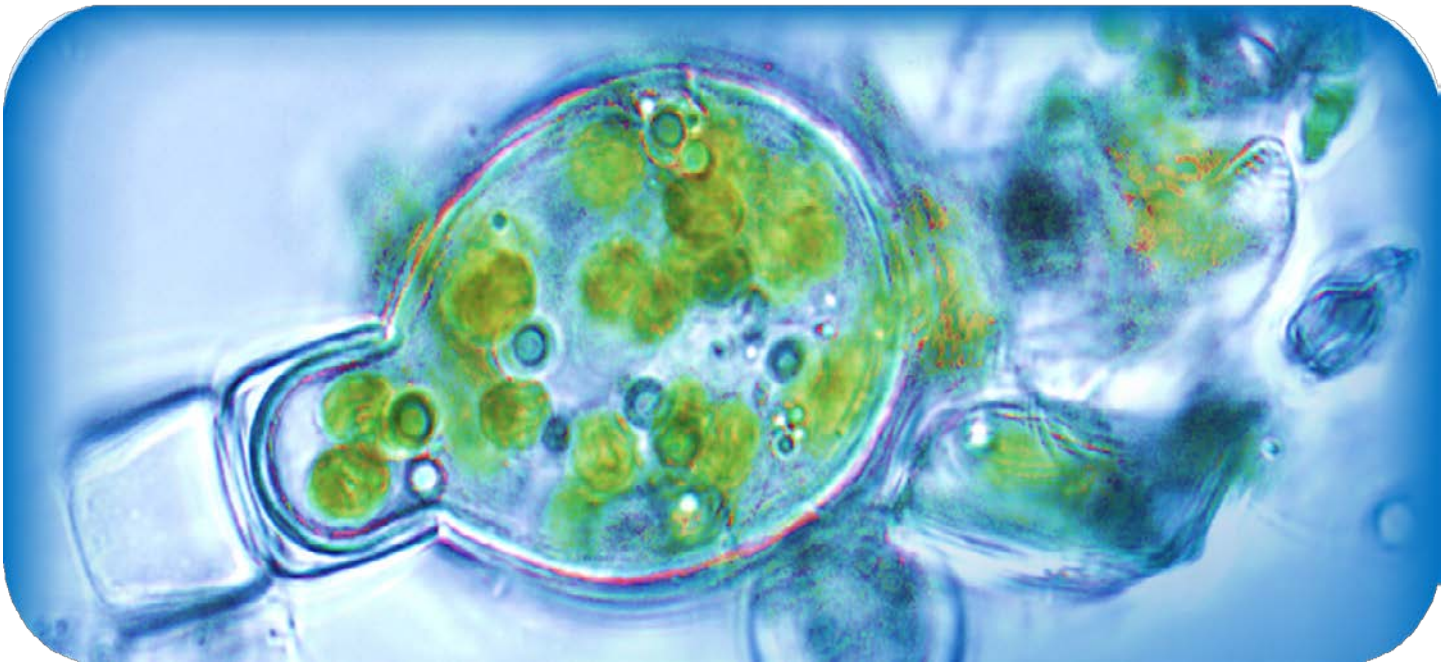
5th Meeting of Swiss Analytical Scientists

*CH*analysis 2019

April 11-12, 2019

Dorint Hotel Beatenberg



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SCS
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Division of
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General Information

Organizing Committee

Ernö Pretsch, ETH Zürich
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Scientific Advisory Board

Eric Bakker, University of Geneva
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Conference Office

Esther Wolff c/o Eawag
Überlandstrasse 133
CH-8600 Dübendorf
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Participation Fee (includes meals and accommodation)

Regular fee:	CHF 300.–
Students including PhD students:	CHF 100.–

Scientific Program

Thursday, April 11

13.00 ***Conference Opening*** - Marc J-F Suter, Eawag, Dübendorf

Session 1 – Chair: Marc J-F Suter, Eawag, Dübendorf

13.05 ***Francesco Pomati***, Eawag, Dübendorf
Understanding and Predicting Algal Blooms Using *In Situ* Automated Monitoring

13.45 ***Barbara F Günthardt***, Agroscope, Zürich
Suspect Screening for Phytotoxins - New Insights on the Occurrence of Natural Toxins in Surface Waters

14.00 ***Christine M Egli***, Eawag, Dübendorf
Analysis of Singlet Oxygen-Induced Transformation Products in Aquatic Extracellular Enzymes

14.15 ***Wei Liu***, University of Geneva
Interaction of Silver Nanoparticles with Key Antioxidant Enzymes

14.30 ***Kamyar Mehrabi***, ETHZ, Zürich
Multiplexed Detection and Quantification of Metal-Containing Nanoparticles with ICP-TOFMS

14.45 ***Coffee Break***

Thursday, April 11

Session 2 – Chair: Kathrin Fenner, Eawag, Dübendorf and University of Zürich

15.15 ***Michael Sander***, ETHZ, Zürich
Adsorption Processes and Enzymatic Transformations at Solid-Water Interfaces: An Environmental Chemist's Perspective on Using a Quartz Crystal Microbalance with Dissipation Monitoring

15.45 ***Stefan Kradolfer***, ETHZ, Zürich
Almost Fifty Shades of White: A Multi-Analytical Approach Facing Lead-White Pigments in Paintings

16.00 ***Akkapol Suea-Ngam***, ETHZ, Zürich
Paper-Based Analytical Devices (PADs) for Rapid and Cost-Effective Single Copy Detection of Methicillin-Resistant *Staphylococcus aureus* (MRSA)

16.15 ***Yoshiki Soda***, University of Geneva
Equipment-Free Detection of K^+ on Microfluidic Paper-Based Analytical Devices Based on Exhaustive Replacement with Ionic Dye in Ion-Selective Capillary Sensors

16.30 ***Eric Bakker***, University of Geneva
A Scientific Journey with Ionophore-Based Sensors
Simon-Widmer Award Lecture

17.00 ***Poster Session and Aperitif***

18.30 ***Dinner***

Get-Together Party in the Muh-Bar

Friday, April 12

Session 3 – Chair: Franka Kalman, HES-SO, Sion

09.00 ***Emilio Yángüez***, FGCZ, ETHZ / University of Zürich
Single Cell Gene Expression Analysis in Biomedical and Basic Research

09.30 ***Jens Sobek***, FGCZ, ETHZ / University of Zürich
Single-Molecule Anaytics: Monitoring Chemical Reactions Using CY3 Dye Fluorescence

09.45 ***Christian Berchtold***, FHNW, Muttenz
Comprehensive Single Cell Multi Omics

10.00 ***Maria Fernanda Cifuentes Girard***, University of Geneva
Automated Parallel Derivatization Strategy for Improved Metabolites Analysis in Liquid Chromatography-Mass Spectrometry

10.15 ***Charlotte Driesen***, Empa, Dübendorf
The AgroPOP Project: Towards a Better Understanding and Mitigation of Transgenerational Transfer of Polychlorinated Biphenyls in Cattle

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10.30 ***Coffee Break***

Friday, April 12

Session 4 – Chair: Eric Bakker, University of Geneva

11.00 ***Markus Mieth***, Sandoz GmbH, Kundl, Austria
Moving to New Technologies: Transmission Raman for Content Uniformity (CU) Testing

11.30 ***Andrea Sterzi***, Empa, Dübendorf
Deep UV Raman Spectroscopy for Online Water Analysis

11.45 ***Teresa Mairinger***, Eawag, Dübendorf
Advancing a Full Picture on Water-Soluble Synthetic Polymers in Wastewater – Different Ionization Strategies for Homologue Series Detection

12.00 ***Saša Bjelić***, PSI, Villigen
Data Mining and Machine Learning Strategies for Non-Targeted Interpretation of High-Resolution Mass Spectrometry Data from Complex Biofuel Samples

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12.30 ***General Assembly of the DAS of the Swiss Chemical Society***

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2. Nomination of scrutineers
3. President's report
4. Treasurer's report
5. Election of board members – approval of the board
6. Section of Chemistry and the Environment
7. Outlook
8. Individual proposals
9. Miscellaneous

13.00 ***End of Meeting***

List of Posters

1 ***Lena Schinkel***, Empa, Dübendorf, Quantification of Chlorinated Paraffins (CPs) in Plastic Products: Improved Pattern Deconvolution with Single-Chain CP Mixtures

2 ***Pia S Bruni***, University of Bern, Mass Spectrometric Investigation of the Interaction of Metallocenes with Biomolecules

3 ***Thomas Stricker***, University of Geneva, Reducing Mass Spectra Complexity through Adduct Annotation for LC-SWATH/MS Metabolomics

4 ***Alena Tierbach***, Eawag, Dübendorf, Mercapturic Acid Pathway is Complete and Functional in Early Stages of Zebrafish (*Danio rerio*) Development

5 ***Daniela Rechsteiner***, Agroscope, Zürich, Determination of Natural Estrogens in Cattle and Pig Manure using QuEChERS and Liquid Chromatography-Mass Spectrometry

6 ***Mathieu Zollinger***, HES-SO, Sion, Investigation of the Molecular Weight Distribution of Endotoxins by Size Exclusion Chromatography Coupled to High-Resolution Mass Spectrometry (SEC-MS)

7 ***Carina D Schönsee***, Agroscope, Zürich, Using Column Chromatography to Assess Mobility of Natural Toxins in the Aquatic Environment

8 ***Jonas Mechelke***, Eawag, Dübendorf, Enantiomeric Fractionation – An Indicator of Biotransformation During a Water-Sediment Flume Study

9 ***Christelle Oltramare***, Eawag, Dübendorf, Use of PDMS Sheets for Sampling Pyrethroids and Organophosphates in Rivers of the Wakiso District, Uganda

10 ***Judith Riedo***, Agroscope, Zürich, Multi-Residue Trace Analysis of Plant Protection Products in Soils from Different Farming Systems

11 ***Polyxeni Damala***, University of Geneva, Miniaturized Solid-Contact Ion Selective Electrodes for Environmental Sensing

12 ***Tara Forrest***, University of Geneva, Thin Layer Potentiometry for Anion Sensing

13 ***Sutida Jansod***, University of Geneva, Colorimetric Readout of Potentiometric Probes with Closed Bipolar Electrodes and Prussian Blue Film

14 ***Pitchnaree Kraikaew***, University of Geneva, In-Line Capacitive Readout for pH Analysis of Ion-Selective Electrodes

15 ***Canwei Mao***, University of Geneva, Multiple Ion Activity Sensing by Ionophore-Based Voltammetry on a Microelectrode

16 ***Lu Wang***, University of Geneva, Emulsified Cation and Anion Ion-Selective Optical Sensors Based on Solvatochromic Dyes

17 ***Supacha Wirojsaengthong***, University of Geneva, Thin Layer Anion-Selective Membrane Based on Copper Mediated Electrochemistry for Ion Transfer Solid Contact Electrodes

18 ***Zahra Halvorsen***, ETHZ, Zürich, Miniaturization of Fluid Sample Preparation Platform for an Automatic Flow Cytometer

19 ***Giovanni L Bartolomeo***, ETHZ, Zürich, Characterization of Biomimetic Membranes with Scanning Probe Microscopy and Tip-Enhanced Raman Spectroscopy

20 ***Thomas Vonderach***, ETHZ, Zürich, Uptake Studies in Chinese Hamster Ovary Cells using Single Cell ICP-TOFMS

