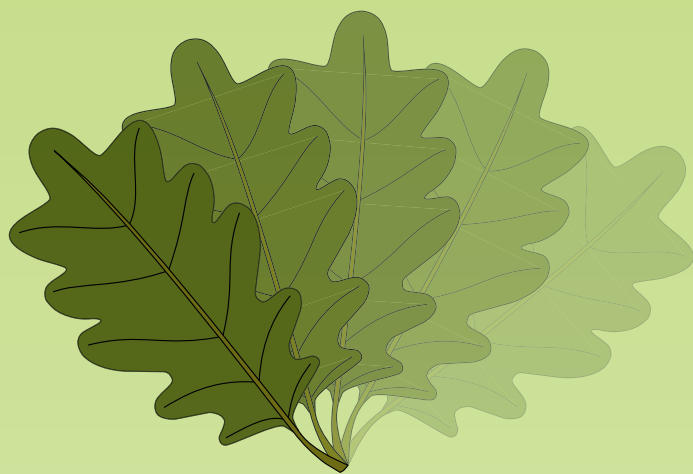




Report 2024–2025



Johan Gadolin
Process Chemistry Centre

Johan Gadolin

Process Chemistry Centre

at

Åbo Akademi University

Report 2024-2025

Åbo, Finland, 2026

<https://www.abo.fi/en/johan-gadolin-process-chemistry-centre-pcc/>

Inquiries: Johan Gadolin Process Chemistry Centre at Åbo Akademi University
Professor Johan Bobacka
E-mail: pcc@abo.fi

PCC logo: Linus Silvander
Painosalama, Turku/Åbo
2026

Table of Contents

1. Overview of PCC activities in 2024-2025.....	6
2. Highlights from <i>PCC</i>	11
3. Our organization and who we are	28
3.1 Organization of <i>PCC</i>	28
3.2 Process Analytical Chemistry	30
3.3 Natural Materials Technology	33
3.4 Industrial Chemistry and Reaction Engineering.....	36
3.5 High-Temperature Processes and Materials.....	39
3.6 Organic Chemistry	42
4. Current Research	45
5. PCC publications and reports 1.1.2024-31.12.2024	116
5.1 Theses 2024.....	116
5.2 Publications 2024.....	117
5.3 Edited conference proceedings and reports.....	124
5.4 Patents and invention disclosures.....	124
5.5 Awards granted 2024	124
5.6 Editorials.....	124
6. PCC publications 1.1.2025-31.12.2025.....	125
6.1 Theses 2025	125
6.2 Publications 1.1.2025-31.12.2025.....	127
6.3 Patents and disclosures	136
6.4 Awards granted.....	136
7. External interactions 2024	137
7.1 Organization of conferences/courses/meetings 2024.....	137
7.2 Visits and visitors	137
7.3 Evaluation of candidates	138
7.4 External evaluations and reviews 2024	139
7.5 Editorial Boards	139
8 External interactions 2025	142
8.1 Organization of conferences/courses/meetings 2025.....	142
8.2 Visits and visitors	142
8.3. Evaluation of candidates	143
8.4 External evaluations and reviews 2025	143
8.5 Editorial boards.....	144
9. Doctoral Theses in Progress at PCC	148

1. Overview of PCC activities in 2024-2025

Background and news

The Johan Gadolin Process Chemistry Centre (**PCC**) started its journey in 1998. The **mission of PCC** is to “*aim at detailed understanding of physico-chemical processes in environments of industrial importance, in order to meet the needs of tomorrow’s process and product development*”, which we call “**Molecular Process Technology**”. Our activities are guided by our **fundamental values**, which are:

- Deep knowledge and high quality in science
- Curiosity and creativity
- Respect for individuality
- Openness and transparency
- Sustainable development

