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From circular economy to soil health?

Carbon from Methane Plasmalysis (CMP) as a potential soil amendment

Aim of the project

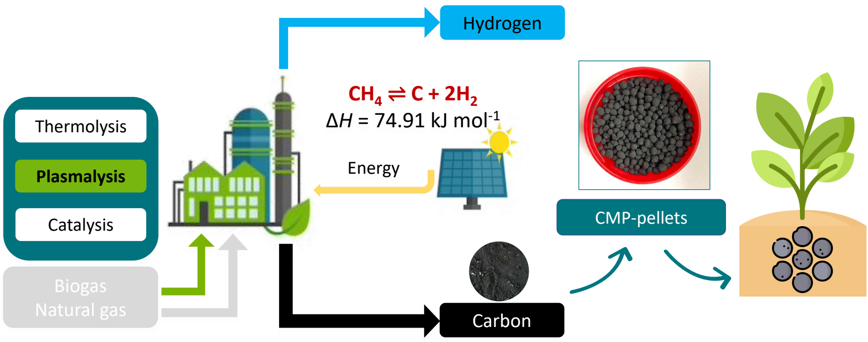

Fig. 1. Pyrolysis of methane and the subsequent application of the resulting carbon (CMP) as a soil amendment.

The production of hydrogen from CH_4 results in an important by-product: **solid carbon**.

This study investigates the potential of CMP as a soil amendment. **CMP is a highly pure material** that can be applied without concern.

Its effects on soil and plant performance were examined through greenhouse, field, and multi-sensor growth chamber experiments.

Growth experiments on CMP treated soil & quartz sand

Greenhouse experiment

After CMP characterisation, its effects on soil properties and maize performance were tested in a greenhouse trial with three soils. Different amounts of pure CMP and CMP with additives were analysed.

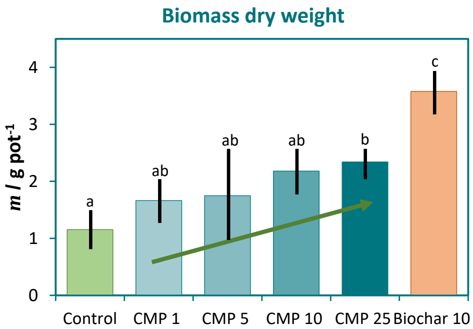

Fig. 2. Dry weight of the aboveground maize biomass. CMP (% relative to soil) compared with biochar. SD (n = 3). a, ab, b, c indicate significant differences (p < 0.05).

Field experiment

The effects of CMP on soil properties and crop performance were investigated in a 29-month field trial with maize and wheat. Crops were grown in CMP-amended soil, with three harvests and six soil samples.

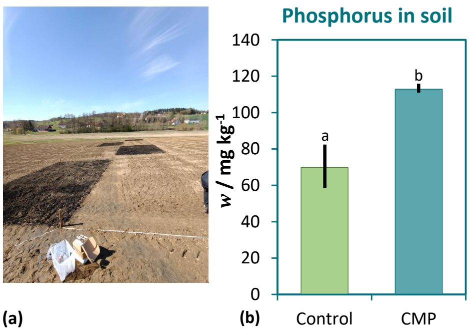

Fig. 3a. Image of the field with and without CMP treatment. **Fig. 3b.** Plant-available P in control and CMP-treated soils. SD (n = 4). a, b indicate significant differences (p < 0.05).

Growth chamber experiment

The effect of pelletised CMP on soil conditions and plant performance was analysed in a growth chamber using wheat grown in agricultural soil and barley in quartz sand to assess its potential to mitigate drought stress.

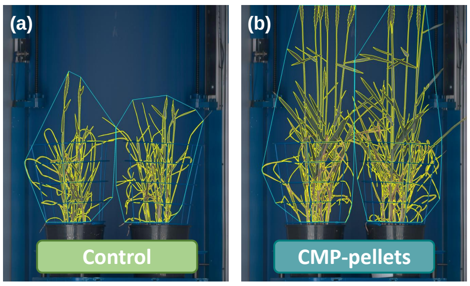

Fig. 4. RGB images of the leaf area 47 days after planting on (a) control soil and (b) CMP-chicken manure treatment under drought stress without fertilisation.

Conclusions

The benefits of applying CMP to soil were evident in all three studies: increased biomass in the greenhouse experiment, higher plant-available phosphorus in the field trial, and improved drought resistance in the growth chamber through reduced leaf surface temperature and potentially lower water loss.

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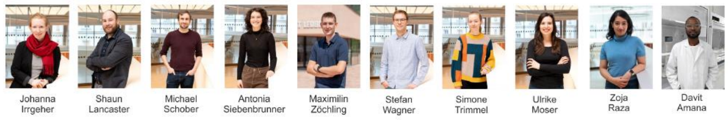
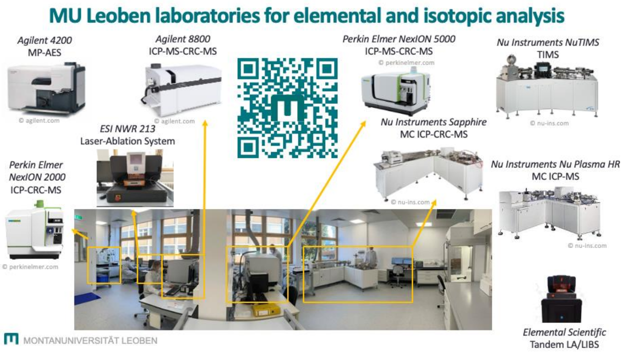
CHAIR OF GENERAL AND ANALYTICAL CHEMISTRY

RESEARCH GROUP ISOTOPIC ANALYSIS

Head: Assoc.Prof. DI Dr. Johanna Irrgeher

TEAM / INFRASTRUCTURE





IMPRESSIONS FROM THE GROUP

TEACHING

Our team is especially entrusted with courses in the field of Analytical Chemistry, both in bachelor and master programs. There are always opportunities to join the team within project-based courses in the lab.
Bachelor and master projects are embedded into our research projects in different fields of basic and applied sciences.

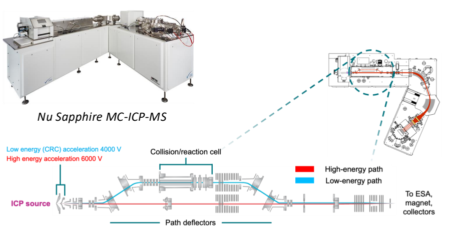
RESEARCH

The research group isotope analysis deals with the development and application of new analytical methods for isotope analysis. The research includes fundamental method development with a main focus on mass spectrometric methods ((MC) -ICP-MS, TIMS). The applications cover tracing, spiking and fingerprinting in the area of strategic/critical elements and raw materials, provenance studies of environmental and geomaterials in the context to support the UN sustainable development goals.

MAIN RESEARCH TOPICS

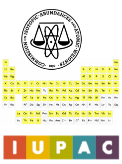
Fundamentals of Isotope Ratio Analysis

Our group specializes in advancing MS-based techniques and refining sample preparation protocols. We're dedicated to crafting meticulously validated methods, including precise analyte/matrix separation, innovative calibration strategies, exhaustive interference analysis, meticulous consideration of measurement uncertainties, pioneering the development of reference materials, and state-of-the-art data processing.



Atomic Weights of the Elements

Isotope ratio measurements are the basis for the determination of the Atomic weights of the Elements. Formally established in 1899, the Commission on Isotopic Abundances and Atomic Weights remains one of the oldest continuously serving scientific bodies. Our group is currently chairing CIAAW within IUPAC.



Tracing – Spiking - Fingerprinting

Isotope ratios of many elements can be used in environmental sciences, archaeometry and material sciences to trace the fate of a certain element. Alternatively, enriched stable isotopes are used to alter the isotopic composition and label a selected element. This help to understand natural and technological processes.

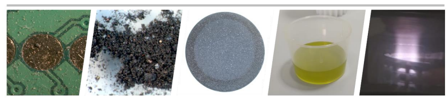
Our projects in this field span from tracking inorganic pollutants in river systems (e.g. the Mur River), to investigating the biological mechanisms behind Nickel hyperaccumulating plants used for phytoremediation to tracing sources of non-metallic inclusions in the steel production.

Furthermore, we include Citizen-scientists in our research projects and support activities to foster passion for STEM subjects.

Sustainable Chemistry & Beyond

Today, analytical chemistry contributes more than ever to addressing the global challenges we face by supporting the achievement of the United Nations Sustainable Development Goals (SDGs).

Through precise measurements and the identification of pollutant sources, analytical chemistry enables us to take targeted measures for environmental improvement and sustainable development in support of the EU Green Deal.



