Technical University of Leoben

Science 4 Technology – Poster Exhibition 2026

Department: General, Analytical and Physical Chemistry

Chair: Physical Chemistry

BRW Works Council of the Scientific Staff

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Ceramics4Energy – Research Group Bucher @ LPC

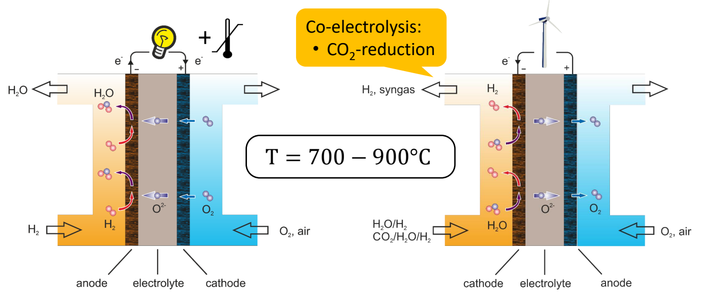
Solid oxide fuel and electrolyzer cells for highly efficient and sustainable electrochemical energy conversion and storage

Our research focus is on fundamental aspects of material design, mass and charge transport properties, electro-chemistry, and degradation mechanisms of solid oxide cells. The know-how gained is incorporated into application-oriented research within the framework of funded projects with scientific and industrial partners.

Fundamental and application-oriented research

- Synthesis of functional ceramics for all components of solid oxide cells including new sustainable materials and advanced processing methods
- Determination of fundamental mass and charge transport properties of mixed ionic-electronic conductors and solid electrolytes
- Characterization of crystal structure and microstructural features including complex 3D-morphology of porous electrodes
- Electrochemical characterization including deeper insights into underlying mechanisms and studies of long-term degradation
- Design of solid oxide cells with high performance and improved lifetime for energy conversion and storage in future energy systems

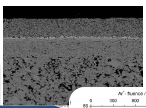
Solid oxide fuel cell (SOFC) **Solid oxide electrolyzer cell (SOEC)**

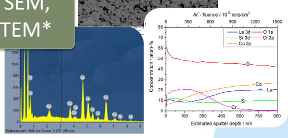


$\eta_{el} = 50 - 60\ \%, \eta_{tot} = 90 - 95\ \%$ $\eta_{el} = 80\ \%$

Post-test analysis

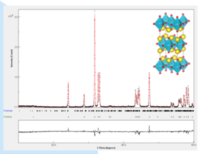
- XRD, SEM, XPS, TEM*





Synthesis

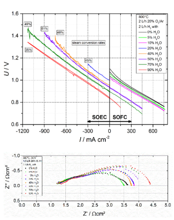
- Sol-gel processes, milling, calcination, sintering, cutting, polishing



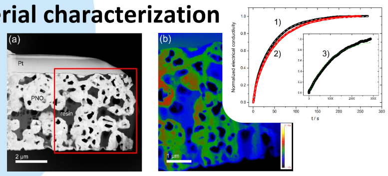
- XRD, TG, DSC, DIL, PSD, SEM, TEM*
- dc-conductivity (relaxation)

Electrochemical tests

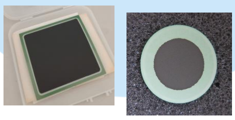
- EIS, i-U, DRT, ageing studies



Material characterization



Cell preparation



- Rheology, screen printing, tapecasting*, additive manufacturing*, sintering

* In cooperation with partners

Expertise

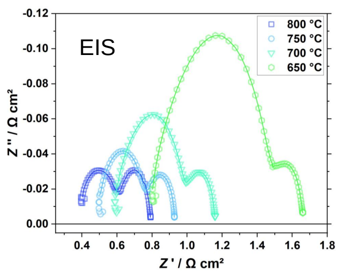
- The research portfolio covers the entire range from material synthesis and fundamental characterization, over cell fabrication and electrochemical testing, to post-test analysis.

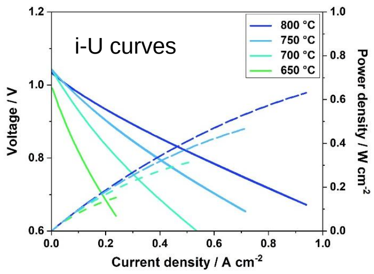
Innovation

- New electrodes without critical raw materials (free of cobalt and rare-earths) for improvement of sustainability and cost-efficiency
- Advanced processing methods such as 3D-printing and multi-material tape casting for design of electrolytes with higher performance and strength

