

Antwerp, 14/09/2015

Dear colleagues,

It is our pleasure to invite you to the Annual Dutch/Belgian meeting of the KNCV Working Group on Electrochemistry.. It will take place in Wageningen and will have the following theme:

Electrochemistry for quality of life

Date: **Friday, 6 November 2015**
Location: **Hotel de Nieuwe Wereld, Marijkeweg 5, 6709 PE Wageningen,
The Netherlands**

Programme description:

The theme of the meeting is a reference (with a wink) to the slogan of Wageningen University and Research Centre: *"For quality of life"*. The meeting focusses on the role of electrochemistry in sustainable development in relation to energy supply, re-use of materials and environmental technology. Topics include bioelectrochemical systems such as microbial fuel cells (MFCs), which convert chemical energy stored in organic substrates to electricity, electrochemical membrane reactions, capacitive deionization for electrochemical water desalination, and a novel bionanofluidic sensor for sensitive detection of phenolic compounds.

Registration:

You can confirm your participation via e-mail, see last page. The participation fee is €40 and includes lunch. You are kindly requested to transfer your payment before 26 October to:

IBAN: BE69 0016 7856 3778 BIC/Swift code: GEBABEBB, in name of:
Tom Breugelmans, Lindekensbaan 2, 2560 Kessel
Please mention "KNCV-EIChem" and the name(s) of the participant(s)

Alternatively, you can pay during registration at the symposium.

On behalf of the organizing committee,

Annemiek ter Heijne
Mieke Kleijn
Maarten Biesheuvel

Enclosed: Programme, map and registration information

Programme of the Annual Symposium of the KNCV Working Group on Electrochemistry

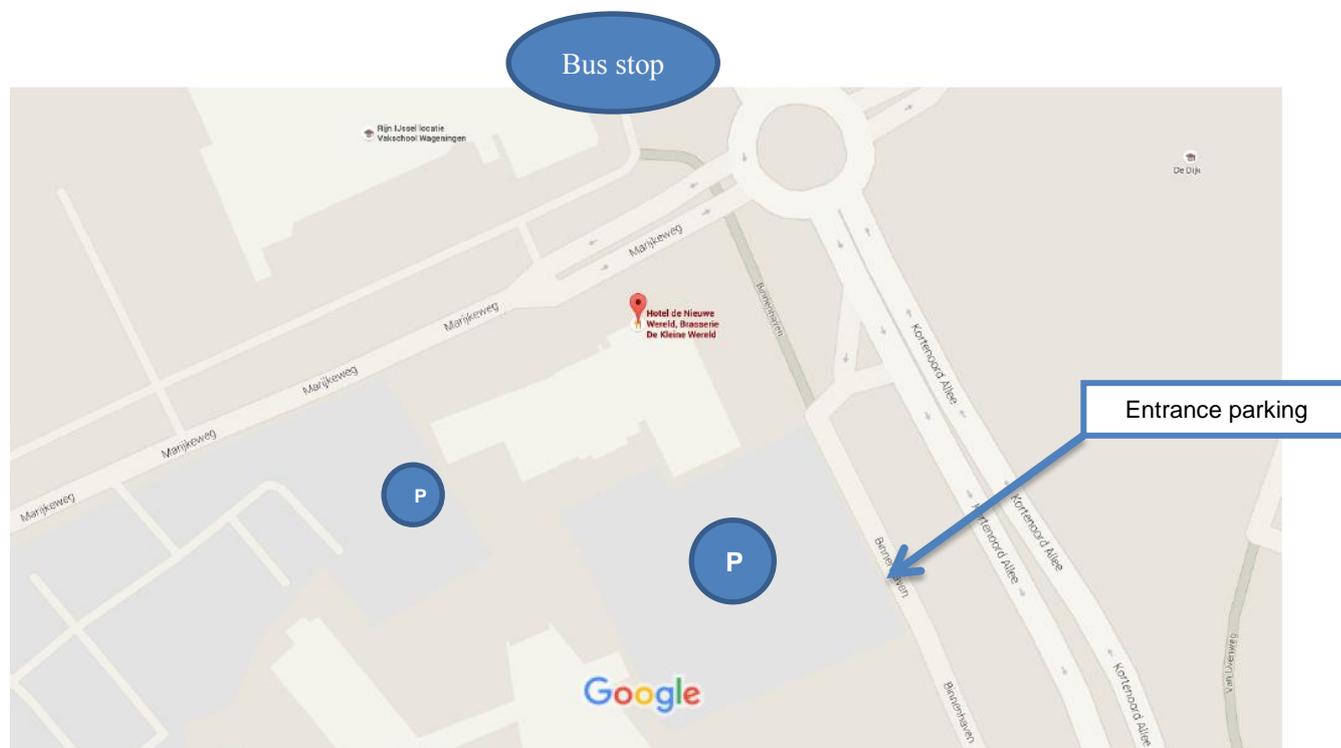
Electrochemistry for quality of life

Date: **Friday 6 November 2015**

Location: **Hotel de Nieuwe Wereld, Marijkeweg 5, 6709 PE Wageningen, The Netherlands**