Our projects in this field aim at identifying conventional and modern sources of pollutants, the interaction between solid and liquid phases and the identification of specific pollutant carriers.

In the context of the EU Green deal, we develop analytical methods to accurately determine (technology-)critical elements in electronic waste in order to support recycling possibilities.

Inclusion in lab

Our team is also dedicated to promote inclusion in the analytical laboratory and support actions to reduce barriers in order to promote access to science to everyone passionate about science.

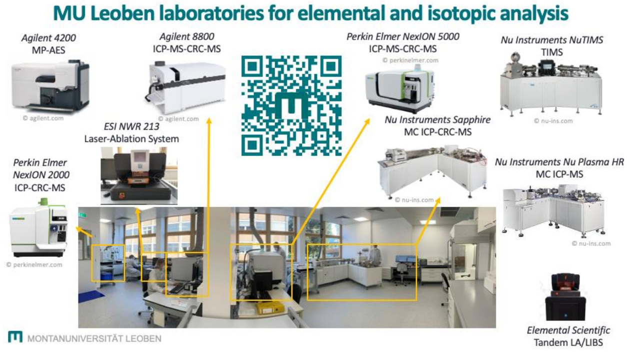
CHAIR OF GENERAL AND ANALYTICAL CHEMISTRY

RESEARCH GROUP METROLOGY-TECHNOLOGY

Head: Univ.-Prof. Dipl.-Ing. Dr. techn. Thomas Prohaska

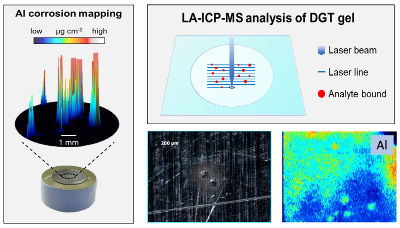
TEAM / INFRASTRUCTURE

RG Metrology-Technology

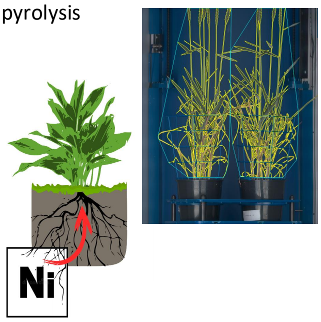


NEWS

The application of carbon in agriculture is one of the most promising applications of carbon produced by methane pyrolysis



Diffusive Gradient in Thin Films (DGT) provide a promising tool for in-situ imaging of surface processes



Ni isotope spikes are used for investigating Ni hyper-accumulating plants

TEACHING AND RESEARCH

Fundamental teaching activities are within the first year for all bachelor studies in the field of general chemistry.
Basic and advanced courses in analytical chemistry complement the teaching activities.

In the context of Life Long Learning, a course in "Quality Assurance in the chemical Laboratory" is offered as e-learning course.

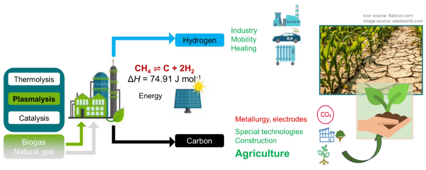
Sound metrological principles are developed and transferred to analytical routines. Innovative analytical tools and technologies are assessed and developed.

A special focus is set on chemical imaging of surfaces using LA-ICP-MS, LIBSN and recently on diffusive gradient in thin film technologies (DGT).
Novel materials are investigated for their chemical properties and effects.

MAIN RESEARCH TOPICS

Chemistry of New Products: Technological Carbon in Agriculture

Within the hydrogen core activities of the Montanuniversität Leoben, one pathway is the production of H_2 and C via different processes of CH_4 pyrolysis. Whereas the application of H_2 as energy source or valuable chemical is straight forward, the usage of the achieved amounts of pure C as value product is manifold.



In a joint project between the Montanuniversität Leoben and the University of Natural Resources and Life Sciences, along with other partners, a project to apply technologically produced carbon by methane pyrolysis (CMP) in agriculture has been set-up with first convincing observations, which result in the major hypothesis:

- Addition of CMP leads to an improvement in soil quality and consequently improved plant growth.
- Addition of CMP leads to an improvement in the soil water balance and consequently to reduced drought stress in plants and reduced irrigation requirements.

Chemical Imaging

LA-ICP-MS and LIBS

Chemical imaging captures spatially resolved chemical data. Techniques like LA-ICP-MS and LIBS use lasers to selectively analyze materials, providing high sensitivity and spatial resolution in the µm range. They are crucial for elemental and isotopic mapping of a wide variety of samples.

Diffusive Gradient in Thin Films (DGT)

DGT is a powerful method as it enables precise measurement of labile metal concentrations in various environments. Its controlled diffusion process provides spatial information, enhancing our understanding of e.g. metal release both in environmental and technological samples.

Physicochemical Maps

The combination of chemical and physical properties of a region allow for a multitude of interpretations such as :

- Provenance and authenticity of products
- Movement and migration pattern of past and present humans and animals
- Prediction and interpretation of changes (e.g. climate change adaptions) in geo- and biospheres
- Modelling of chemical fluxes

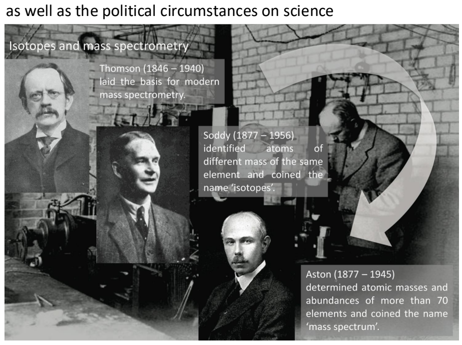
Metrological Principles

(Metrology = The Science of Measurements)

The development of metrological principles is of major importance in order to achieve sound analytical results and to avoid that conclusions are drawn form analytical artefacts.
A major focus is the development of uncertainty calculation tools for analytical data.

History of mass spectrometry

In the context of a cross-disciplinary topic, to rework the contribution of past scientists on analytical science, has reopened a new aspect and understanding of the todays state-of-the art analytical chemistry. It is the in-deep understanding of the complex interaction between scientific development and society as well as the political circumstances on science

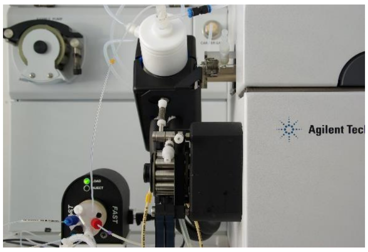


Science 4 Technology @ MUL
Poster Exhibition 2026

RESEARCH GROUP SPECTROSCOPY

„We find the pin in the haystack!“

Research:
We specialize in the detection of tiny particles such as inclusions in steel and microplastics, but also in the measurement of ultratrace elements and isotope ratios of rare elements, e.g., REE and PGE (Os, Ir, Ru) in natural and technical materials.

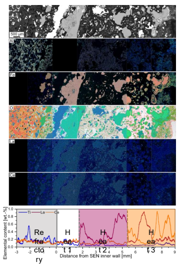



Instrumentations
ICP-MS (Agilent 7500), TIMS (Nu Instruments), ICP-MS/MS (Agilent 8800), XRF (Axios, Panalytical/Malvern (from left to right)

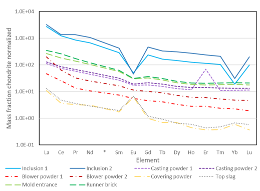
MAIN RESEARCH TOPICS

Elemental trace analysis

When measuring ultra-trace elements, special care is required during sample preparation. The complete recovery of the analyte is important here, whereby losses or contamination must be avoided. The instruments of choice are solution- and laser-based ICP-MS and TIMS.



BSE image and the corresponding elemental mappings of the main elements detected in the clogging layer from the investigated SEN; below: EDS detected elemental content of Ti, La and Ce over the clogging layer.

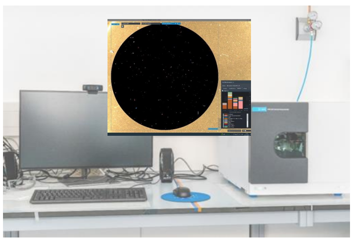


Chondrite normalized REE mass fractions determined in inclusions 1 and 2 (LA-ICP-MS) and reference samples (ICP-MS after Na_2O_2 sintering digestion). For better visibility of the REE patterns, the value for promethium (*), which does not occur naturally, is interpolated between Nd and Sm.

Micro- and Nanoplastics

The analysis of microplastics is an emerging, timely and highly relevant field. Microplastic particles (MP) are found in all areas of our planet and their health effects are unknown. Intensive and interdisciplinary research is essential for the development of new, reproducible and rapid measurement methods.