21 ***Mohammad I Nouraddini***, ETHZ, Zürich, Element Mass Spectrometry Using an Affordable Plasma Source: Microwave Inductively Coupled Nitrogen Plasma

22 ***Christoph Neff***, ETHZ, Zürich, Single Pulse Quantification using LA-ICP-TOFMS for Forensic Investigation of Glass Fragments in Perspective of Reducing Required Sample Size

23 ***Jovana Kocic***, ETHZ, Zürich, Gold Nanoparticles Performance Study: Detection Efficiency Comparison of Different Sample Introduction Strategies and Matrix Effects Using ICP-MS

24 ***Peter Keresztes Schmidt***, ETHZ, Zürich, A Versatile Software Suite for Advanced Laser Ablation ICP-MS Element Imaging

25 ***Olga Sambalova***, Empa, Dübendorf, HAXPES-XPS Combination Reveals Surface Structure Changes of $La_{0.3}Sr_{0.55}Ti_{0.95}Ni_{0.05}O_{3-\delta}$

26 ***Gunnar Schwarz***, ETHZ, Zürich, On Challenges and Opportunities of Multiple-Choice Questions for Teaching Analytical Chemistry

Abstracts of Oral Presentations

Understanding and Predicting Algal Blooms Using In Situ Automated Monitoring

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Aquatic ecosystems are highly diverse and dynamic. They sustain globally important ecosystem processes, like the carbon and nitrogen cycles, and harbor a significant share of earth taxonomic and functional diversity. Plankton communities dominate open water environments and rest at the base of aquatic food-webs. Phytoplankton (microscopic algae), in particular, represent the most important primary producers in aquatic environments, and are very sensitive to human impacts like eutrophication, chemical pollution, and climate change. Algal blooms are, in fact, an emergent property of the complex planktonic food-web and are recognized as a threat for aquatic ecosystem services (water quality, fishery, farming, recreation) worldwide, with annual societal costs in the billions of dollars. Identifying the mechanisms and processes that govern plankton communities has important practical consequences in the management of aquatic ecosystems, particularly of lakes that provide vital services to human society. Still, our ability to predict plankton ecological dynamics is limited.

A naturally fluctuating environment and complex internal interactions among individuals and species make planktonic communities difficult to understand and fundamentally hard to predict. We can however shift our efforts from prediction (mechanism-based model) to probabilistic forecasting (statistical model able of making statements about the future based on the history of the system). Three main issues are crucial to afford effective forecasting: i) acquiring environmental data at the appropriated scale of space and time; ii) turn large and high dimensional datasets into information that can be used for forecasting, iii) apply the most appropriated forecast approach.

During this seminar, I will briefly review the above issues hindering the predictability of plankton communities, and show advantages and limitations of approaches based on environmental monitoring data (biological, physical and chemical) sampled at different scales, coupled with machine learning, to forecast phytoplankton dynamics across scales of time and space. I will particularly focus on how high-resolution monitoring, particularly by recently developed technology, can inform machine-learning tools and deliver targets ecological and data-driven models, helping elucidate the mechanisms underlying plankton dynamics and forecasting of algal blooms.

Suspect Screening for Phytotoxins – New Insight on the Occurrence of Natural Toxins in Surface Waters

Barbara F Günthardt[1,2,3], Juliane Hollender[2,3], Martin Scheringer[3,4], Konrad Hungerbühler[3], Thomas D Bucheli[1]

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[3] Institute for Biogeochemistry and Pollutant Dynamics, ETHZ, 8092 Zürich, Switzerland
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Phytotoxins are natural toxins produced by plants with widely varying molecular structures and toxic effects. Despite possibly high concentrations of natural toxins in vegetation, they are not yet commonly perceived as problematic for the aquatic environment. This far, environmental exposure studies have only been conducted for a very limited number of phytotoxins, and systematic and larger monitoring campaigns are completely lacking. Therefore, we combine target and suspect screening assessing the contamination of surface waters in Switzerland with phytotoxins.

This far, water grab samples were taken in high vegetation (June 2018) from ten sites in the canton of Zürich with different land use and high numbers of toxic plants in the catchment areas. We adapted a method in which the water samples are enriched with solid phase extraction (SPE) and analyzed using liquid chromatography coupled with electrospray ionization to high-resolution mass spectrometry (LC-HRMS) [1]. Suspects were defined from a previously performed assessment identifying the potentially most relevant phytotoxins based on persistence, mobility, and toxicity [2]. Within these suspects 50 targets were available with reference standards.

First results indeed show the occurrence of different phytotoxins. Isoflavones were detected at several sites in proximity to grasslands, confirming the occurrence of these estrogenic phytotoxins in surface waters from previous research [3]. Furthermore, we found toxic pyrrolizidine alkaloids most probably leaching from *Senecio spp* into the surface water with concentrations up to 100 ng/l (Senecionine N-oxide). Pyrrolizidine alkaloids are highly important in food and feed safety [4], and should also be further investigated in regard to environmental safety.

[1] S Kern, K Fenner, HP Singer, RP Schwarzenbach, J Hollender, *Environ Sci Technol* **2009**, 43 (18), 7039-7046.
[2] BF Günthardt, J Hollender, K Hungerbühler, M Scheringer, TD Bucheli, *J Agric Food Chem* **2018**, 66 (29), 7577-7588.
[3] CC Hoerger, FE Wettstein, K Hungerbühler, TD Bucheli, *Environ Sci Technol* **2009**, 43 (16), 6151-6157.
[4] PP Mulder, PL Sánchez, A Thesis, A Preiss-Weigert, M Castellari, *EFSA*, **2015**, 12 (8).

Analysis of Singlet Oxygen-Induced Transformation Products in Aquatic Extracellular Enzymes

Christine M Egli[1,2], Elisabeth M-L Janssen[1,2]

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Various bacteria and algae excrete extracellular enzymes that play central roles in the biogeochemical cycling of nutrients and carbon by breaking down macromolecular organic matter. Activities of extracellular enzymes are ubiquitous in surface waters and the ability of these enzymes to influence aquatic systems critically depends on their stability. Once released by the cells, extracellular enzymes are susceptible to various transformation processes that can lead to inactivation, including biodegradation, sorption, direct and indirect light-induced reactions. In the presented work, we focus on photochemical processes as major inactivation pathways in surface waters. By employing proteomics techniques and enzymology we study site-specific transformations in the macromolecular structure of extracellular enzymes and inactivation rate constants.

Here, we exposed enzyme solutions to photochemically produced reactive intermediates, including singlet oxygen. During the exposure, we monitor the enzyme activity by following substrate conversion rate constants and site-specific molecular changes by proteomics techniques. Our refined proteomics protocols allow us to monitor peptides covering the full sequence of each model enzyme. Hence, we can produce nearly complete pictures of the site-specific damage within the enzyme structure. We compare the fingerprint of site-specific damage caused by discrete photooxidants to the more complex degradation and inactivation enzymes undergo in sunlit surface waters.

We further developed a workflow for a transformation product analysis based on a suspect screening including possible transformation products identified from plausible reaction mechanisms. By respecting the local environment of phototransformed amino acids we aim to trace singlet oxygen-induced degradation pathways. Our proteomics approach to study intramolecular processes within the higher order structure of enzymes can also be applied to various other processes beyond photochemistry where amino acids undergo chemical changes.

Interaction of Silver Nanoparticles with Key Antioxidant Enzymes

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Silver nanoparticles (AgNPs) are widely used owing to their antimicrobial properties and represent about 30% of nanotechnology-based consumer products. The unintentional release of AgNPs in the environment is suspected to impair some key biological functions in organism e.g. by inducing oxidative stress. The cellular concentrations of reactive oxygen species (ROS) are controlled by different antioxidants including enzymes. However, little is known on how the interactions of metallic nanoparticles with key antioxidant enzymes and thus possible disturbance of the cellular redox state. In this mechanistic study, in depth investigations were carried out into the interaction of citrate-coated AgNPs (20 nm) and three methalloproteins. Catalase (CAT), cytrochrome C (CytC) and superoxide dismutase (SOD) were selected due to their important antioxidant activity and difference in their structure and native metals bound. This comparative study will provide an information on the importance of chemical nature of these interactions and will clarify the mechanism of oxidative stress caused by the bound AgNPs from the functional macromolecular level.

The behavior of the AgNPs and the related consequences for the proteins in terms of structural changes and metal displacement were studied by complementary approaches combining dynamic light scattering, UV-vis spectroscopy, fluorescence spectroscopy and circular dichroism spectroscopies. The isolation of the different populations formed together with online quantifications of their metal content were performed by asymmetrical flow field-flow fractionation linked to inductively coupled plasma mass spectrometry. The “protein corona” profit and the conformation change of three protein will be discussed, taking into account the structure characteristics of the protein.

Taken together, the results indicate that both proteins (CAT, SOD, CytC) come into contact with AgNPs and formed the protein corona. CAT formed a corona around AgNPs promoting NPs dissolution. AgNPs-CAT complex induced the perturbation in the enzyme second and tertiary structure. However, dissolve Ag ions is no impact on heme site. However, SOD established a stable layer around the AgNPs over 24h incubation. AgNPs do not dissolved over time. No metal displacements of the metal binding sites inside SOD. SOD-AgNPs complex do not have impact on the enzyme second and tertiary structure. Finally, CytC aggregate in our experimental condition. The presence of AgNPs induced larger species suggesting the formation of AgNPs-CytC complexs which impact CytC second and tertiary structure. AgNPs do not affected the heme site over time. Overall, the results shows that the stability of protein corona, changes in the proteins structure and also on the dissolution of AgNPs depending on the protein structure including the accessibility and geometry of metal binding sites.

Multiplexed Detection and Quantification of Metal-Containing Nanoparticles with ICP-TOFMS

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Widespread use of nanoparticles (NPs) continues to increase the risk of NP emission into environmental and biological systems. Better characterization and quantification of NPs in complex matrices requires robust and high-throughput measurements. To this end, single-particle inductively coupled plasma time-of-flight mass spectrometry (*sp*-ICP-TOFMS) is a promising approach that enables multiplexed detection and quantification of diverse metal and metal-oxide NPs [1]. We present an online microdroplet calibration strategy to size and count NPs in a single step. In our system, we introduce two types of samples concurrently to the ICP. First, a NP-containing solution is introduced through a conventional nebulizer and spray chamber for high-throughput sample introduction. Second, microdroplet standards (MDSs) are introduced into the carrier gas stream to the ICP, and are used to determine elemental detection efficiencies (counts/atom) and calibrate for element mass in individual NPs [2]. Additionally, by spiking a known concentration of cesium (Cs) into NP-containing samples and the MDSs, and detecting the Cs in both, we are able to directly measure the mass flux of analyte into the plasma (q_{plasma}). Particle number concentration (PNC) can be determined based on $q_{plasma}$and the frequency of detected particles. As a proof-of-principle, we applied this approach to different matrices for detection of spiked NPs (Ag, Pt, and Au NPs). We analyzed waste water treatment plant (WWTP) effluent for endogenous NPs and spiked NPs in single run. Results demonstrate accurate quantification of diverse NPs in terms of element mass and PNC, and provides insight into NP type and number in WWTP effluent.

[1] L Hendriks, A Gundlach-Graham, D Günther, *CHIMIA*, **2018**, *72*, 221-226.
[2] L Hendriks, B Ramkorun-Schmidt, A Gundlach-Graham, J Koch, RN Grass, N Jakubowski, D Günther, J Anal At Spectrom, 2019, Advance Article.

