the field of advanced biological wastewater treatment technologies. We jointly founded AqWise in year 2000 and brought it into a significant global success (www.aqwise.com).

We started to look for ways to reduce the operational cost of wastewater treatment. We came to the conclusion that the space of Microbial Fuel Cell (MFC – this is also the phonetic source for our company name, Emefcy) is exciting and promising. We knew that the path to scale-up is long and challenging, but we realized that our experience, contacts and background would enable us to contribute to the commercialization of Microbial Fuel Cells.

Which are the products your company provides?

Emefcy develops the EBR (Electrogenic Bio- Reactor, the term we prefer to use for MFC or BES) and the SABRE (Spiral Aerobic Biofilm Reactor). Both provide energy efficient wastewater treatment.

What is your competitive advantage?

Besides the energy efficiency features, EBR and SABRE have a modular structure, enabling fast construction and gradual expansion, they have a very low sludge yield, they are odorless and silent. Their ‘black-box’ type of operation makes them robust and easy to operate. Their costs, both capital cost and operation cost, are lower than those of conventional technologies, in the market niches we intend to address by them.

Which are your customers?

EBR and SABRE are offered to municipal and industrial wastewater treatment plant owners. The modular nature of both sets size limits to which they are competitive. We prefer to offer them in applications that leverage the competitive advantages, in order to maximize the customer value.

Where is the watertech market going?

The market is becoming more and more open to new technologies. Innovation is welcome by municipal and industrial users. The conservative nature of this market and the price of failure make market penetration a challenging task for new. However, a good go-to-market plan can find ways to accommodate these obstacles. Generally, I believe that following the ‘membranes revolution’ we saw in the watertech market, the next growing spaces will be around ‘Wastewater Resource Recovery’ (10M Google results) and ‘Water Energy Nexus’ (2.3M Google results). Both very well connected to ISMET’s focus.

How do you see METs in a decade?

I believe that MET will provide an added tool in the toolbox of wastewater treatment professionals, aside MBR, SBR, RBC or CAS. It will definitely not be suitable for every application, and not for every size, but in some application it will become the leading solution. With the performance improvements and cost reduction over time, these systems will emerge to become a dominant wastewater treatment technology. Spin-off applications of MET may reach other industries, like biorefining and biotechnology, but these will follow an establishment of these technologies in the wastewater treatment market.

A piece of advice to ISMET members thinking about starting up a business based on MET.

The key is funding. The development process requires investment of tens of millions of dollars. The commitment of the founding team and the investors are a key criteria the eventually succeed in this difficult journey.
Job opportunities

Faculty Position in Environmental Engineering - University of Nevada, Reno

The Department of Civil and Environmental Engineering at the University of Nevada, Reno, 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.

Application materials will be held in the strictest confidence. All other inquiries may be directed to Prof. Ahmad Itani (itani@unr.edu), Department Chair. Full consideration will be given to all applications received by November 15, 2013.

Two senior Research Fellow (SRF) – 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 senior Research Fellow (SRF) 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).

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64th Meeting of the ISE up-to-date

The 64th Annual Meeting of the International Society of Electrochemistry, “Electrochemistry for a new era” will take place in Santiago de Querétaro, México from the 8 to 13 September 2013. Topics covered include electroanalysis, bioelectrochemistry, corrosion, fuel cells and batteries, to microbial electrochemical systems, among others. Tutorial 2 will be presented by EU-ISMET members Korneel Rabaey (UGent) and Xochitl Dominguez-Benetton (VITO), on the topic of Microbial Electro catalysis. Its aim will be to understand the underlying principles of microbial electrocatalysis and expand the knowledge for high-quality design, operation and characterization thereof. A special issue of the Society's journal, *Electrochimica Acta*, is planned based on selected original contributions made at the conference. Selection will be made by an international editorial Committee comprising the Editors and Guest Editors, one for each of the Symposia in which the meeting is articulated. The action of the editorial Committee will be co-ordinated by Sergio Trasatti, Editor-in-Chief of *Electrochimica Acta*. Submission only on invitation of one of the Guest Editors.