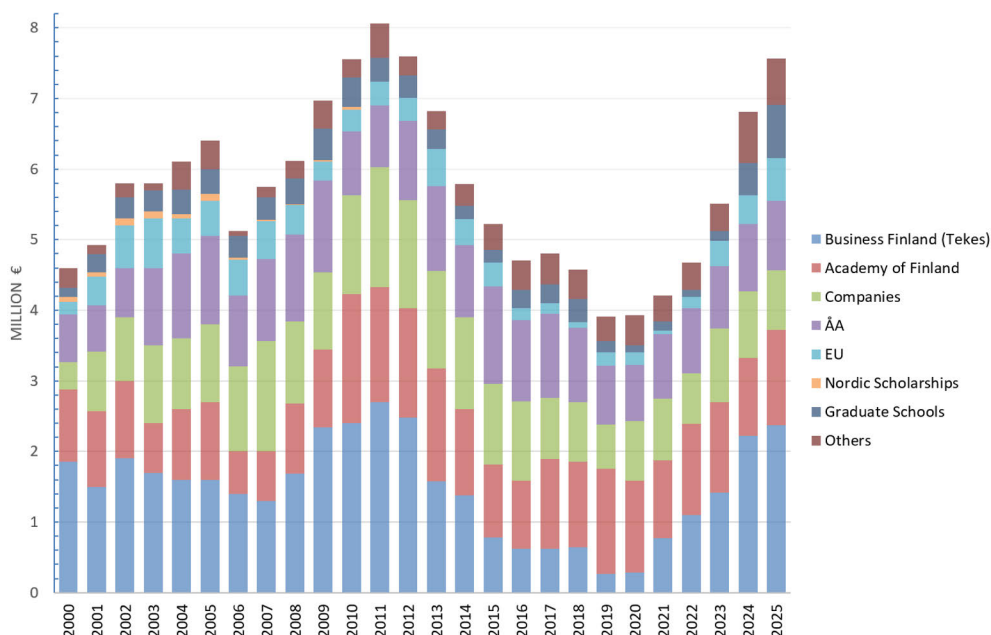
During 27 years of groundbreaking research, *PCC* held the status of Centre of Excellence granted by the Academy of Finland for 12 years (2000–2011) and Centre of Excellence at Åbo Akademi University for four years (2015–2018). These earlier achievements and recognitions gave our Centre a momentum in research and development as well as a critical mass to address global challenges, such as the climate change. Our Centre owns a unique combination of knowledge and experience in chemistry and chemical engineering, which makes *PCC* a key player in enabling the *green transition*. We are committed to promoting renewable and clean energy, sustainable industrial production, health and well-being. These are the overarching and long-term goals of our everyday-research work. Hence, our activities are well aligned with the following research profiling areas of Åbo Akademi University: Technologies for a Sustainable Future, Solutions for Health, and The Sea. In this report we highlight some of our key achievements during the years 2024 and 2025 (1.1.2024–31.12.2025).

The years 2024-2025 in numbers

In 2024-2025, more than 160 senior researchers and full-time PhD candidates worked in the research projects of the Centre. In addition, several shorter-term visitors, Master’s students, and support personnel contributed to our activities.

The figure below depicts the funding trend of the Centre since 2000. Notably, the funding from Business Finland has increased dramatically since hitting a low point in 2019. Overall, the total funding has almost doubled since 2020, and increased by 41% since the previous reporting period (2022-2023). We can safely say that our hard work has paid off.

1. Overview of PCC activities in 2024-2025

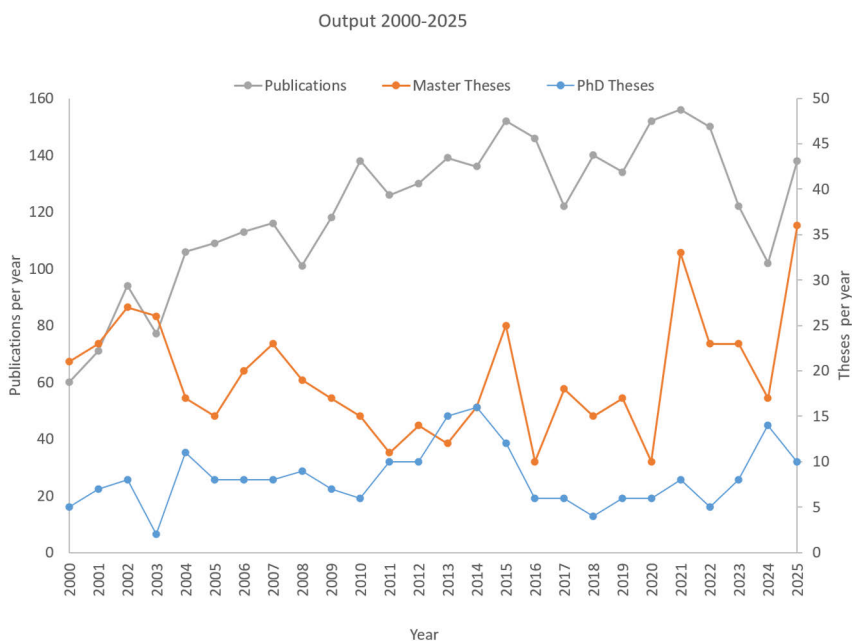


Visual representation showcasing the funding timeline (2000-2025) of the Johan Gadolin Process Chemistry Centre