Adsorption Processes and Enzymatic Transformations at Solid-Water Interfaces: An Environmental Chemist's Perspective on Using a Quartz Crystal Microbalance with Dissipation Monitoring

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Solid-water interfaces are highly-reactive microenvironments and thus play key roles in diverse important processes in natural and engineered systems. These processes include the adsorption and desorption of (macro)molecules to and from the interfaces as well as abiotic and enzymatic chemical reactions and transformations at the interfaces. Among several analytical techniques employed to study these interfacial processes is Quartz Crystal Microbalance with Dissipation monitoring (QCM-D). This acoustic resonator technique is unique in that it allows to determine changes in the mass and viscoelastic property of adlayers at the solid-water interface at the nanometer scale, in real time, and at very high sensitivity (down to a few ng per cm^2). This contribution will have three parts. In the first part, I will briefly introduce the QCM-D technique and discuss its capabilities (but also allude to its limitations). The second part will illustrate the use of QCM-D to study the adsorption and desorption of molecules to and from interfaces, using bacteriophage viruses and natural dissolved organic matter as examples. The third part will address the possibilities of QCM-D to elucidate reactions at interfaces, which will be highlighted by the hydrolytic breakdown of synthetic polyesters by extracellular microbial esterases. While the illustrative examples presented in the talk center around environmental processes - reflecting the research interest and expertise of the speaker -, the contribution will allude to use of QCM-D to study comparable processes also in other research fields.

Almost Fifty Shades of White: A Multi-Analytical Approach Facing Lead-White Pigments in Paintings

Stefan Kradolfer[1], Laura Hendriks[1,2], Irka Hajdas[2], Bodo Hattendorf[1], Hans-Arno Synal[2], Detlef Günther[1]

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The prevention of art fraud and verification of provenance for paintings is an ongoing challenge [1]. The continuous demand for new approaches concerning sampling, analysis and data interpretation is therefore the driving force for this study.
The presented work will describe the multi-analytical chemical analysis of the paint itself, more specific the white carbonate-bearing pigments cerussite ($PbCO_3$) and hydrocerussite ($2PbCO_3 \cdot Pb(OH)_2$) in organic binder, regarding their age or production process (^{14}C-dating) and geographical information (Pb-isotope analysis).
The priming workflow consists of several steps including: classical art-historical research; preliminary non-invasive XRF-spectroscopy directly on the painting to evaluate the best sampling position, followed by a minimally invasive sampling of the pictorial layer in the µg-mg range; and qualitative investigations of the taken sample by FT-IR/Raman spectroscopy. The combined results allow to assess the overall paint composition and the presence of possible interferences (i.e. interfering additives). Suitable lead white bearing paint samples are measured by accelerated mass spectrometry (AMS) first by specific degradation of the Pb-carbonate to CO_2 [2], then of the extracted organic binder [3], hereby yielding two distinct ^{14}C ages. The residue is then digested, diluted and analyzed for the elemental composition and isotope ratios of lead by Q-ICPMS and MC-ICPMS [4] respectively.
Several paintings, dating from the 16th to 20th century were analyzed by this approach providing two individual ^{14}C ages specific for the time of production of the raw materials used, in particular the age from the Pb-carbonate gives insight into its production process; traditional stack process (organic carbon source) or industrial methods (fossil carbon source). The lead-quantification refers directly to the overall amount of all lead species, and indirectly to the lead-white fraction in the sample. Furthermore, the isotope signatures of lead may provide an indication for the geographical location of the raw material sources with regards to European ores or even specific painters based on existing work [4].
Therefore, this study proposes the novel complementary use of different techniques to access an almost complete picture of a painting while sampling a minimal amount of paint.

[1] J Ragai, in *The Scientist and the Forger: Insights into the Scientific Detection of Forgery in Paintings*; J Ragai, Publisher: Imperial College Press, 2015.
[2] L Hendriks, I Hajdas, ES Ferreira, N Scherrer, S Zumbühl, M Küffner, L Carlyle, HA Synal, D Günther, *Radiocarbon* **2018**, 1-21.
[3] L Hendriks, I Hajdas, ES Ferreira, N Scherrer, S Zumbühl, M Küffner, L Wacker, HA Synal, D Günther, **2018**, *Radiocarbon*, 60(1), 207-218.
[4] G Fortunato, A Ritter, D Fabian, *Analyst* **2005**, 130(6), 898-906.

Paper-Based Analytical Devices (PADs) for Rapid and Cost-Effective Single Copy Detection of Methicillin-Resistant Staphylococcus aureus (MRSA)

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Antimicrobial resistant bacteria (AMR) pose severe health risks and are becoming problematic in routine procedures in medical communities. MRSA is a major AMR regularly found in such settings, but rapid and accurate detection is difficult [1]. Isothermal amplification methods such as LAMP (loop-mediated isothermal amplification) have been leveraged in nucleic acid detection of AMR, providing rapid, sensitive and cost-effective analysis [2]. Recently, PADs have been used in bioanalytical assays, and are promising for use in resource-limited settings [3]. Here, we report the first demonstration of *in situ* LAMP directly on a PAD for the rapid and cost-effective single copy detection of MRSA. The qualitative analysis was achieved by naked eyes under UV irradiation, employing DNA intercalating dye. Moreover, a smartphone-based detection allowed achievement in quantitative analysis. Subsequently, PADs provided DNA target concentration in the linear range between 1 and 10^4 copies using the optimized conditions with 40 minutes at 58 °C. Additionally, high selectivity of PADs was revealed against the regular found epidermal bacteria, providing well agreement with the gold standard method, polymerase chain reaction (PCR). The developed system is the first demonstration of *in situ* LAMP on a µPAD, and is highly promising for rapid and effective pathogen detection in resource-limited areas.

[1] J Kluytmans, M Struelens, *Bmj* **2009,** *338*, b364.
[2] Y Mori, T Notomi, *J Infect Chemo* **2009,** *15 (2)*, 62-69.
[3] MM Gong, D Sinton, *Chem Rev* **2017,** *117 (12)*, 8447-8480.

Equipment-Free Detection of K^+ on Microfluidic Paper-Based Analytical Devices Based on Exhaustive Replacement with Ionic Dye in Ion-Selective Capillary Sensors

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Metal ions in a human body are maintained by biological function to achieve homeostasis. Abnormal levels in a variety of biofluids, such as blood, urine and tear fluid indicate breakdown of homeostasis and possible sickness or even a critical disease. Quantification of such metal ions is, therefore, a most important test in medical diagnostics.

The last decade has witnessed a rapid growth of research towards point-of-care diagnostics on the basis of microfluidic paper-based analytical devices, or µPADs [1]. They require small sample volumes to conduct a diagnosis and are less costly than conventional instrument-based methods. The importance of metal ion detection in diagnostics has motivated researchers to develop µPADs for point-of-care quantification of biologically important ionic species. However, the lack of user friendliness caused by the usage of external equipment to analyze signals has hampered their practical realization. While several equipment-free detection approaches for metal ions on µPADs have been reported [2,3], important challenges remain that include low sensitivity and applicability to biosamples, and a high dependence on sample pH.

We report here on µPADs for equipment-free K^+ quantification based on H^+-free ion exchange reaction enabling pH-independent detection that are in contrast to conventional optode methods [4]. The detection system was separated into two parts. It involves a K^+ recognition part where K^+ in a sample is exhaustively replaced with an ionic dye from a chemically selective plasticized PVC film solvent-cast onto the inner wall of a glass capillary. The second part quantifies the exchanged ionic dyes by flowing it in a paper channel and adsorbing it electrostatically on cellulose fibers of the paper substrate. The resulting length of the color band generated on the µPAD by the ionic dye adsorption reflects the initial amount of K^+ in the sample. This highly sensitive, exhaustive detection by ion replacement enables K^+ quantification within a narrow range (ca. 2~6 mM) in serum samples.

[1] AW Martinez et al, *Angew Chem Int Ed* **2007**, *46*, 1318–1320.
[2] H Shibata et al, *Analyst* **2019**, *144*, 1178–1186.
[3] CT Gerold et al, *Anal Chem* **2018**, *90*, 4894–4900.
[4] E Bakker et al, *Chem Rev* **1997**, 97, 3083–3132.

A Scientific Journey with Ionophore-Based Sensors

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This talk aims to outline some key steps that resulted in conceptual advances in the field of ionophore-based sensors in the past 30 years. Major emphasis will be placed on how a simplified understanding of membrane electrode theory has resulted in a plethora of new readout principles, characterization protocols and analytical advances that go far beyond what was thought possible in this chemical sensing field.

Simon-Widmer Award Lecture

The Simon-Widmer Award in memory of Prof Wilhelm Simon and Prof Michael Widmer honors distinguished scientists for their contribution to fundamental and applied analytical science and the education of analytical scientists.

Wilhelm Simon, ETH Zurich, the legendary Swiss analytical chemist.

Past Award Winners

2019: Prof. Eric Bakker, University of Geneva

2017: Prof. Takehiko Kitamori, The University of Tokyo

2015: Prof. Detlef Günther, ETH Zurich

2009: Prof. Rolf Fuhr, retired (Fraunhofer IBMT)

2006: Prof. Renato Zenobi, ETH Zurich

2004: Prof. Barry Karger, Northeastern University, Boston

2002: Prof. Ruedi Aebersold, ETH Zurich

2000: Prof. Csaba Horváth (†2004)

Michael Widmer, Novartis, the first SACh president.

Single Cell Gene Expression Analysis in Biomedical and Basic Research

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DNA sequencing technologies were the main driving forces behind the molecular biology revolution, which reached a milestone in 2001 with the first sequence analysis of the human genome. Almost 20 years later, a second revolution has started: the single cell revolution. The ability to sequence the RNA of individual cells (scRNA-seq) allows us to obtain a snapshot of the genes that are active at a given moment. The expression of these genes, which are translated into effector proteins, ultimately define what a cell does. The popularization of single cell sequencing technologies is completely changing our understanding of fundamental biological processes such as development, immunity or pathology. Current approaches enable us to define the gene expression profiles of thousands of single cells in parallel with high resolution, allowing us to characterize tumors, developing organs or even whole organisms. Moreover, we can label individual cells to reconstruct their relationships in space and time. Combined efforts involving different scientific disciplines have allowed us to jump from the first single cell ever sequenced in 2009 to a deep transcriptomic analysis of a whole embryo with single-cell resolution. In the Functional Genomics Center Zürich (FGCZ), we have implemented different pipelines to provide our users with access to state-of-the-art single cell technologies. We are applying our expertise to combine different single-cell sequencing strategies adapting them to the requirements of the researchers and the complexity of the analyzed samples. During the talk, following an introduction about current DNA sequencing platforms, the latest technological advances in single cell sequencing will be presented. Moreover, different examples about how the single cell revolution is helping to answer challenging biological questions will be highlighted.