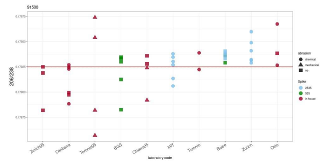
Spectroscopic methods are state of the art for the rapid detection of microplastics and routine measurements of MP. However, as direct measurements of MP in complex matrices are currently not possible, complex sample preparation methods must be used to separate the MP from their matrix (e.g., tissue or food). This is where our RG will be very active.



Using the LDIR for the quantification of microplastic particles in coral tissues from the Red Sea

Reference Materials

Reference materials are essential for method development and validation. The harmonization and standardization of measurement methods and results is only possible if RM have traceable properties.
The characterization, development and certification of geological reference materials for the measurement of platinum group elements mass fractions is a long-standing project. However, the development of RM for micro- and nanoplastics research is now part of our main research focus.



Re-characterization of the famous zircon reference material 91500 using TIMS data.

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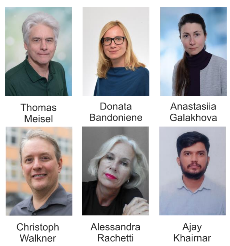
Research Group Members
- DI. Dr. Christoph Walker
- DI. Alessandra Rachetti
- Ajay Khairnar, MSc



Move mountains

Oxygen isotope ratio determinations by plasma-based mass spectrometry: Unlocking new approaches for climate research

Oxygen isotope ratios are one of the major keys to unlock historical climate information stored within natural archives (e.g. ice cores, speleothems, tree rings, etc.) that contain a chronological record of the oxygen isotopic signature across a large time scale.
The ratio between the ^{16}O and ^{18}O isotopes of oxygen can be used as a proxy for temperature. Water molecules containing ^{16}O preferentially evaporate and water molecules containing ^{18}O preferentially condense (e.g. rainfall). This property causes isotopic fractionation (a change in the ratio between the two isotopes) that depends on temperature.

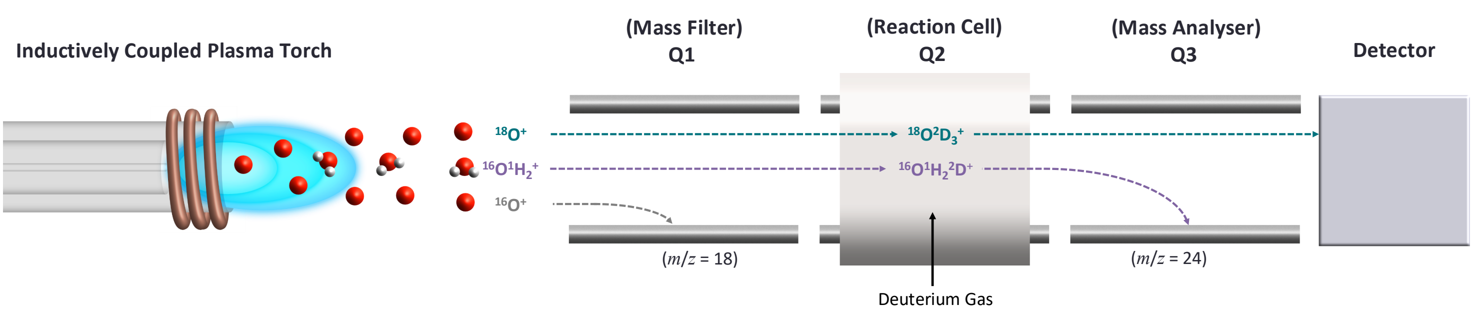
Current Tools Face Challenges

The measurement of oxygen isotope ratios was first achieved in the 1950s. Since then, the analysis has become well established, where the oxygen is chemically converted to a measurable form (e.g. CO_2, H_2O, O_2) and analysed by isotope ratio mass spectrometry.
Despite instrumental advances, **the measurements today are still based largely on these early principles** of chemical conversion and analysis. This presents a great challenge for new research questions that focus on *in situ* analysis of materials with laser ablation, with current methods being to time consuming, to low resolution, or too costly to be used for such analysis.

We Needed To Think Outside Of The Box

To advance the field of climate research further, a completely new approach is required. **Inductively coupled plasma mass spectrometry** (ICP-MS) is a very well established and versatile technique, however **oxygen isotope measurements by this approach are widely considered “impossible”** due to interferences.
At MUL, we embraced this challenge and achieved a successful proof-of-concept study, using deuterium reaction gas to remove the interferences and **make the unmeasurable measurable**. The future of this work will focus on advancing the capabilities of different ICP-based mass spectrometry instrumentation, as well as using laser ablation for rapid *in situ* analysis.

The Inductively Coupled Plasma Mass Spectrometry Approach Developed at MUL



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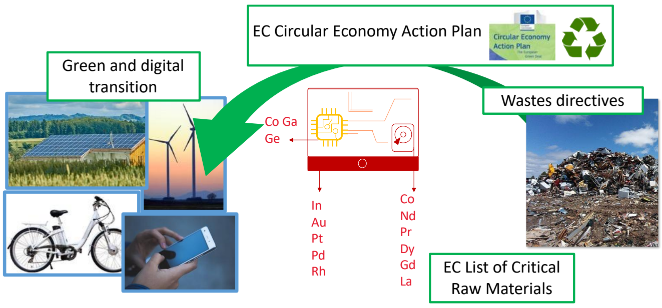
Das Land Steiermark
EMPIR
EURAMET
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
PerkinElmer
RSC INTEREST GROUP ATOMIC SPECTROSCOPY
MetroPOEM
FWF Österreichischer Wissenschaftsfonds
Science the better way

Publication

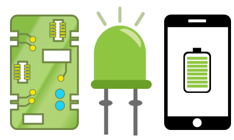
Metrology for the recycling of Technology Critical Elements to support Europe's circular economy

Technology critical elements (TCEs) are irreplaceable raw materials that are vastly used in consumer products throughout society; including phones, computers, and renewable energy products. Dwindling supplies of TCEs, as well as rapidly changing geopolitical climates, threaten to disrupt technology production worldwide. Therefore, the European Union (EU) strives for a circular economy approach.



The MetroCycleEU project aims to **develop new reference methods** and **materials** to:

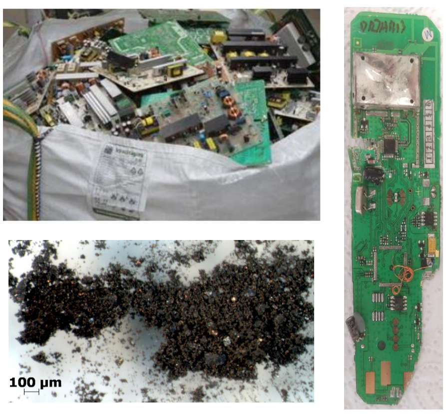
- Enable reliability, traceability, and comparability of sampling strategies and analytical results.
- Improve knowledge of TCE stocks in the recycling industry and inform on the recycling process.
- Target matrixes:
  - printed circuit boards (PCBs),
  - light emitting diodes (LEDs), and
  - Li-ion batteries.



THE CHALLENGES

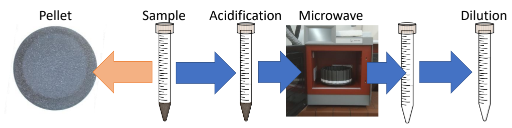
SAMPLING

The first major challenge for the analysis of electronic waste is to obtain a representative sample. E-wastes, such as PCBs, are extremely heterogeneous materials. 10-400 kg of material was sampled for producing certified reference materials in this project.



SAMPLE PREPARATION

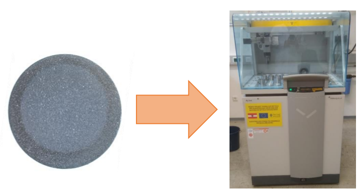
Samples preparation depends on the analysis technique., e.g. acid digestion and pelletizing material. Complete digestion of e-waste is very difficult and typically requires harsh, toxic reagents, such as hydrofluoric acid. As such, the development of improved digestion methods are a key focus.



ANALYSIS

1) Inductively coupled plasma tandem mass spectrometry (ICP-MS/MS) is a widely used tool for routine analysis that is able to resolve interferences from other elements and provide reliable results.

2) X-ray fluorescence spectrometry (XRF) requires minimal sample preparation and can provide rapid analysis of materials. However, low sensitivity makes detection of low quantities of TCEs challenging.



The project MetroCycleEU is currently in the final project phase where the candidate materials for PCB, LED and LiB are being characterized in interlaboratory comparisons for technology-critical elements.