9:30 – 10:00	Welcome and coffee
10:00 – 10:10	Introduction by Prof. Marc Koper (Chairman, Leiden University)
11:10 – 11:50	Nanogaps: From fabrication to sensing <u>Prof. Liza Rassaei</u> (Delft University of Technology)
10:50 – 11:35	To be determined <u>Prof. Anders Bentien</u> (Aarhus University)
11.35 – 12.00	Capacitive deionization (CDI), an emerging technology for electrochemical water desalination <u>Tania Mubita</u> , MSc (Wetsus - Centre of Excellence for Sustainable Water Technology, Leeuwarden)
12:00 – 13:30	Lunch
13.30 – 14:15	Bioelectrochemical conversion of CO₂ to chemicals: Electrosynthesis via bacteria and enzymes <u>Dr. Pant Deepak</u> (Flemish Institute for Technological Research (VITO), Antwerp)
14.15 – 14:40	Electrical current is more than hydrogen during microbial electrosynthesis and electrofermentation <u>Dr. Jan Arends</u> (Ghent University)
14.40 – 15.15	Hydrodynamic chronoamperometry for probing kinetics of anaerobic microbial metabolism <u>Dr. Antonin PrévotEAU</u> (Ghent University)
15:15 – 15:40	Coffee & Tea break
15:40 – 16:05	Characterization of granular activated carbon (AC) for its application on bio-anodes <u>Leire Caizan</u> , MSc (Wageningen University)
16:05 – 16:50	New electrochemical membrane reactor processes <u>Prof. Matthias Wessling</u> (Aachen University)
16:50 – 17:00	Announcements and closures
17:00 – 18:00	Drinks

**Location: Rijn IJssel Vakschool Wageningen and Hotel de Nieuwe Wereld
Marijkeweg 5, 6709 PE Wageningen**



Route description to Hotel de Nieuwe Wereld and Rijn IJssel Vakschool Wageningen

(see <http://www.denieuwewereld.nl/downloads/routebeschrijving.pdf>)

By Car:

- All destinations are within reach by car. Wageningen itself is enclosed by the A12, A15 and A50 motorways.
- Two parking lots are located near the conference venue and can be used (see P marked on the map):

Public Transport

- By train: Wageningen is linked with the international railways via Amsterdam, which is connected to several major European cities. The European high-speed train project includes the Thalys, the Eurostar and the Eurotunnel. There are rail links via Amsterdam with different cities in France, the Netherlands and Germany. Wageningen can be reached from the UK by Eurostar via Amsterdam. Wageningen station (Station Ede-Wageningen) is a 20' bus drive away from Hotel de Nieuwe Wereld. More information available via <http://9292.nl/>

Registration

for the Annual KNCV Electrochemistry Symposium on Friday 6 Nov. 2015

Number of participants :

Name(s) :

Affiliation :

Address :

E-mail :

Payment transferred to: BE69 0016 7856 3778 on: (date)
or: will pay at symposium

Please copy/past the text above and e-mail it to: tom.breugelmans@uantwerpen.be

(acknowledgement of receipt will be sent)

Nanogaps: From fabrication to sensing

Liza Rassaei*

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The increasing interest exists in miniaturized bioanalytical systems based on micro- and nanofluidic devices as sensitive and selective signal transduction elements [1]. Nanogap sensors working based on redox cycling amplification allow novel fundamental studies at the nanoscale as well as more sensitivity for practical applications. Nanofluidic channels incorporating two planar microelectrodes (~ 10-50 μm) separated by a thin layer of fluid (with a thickness of <100 nm) are fabricated on a chip using photolithographic patterning. Redox active molecules can freely diffuse in and out of the nanochannel and undergo electrochemical redox cycling at both suitably-biased potentials. Since these molecules can repetitively undergo oxidation and reduction, each molecule transfers, on average, thousands of electrons by traveling between the electrodes before leaving back out into the bulk. This leads to a corresponding boost in sensitivity and selectivity.

Here, I summarize the fabrication procedure for nanogap sensors and our recent work on nanogap sensors with more emphasis on a bionanofluidic sensor where we combined an enzymatic recognition element and electrochemical signal transduction within a six-femtoliter volume. Tyrosinase converts redox inactive monophenols into redox active diphenols and quinones in the nanochannel. We show how this can lead to a novel bionanofluidic sensor for sensitive detection of minute amounts of phenolic compounds [2].