Single-Molecule Analytics: Monitoring Chemical Reactions Using CY3 Dye Fluorescence

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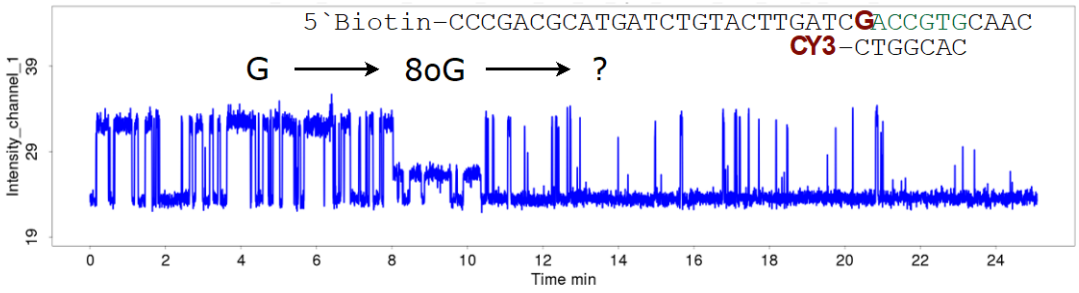
Hybridization of cyanine dye labeled short oligonucleotides to surface immobilized probes was investigated in zero-mode waveguide nanostructures using a modified commercial single-molecule DNA sequencer. In CY3 dye labeled oligonucleotides, stacking interactions bring the dye into close proximity with paired nucleobases. Since CY3 fluorescence is very sensitive to the molecular environment, chemical changes in the nucleobases can be monitored. We tested this by measuring CY3 dye fluorescence during hybridization over a period of up to 1 h. Hybridization manifests by a simple pulse pattern which is characterized by the rate constants of association and dissociation, respectively, and pulse intensity. This pulse pattern represents a signature of the molecular system under study. On hybridization performed over longer periods, characteristic changes of pulse pattern were observed depending on experimental conditions. These changes were caused by chemical reactions proceeding at the nucleobases. Reactions were initiated by a photoinduced electron (hole) transfer from G to CY3 dye and followed by subsequent irreversible reactions. As a first reaction product, 8-oxoG was identified by its characteristic pulse pattern. This assignment was supported by static fluorescence and SPR measurements as well as single-molecule hybridization measurements using an 8-oxoG modified oligonucleotide. Subsequent reactions result in formation of higher oxidation products. Using the same chip, in a second step the DNA sequencer allows to sequence the immobilized oligonucleotide in order to identify reaction products by analysis of polymerase kinetics.



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Comprehensive Single Cell Multi Omics

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The comprehensive combination of various analytical methods is a crucial feature for the future of biochemical investigations. Analyzing metabolites and proteins from the same sample, especially from the same cell, might be extremely supportive of gaining a fundamental understanding of cellular processes.
A recently developed single-cell picker [1,2] allows the sampling and lysis of individual cells. This enables the picking of cells according to phenotypical appearance. In this proof of concept study, we used this system to deposit the lysate from one or a few cells on dedicated slides. Using a modified CAMAG TLC-MS interface, the cell lysate was transferred into a standard LC-MS system including chromatographic separation. Highly abundant metabolites such as glutamine or glutamic acid were detected to a level of single cells. Proteins remained on the microscope slide and were detected by antibody staining after LC-MS analysis of the same cell.
Finally, we could demonstrate a strategy to combine several techniques to detect metabolites and proteins from the same sample. However, the concept needs further optimization according to sensitivity, robustness, and speed for quantitative high-throughput measurements.

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Automated Parallel Derivatization Strategy for Improved Metabolites Analysis in Liquid Chromatography-Mass Spectrometry

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Liquid Chromatography-Mass Spectrometry (LC-MS) has been extensively used for metabolomics due to high dynamic range, high selectivity and sensitivity. However, due to the vast variety of metabolite physicochemical properties there is no single workflow which can provide large-scale metabolomics coverage in particular for polar metabolites. With LC-MS several limitations have to be addressed including: poor MS response factor, chromatographic retention time and MS/MS fragmentation. Among different techniques, chemical derivatization has proven to be a suitable workflow to address these issues. Dansyl chloride (DnsCl) and dansylhydrazine (DnsHz) are able to derivatized metabolites which contain amines, phenols and carbonyl functional groups but require different conditions. To overcome these limitations and to enable QUAL/QUANT analysis we propose an automated parallel derivatization approach based on two derivatization procedures in a single LC-MS run using data independent acquisition. Quantification could be achieved with the use of ^{13}C labelled reagents.

Automation was performed in a PAL RTC autosampler (CTC Analytics) and was found to be essential to allow reproducible derivatization. The integration of a dual column-switching was critical to remove excess of reagents and salts which can significantly affect the ionization efficiency and chromatographic performance. Data were acquired on a QqTOF (TTOF 5600, Sciex) using data independent acquisition (SWATH/MS). A highlight in derivatization is the possibility to tag analytes using specific fragments, in which DnsCl and DnsHz after collision induced dissociation gives signature fragments *m/z* 171 and *m/z* 156 which can be used to identify unknowns based on functional groups. In addition, was synthesized the analogously labelled $^{13}C2$-DnsCl and $^{13}C2$-DnsHz as suitable internal standards that can be generated for any analyte that combined with SWATH-MS acquisition allows targeted quantification and untargeted profiling that generate valuable additional sample information of precursor, fragment ions and chemically related analytes within same batch. Besides the significant improvement in chromatographic separation and MS response. The method could be applied for quantitative and qualitative analysis of different metabolites in biological samples from a clinical investigation.

The AgroPOP Project: Toward a Better Understanding and Mitigation of Transgenerational Transfer of Polychlorinated Biphenyls in Cattle

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Polychlorinated biphenyls (PCBs) are highly persistent organic pollutants (POPs) that are still of concern, although they have been banned in Switzerland since 1986. Besides being toxic to humans and the environment, PCBs are easily dispersed in the environment, are highly hydrophobic and bioaccumulate in the food chain. Therefore, the main PCB exposure route for humans is the consumption of food of animal origin that accounts in Switzerland for more than 90% of the overall human exposure, of which 70% is from bovine meat and dairy products [1]. Apart from potential long-term adverse health effects, elevated PCB levels in animal products may also lead to loss of the livestock at the expense of the farmer. To address this problem, the aims are i) the identification of a potential PCB entry pathway into food products, as well as ii) the assessment of the toxicokinetics of PCBs to improve risk management. Therefore, an *in vivo* experiment is currently conducted, in which mother cows are orally exposed over a long time period to a soil-grass silage mixture containing PCB levels close to the feed maximum regulatory limit, while feeding their calves through milk. These experimental data will be used to assess the predictive ability of a dynamic model that incorporates the soil uptake from grazing and the PCB transfer from the mother cows to their calf [2]. The combination of *in vivo* and *in silico* will help to better understand the accumulation process of PCBs in cattle and, on this basis, to derive recommendations to further mitigate PCB levels and improve food safety.

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Moving to New Technologies: Transmission Raman for Content Uniformity (CU) Testing

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Only a few years ago, Raman spectroscopy was widely introduced in the routine analysis of the pharmaceutical industry. At this time the implementation of rapid, non-invasive and non-destructive analytical techniques to identify incoming goods - such as (portable) Raman and NIR spectrometers - were essential to meet regulatory requirements. Whereas NIR spectroscopy is already used for some time for quantitative analysis in the pharmaceutical industry, the field of application of Raman spectroscopy has been limited mainly to qualitative analysis, yet.
The availability of the first transmission Raman spectrometer, which also meets the comprehensive regulatory requirements in the GxP environment, opens up a new, extensive deployment scenario, which is difficult to cope with common analytical techniques regarding the ever-increasing regulatory requirements for test scope and frequency as well as the need for increased efficiency in the highly competitive business of generic drugs.

In this lecture, the pilot project for the introduction of the transmission Raman spectroscopy for routine analysis at Novartis will be presented. Among other things, the following questions will be answered:

- What are the advantages over other analytical techniques such as HPLC or NIR spectroscopy?
- What are the efforts and challenges regarding device qualification, method development and validation?
- What is the regulatory framework for the application of quantitative Raman spectroscopy in the pharmaceutical industry?
- How can you ensure that the method will still deliver reliable results in a few years?

Deep UV Raman Spectroscopy for Online Water Analysis

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During the last decades, the scientific interest in wastewater analysis has been growing due to the persistent presence of contaminants in treatment plants and due to the degradation of groundwater quality. Agriculture-derived inorganic compounds as ammonium, nitrate and nitrite, and phosphate ions have been reported with typical concentrations of tens mg/l or lower [1,2]. Raman spectroscopy in the visible range is a promising online technique capable of detecting most of the pollutants in one measuring step. Due to low Raman cross section and overlap of fluorescence and Raman emission the limits of detection (LOD) of visible Raman spectroscopy is above the threshold required to be used in online monitor in waste-water analytics [3,4]. However, by changing the excitation energy it is theoretically possible to vary the relative intensity of the Raman and fluorescence signal.
We demonstrated the proof of this concept using an Optical Parametric Oscillator (OPO) as excitation source for Deep UV radiation. We achieve LOD for nitrate better by a factor of ten than 25 mg/l as required for an online water analysis method [5,6]. In addition to its use as a practical tool, we are able to study fundamental photochemical processes taking place upon UV-illumination. The nitrate - nitrite photolysis process upon deep UV radiation has been investigated in detail [7].

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Advancing a Full Picture on Water-Soluble Synthetic Polymers in Wastewater - Different Ionization Strategies for Homologue Series Detection

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Synthetic water-soluble polymeric materials are widely employed in e.g. cleaning detergents, personal care products, or textiles. Accordingly, these polymers reach municipal wastewater and may enter receiving waters and the aquatic environment. To understand the fate of these synthetic macromolecules in the aquatic environment, more information is necessary. Characteristically, these molecules show a polydisperse molecular weight distribution, comprising multiple repeating units, i.e. homologue series. Their analysis in environmentally relevant samples has received some attention over the last two decades [1], however, the majority of previous studies focused on surfactants and a molecular weight range <1000 Da. Synthetic water-soluble polymers were studied in samples collected at different stages of wastewater treatment (primary and secondary clarifier, and ozonation) at a Swiss plant. Sample preparation comprised centrifugation and optionally a pre-concentration step using evaporation. To prevent contamination, plastic material was avoided.
For analysis, reversed phase liquid chromatography was coupled to a Q-Exactive Plus high-resolution mass spectrometer (ThermoFischer Scientific, US) in data-dependent acquisition mode. Aiming at covering a wider range on the mass to polarity plane, ionization was realized optimizing different interfaces, namely electrospray (ESI), atmospheric pressure chemical ionization (APCI) and atmospheric pressure photoionization (APPI) in terms of temperature, gas flows and dopant addition.
Data was evaluated combining a non-targeted and screening workflow in enviMass that includes advances in the non-targeted homologue series (HS) extraction tool, enviHomologue [2]. The workflow for investigating higher molecular masses as well as the benefits and drawbacks of the different ionization methods will be discussed based on results of the sampled Swiss WWTP.

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Data Mining and Machine Learning Strategies for Non-Targeted Interpretation of High-Resolution Mass Spectrometry Data from Complex Biofuel Samples

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High-Resolution Mass Spectroscopy (HRMS) has been for years applied for harnessing knowledge in the fields such as proteomics, and workflows exist today for a nearly automated "sample to knowledge" transfer. This is not the case for most of the renewable energy sciences, which are just starting to take advantage of those powerful techniques. The instrumental challenges are multifaceted (e.g., analyte transfer into the instrument, successful separation of concentrated samples, and effective ionization of the species), but relatively simple compared to the questions of assessment of such complex data sets. Numerous non-targeted techniques have been employed to breach the gap (e.g., van Krevelen diagrams and aromaticity index) for effective visualization and comparison of samples, but it is just the tip of the iceberg.