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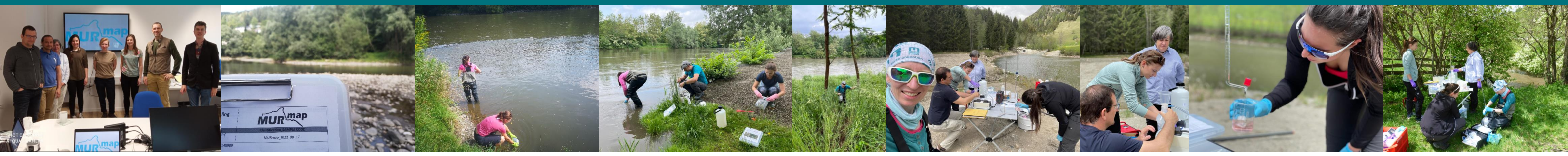
This project (20IND01 MetroCycleEU) has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

Funder name: European Partnership on Metrology

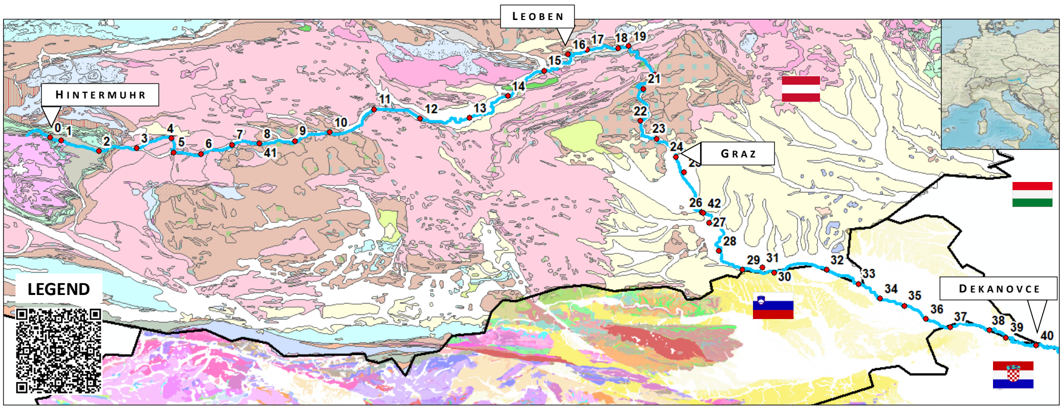
EURAMET
MetroCycleEU



Comprehensive (geo)chemical characterization of the Austrian-Slovenian Mur/Mura River catchment

MURmap

The project "**MURmap**" aims to shed light on the spatial and temporal distribution of elemental mass fractions in the Mur River. In three campaigns, representing high, medium and low water tide investigations on influences on the river from:



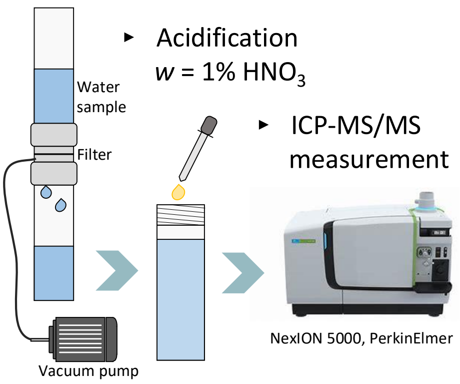
(1) natural geochemical background of the catchment
(2) historical and recent anthropogenic sources and
(3) solid/liquid phase interaction of chemical elements were carried out.

In order to comprehensively characterize the Mur River catchment

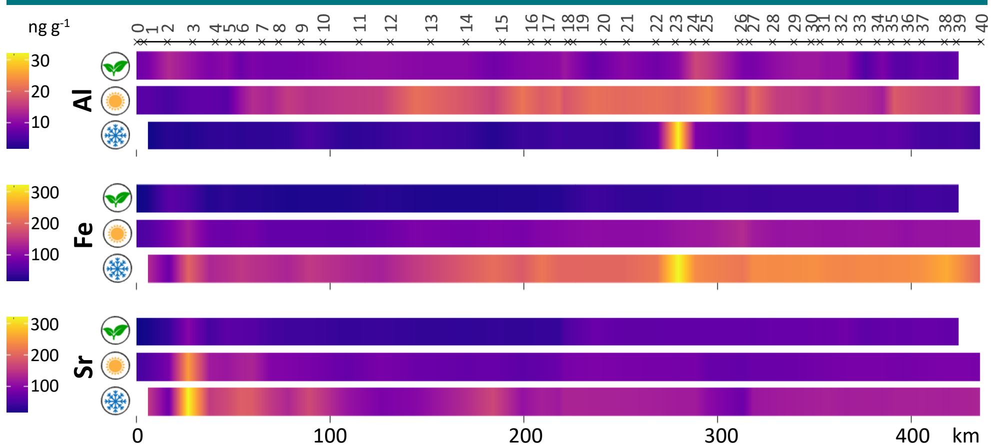
- water samples
- suspended particulate matter, and
- alluvial and stream sediment samples were taken and processed.

Methods

- Vacuum filtration (0.45 µm)
- Acidification w = 1% HNO_3
- ICP-MS/MS measurement



Results



Interpretation

- COMPARISON OF SEASONS
  - Significant differences in water discharge
  - Significant dilution/concentration effects in high/low water regime
- GEOLOGY
  - The change of geological units throughout the flow of the Mur River is detectable within the water.
- INSIGNIFICANT INFLUENCE OF CONSTRUCTION SITES
  - A construction site next to the river shows elevated signals on spot due to higher sediment load.

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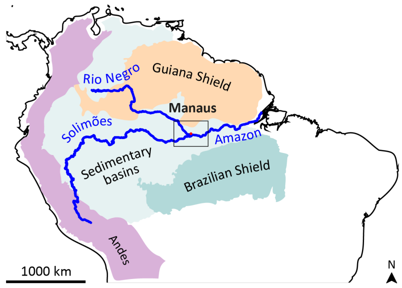
GeoZS Geološki zavod Slovenije
AWW Abfallverwertungstechnik & Abfallwirtschaft
Universität Augsburg University
National Institute of Chemistry
FWF Project P 34719
AAC Everyone is awesome
Uni Graz

Strontium (Sr) Isotope Ratio Analysis of Amazonian Rivers under Different Discharge Regimes

The Amazon basin is drained by over **1000 tributaries**, making up almost **20 % of the global freshwater**. Yet, **river and sediment dynamics** in this fascinating region are **poorly understood**. This study examined the **Rio Negro** and **Solimões** rivers, which form the **Amazon River** at their **confluence**. The **geology** of the Amazon basin (Guiana Shield, Andes) provides the two rivers with **contrasting characteristics** (pH value, humic substances, suspended solids, etc.).



The project aims to:

- Employ **different sampling strategies** (grab vs passive sampling) in a **challenging river environment**
- Compare **$^{87}Sr/^{86}Sr$ ratios**, which can be used as environmental tracers, in **sediment** and **water** under different **discharge regimes** (dry and wet season)

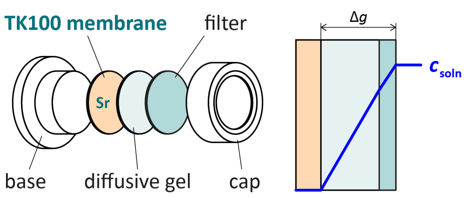
Grab vs passive sampling

Traditional active sampling

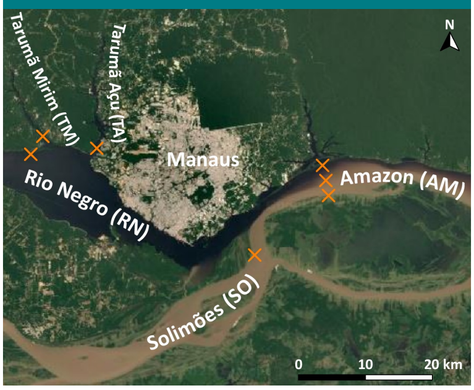
⊖ Composition snapshot
⊖ No analyte preconcentration
⊖ ≠ bioavailable fraction
⊖ Matrix rich samples
⊕ Methods readily available

Passive sampling (e.g., DGT)

⊕ Average over deployment
⊕ Analyte preconcentration
⊕ ≈ bioavailable fraction
⊕ Highly pure samples
⊖ Method development necessary



Methods



Dry season sampling

- Only grab samples
- Low Sr concentrations
- High Rb/Sr ratios

Wet season sampling

- Water & sediment grab samples
- DGT deployment in rivers for 48h
- DGT applied to sediments in lab

Results

Pronounced $^{87}Sr/^{86}Sr$ variation

- **Seasonal** variation
- **Spatial** variation (geology)
  - Guiana Shield → Rio Negro
  - Andes → Solimões