Keywords: Nanogap sensors; bionanofluidics; biosensors

References:

- [1] K. Mathwig , T. Albrecht , E. D. Goluch, and L. Rassaei, *Analytical Chemistry*, 87 (2015) 5470–5475.
- [2] L. Rassaei, K. Mathwig, S. Kang, H. A. Heering, and S. G. Lemay, *ACS Nano*, 8 (2014) 8278–8284.

Capacitive deionization (CDI), an emerging technology for electrochemical water desalination

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Leeuwarden, The Netherlands*

Capacitive deionization (CDI) is an electrochemical technology which removes ionic species from aqueous solutions by ion electrosorption at the surface of a pair of electrically charged electrodes. In order to have a maximum contact area between the electrode and the water, CDI commonly employs porous carbon electrode materials. CDI is typically applied to the desalination of brackish water sources. However, recent startling studies on new cell architectures and system designs have opened the possibility for the desalination of higher salinity feeds. In addition to experimental explorations to broaden the applications of this technology, theoretical investigation of the electrochemical process in CDI systems has produced considerable insight and understanding into the desalination process. The increasing number of experimental and conceptual research is heralding new developments for CDI to reach its full application potential as a cost- and energy-efficient electrochemical solution for water purification.

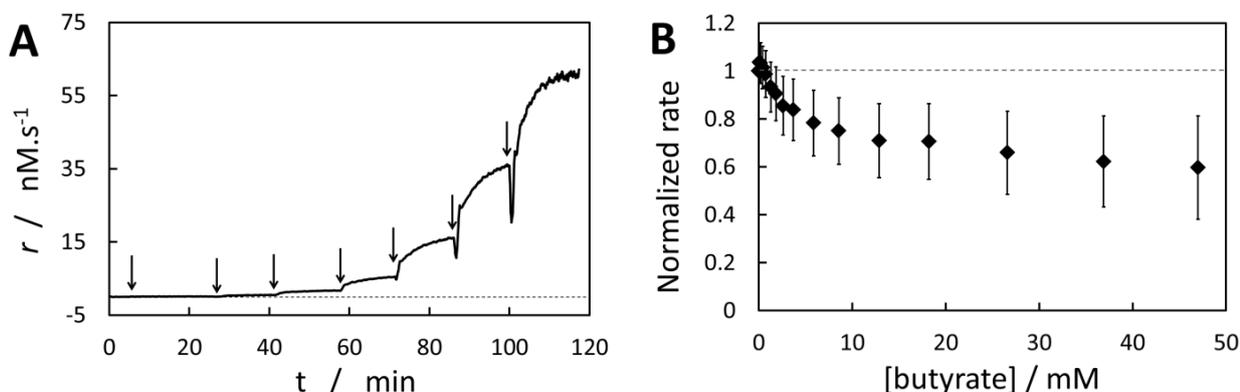
Hydrodynamic chronoamperometry for probing kinetics of anaerobic microbial metabolism

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In vitro monitoring of the metabolic activity of microorganisms aids bioprocesses and enables better understanding of microbial metabolism. Redox mediators can be used for this purpose via different electrochemical techniques that are either complex or only provide non-continuous data. Hydrodynamic chronoamperometry using a rotating disc electrode (RDE) can alleviate these issues but was seldom used and is poorly characterized. The kinetics of *Faecalibacterium prausnitzii* A2-165 in suspension, a beneficial gut microbe, were determined using a RDE with riboflavin as redox probe. This butyrate producer anaerobically ferments glucose and reduces riboflavin whose continuous monitoring on a RDE provided highly accurate kinetic measurements of its metabolism, even at low cell densities. The metabolic reaction rate increased linearly over a broad range of cell concentrations (9×10^4 to 5×10^7 cells.mL⁻¹, Figure 1(A)). Apparent Michaelis-Menten kinetics was observed with respect to riboflavin ($K_M = 6 \mu\text{M}$; $k_{\text{cat}} = 5.3 \times 10^5 \text{ s}^{-1}$, at 37°C) and glucose ($K_M = 6 \mu\text{M}$; $k_{\text{cat}} = 2.4 \times 10^5 \text{ s}^{-1}$). The short temporal resolution allows continuous monitoring of fast cellular events, such as kinetics inhibition with butyrate (Figure 1(B)). Furthermore, the high sensitivity of the technique allowed to detect for the first time the much slower riboflavin reduction by another potential probiotic, *Butyricoccus pullicaecorum* ($k_{\text{cat}} = 8 \times 10^3 \text{ s}^{-1}$). The ability of the RDE for fast, accurate, simple and continuous measurements makes it an *ad hoc* tool for assessing bioprocesses at high resolution. Further development of this technique will allow understanding of product inhibitions and substrate affinities in bioelectrochemical systems.



(A) Real-time evolution of metabolic consumption rate of riboflavin (r) with successive additions of *F. prausnitzii* concentrated suspension (arrows). Inset shows that the maximal rate is proportional to the bacterial concentration.
(B) Metabolic inhibition by butyrate successive additions ($n = 5$).