In our previous work, we have shown that closing carbon balances of both volatile, semi-volatile, as well as non-volatile fractions of the products is possible by application of ultra-high pressure liquid chromatography coupled to high-resolution mass spectrometry (UHPLC-HRMS) [1,2]. In the current work, we have combined UHPLC-HRMS data (using ESI and APCI ionization) with tailored data mining, and machine learning techniques to extract meaningful information about the composition of complex environmental samples originated from the production of sustainable fuels and chemicals. The methods involved discriminatory analysis based on weighted kernel density estimation (KDE), Kendrick mass defect (KMD) method, multivariate data analysis (MDA), and multidimensional Volcano charts for statistically significant species.

Preliminary results have shown that the applied methods supply a crucial level and depth of information for a better understanding of the underlying chemical processes and transformations. Kernel density estimation (KDE) is a non-parametric technique for estimating probability density function of a random variable, in this case, molecular weight (MW) and double bond equivalency (DBE). In this strategy, no cut-off is necessary, and all data are used and weighted by their peak area as observed by mass spectrometry measurements. The results allow us to track changes in the selected process responses according to the process conditions along local maxima and minima. Principal component analysis (PCA) was performed on the results with the aim of mining hidden trends. PCA is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components (PCs). The method was performed directly on the raw data as well as on the normalized peak areas, thus enabling us to mine hidden data trends correlating with the physical process conditions. Kendrick plots showing the nominal Kendrick mass (NKM) as a function of Kendrick mass defect (KMD) was used to group homologous series of species. The Kendrick mass is defined by setting the mass of a chosen molecular fragment, in this case CH2, to an integer value in

atomic mass units, here 14 (1xC+2xH=1x12+2x1=14). The advantage of this method is that species belonging to a homologous series are positioned on a horizontal line due to identical mass defects. This provides a compact visualization of the composition of the core conversion products, as well as easy identification of the species according to their locations between identified species on the homologous lines.
Successful application of those newly developed methods (scripts written in Python) for semi-targeted analysis of complex environmental samples.

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Poster Abstracts

Quantification of Chlorinated Paraffins (CPs) in Plastic Products: Improved Pattern Deconvolution with Single-chain CP Mixtures

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Chlorinated paraffins (CPs) are high production volume chemicals applied in various polymeric products as plasticizers and flame retardants. They are produced as complex mixtures covering a wide range of carbon chain lengths (C_{10}-C_{30}) and different chlorination degrees (30-70 wt%Cl). In 2017, short-chain CPs (SCCPs, C_{10}-C_{13}) have been classified as persistent organic pollutants (POPs). Thus, SCCP monitoring has become an important task which is usually done by mass spectrometric analysis. However, due to the unknown and variable composition of CP mixtures, their quantification is a challenging task.

Typically, complex standard mixtures are used for quantifying SCCP sum parameters in samples. Quantification is done by finding a linear combination of several SCCP standards (of different chlorination degrees) that best describes the measured CP homologue pattern of the sample [1]. This process, called pattern deconvolution, requires a high similarity of CP patterns of the sample and the applied CP standards. Figure 1 (top) shows a measured CP homologue pattern of a tested yoga mat. Only C_{12}- and C_{13}-CP homologues are present. However, commonly used SCCP standards also contain C_{10}- and C_{11}-CP homologues. Thus, it is impossible to find a linear combination of the three standards, given in Figure 1, to describe the sample's pattern [2]. This impedes a correct quantification of SCCPs since the detection sensitivity greatly depends on the type of CPs considered. Single-chain CP mixtures of only one chain length but with varying chlorination degrees are a promising alternative. Figure 2 (bottom) shows that the homologue pattern of the yoga mat can be described well by a linear combination of these single-chain CP mixtures. The measured and reconstructed patterns show high similarity as indicated by a coefficient of determination of R^2=0.99.

In conclusion, SCCP homologue patterns in consumer products can vary strongly and differ from the available SCCP standard mixtures. As shown, the use of single-chain CP mixtures can improve the pattern deconvolution process and thus the quantitative analysis of CPs.

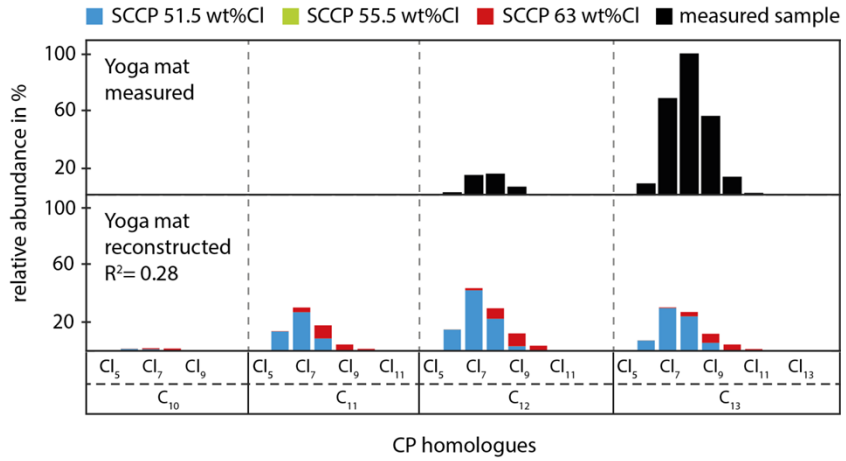

Figure 1. The measured CP homologue pattern of a tested yoga mat contains C_{12}- and C_{13}-CP homologues(top). Pattern deconvolution with three complex SCCP standards (C_{10}-C_{13}) fails and the observed pattern could not be reconstructed (bottom). (modified from [2])

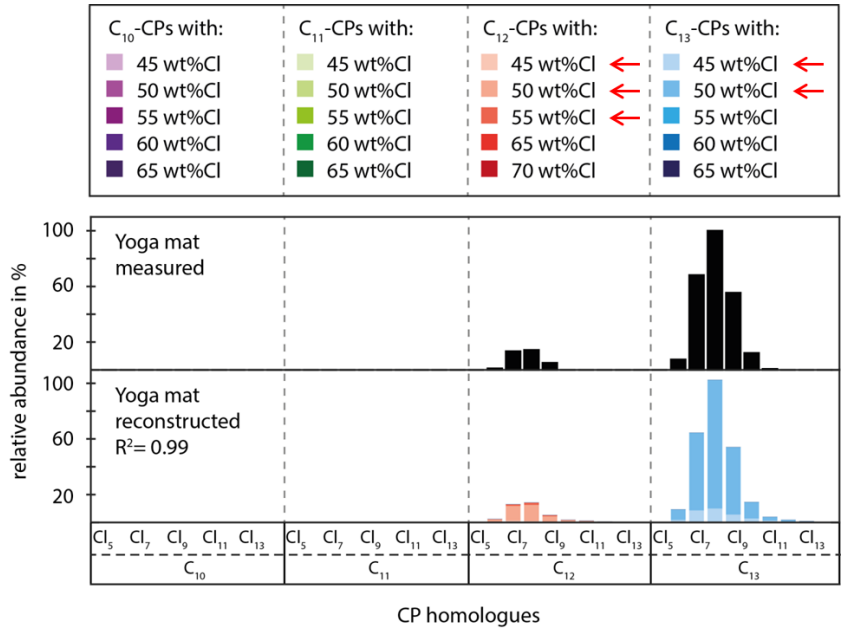

Figure 2. It is possible to reconstruct the measured CP pattern of the tested yoga mat using five (red arrows) single-chain CP mixtures (bottom). (modified from [2])

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Mass Spectrometric Investigation of the Interaction of Metallocenes with Biomolecules

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In recent years a great number of transition metal complexes has been investigated for their antiproliferative properties against various cancer cell lines. Besides the highly promising ruthenium and osmium arene complexes, bent metallocenes (Cp_2MCl_2) comprising modified cyclopentadienyl ligands have found widespread interest as anticancer agents. The majority of anticancer metallodrugs are prodrugs that undergo in vivo conversion into the active compounds by ligand exchange or redox reactions, which subsequently interfere with their protein or nucleic acid targets and evoke apoptosis. However, many aspects of prodrug activation, cellular uptake, target recognition, and the final mechanism of action still remain elusive.
In this study, the role of ubiquitous biomolecules in prodrug activation and target binding is investigated. Competition experiments with amino acids, peptides, proteins, and nucleic acids provide information about potential target sites and binding preferences of the various metallodrugs. Furthermore, the susceptibility of the different transition metal coordination centers to reduction and ligand exchange is probed by mass spectrometry.

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Reducing Mass Spectra Complexity through Adduct Annotation for LC-SWATH/MS Metabolomics

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A wide variety of ions are commonly observed in full scan electrospray mass spectra of low molecular weight compounds. Multimers and alkali/metal adducts ions are frequently seen along with the protonated and deprotonated forms, in positive and negative mode. The type of adduct and their intensities vary according to the analyte, sample, source conditions and mobile phase. Adducts are generally undesirable because they artificially increase data complexity, affect the sensitivity of quantitative assays and challenge analyte identification. We propose a novel metabolomics workflow to process LC-MS Data Independent Acquisition (SWATH) using an open source annotation software (mzAdan) for feature (RT, m/z) annotation and metabolite identification based on the SWATH-MS spectra of $[M+H]^+$ candidates.

Flow injection analysis (FIA) on a high resolution QqTOF (TTOF 5600, Sciex) of 600 metabolites included in the human metabolome database (HMBD) was performed using electrospray ionization in positive and negative modes. Adduct distribution in LC-MS analysis of a standard mix of 52 metabolites under different reversed phase LC conditions were compared to that obtained in human urine. In LCMS, SWATH acquisition was used to generate MS/MS spectra of the observed forms. Sodium and potassium adducts were observed with multimers, regardless of the brand instrument used. FIA-MS and LC-MS data showed that adducts are more prevalent than expected. Major differences were observed in adduct intensity and distribution. For the metabolite QC standards in the LC-mixture, our workflow properly annotated 44 metabolites, as $[M+H]^+$, while this figure dropped to 20 using CAMERA, currently a top reference in annotation software. Furthermore, 57% of adduct annotations were missed by CAMERA. Lastly, the number of features (RT, m/z) in our LC-MS metabolomics dataset was substantially reduced by 43%, enabling more efficient and accurate metabolite identification.

This work demonstrates that annotation is critical for data dependent acquisition and increased accuracy and robustness in quantitative LC-SRM/MS assays. In SWATH acquisition the $[M+H]^+$ annotation is essential for library search.

Mercapturic Acid Pathway is Complete and Functional in Early Stages of Zebrafish (Danio rerio) Development

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Conjugation of electrophilic substances with glutathione and further metabolism of the conjugate within the mercapturic acid pathway is generally considered a detoxification route. Nonetheless, some chemical groups, including isocyanates, 1,2-dihaloalcanes and haloalkenes can be bio-activated to toxic biotransformation products within the pathway or through a diversion from the pathway. To avoid false positive or false negative results in chemical risk assessment, toxicity studies require appropriate model systems with a complete and functional mercapturic acid pathway.

Zebrafish early life stages offer a versatile model system for the study of bioactive compounds due to their genetic similarity to humans and the availability of well-established high-throughput techniques. In order to understand the validity of this model for comprehensive risk assessment, it is important to characterize the biotransformation capacity [1], including the formation of mercapturates, in zebrafish embryo and early larvae.

Here we established a method to precisely analyze biotransformation products of the reference substrate 2,4-dinitrochlorobenzene (CDNB) *via* liquid chromategraphy coupled with high resolution mass spectrometry. By monitoring the CDNB-conjugates of the mercapturic acid pathway throughout zebrafish development, we show that zebrafish embryo and larvae are capable of catalyzing glutathione conjugation reactions and further process the compounds to the respective mercapturate. The presence of this important chemical activetion/deactivation and clearance route within zebrafish early life stages supports the functionality of this model organism as an alternative model in toxicology and chemical hazard assessment.