Grab vs passive sampling

- **Water:** Excellent agreement between DGT and grab
- **Sediments:** DGT fraction resembles river water

Outlook

Sampling campaign 09/2026

- 10-day boat ride on Solimões
- DGT deployment at 25 sites

Meeting of the Waters
OeAD
Project BR 01/2026

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INPA Instituto Nacional de Pesquisas da Amazônia
FAPESP São Paulo Research Foundation
Queen's University
unesp Universidade Estadual Paulista "Júlio de Mesquita Filho"
GEMB
MURmap
DISCOVER
TRISKEM Expertise in Separation Chemistry
FWF
Erasmus+
AAC

Science 4 Technology @ MUL
Poster Exhibition 2026

Paul Töppmann · Gabriel Kasozi · Simone Trimmel · Johanna Irrgeher · Thomas Prohaska

Plant Leaves as Indicators of Trace Metals from Traffic Pollution in Kampala, Uganda

Elemental Analysis using Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

1. Background

- High **air pollution** levels in **Kampala, Uganda**
- Air pollution can contain **harmful metals**
- **Vehicle traffic** as a major pollution source
- **Plant leaves** can collect particles from air


Kampala Traffic. Source: R. Mirembe

Kampala Air Quality. Source: IQAir

153 US AQI* Unhealthy

Main pollutant: PM2.5 59 µg/m³

$PM_{2.5}$ = particulate matter with diameter < 2.5 µm

WHO guideline: 5 µg/m³ (annual mean)

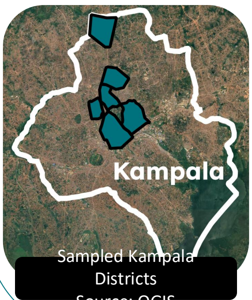
2. Research Question

Can plant leaves be used to monitor trace metal pollution from traffic in Kampala?

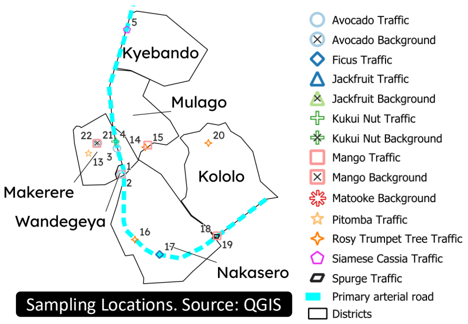
3. Study Design

- **7 districts** in Kampala
- **Road and garden** locations
- 22 sampled plants
- 10 different **plant species**
- **Young and mature leaves**
- $n = 44$ samples

Map of Uganda. Source: QGIS



Sampled Kampala Districts Source: QGIS



Sampling Locations. Source: QGIS

4. Methods

- Plant leaves dried and ground into powder
- Microwave-assisted acid digestion

Sampling · Grinding · Digestion · ICP-MS Measurement

5. Metal Emissions from Road Traffic

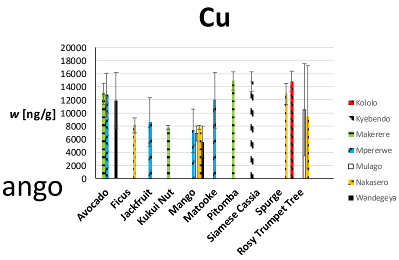
Engine wear · **Brake wear** · **Fuel combustion** · **Natural road dust** · **Lubrication oil** · **Tyre abrasion**

Ba · Cr · Cu · Fe · Ni · Pb · Sb · Zn

6. Results

Leaf age:
Mature leaves contain higher **Fe**, **Pb**, and **Sb** concentrations than young leaves of the same plants

Plant species:
Cu concentrations differ between plant species; Avocado and Pitomba contain more **Cu** than Mango



Traffic exposure:
No overall difference between road and garden sites

7. Conclusion

Leaves show potential as a simple tool for monitoring trace metals from traffic pollution in Kampala.

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Co-funded by the Erasmus+ Programme of the European Union

Move mountains

Technology-critical elements – are anthropogenic emissions increasing due to increased use?

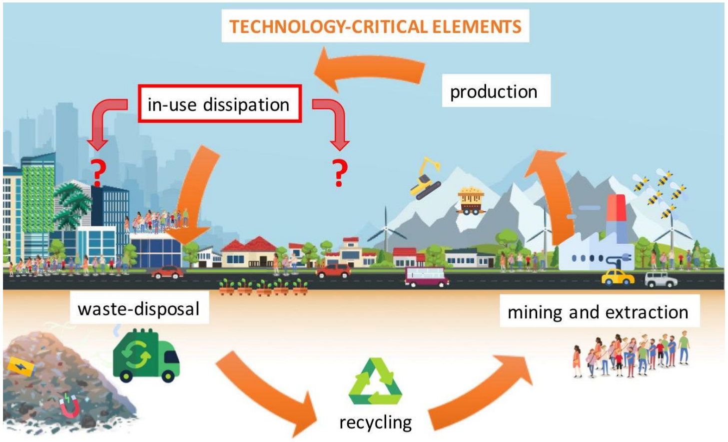

Fig. 1: TCE lifecycle stages potentially leading to release

Technology-critical elements (TCEs) are used in, e.g., information and telecommunication (ITC) technologies, healthcare and transport. There are substantial knowledge gaps related to released quantities, environmental cycles and potential health hazards.

In the project TecEUS (Technology-critical Elements in Urban Spheres), the release and distribution of selected TCEs is assessed in the urban environment of Vienna. Thereby, urban greening is applied as model system due to its particular exposure to anthropogenic pollution. For this purpose, advanced analytical techniques based on inductively coupled plasma tandem-mass spectrometry (ICP-MS/MS) are applied in combination with models for material flow analysis.

Method development

- Microwave-assisted acid digestion and ICP-MS/MS
- Comprehensive method validation with 7 certified reference material
- Challenges:
  - Low levels of TCEs (pg g^{-1})
  - Scarce reference values

Field experiments

- 292 plant samples from green facades in Vienna taken over 1 year
- Effects of plant species, season and sampling height investigated
- Challenges:
  - High natural variation
  - Limited sample availability

Conclusions & outlook

- Validated method for TCE analysis
- First comprehensive data on rarely analysed elements in plants
- Highest TCE levels in lower levels of the buildings
- Highest level after winter season

Fig. 2: Leaf washing in the lab

Fig. 3: Sampling sites in Vienna: MA31 (left) and MA48 (right)

PhD
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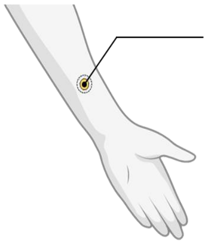
FWF P 33099-N Der Wissenschaftsfonds. BOKU UNIVERSITY AAC EVERYONE IS AWESOME TecEUS
EMPIR EURAMET ÖAW BG BRG LEOBEN MetroCycleEU
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States
WIENER WASSER DIE 48ER ASAC AUSTRIAN SOCIETY OF ANALYTICAL CHEMISTRY
UNI GRAZ universität wien TU WIEN TECHNISCHE UNIVERSITÄT WIEN MEDIZINISCHE UNIVERSITÄT WIEN

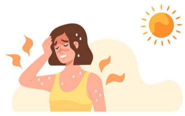
Smart Materials for Non-Invasive Diagnostics

Development of Skin Patches for Elemental and Isotopic Analysis in Sweat



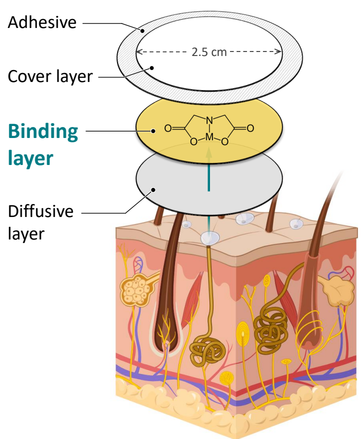
This project aims at the development of skin patches based on **diffusive gradients in thin-films (DGT)**. It is an innovative approach to a new diagnostic tool for the non-invasive and quantitative assessment of **trace elements and isotopic signatures (copper) as biomarkers** in **single drops of sweat** on human skin, potentially enabling early diagnosis of diseases.