A. PrévotEAU *et al.*, *Sci. Rep.*, 5 (2015), 11484. 4

Electrical current is more than hydrogen during microbial electrosynthesis and electrofermentation

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Electricity is being used to drive microbial and enzymatic reactions. This is mostly done on the basis of setting an electrode potential and thus facilitating a certain redox reaction. Applying a fixed current has several implications in bioelectrochemistry besides delivering or withdrawing reducing equivalents at a fixed rate. During microbial electrosynthesis, a microbial reduction reaction is driven at the cathode, for example CO₂ fixation into volatile fatty acids (VFA) or glycerol conversion into 1,3-propanediol (1,3PDO). Driving these reactions by means of an electrical current enables chain elongation of VFA's, and production of alcohols at higher rates compared to addition of H₂ gas. The pH decreases due to the activity of the microorganisms at the cathode, especially during fermentation of heterotrophic substrates. By balancing the current with the rate of microbial fermentation, base dosing can be lowered or even avoided due to the creation of base at a fixed rate at the cathode based on water electrolysis. A third benefit of current over hydrogen gas is based on charge movement in an electrochemical cell. Charge balancing is usually achieved by the movement of small (in)organic ions. However, by making use of selective membranes and an electrical current, extraction of specific charged compounds (for example VFAs or NH₄⁺) can be achieved. Thus creating a pure product stream separated from the microbial broth. In conclusion, electrical current is and can do more than just delivering reducing equivalents for a bioelectrochemical reaction.

Bioelectrochemical conversion of CO₂ to chemicals: Electrosynthesis via bacteria and enzymes

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Increasing renewable electricity leads to moments of overproduction. In a scenario of 100% renewable energy, about 20% of the yearly production will need to be stored to keep the system in balance. The conversion of CO₂ into new molecules guarantees using this excess electricity ensures that the final balance on energy use and CO₂-emissions are lower than in the classical production. Microbial Fuel Cells (MFCs) are devices which convert the chemical energy stored in organic substrates to electricity. Recently, a new concept of microbial electrosynthesis has evolved where similar setups, generally known as bioelectrochemical systems (BES), are being used for the production of chemicals. Already the bioelectrochemical reduction of CO₂ to acetate has been achieved, as well as the reduction of CO₂ to methane and multi-carbon compounds. The key advantage here is the use of excess electricity that is often generated renewably, from solar cells and wind mills, all of which cannot be utilized immediately and can be fed into BES to produce chemicals. Enzymes can also be used for chemical transformations including both the reduction and oxidation reactions. We are using CO₂ as substrate for the production of formic acid and ethanol which will have a significant positive impact on environment as well as energy crisis. A global overview of these processes will be presented along with the recent research findings.

Characterization of granular activated carbon (AC) for its application on bio-anodes

Leire Caizán Juanarena

Environmental Technology, Wageningen University, The Netherlands

Microbial Fuel Cell (MFC) is a technology able to efficiently recover electricity from organics in wastewater. Classical MFCs have limitations, such as energy losses in the anode/cathode and high material costs. Capacitive MFCs are a potential solution to these problems, via the use of capacitive materials to which the biofilm can attach. Among capacitive materials, we choose activated carbon (AC) granules because of two reasons: they can easily be implemented in an anaerobic fluidized bed reactor for wastewater treatment, and they have large porous and conductive surface area that allows formation of biofilm by electrochemically active microorganisms (i.e. bio-anode). These microorganisms will extract electrons from wastewater and store them within AC granules. At the same time, protons and other cations present in wastewater will be attracted towards the granule and will form an electrical double layer to maintain electro-neutrality. We aim to study the combination of an electro-active biofilm with capacitive AC granules. For that purpose, we first focus on characterizing single abiotic granules by their charge-discharge behaviour and on quantifying their charge storage (capacitance). Granular AC with different physical properties (e.g. size, porosity) are used to evaluate the influence of such properties on capacitance. Our second focus is to characterize single biotic granules in the same way as abiotic ones to determine if formation of biofilm has an added (or not) capacitive effect and to what extent it can affect charge/discharge of electrons.

New electrochemical membrane reactor processes

Matthias Wessling

RWTH Aachen University, Leibniz Institute for Interactive Materials

Electrochemical membrane reactors are well known for processes such as water electrolysis, chlor-alkali-electrolysis and bipolar membrane electrodialysis. In many cases, an ion exchange membrane are combined with electrochemical reactions. In this presentation, three new processes using membrane and electrode configurations will be described.

1. Ammonia synthesis from water and nitrogen
2. Gas-phase reduction of CO₂ to alkanes
3. Lignin oxidation with nanofiltration supported in-situ product removal

References

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