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Determination of Natural Estrogens in Cattle and Pig Manure using QuEChERS and Liquid Chromatography-Mass Spectrometry

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Estrogens in surface waters have negative effects on the reproduction and development of aquatic organisms [1]. Agriculture may be a significant source for natural estrogens in this environmental compartment [2]. Several studies in different countries have demonstrated that the application of manure from husbandry animals to soil causes the release of natural estrogens to surface waters [3,4]. Therefore, we quantified the load of natural estrogens in cattle and pig manure to estimate the natural estrogen input from agriculture to the environment.

To the best of our knowledge, the QuEChERS approached [5] is used for the first time to extract natural estrogens from cattle and pig manure. After the extraction, we derivatized the natural estrogens with dansyl chloride. Quantification of natural estrogens was conducted by LC-MS/MS.

Samples of different pig and dairy farming manure storage pits were gathered to obtain an overview about the prevailing natural estrogen concentrations in Swiss manures. Additionally, over a period of three months we monitored natural estrogen concentrations in an experimental dairy farming manure storage pit to study the effect of aging on natural estrogen concentrations in manure. The samples are currently analyzed and results will be presented.

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Investigation of the Molecular Weight Distribution of Endotoxins by Size Exclusion Chromatography Coupled to High-Resolution Mass Spectrometry (SEC-MS)

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Endotoxins (ET), which are also called lipopolysaccharides (LPS), are a major contaminant found in pharmaceutical active substances as proteins but also in the environment (water, air, dust etc.). The presence of small amounts of ETs in pharmaceutical preparations can cause undesired effects to the human body such as septic shock, tissue injury and even death when entering the bloodstream. Due to these health concerns, it is essential to remove ETs from drugs, injectables, and other biological or pharmaceutical products down to very low concentrations. ETs are very stable, amphiphilic molecules, which can easily contaminate drugs and food, but also labware or other surfaces. They are difficult to handle e.g. in a laboratory or medical environment [1].
The aim of this project was to develop a simple analytical strategy to characterize ET aggregation and a method to determine average MW and monomer MW distribution by SEC-UV followed by MS-based molecular weight determination. Impact of the solvent composition and sample handling on ET aggregation including the impact of sample preparation and temperature storage have been investigated. Different SEC column with various chemistry and MW separation range have been compared using mobile phase containing different denaturing additives as DOC or 2-propanol. MS ionization parameters have been optimized for high quality MS spectra. Prior to MS analysis, MS incompatible MP was used in SEC fraction collection to investigate ET denaturation.

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Using Column Chromatography to Assess Mobility of Natural Toxins in the Aquatic Environment

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Over 34% of recently evaluated plant secondary metabolites (natural toxins) were found to fulfil the criteria for aquatic persistency, mobility and toxicity based on predicted property data [1,2]. However, as prediction tools show limited applicability [3], experimental evaluation of the organic carbon-normalized sorption coefficient (K_{oc}) as a primary mobility parameter is a crucial step to determine if natural toxins end up in potential drinking water abstraction sites.

Column chromatography was applied in the systematic evaluation of sorption behavior of a large diverse set of natural toxins to organic matter. Experiments were generally performed as described previously [3]. However, in this study the method was applied to a substantially larger set of compounds and experimental conditions varied to study effects of e.g., temperature and pH on K_{oc}. In addition, method performance parameters were evaluated to ensure method applicability.

The case of natural toxins shows that column chromatography is a suitable method for quantitative, reproducible analysis of sorption to organic matter. It is generally applicable to large sets of mobile compounds (log K_{oc} between 0.5 and 3.5). According to the obtained data, most analyzed phytotoxins can be categorized as mobile in the aquatic environment with log K_{oc} values well below the defined cut-off criterion for mobility of log K_{oc} = 4.5. [2] Many toxins are also ionizable and appear in the more water-soluble cationic form in the environmentally relevant pH range and thus show even higher mobility. The very short analysis time and little material requirements easily allow systematic investigations of differing influences on sorption. Thus, detailed mechanistic insights are gained that are of great value for understanding transport and fate processes in the environment. Applying the method to other different sorbents in the future (e.g., minerals, activated carbon) will help to determine their individual contribution to the natural toxins' overall mobility on their path from source to tap (drinking water).

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Enantiomeric Fractionation – An Indicator of Biotransformation During a Water - Sediment Flume Study

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Many organic contaminants that enter the aquatic environment feature stereogenic structural elements that give rise to enantiomerism. While abiotic processes (e.g. sorption, photo transformation, dilution) usually act identical on enantiomers, biotic processes, such as biotransformation (degradation) often happen to result in enantiomeric fractionation (EF), i.e. the change of the relative abundance of enantiomers. Therefore, EF offers the opportunity to differentiate biodegradation in complex environmental systems from abiotic processes. The aim of this study was to test this indicator for the characterization of the attenuation of eight chiral organic contaminants (pharmaceuticals) in 24 recirculating water-sediment test flumes. Major variables among the flumes were bacterial diversity and hyporheic flow. Both were established at three levels (low, medium, high) by different amounts of river sediment inoculum (bacterial diversity) and number of bedforms (zero, three, six) in the flume sediment (hyporheic flow), respectively. Over a period of 56 days, parent compound concentrations, transformation product formation and enantiomeric composition of the eight chiral contaminants were monitored in flume surface water. Enantiomers were quantified using a specially developed chiral LC-ESI-HRMS/MS multi-residue method. All eight substances were attenuated by at least 60% in all 24 flumes, of which five (atenolol, metoprolol, celiprolol, propranolol, flecainide) displayed EF. No EF was observed for citalopram, fluoxetine and venlafaxine despite almost complete attenuation (80 to 100%). Celiprolol, a barely studied beta-blocker, revealed an interesting enantioselective behavior indicating biodegradation at highest bacterial diversity. This is supported by the fact that attenuation in the autoclaved control was not accompanied by EF. Moreover, celiprolol showed the most distinct EF among all investigated substances.

Use of PDMS Sheets for Sampling Pyrethroids and Organophosphates in Rivers of the Wakiso District, Uganda

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As in many tropical countries, farmers of the Wakiso district in Uganda use pesticides to protect crops and animals. After use, these toxic substances may end up in streams, especially after intense tropical rainstorms. From the applied pesticide, pyrethoids and organophosphates belong to the most toxic compound groups for the aquatic organisms. Facing several challenges such as i) very low required quantification level at picograms per litter, since these compounds have very low environmental quality standards (EQS), ii) the difficult accessibility or security of the sampling sites, iii) the lack of time-integrated pesticide data, passive samplers seem to be a good tool for a monitoring of such pollutants in aquatic systems. With the use of polydimethylsiloxan (PDMS) sheets as passive samplers, 2- to 4 weekly time integrated pyrethroid and organophosphate data can be obtained.

The analytical method developed and optimized to extract insecticides from PDMS by C Moschet et al [1] was applied in this study. The technique is based on an Accelerated Solvent Extraction (ASE), followed by a clean-up on C18 and silica gel, for a targeted analysis of 15 pyrethroids and 2 organophosphates. Finally, the detection is performed with atmospheric pressure chemical ionization and tandem gas chromatography (GC-APCI-MS/MS). With the PDMS method, detection limits down to 2 pg/L could be reached for all substances.

During our sampling campaign in the Wakiso district in Uganda from the 19th September to the 28th of November in 2017, biweekly samples were collected at 5 river sampling sites. Out of our 17 analytes: chlorpyriphos, allethrin, phenothrin, lambda-cyhalothrin, cypermethrin, and deltametrine were found in the samples. Chlopyriphos and cypermethrin were detected in all the sites during the entire sampling period at concentrations between 12 to 2’960 pg/L and 1 to 22 pg/L respectively.

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Multi-residue Trace Analysis of Plant Protection Products in Soils from Different Farming Systems

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In Switzerland approximately 250 different chemical synthetic active ingredients are used as plant protection products (PPP) [1]. The application of PPP constitutes one of the largest intentional input of potentially harmful substances into the environment [2]. Depending on its application, it is possible that only a minor fraction of applied PPP reaches its targets, leading to a large amount of potential persistent and toxic residues in the environment that might harm non-targeted organisms [3]. This soil contamination raises concerns on soil functions, soil biodiversity and soil fertility, and consequently on food quality. Especially as the environmental behavior, persistence and bioavailability of PPP residues are poorly understood [4].

To get an overview about the content of PPP and its metabolites in soil, samples were collected from 60 sites distributed across Switzerland (20 conventional, 20 notill and 20 organic farming sites). Thirty-seven target analytes (14 herbicides, 17 fungicides, six insecticides) and eight of their transformation products were accelerated solvent extracted using different solvent compositions (organic and acidic) [5]. Separation and detection with method detection limits in the low ppb concentration range took place with liquid chromatography-tandem mass spectrometry.

The screening showed that PPP residues and its degradation products were present in the soils of all 60 sites. Atrazine and its metabolites were measured most frequently, with concentrations up to 108 µg/kg. The results indicate that residues remain longer in the environment as their degradation half-lives suggest. Further studies will focus on the bioavailability of fungicides and their effects on soil fertility indicators (e.g. enzymatic activity), and soil functionality indicators (e.g. leaching).

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Miniaturized Solid-contact Ion Selective Electrodes for Environmental Sensing

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Research on the field of environmental sensors continues to grow at a significant pace, giving rise to scientific and technological advances in this domain. Monitoring the quality of our water resources is one of the objectives set in environmental sensing. Today, numerous systems of varying complexity targeting a wide range of analytes have become available. While electrochemical sensors for water monitoring made their first appearance a long time ago, there is a particular and ongoing interest to reach smaller scale and size. One advantage that comes with the application of small-scale sensors includes a less biased measurement that can be achieved by the use of miniaturized sensors, especially in the case of particularly vulnerable water media.

Ion-selective Electrodes (ISEs) form an active field of research, with much attention towards the use of new materials that may result in robust electrochemical performance [1]. The present study focuses on the development of miniaturized solid-contact Ion-selective Electrodes for the measurement of various environmental analytes, such as nitrate, chloride, carbonate, calcium and hydrogen ions. Miniaturized platinum and glassy carbon electrodes are tested with diverse coating materials, including conducting polymers (e.g. PEDOT-C_{14}) and functionalized carbon nanotubes. Different membrane components (e.g. ion exchangers) and polymer matrices (e.g. polyvinyl chloride) are also under examination. The overall aim of the research is to find the most promising combination of materials and methods that will enable the development of robust miniaturized sensors targeted to environmental sensing applications.

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Thin Layer Potentiometry for Anion Sensing

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Recently, thin layer membranes (a few hundreds nm thickness) have been thoroughly studied in the field of ion transfer [1] and stripping voltammetry [2], yielding detection limits in the nanomolar range. Although thin membranes are already considered to be a well-established tool within these methods, only a limited number of publications combine thin layer membranes and potentiometry. Hyphenating these two concepts could open the field for new sensing principles such as multianalyte detection.
Recently, Zdrachek et *al*. [3] presented a switchable potentiometric probe with thin polymeric membrane suitable for subsequent cation and anion detection. As seen in this work, although the use of poly(3-octylthiphene) (POT) as a transducer layer is well suited for cation detection, results are less accurate and tend to lack stability when switching to anion sensing mode. Here, we explore different transducers in thin layer potentiometry for anion sensing. Based on the work performed by Yuan et *al.* [4] and Guzinski et *al*. [5] functionalized multiwalled carbon nanotubes (f-MWCNT) and poly(3,4-ethylenedioxythiophene) (PEDOT) derivatives were considered as promising candidates. By achieving a stable anionic response, the goal is to improve the switching probe system and develop a multianalyte detection probe.