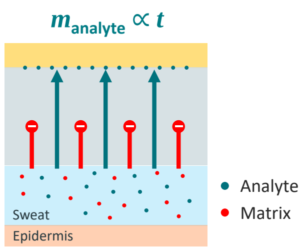
Fe	Ni	Cu	Zn	Cd	Pb
Iron	Nickel	Copper	Zinc	Cadmium	Lead




Picture/icon credits: biorender.com, Adobe Stock, dpa, NewAfrica, Pinterest

SAMPLING SWEAT



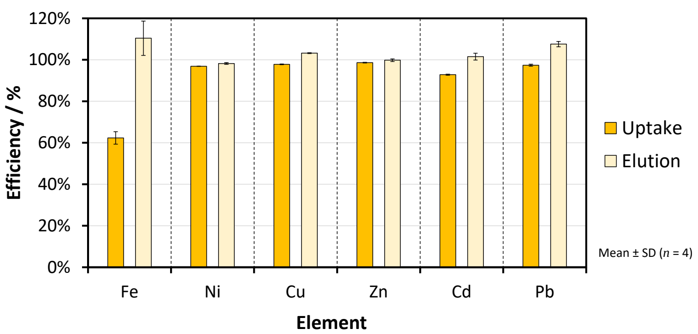


Analytical advantages

- High selectivity
- Time-integrated (min-d)
- Spatially resolved (µm)
- Low combined uncertainty
- Low cost

Skin model credit: biorender.com

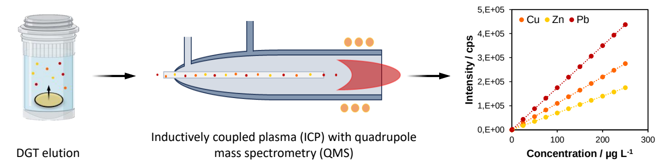
RESULTS



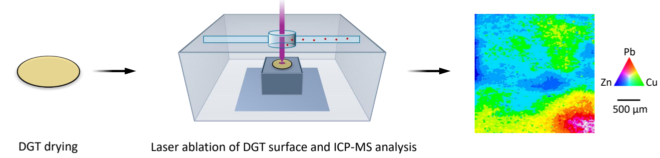
- Quantitative uptake of Ni, Cu, Zn, Cd, and Pb from synthetic sweat using biocompatible polyurethane membranes with metal-chelating iminodiacetate functionality; Fe remains challenging
- Quantitative elution of all analytes by immersion and shaking in dilute HNO_3 (c = 1 mol L^{-1}, V = 5 ml, t = 24 h)

ELEMENTAL AND ISOTOPIC ANALYSIS

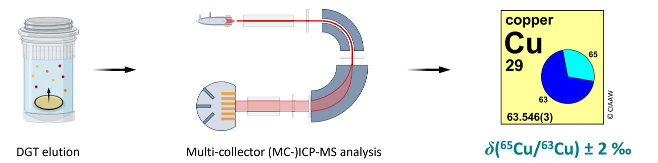
I DGT elution and analyte quantification by ICP-QMS



II Spatially resolved analysis by LA-ICP-MS

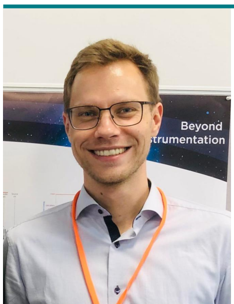


III High-precision Cu isotope ratio analysis by MC-ICP-MS



SUMMARY

Results demonstrated the capability of DGT for **selective, quantitative, and simultaneous sampling** of **Ni, Cu, Zn, Cd, and Pb** from a complex sweat matrix. Further characterization and combination with high-end mass spectrometric methods will show the technique's full potential for non-invasive medical diagnostics.



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This project has received funding from Das Land Steiermark (Federal State of Styria, Austria) under the "UFO - Unkonventionelle Forschung" (2023) program (PN08 - MicroPatch).

Das Land Steiermark
Economy, Tourism, Science and Research

TRISKEM
Expertise in Separation Chemistry

Evaluating hydrogen embrittlement susceptibility of L485 pipeline steel using SSRT and ripple load tests in H_2 up to 1000 bar

A. Hamed, G. Mori

Chair of General and Analytical Chemistry, Montanuniversität Leoben, Franz-Josef-Strasse 18, 8700 Leoben, Austria

Overview

Within the framework of the HyGrid2 project (the first project in Austria to repurpose existing natural gas pipelines for pure hydrogen transport), an existing L485 pipeline, including a weld, was investigated using SSRT and RLT tests up to 1000 bar to determine its applicability for pure hydrogen transport. The project is supported by the Austrian Research Promotion Agency (FFG) as a crucial step towards achieving the goal of carbon neutrality by 2050. The project outcomes will help in the decision-making process for repurposing and provide a manual for recommended operating conditions in the future. A demonstration place is currently being built in the south of Graz.

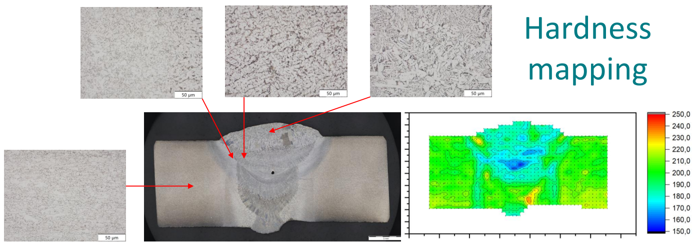
Materials

Chemical composition

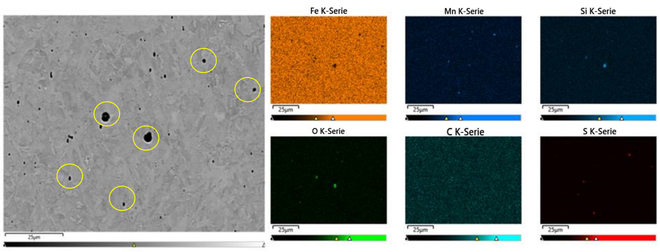
Material	C	Si	Mn	P	S	Cu	Cr	Ni	Mo	Ti	V	Al
Pipeline	0.08	0.43	1.64	0.01	0.005	0.11	0.05	0.14	0.01	0.02	-	0.043
Weld	0.18	0.31	0.92	0.01	0.006	0.04	0.02	0.14	-	0.01	-	0.005

Microstructure

Hardness mapping

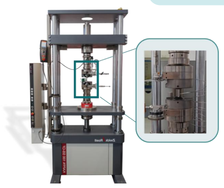


EDX mapping of NMIs at the weld

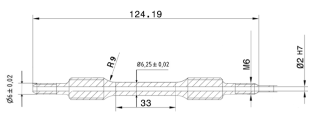


Methods

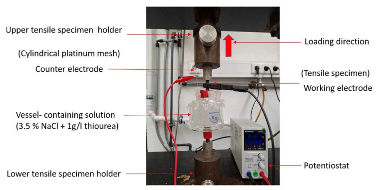
Gaseous charging



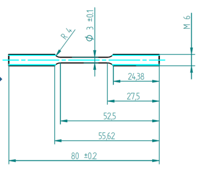
Hollow specimen



Electrochemical charging

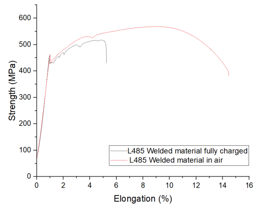


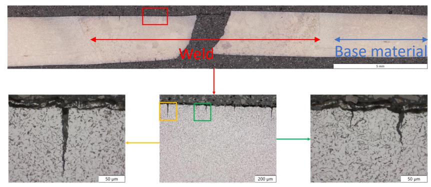
Conventional specimen



Results

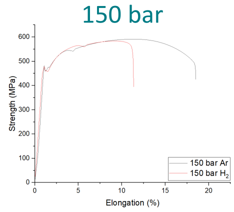
Electrochemical charging



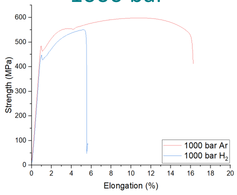


Gaseous charging

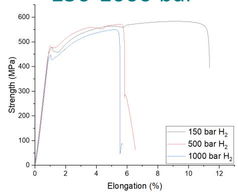
150 bar



1000 bar



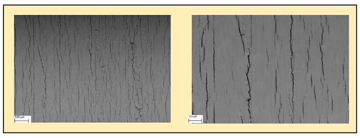
150-1000 bar

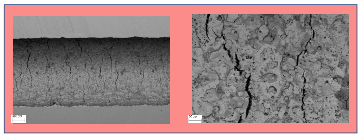


Ripple load tests

Stress level [%YS]	Hydrogen pressure [bar]	Stress amplitude [MPa]	Number of cycles	Failure Status (gas leakage) [Yes/No]	Presence of inner surface cracks [Yes/No]
80 - 100	150	368-460	10000	No	No
80 - 100	500	368-460	10000	No	yes
80 - 110	1000	368-505	10000	No	Yes

Cracks occur only in the weld





Conclusions

- Rapture and cracks occur only in the weld, not in the base material.
- The L485 pipeline is applicable and safe for pure and dry hydrogen transport up to 70 bar H_2.