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<u>Doctoral Theses</u>	5	7	8	2	11	8	8	8	9	7	6	10	10
<u>Master's Theses</u>	21	23	27	26	17	15	20	23	19	17	15	11	14
Journal Articles	60	71	94	77	106	109	113	116	101	118	138	126	130
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
<u>Doctoral Theses</u>	15	16	12	6	6	4	6	6	8	5	8	14	10
<u>Master's Theses</u>	12	16	25	10	18	15	17	10	33	23	23	17	36
Journal Articles	139	136	152	146	122	140	134	152	156	150	122	102	138

Theses and peer-reviewed journal articles by the Johan Gadolin Process Chemistry Centre 2000-2025

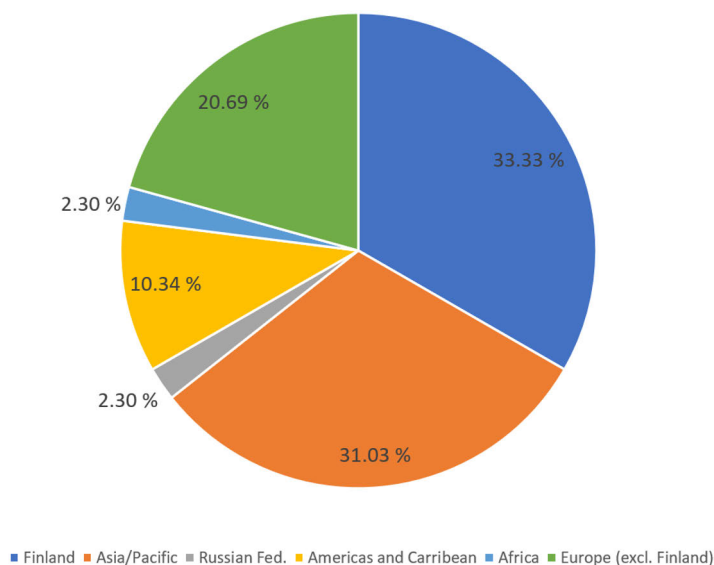
From the academic point of view, the years 2024-2025 were productive. The table and figure below show the number of theses and peer-reviewed publications from PCC since the year 2000. The number of publications and Doctoral theses remain high, and the number of Master theses reached an all-time high in 2025.



Trendline of theses and peer-reviewed publications per year (2000-2025)

Doctoral students

A major part of our research activities is done as doctoral thesis works. Altogether **71** PhD thesis projects are actively underway at *PCC*. Our doctoral students are very international, as ca 67 % originate from countries other than Finland (see the graph below). Among our foreign doctoral students in 2024-2025, the top-3 nationalities were China (11), Italy (8), and India (6), whereas those from Finland were 25 in total. *PCC* is certainly one of the most international units at our University.



Origin of PhD students at Johan Gadolin Process Chemistry Centre during 2024-2025

Boards and task forces

PCC is led by an *executive board* consisting of Prof. Johan Bobacka (chair), Prof. Patrik Eklund, Prof. Henrik Grenman (vice chair), Prof. Daniel Lindberg, Prof. Tapio Salmi, and Prof. Chunlin Xu.

The *PCC* executive board is supported by a *Scientific Advisory Board* and a *Forum for Society*. In 2024-2025 our Scientific Advisory Board consisted of Prof. Raimo Alén from the University of Jyväskylä (Finland), Prof. Tuomas Koiranen from LUT University (Finland), Prof. Lars J. Pettersson from KTH Royal Institute of Technology (Sweden), Dr. Sari Rautiainen from VTT Technical Research Centre of Finland (Finland), Prof. Thomas Rosenau from BOKU University (Austria), Prof. Andreas Seidel-Morgenstern from Max Planck Institute Magdeburg (Germany), and Prof. Maija Tenkanen from the University of Helsinki (Finland). Our Forum for Society consists of representatives of key industrial companies, as well as members of society, who are collaborating with *PCC*.