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Colorimetric Readout of Potentiometric Probes with Closed Bipolar Electrodes and Prussian Blue Film

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A thin film of Prussian Blue (PB)/Prussian White (PW) is used as a tunable colorimetric redox probe at the end of a closed bipolar electrode, thereby forming a detection compartment that is physically separated from the sample. The potentiometric probe in the sample compartment directly translates the potential signal to the optical transducing film. A constant electrical potential is imposed across the bipolar electrode. The potential change at the ion-selective electrode (ISE) is compensated by an opposite change at the detection side. This triggers change in the ratio of the redox states of the PB/PW film, resulting in a change of the equilibrium colorimetric response [1,2]. A transient current caused by a turnover of PB/PW must pass across the ISE membrane, which may place practical limits on the approach. To minimize this effect, the membrane is doped with an inert lipophilic electrolyte, ETH 500 and the colorimetric spot is chosen to be sufficiently small. The response of the PB/PW film is analyzed by the extend of color saturation. Scan rate dependence studies of peak current suggest thin layer behavior, meaning that mass transport is not rate limiting. The optical response range can be modulated by the external applied potential. This approach forms the basis for the imaging of sensor arrays by acquiring an array pattern images.

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In-Line Capacitive Readout for pH Analysis of Ion-Selective Electrodes

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This work reports on a novel approach to monitor pH change by capacitive signal readout of potentiometric sensing probes. As reported by Bobacka [1,2], constant potential coulometry is used, where the potential of sensing electrode vs reference electrode is kept constant. The change in ion activity results in a potential change at the sensing electrode, which is compensated by an equivalent opposite potential change at the capacitor. This results in a transient current that is integrated with time to obtain charge–time and charge–ion activity relationships.
This work introduces two innovations to make this attractive approach practically useful. In contrast to the earlier used conducting polymer capacitive layers [1,2], we explore here instead the use of commercial electronic capacitor components. As a consequence, a range of capacitances of exactly predefined values can be applied as needed. Secondly, the approach is integrated into a segmented flow system to achieve rapid and reversible concentration changes, making allowing one apply this technique to real world samples.
The approach is first explored with a Ag/AgCl electrode as model system and further developed with a ionophore-based polymeric membrane pH probe. The experimental data correlates well with a recently introduced theoretical model [3]. The approach is explored for continuous measurement of vary small changes in ion activity, using small pH changes as example of practical relevance.

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Multiple Ion Activity Sensing by Ionophore-Based Voltammetry on a Microelectrode

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Thin layer multiple ionophore based ion-selective electrode have recently been introduced on the basis of large surface area electrodes [1]. In this manner, the activity of different ions can be detected within a single cyclic voltammogram in complex real world samples. On top of the electron conductor, adequate electron-to-ion transduction can be achieved by redox conversion of a poly 3-otylthiophene (POT) thin film. The two ionophores result in two bell-shape peaks in the cyclic voltammogram that are separated owing to the different formation constants. However, in applications such as cellular imaging, the size of the probe must be adequately reduced, which has the added benefit of increased mass transport efficiency for lower detection limits. We first characterize only POT on the gold microelectrode, exhibiting a thin layer electrochemical behavior corresponding to a linear relationship between peak current and scan rate. Lithium ion activities were detected by cyclic voltammetry on a 10 µm diameter gold microelectrode at various concentration. The combination of different ionophores is studied in terms of multianalyte detection and selectivity for complex environments. The in situ multiple ion detection will be of benefit in a range of applications because their changes could then be studied at the exact same location, including scanning electrochemical microscopy.

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Emulsified Cation and Anion Ion-Selective Optical Sensors Based on Solvatochromic Dyes

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In this work, a series of positively charged solvatochromic dyes (SDs) were synthesized and applied as transducers and optical signal reporters in the ion-exchange progress based optical sensors [1]. Optical emulsion sensors for K^+ and CO_3^{2-} were prepared in the absence of additional emulsifier. K^+- selective sensors were composed of a polymeric phase containing cation exchanger, valinomycin and SD [2], while CO_3^{2-} ionophore VII and SD for CO_3^{2-}-selective optical emulsion sensors. Both kinds of optodes exhibit a fast response and excellent selectivity that are much improved compared to previous emulsification approaches. The SDs here share an identical fluorophore group but different alkyl or PEG chains and therefore exhibit different lipophilicity and partition coefficients. The functional response range can be successfully tuned by choosing the appropriate dye, making them potentially attractive for wider concentration range measurements.

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Thin Layer Anion-Selective Membrane Based on Copper Mediated Electrochemistry for Ion Transfer Solid Contact Electrodes

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Currently available conducting polymer materials as ion to electron transducers are often not suited for the development of ion transfer voltammetric probes for anionic species. To overcome this limitation, we present here a thin layer ion-selective membrane based on a di-tripodal amine calix[4]arene [1] for copper mediated anion transfer at thin layer membranes electrodes [2]. Copper(II) ions are introduced into thin polymeric membrane to form strong complexes with the di-tripodal amine calix[4]arene receptor, resulting in the concurrent co-extraction of a sample anion. Reduction of copper at the electrode substrate transfers the anionic species to solution, forming the basis for ion transfer voltammetry of anionic species. Copper mediated ion transfer voltammetry exhibit reversible and reproducible oxidation/reduction behavior with peaks of Gaussian shape for anion transfer. The membranes are composed of di-tripodal amine calix[4]arene, dodecyl 2-nitrophenyl ether (NPOE), polyurethane (PU) and sodium tetrakis[3,5-bis(trifluoromethyl)phenyl] borate (NaTFPB). A linear relationship between current and scan rate is confirmed to demonstrate thin-layer behavior. A near-Nernstian shift of the peaks with increasing thiocyanate concentration is established. The proposed thin membrane demonstrates an anti-Hofmeister series selectivity sequence, giving the highest selectivity to thiocyanate relative to other anions. The developed thin membrane with copper(II) di-tripodal amine calix[4]arene can be utilized as solid contact redox probes for thiocyanate determinations.

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Miniaturization of Fluid Sample Preparation Platform for an Automatic Flow Cytometer

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Fluorescent staining coupled with flow cytometry (FCM) is often used for quantification and characterization of bacteria in water sample as most commercially available flow cytometers are full-sized laboratory bench-top instruments, which are expensive to be generally dedicated to limited applications like analysing the quality of drinking water and fluidic sample preparation is usually done manually by a trained laboratory expert, In this respect, there is a great potential to develop flow cytometers that adopt miniaturization and automation in the fluidic sample preparation part and has the major advantages in terms of portability. In this project, an automated and miniaturized fluidic sample preparation platform for monitoring the quality of water has been developed, the detection method is based on a DNA stain that makes any bacteria cell detectable with flow cytometry methods. A novel fluidic sample preparation platform for a flow cytometry application capable of filtering, dosing, mixing, incubation, and cleaning has been designed and evaluated. A miniaturized bidirectional syringe pump is used to load reagents (water sample, the fluorescent dye, cleaning and rinsing solution) into a microfluidic device which is integrated directly on a rotary distribution valve. The glass microfluidic device is fabricated using laser micromachining and contains several micro-channels. Each fluidic channel is dedicated to one of the reagents and mixing takes place in a separate reservoir with a magnetically actuated element. The rotary distribution valve is used to connect the valve to the different solution cartridge as well as to actuate the mixing element. The entire device has a minimized the dead volume which is essential to avoid cross-contamination and reduce the amounts of sample, reagent, and cleaning needed to conduct a measurement. The mixed sample is then incubated and injected at a controlled rate into the flow cytometer capillary. DNA-free particles are also detected due to light scattering. The fluorescence and light scattering signals together allow differentiating between live bacteria and any other particulate content in the water sample. Combining the fluid distribution and mixing in microfluidic device benefits from lower power consumption, lower reagent and waste production per each measurement, significantly lower manufacturing costs which enable the rapid, precise, and fully automated analysis of bacteria quantity in water, and find applicability in a broad range of industries.

Characterization of Biomimetic Membranes with Scanning Probe Microscopy and Tip-Enhanced Raman Spectroscopy

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Cell membranes (CMs) represent the physical barrier and interface between the cell and the external environment. They are typically composed of a phospholipid bilayer and contain several different highly functionalized structures (e.g. trans-membrane proteins, glycoproteins) that help regulating the basic functions of the cell. The detailed study of CMs, and especially of their functionalized domains is important because they play a major role in cell signaling and may act as regulators of the cell activity, being thus of key significance for biomedical sciences and drug design [1].
Supported lipid bilayers (SLBs), prepared by the vesicle fusion technique, are widespread models for biological membranes and are widely used in the research community. They are easy to prepare, do not require particular instrumentation and offer a good and reliable "workbench" for preliminary studies [2].
The technique of choice to study SLBs samples is atomic force microscopy (AFM), especially because of its very high resolving power (down to <1 nm) and because it does not require samples to be conductive [3]. Despite the very high spatial resolution, though, the AFM is "chemically blind", i.e., it can only give some tentative characterization of chemical properties, e.g. by means of phase or friction force imaging.
Tip-enhanced Raman spectroscopy (TERS) was pioneered in our lab in the early 2000s and combines scanning probe microscopy (such as AFM) with Raman spectroscopy with the aim of obtaining a vibrational spectrum from very small spots of the sample, well below the optical diffraction limit. Recently, a spatial resolution down to 1.7 nm has been demonstrated in ambient conditions [4].
In this work, the formation of reliable SLBs through vesicle fusion on different substrates has been evaluated, with the goal to achieve stable and reproducible model samples for chemical imaging studies. Preliminary TER spectroscopy is shown to be feasible for nanoscale chemical characterization of membranes. Promising results were obtained in terms of chemical differentiation of domains. This work highlights the possibility of performing TERS on delicate samples.

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Uptake Studies in Chinese Hamster Ovary Cells using Single Cell ICP-TOFMS

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Since the biological cell is the building block of any organism, the development of single cell analysis approaches and the investigation of cell-to-cell variability has become an essential research topic in the fields of Life Sciences, Biology and Analytical Chemistry. Besides the powerful technique called Flow Cytometry (FC), elemental mass spectrometry using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) provides the unique capabilities to quantitatively analyze certain elements in a biological cell or to assess the uptake of metals into single cells, which is especially in the field of metal-containing drug design and the implementation of nanoparticles for targeted drug delivery of major interest. In ICP-MS, cell suspensions are usually introduced into the Plasma using a nebulizer. This leads to transport efficiencies, which are dependent on the size and size distribution of the droplets [1]. Additionally, we expect the transport efficiencies to be dependent on the size and size distribution of the investigated cell sample [2]. To which degree and how many cell fractions get lost during nebulization and transportation is still unknown and object of current research. So far, rather small and insensitive cells such as yeast cells have been studied [2,3], and most applications have used sector field ICP-MS or quadrupole-ICP-MS, which limits simultaneous multi-element uptake studies into cells. Therefore, our cell studies were carried out using a microdroplet generator coupled to an ICP-TOFMS (icpTOF, TOFWERK AG). In this work, Chinese Hamster Ovary (CHO) cells with an average diameter of 13 µm were successfully transported via monodisperse droplets and analyzed using single cell ICP-MS to investigate the uptake of various elements [4]. Every sampled cell was embedded into a droplet with the help of a so-called Autodrop Pipette (microdrop Technologies GmbH, Germany). It is equipped with an actuated piezo actuator, which is used to selectively emit droplets at a selectable frequency (1 to 2000 Hz) and droplet size (30 to 90 µm). The CHO cells were measured as suspensions in either phosphate-buffered saline (PBS), water or mixtures of such. The cell size distribution, which occurs naturally as a rather broad distribution (9 to 19 µm, Cedex HiResAnalyzer, Roche), was studied in detail. A workflow for the single cell analysis of CHO cells, calibration strategies aiming to the quantitative determination of the uptake of various elements into each individual cell and the investigation of matrix effects will be presented.