MSc
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Synthesis of Standardized Core–Shell Nano Plastics for Environmental and Toxicological Research

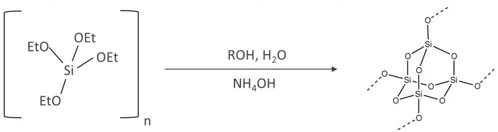
Ajay B. Khairnar, Gisbert Rieß, Thomas C. Meisel

1 Introduction

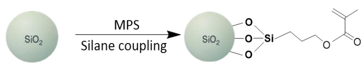
- The lack of standardized, well-characterized micro- and nanoplastics (MNPs) hinders research reproducibility, limits data comparability, and ultimately undermines the reliability of conclusions about their hazards
- Therefore, there is urgent need for well-characterized testing materials to standardize methods, provide controls, and support toxicity studies
- In this work, we have adopted a bottom-up approach to synthesize core–shell nanoparticles using emulsion polymerization method

2 Reaction Scheme

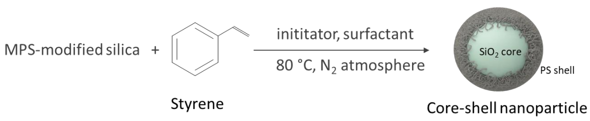
- Step I: Stöbber process for silica nanoparticle synthesis



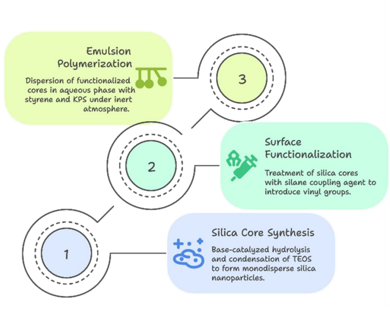
- Step II: Silica modification with 3-methacryloxypropyltrimethoxysilane (MPS)



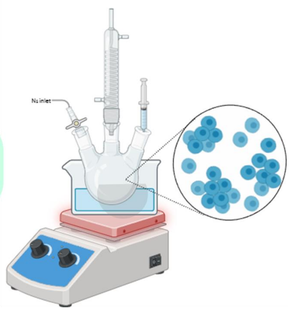
- Step III: Emulsion Polymerization



3 Synthesis Methodology

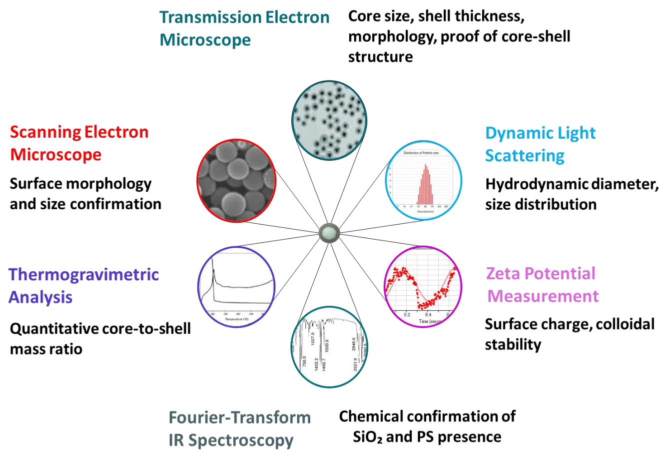


Synthesis pathway of polystyrene-coated silica nanoparticles



Laboratory setup for synthesis

4 Planned Characterization



5 Significance

- **Reference Material:** This work will provide a critically needed, well-characterized material for calibrating analytical techniques like SP-ICP-MS, NTA, and spectroscopic methods in nanoplastic research
- **Toxicology Studies:** The particles will enable more reproducible and reliable ecotoxicological studies by providing a consistent and traceable nanoplastic model
- **Method Validation:** The distinct core-shell structure allows researchers to distinguish their synthesized nanoplastics from background contaminants, validating extraction and detection protocols

6 Future Directions

- Our ongoing research will extend this synthesis approach to other major polymers, including PVC, PP, PMMA, and PE
- Scale-up of the synthesis protocol for gram-scale production
- Development of a series of testing materials with varying core sizes and shell thicknesses
- Inter-laboratory comparison (LIC) and validation of the material

7 Summary

- This work presents a robust synthesis protocol for monodisperse core–shell SiO_2@PS nanoparticles
- Provides a standardized, well-characterized material for environmental and toxicological research

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Influence of surface treatments on hydrogen absorption and embrittlement of tempered martensitic steels

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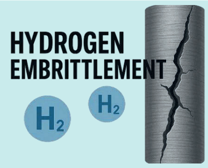
Motivation

Hydrogen is widely regarded as a promising and sustainable alternative to fossil fuels. However, establishing a reliable and safe supply chain is essential for its large-scale utilization. Since many components in hydrogen infrastructure are constructed from steel, improving their resistance to hydrogen embrittlement (HE) is critical.

Objective: Can surface barriers mitigate hydrogen uptake?



Methodology

Optimization of surface treatments

- **Investigated surface treatments:** Shot peening, Laser oxidation and Organic coatings
- **Material of focus:** high-strength martensitic steel (UTS= 910 MPa)

Microstructural characterization

- Scanning Electron Microscopy (SEM), EDS, Electron Backscatter Diffraction (EBSD), X-Ray Diffraction (XRD)

HE testing methodology

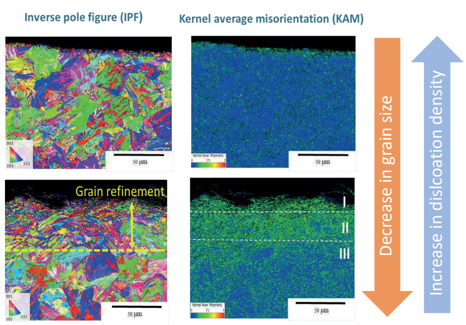
- Electrochemical and gaseous H charging, Electrochemical permeation, Thermal Desorption Spectroscopy (TDS), Slow Strain Rate Tensile (SSRT) tests, Constant Load Tests (CLT)

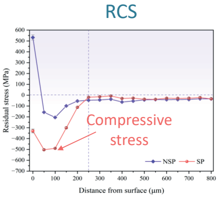
H blocking performance

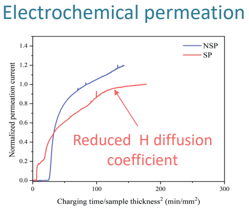
- Quantification of H uptake
- Effective diffusion coefficient
- Hydrogen Embrittlement Susceptibility (HES) index

Shot peening

- Shot peening (SP) results in residual compressive stress (RCS), an increase in dislocation density and grain refinement

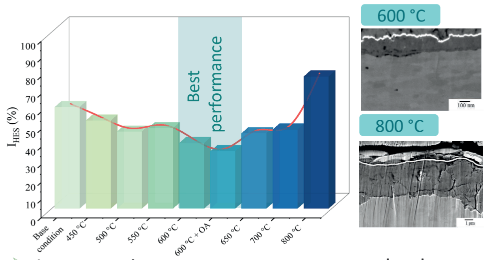




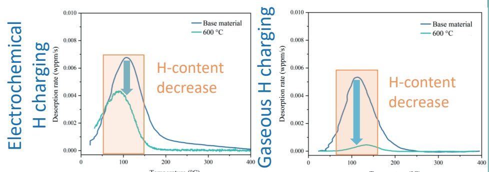


- SP layer results in lower H diffusion and reduced HE susceptibility

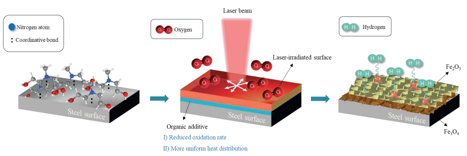
Laser oxidation



- Increase in process temperature leads to reduced performance of oxide layers due to a change in the oxide layer morphology

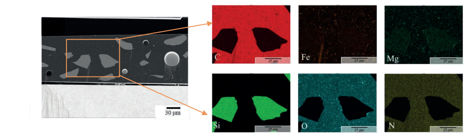


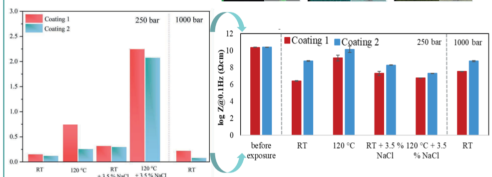
- Oxide layer decreases hydrogen uptake



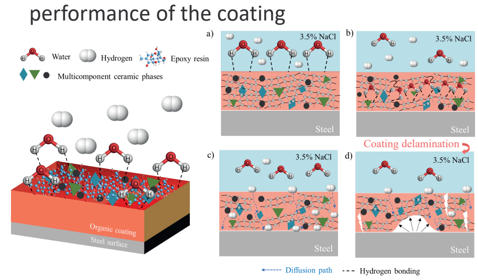
Organic coatings

- Composite epoxy/ceramic coating without (C1) and with inhibitor underlayer (C2)