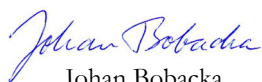
Acknowledgements

This report covers the activities of *PCC* over two calendar years (1.1.2024–31.12.2025). The report was compiled by an Editorial board, including Prof. Johan Bobacka, Dr. Rose-Marie Latonen, Dr. Jonne Niemi, Dr. Tiina Saloranta-Simell, Dr. Pasi Tolvanen, Dr. Johan Wärnå, and Dr. Hao Zhang. Big thanks to the Editors for their tremendous efforts in collecting and organizing all the information summarized in this report!

We want to thank all our collaborating partners in Finland and all over the world for another two years of interesting and inspiring work together.

While the World is facing major challenges, we at *PCC* are committed to enabling a better future for all.

On behalf of the Board of the Johan Gadolin Process Chemistry Centre (*PCC*),



Johan Bobacka
Chairman



2. Highlights from *PCC*

Interview with fresh Doctor Polina Sinitsyna

What was your most important independent achievement during your PhD studies?

My most important independent achievement was identifying deviations from the nominal composition in certain fractions of commercially available bioactive glass microspheres. Through extensive experimental work and analysis, I established these discrepancies and demonstrated their influence on glass dissolution behaviour. This unexpected finding led to new scientific insights and opened up opportunities for further research projects, making it a potentially important contribution to the field. The results of my PhD project also contributed to the first validated predictive simulation of ion release from bioactive glass microspheres.



What was the most challenging part of your PhD studies?

The most challenging part of my PhD was the first two years, when working with commercial glass materials and writing the article on the unexpected results took much longer than I had initially expected. Many of the experiments lasted up to a week and required continuous monitoring and careful control. There were times when I felt uncertain about my progress, and the pandemic added further challenges. However, overcoming these difficulties strengthened my resilience and increased my confidence as an independent researcher.

What is your plan for your personal career after PhD?

Currently, I continue my work as a Postdoctoral Researcher at Åbo Akademi. My plan is to continue my career in academia and gain more international experience.

What do you like most about Åbo Akademi?

As a relatively small university, it's easy to get to know people from different departments and research groups. One of the things I value most is the supportive atmosphere among colleagues. Office doors are often open, so it's easy to ask for help, discuss ideas, or simply have a quick chat. I really appreciate this collaborative environment, where people are approachable, supportive, and willing to help each other.

Interview with fresh Doctor Diosangeles Sotoveliz

What was your most important independent achievement during your PhD studies?

Going from a purely chemical engineering background to confidently working in cell biology was probably my most important achievement during my PhD studies. It blurred the lines between sciences and required me to overcome a steep learning curve, which was only possible thanks to the support I had. My supervisor trusted in my ability to learn and adapt more than I would have, in hindsight. And luckily, during that process, I found confidence in myself as a researcher. Now I know my background doesn't define where science can take me, and I've found joy in stepping out of my comfort zone.



What was the most challenging part of your PhD studies?

It was challenging to work between two different fields. Interdisciplinary science can feel lonely as a shy PhD student, and I often couldn't find the right place to discuss my everyday difficulties with experiments, planning, or understanding results. It also meant putting in a lot of extra effort to absorb everything, be independent and proactive, engage with others, and overall adapt to the challenges of a different field.

What is your plan for your personal career after PhD?

Lead national and European research projects with highly interdisciplinary topics. I want to continue learning and be at the forefront of where materials science may go.

What do you like about Åbo Akademi?

The lifelong connections I've made are by far my best take-away from Åbo Akademi. I've made great friends, even chosen family. I was fortunate enough to do my PhD surrounded by incredible people who made every day worth it.

Interview with fresh Doctor Qingbo Wang

What was your most important independent achievement during your PhD studies?

To be honest, I don't think any of my research achievements were completely independent. Almost everything I accomplished during my PhD benefited from the help and collaboration of many people. When you are reading this part, definitely, you could recall the moments when I came to you for help in different ways. But toward the end of my PhD study, I started working with younger students, changed from a trainee to a trainer. I start to take responsibility not only for my own experiments, but also for helping them design experiments, solve problems, and develop their laboratory skills.

That was probably the point when I really felt that I had become more independent as a researcher.

So, if I had to choose one independent achievement, I would say I gave pretty good support for younger researchers, and that process feels good. ^_^



What was the most challenging part of your PhD studies?

Research work has always been difficult and challenging for me, especially when things did not go as expected. T_T

Facing and accepting this uncertainty was probably the most challenging part. Wait a second, can I use this answer for the most important independent achievement question?

What is your plan for your personal career after PhD?