Cell characterization

- Electrochemical impedance spectroscopy (EIS) is applied to analyze processes with different characteristic frequencies
- Current density vs. voltage curves provide insights into cell performance and long-term stability at different operating conditions
- Scanning electron microscopy (SEM) reveals the microstructure and elemental distribution as well as details on degradation mechanisms
- The understanding of the complex relations between electrochemistry, microstructure, and material properties is applied to improve cell design





Assoc.Prof. DI Dr.
Edith Bucher

Chair of Physical Chemistry
Department of General, Analytical and Physical Chemistry
edith.bucher@unileoben.ac.at

Further information on Research Group Bucher at LPC:

physikalische chemie
https://physchem.unileoben.ac.at/

Move mountains

Science 4 Technology @ MUL
Poster Exhibition 2026

Montanuniversität Leoben

Betriebsrat Wissenschaft

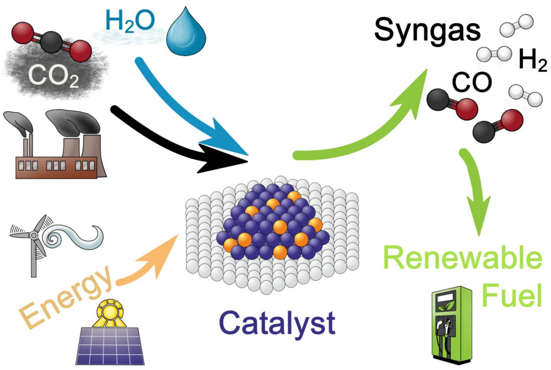
Tunable Catalysts for CO_2 Transformations: Chemicals and Fuels from Waste Gas

Research Group of Christoph Rameshan

T. Berger, T. Cotter, H. Drexler, M. R. Groiß, L. Lindenthal, J. Michalke, I. Pichler, J. Rollenitz, T. Ruh, N. Samuiloff, M. Teber Aksoy

Chair of Physical Chemistry, Montanuniversität Leoben

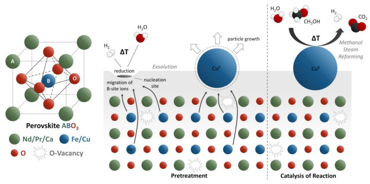
Development of New Catalytic Systems

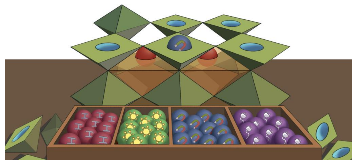


We develop and test new catalytic materials based on **complex oxides**. They facilitate a **rational design approach**, which cuts down development time and increases efficiency.

In recent studies, we have shown the applicability of these catalysts not only for **CO_2 utilisation** but also to reactions useful for **H_2 storage** and **CH_4 conversion**.

In the end, our novel materials could help mitigate climate change by **transforming greenhouse gases** and creating a **carbon neutral circular economy.**



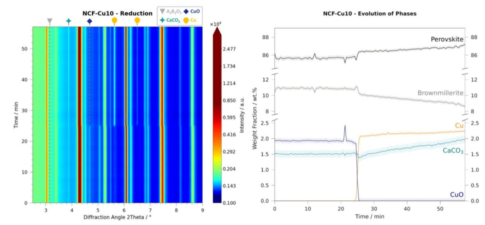


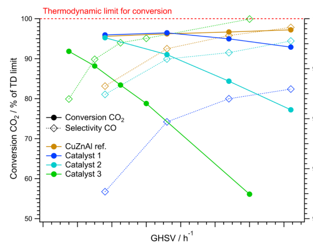
Material Characterisation: *In-situ* Studies and Theory Predictions

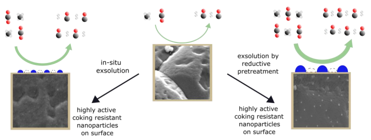
For a rational catalyst design, it is crucial to obtain insights into how desired reactions work on a molecular level. To achieve this, we utilise a multitude of **high-end, state-of-the-art *in-situ/operando* methods,** both in our own laboratories and at **international research facilities.**

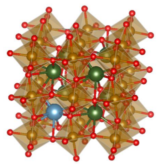
Combined with predictions via theoretical models, a direct correlation of catalyst structure and its reactivity is possible.

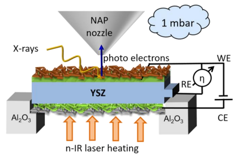
In the past years, we expanded our research focus to electro-catalytic processes, particularly focused on CO_2 reduction and green H_2 generation.