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Element Mass Spectrometry Using an Affordable Plasma Source: Microwave Inductively Coupled Nitrogen Plasma

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The argon-sustained Inductively Coupled Plasma (Ar-ICP) is the most used ion source for element and isotope mass spectrometry (MS). Despite many advantages for precise and sensitive analysis, it suffers from several drawbacks, like the need for sophisticated RF-power generators, high running costs due to Ar consumption, and abundant Ar-based polyatomic interferences. Recently, a nitrogen-based Microwave Inductively Coupled Atmospheric-Pressure Plasma (N_2-MICAP) has been introduced and it was shown to be a feasible alternative for replacing the conventional ICP, both for optical emission spectroscopy (OES) [1,2] and time-of-flight mass spectrometry (TOFMS) [3].

Here, we swapped the Ar-ICP on the quadrupole MS (ELAN 6100 DRC, Perkin Elmer) with the N_2-MICAP ion source (Radom Corp, U.S.A.) and compared their performance. The sensitivities for various heavy and light isotopes and ionization energies were evaluated.

Also, long and short term stability and fundamental plasma characteristics were investigated. In order to estimate the gas temperature in the source, changes in ion kinetic energies were assessed via occurrence of molecular ions in the mass spectrum as well as adjustment of the ion optics after plasma extraction into the mass analyzer. Both parameters reveal that the gas temperature is very similar to that of the Ar-ICP. However, the lower molecular mass of N_2 compared to Ar causes a higher average velocity after free-jet expansion into the second stage of the differentially-pumped vacuum interface, thus a stronger mass dependence of optimum ion lens settings.

Furthermore, the influence of interface pressure and the use of sampler cones with different orifice size on sensitivity was studied. It was observed that only minor changes were obtained, which indicates that the currently used vacuum interface of the ICPMS instrument is of general applicability also for N_2- MICAP-MS.

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Single Pulse Quantification using LA-ICP-TOFMS for Forensic Investigation of Glass Fragments in Perspective of Reducing Required Sample Size

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Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is an established method in forensic investigation of float glass. A lot of incriminated glass fragments cannot be analyzed using LA-ICP-MS and linked to their origin due to small sample size. The state-of-the-art method using a quadrupole MS detector needs 6 spots with a diameter of 50 – 80 µm and 400 laser pulses each [1].
Here we describe a single pulse quantification method for float glass shards [2]. Therefore, a 193 nm ArF excimer laser (GeoLasC, Lambda Physik, Goettingen, Germany) was equipped with a low dispersion ablation cell to ensure low aerosol dispersion and high peak intensity [3]. The ICP-TOFMS (icpTOF, Tofwerk, Thun, Switzerland) enabled quasi-simultaneous detection of all elements from Na to U and data acquisition with shot-to-shot signal separation. A single pulse quantification approach employing the TOFMS detector reduces the required size of float glass fragments to 100 µm x 100 µm x 10 µm for quantification of signature element composition and allows determining their origin [4]. Due to the single pulse quantification approach, only one ablation spot is required and the number of laser pulses can be reduced to 25. In addition, all elements are detected and unknown compositions and incorporated not presumed elements in glass can be investigated. Furthermore, the multiple small volume quantification allows the assessment of the glass homogeneity and therefore avoid a possible mismatch of the glass fragments.

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Gold Nanoparticles Performance Study: Detection Efficiency Comparison of Different Sample Introduction Strategies and Matrix Effects Using ICP-MS

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Due to their unique functional properties, NPs are involved in more than 1000 products of various fields such as textile industry, cosmetics, food packaging, pesticides, sporting goods, paint, optics and medical devices [1,2]. However, their widespread use requires deeper understanding of potential risks to human and environment that such materials pose, including characterization of nanoparticles (NPs): the determination of mass, size, particle number concentration (PNC), morphology and elemental composition. The ability to detect and quantify NPs in the range of a few nanometers to several hundreds of nanometers still remains a challenge [3,4]. Inductively coupled plasma mass spectrometry (ICPMS) allows fast and sensitive determination of most elements, and can be used for analysis of various NPs' mass, composition and number concentration [5]. The use of sector-field ICPMS offers various advantages in this respect as they can provide high detection efficiency and low instrumental background signals. Still their major drawback is the sequential detection, allowing for only one isotope per NP to be detected. For determination small as possible particles (i.e < 10 nm, containing < 100000 atoms), a high detection efficiency is required in the first place. To investigate the performance offered by a state of the art ICPMS instrument, gold NPs of various size were introduced into the instrument. Different sample introduction setups were compared with respect to sensitivity and reproducibility: microdroplet generation (MDG), desolvation nebulizer system (DSN), or pneumatic nebulization. In particular the difference between "wet" and "dry" plasma conditions, carrier gas composition and the use of a "Jet" interface were investigated. In addition, the stability of NPs and agglomeration versus time in different media (high purity water and different dilutions of citrate buffer) will also be discussed.

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A Versatile Software Suite for Advanced Laser Ablation ICP-MS Element Imaging

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Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) showed significant improvement in providing valuable insights to the elemental distribution within solid materials in terms of lateral resolution and data acquisition speed. Furthermore, the use of the time-of-flight (TOF) mass analyzer and its capabilities for fast and simultaneous multi-element detection made this technique more versatile and attractive for many applications. We think that mere line scans will soon be outdated by more advanced modes of operation, which require experiments, which tightly control the different components (sample stage, laser, and ICP-MS) in order to take full advantage of hard- and software capabilities.

In this work we present a software suite specifically developed for conducting and processing LA-ICP-MS imaging experiments with extensibility and ease of use in mind.

The implementation includes communication interfaces to an ArF excimer laser ablation system (193 nm, GeoLas C, Lambda Physik, Goettingen, Germany) triggered by a separate microcontroller (Arduino Uno). The firmware for the microcontroller was also developed in-house. Positioning controls were implemented for multiple translation stages (SLC-24 series and MCS-3 and MCS2 controller, SmarAct GmbH, Oldenburg, Germany). New communication interfaces can be easily added due to the modular design of the software allowing inclusion of different hardware setups. As programming language Python 3 was chosen to profit from its large library support as well its popularity in the scientific community.

The end-to-end solution allows for custom ablation area masks to be imaged fitting the sample structure. Furthermore, laser pulse patterns are freely programmable so the measurement sequence can be fitted to the sample: more conventional but high spatial resolution fast imaging with edge-to-edge laser spots ideal for compositional overview or hole drilling. In the latter case, multiple laser shots are applied to the same sample position for improved sensitivity and phase contrast. The quantitative data analysis can be dynamically adapted and interfaces are provided for new algorithms to integrate by the user. We will exemplify our approach by quantitative element imaging of geological samples and compare different LA-ICP-TOFMS imaging modes.

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HAXPES-XPS Combination Reveals Surface Structure Changes of $La_{0.3}Sr_{0.55}Ti_{0.95}Ni_{0.05}O_{3-\delta}$

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The chemical analysis of surface and bulk of industrial catalysts is a great challenge as most methods reveal either the surface or the bulk. We demonstrate the use of the HAXPES-XPS combination as a powerful, practical and non-destructive tool for quantitative surface (~1 nm) and subsurface/bulk (~10 nm) chemical composition analysis. The surface-bulk differentiation is achieved via an exchangeable anode system, where the Al (Kα 1486 eV) and Cr (Kα 5405 eV) for XPS and HAXPES analysis, respectively, can be interchanged without affecting X-ray beam position on the sample. As an archetypical catalyst, we study the perovskite-type material $La_{0.3}Sr_{0.55}Ti_{0.95}Ni_{0.05}O_{3-\delta}$ (LSTN), which changes its chemical composition of the surface and the subsurface upon reduction and reoxidation. The HAXPES-XPS analysis confirms the well-known exsolution and formation of Ni nano-particles on the surface upon reduction. Despite the depletion of Ni of the underlying perovskite, the metal (La, Sr, Ti) stoichiometry remains constant. However, the lattice oxygen content increases upon reduction as determined by HAXPS, in accordance with the transformation from $La_{0.3}Sr_{0.55}Ti_{0.95}(Ni_{0.05})O_{3-\delta}$ to $La_{0.3}Sr_{0.55}Ti_{0.95}O_{3-\delta}$. This confirms the structural stability of the perovskite. Here, application of HAXPES analysis is inevitable, as oxygen-containing species adsorbed on the surface dominate the XPS spectra and impede quantification by classical XPS.

On Challenges and Opportunities of Multiple-Choice Questions for Teaching Analytical Chemistry

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Questions (i.e. questions, tasks, problems, etc.) are a central aspect of teaching. In particular, provided exercises and former exam questions tend to drive the focus of students' learning activities. Meanwhile, lecturers who want to encourage their class to actively participate during lectures can be disheartened. Particularly in larger classes, it is common for only a few students to answer questions and fewer take part in discussions around complex problems, which makes interactive pedagogy challenging. Polling the audience by raising hands, showing colored, numbered, or otherwise coded cards yields more feedback. Lately, electronic devices, mostly hand-held remote controls (clickers), were employed and prompted a range of new introduction styles, most prominently peer instruction by Mazur [1]. In a recent article, Salzer [2] argued for smartphones as classroom response systems (CRS). However, the implementation is not as straightforward as advertised.

Besides implementing CRS on a technical level and some changes in the flow of the lectures, main challenges circle around finding or phrasing adequate questions. Although, most textbooks in analytical chemistry offer a variety of questions, most cannot be directly used during a lecture. CRS mostly rely on multiple-choice questions (MCQ) and their design is demanding [3], even if only used for formative assessment (not exams).

Here, I present and discuss a range of multiple-choice questions (MCQ) and students' responses in the context of a course in quantitative instrumental element analysis. These questions aim mostly to probe the students' comprehension. Examples were taken from an undergraduate lecture series from 2017 and 2018, employing Socrative (socrative.com) as an easy to use CRS. As will be shown, MCQ and especially responses to so-called "conceptual" questions can be useful for both students and the lecturer for previously not recognized gaps in students' skills. Moreover, insights were gained when students were asked to provide reasoning for their option choice as open-ended questions via the CRS, indicating that selecting the 'correct' option does not necessarily mean students comprehend the subject matter.

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General Assembly

Divison of Analytical Sciences (DAS)

of the

Swiss Chemical Society (SCS)

Beatenberg, Friday April 12, 12.30

Agenda:

1. Opening of the General Assembly by the president
2. Nomination of scrutineers
3. President's report
4. Treasurer's report
5. Election of board members – approval of the board
6. Section of Chemistry and the Environment
7. Outlook
8. Individual proposals
9. Miscellaneous

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