- Higher impedance (log Z) value corresponds to lower hydrogen uptake and indicates better performance of the coating



Conclusions

- Introduced RCS inhibits crack initiation and propagation
- Grain refinement results in more uniform hydrogen distribution

- Laser oxidation yields a duplex oxide layer of magnetite and hematite
- Homogeneous oxide layers show superior hydrogen blocking ability

- Organic coatings demonstrate the highest performance in a gaseous hydrogen atmosphere regardless of temperature and pressure

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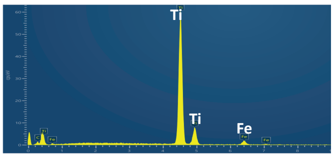
Corrosion Behavior of Titanium Alloys: Effects of Cu^{2+} ions

Gaatha Kainikkara, Magdalena Eskinja, Christian Mitterer, Gregor Mori

Introduction

Titanium is widely regarded as a corrosion resistant material due to its strong tendency to form a stable and protective TiO_2 passive film. However, in high temperatures and very acidic environments, the stability of this passive film can be disrupted. Corrosion performance of titanium was evaluated, with particular focus on the noble metal alloying mechanisms and the influence of oxidizing species such as Cu^{2+} ions.

Material : Ti grade 2



Grade	Composition (%) N (%)	C (%)	H (%)	Fe (%)	O (%)
2	0.03	0.10	0.015	0.30	0.25

Grade	Tensile Strength (MPa)	Yield Strength (MPa)	Fracture Elongation (%)
2	485	357	27.5

Methodology

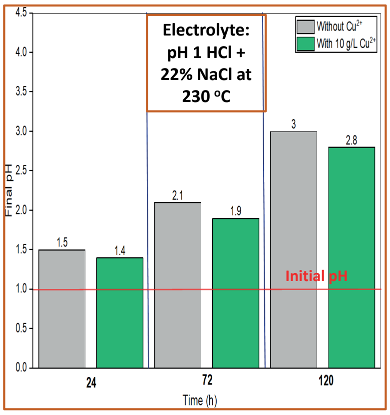
1. 42 mL HCl into PTFE vessel
2. Sample immersed in electrolyte
3. pH = 1.0 /1.7 HCl, 230 °C 24 hours
4. Specimen evaluation Localized attack: Yes/No

Electrolyte: pH 1 HCl + 22% NaCl at 230 °C, Ti grade 2

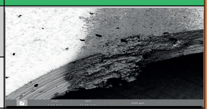
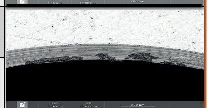
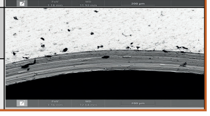
Qualitative analysis: Visible corrosive attack Yes/ No

Results

Optimising testing time (h)



Pd alloying

Grade	pH	Localized attack	Topographic image
2	1	Yes	
	1.7	Yes	
16	1	No	
	1.7	No	
7	1	No	
	1.7	No	

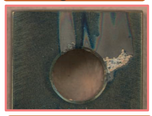
Effect of Cu^{2+}

Electrolyte: pH 1 HCl + 22% NaCl at 230 °C, Ti grade 2

- 10 g/L Cu^{2+} – ✓
- 1 g/L Cu^{2+} – ✓
- 0.1 g/L Cu^{2+} – ✓
- 0.01 g/L Cu^{2+} – ✗
- 0.001 g/L Cu^{2+} – ✗
- 0 g/L Cu^{2+} – ✗

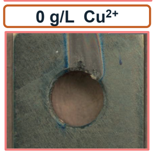
✓ No corrosive attack
✗ corrosive attack

0.01 g/L Cu^{2+}



0.001 g/L Cu^{2+}

0 g/L Cu^{2+}



Conclusions

- **Testing time:** The Optimal testing time is 24 h. Longer duration results in the depletion of electrolytes
- **Pd-alloying:** Grade 7 has better corrosion resistance than grades 2 and 16 in pH 1 and 1.7
- **Effect of pH:** Corrosive attack was observed between 0 and 0.1 g/L Cu^{2+}
  No corrosive attack above > 0.1 g/L Cu^{2+}

Future work

- **pH and temperature** variation will be investigated
- **Electrochemical studies** will be conducted

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- Research focus: Corrosion of Titanium

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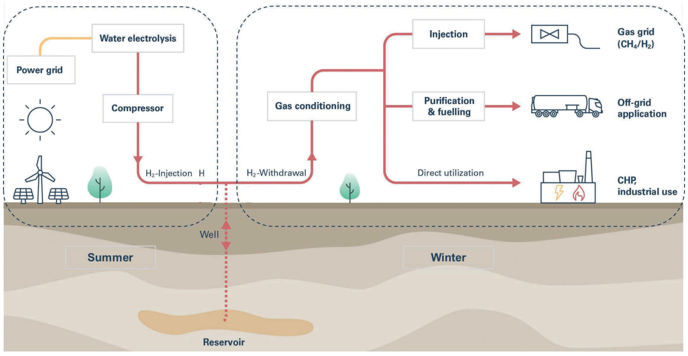
Material Testing for Underground Hydrogen Storage

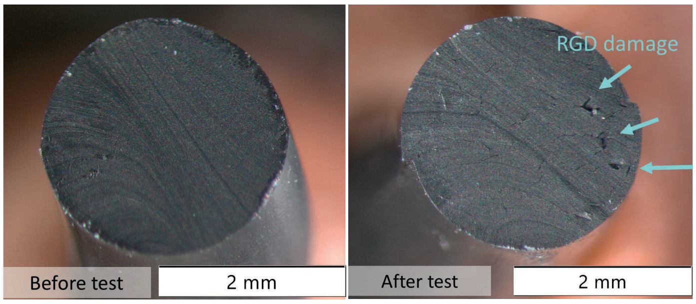
Motivation

The energy transition from fossil fuels to cleaner alternatives is a high-priority topic in Europe. Hydrogen replacing natural gas is considered a sustainable solution for this goal. The EUH2STARS project will demonstrate the seasonal storage of hydrogen gas in depleted natural gas fields. Most of the materials used in these facilities have not yet been tested for hydrogen use. In this project, elastomers and steels will be tested regarding this new application.



Elastomers

- H_2 can induce Rapid Gas Decompression failure (RGD)
- Under high pressure, hydrogen permeates into polymer chains
- Upon rapid depressurisation, hydrogen cannot diffuse out sufficiently quickly
- Nucleation and growth of microbubbles can happen
- Trapped gas generates internal stresses that lead to blistering, cracking, and possibly seal failure

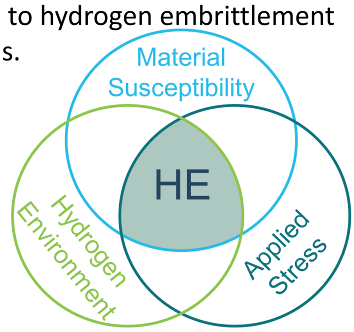


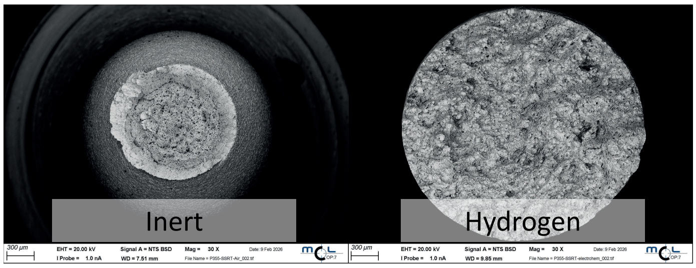
Steels

Hydrogen in metals can lead to hydrogen embrittlement (HE) under certain conditions.
HE can cause:

- Blisters
- Surface cracks
- Internal voids

That leads to a loss in ductility and therefore earlier material failure





Methodology

- Rapid gas decompression tests
- High-speed single-edge notch
- Comparison of hydrogen testing of O-rings with industry testing standards (CO_2, N_2, O_2, CH_4)
- Constant load test under simulated conditions in autoclaves
- Hollow probe tensile testing, under slow stress rate and cyclic conditions

Project Goals

- Evaluate rapid gas decompression damage in O-Rings for hydrogen applications
- Evaluate if carbon steels and stainless steels currently in use in depleted storage facilities are resistant to HE

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