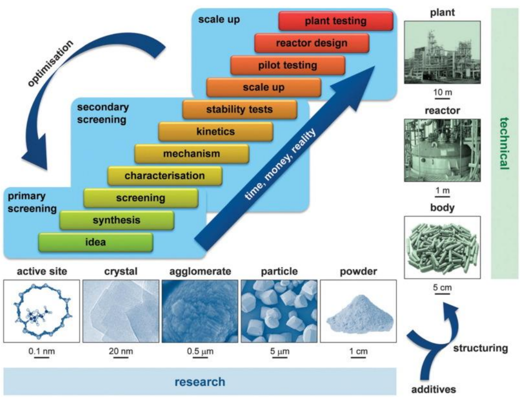


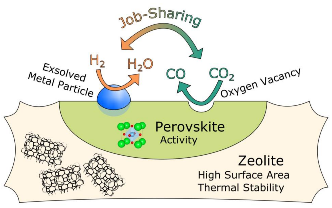


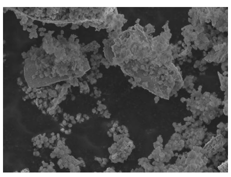




Transfer Developed Catalysts into Industrial Applications

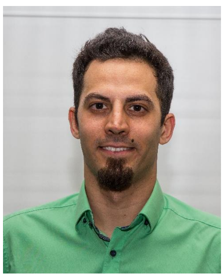






To successfully achieve global impact, the catalysts we develop need to be **implemented into existing industrial processes**. Therefore, the catalytic systems need to be optimised to guarantee **long-term stability** and **low cost** for industrial application.

We are currently researching ways to **combine our catalytic highly active materials with backbone materials already used in large-scale processes**.



Univ.-Prof. Mag. Dr.
Christoph Rameshan
Chair of Physical Chemistry
Department General, Analytical and Physical Chemistry
christoph.rameshan@unileoben.ac.at

TUCAS

Thanks to our partners!

LPC physical chemistry, MCL, VTiU, ESI, EC, WIEN 2k, ESRF The European Synchrotron, DESY, MECS, x-ray center

Move mountains

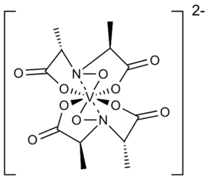
From Toxic Mushroom to Oxidation Catalyst

Utilization of Renewable Ressources for Circular Catalysis

Amanita Muscaria (Fly Agaric Mushroom)

- **Vanadium** uptake of > 100 mg per kg dry mass
- Highest concentration in bulb part **1000 mg per kg dry mass**
- Not dependent on location
- < 75–96 % of the V bound in form of

Amavadin



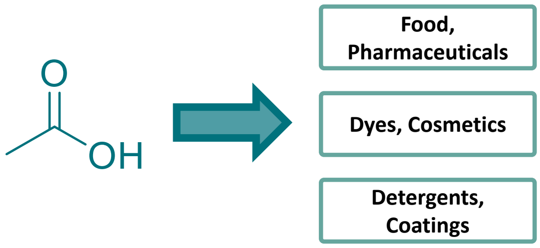
If you're looking for a Bachelor- or Masterthesis, I'd be happy to hear from you to work together on Mushroom catalysis

Use of models for oxidations

- Labor-intensive extraction steps
- Syntheses of model substrates
- Purification steps

Applications

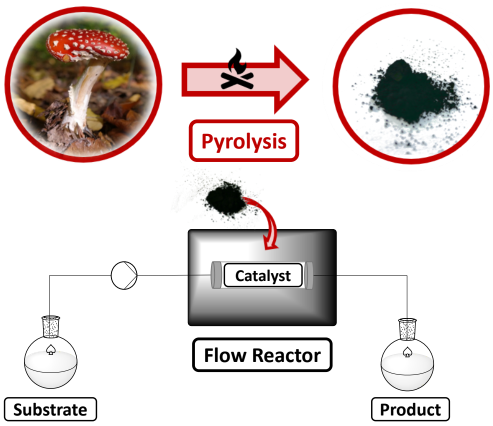
- Acetic acid production **(> 7 Mio. t/a)**



- *Monsanto* or *Cativa* processes rely on **Platin Group Metals** (PGMs)
  - High cost
  - Toxicity (environment & humanity)
  - Global availability

Alternative with Amanita Muscaria

- Drying & **pyrolysis** of fly agaric mushrooms
- **Direct use** of obtained material as **catalyst for oxidations**
- Use of **renewable resources** instead of exploitation
- Optimized utilization and **recycling**
- **Extended lifetime** & efficiency utilizing **flow-chemistry** with particles sealed in stainless-steel cartridge
- **Comprehensive analysis** of the material before and after the reaction
- ~~**Food waste**~~ → toxic if eaten by humans



DI DI Dr. techn.
Jessica Michalke

Chair of Physical Chemistry
Department of Chemistry
jessica.michalke@unileoben.ac.at

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