I have now returned to China and working in a university. Academic research remains an important part of my career, but I also found that I really enjoy teaching and communicating with students and seeing how they understand a topic in different ways. So in the future, I wish I could do something meaningful in research and teaching.

What do you like most about Åbo Akademi?

The whole research experience there. I really enjoyed the moments when we were working together, discussing research, and helping each other. As well as the coffee and dinner time.

Interview with fresh Doctor Rajesh Koppolu

What was your most important independent achievement during your PhD studies?

It is hard to point to a single achievement. Looking back, I see a collection of small improvements that together made me the researcher I am today. If I had to summarize it: my PhD taught me how to tackle a problem. How to research the background, form my own understanding, make good use of the tools available to me, work systematically towards an answer, and finally present it convincingly. That confidence is the most important thing I took from my studies.

What was the most challenging part of your PhD studies?

The first years were by far the hardest. It took time to find and pinpoint the right research question; to really understand what problem my thesis was trying to address. On top of that came learning how to write manuscripts, how to make sure experiments were set up properly, and how to use a whole range of new tools. It was overwhelming at the beginning, but step by step it all came together.



What is your plan for your personal career after PhD?

knew I wanted to stay in research, but with a more applied focus and a close connection to industry. After my PhD, I have been at VTT Technical Research Centre of Finland, working on applied research projects. As both an engineer and a researcher, I also want to see my own ideas and inventions come to life, so these days I am actively pursuing the deep-tech startup path to bring some of those technologies to market.

What do you like most about Åbo Akademi?

The small scale of the university. Everyone knew everyone, and there was a real sense of community. People helped each other out and colleagues became good friends. Ideas were discussed openly, and the whole environment had a home-like comfort to it. It was extremely satisfying, and something I'm sure I will miss a great deal.

Interview with fresh Doctor Aayush Jaiswal

What was your most important independent achievement during your PhD studies?

I gained many important career skills during my PhD - critical thinking, paying attention-to-detail, and public communication, to highlight a few other than subject matter knowledge. Out of these, I consider communication skills to be the most important one. Through practice and iteration during the PhD studies, I have learned to visualize and communicate complex topics (like my scientific work) to a range of audience including fellow scientists from own or different fields, industry professionals, journalists, investors, politicians, and also my grandmother.



What was the most challenging part of your PhD studies?

Doing a part-time PhD at ÅÅU along with a full-time job was a very challenging endeavour at times. When the studies were about 80% done, I faced a drop in motivation where I wondered if spending long days and weekends to finish the thesis was worth it when having the comfort of a job already. Thankfully, I overcame this hurdle with the support and encouragement of my mentors and family, without whom it wouldn't have been possible. This has made me realize the importance of maintaining a work-life balance even in tough periods since burnout can lead to a sudden decline in motivation.

What is your plan for your personal career after PhD?

An exciting (and new) journey lies ahead as I am working on commercializing a technology that I've been developing at VTT along with my colleagues. We plan to establish a spin-off soon and I will be ending my 8+ years long career at VTT to step into the entrepreneurial world to tackle the global problem of high energy consumption in air conditioning.

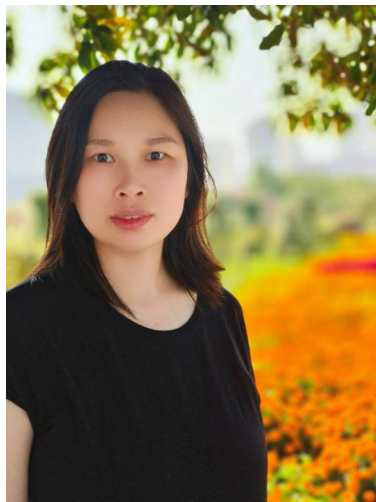
What do you like most about Åbo Akademi?

When I moved out from India in 2017, ÅAU was the first place where I started my studies as a M.Sc. student in Chemical Engineering, so ÅAU has a special place in my heart. I have always liked the coziness and warm atmosphere at ÅAU, be it in student circles, research labs, or university staff. This welcomes free and open discussions between peers and professors and helps build long-lasting connections.

Interview with fresh Doctor Rui Liu

What was your most important independent achievement during your PhD studies?

During my PhD, I independently developed a systematic understanding of how the heterogeneity of industrial softwood kraft lignin influences its fractionation, properties, and nanoparticle formation. I designed a sequential solvent-fractionation method, characterized the fractions with various analytical techniques, and linked molecular differences to their nanoparticle performance. The work involved planning, advanced characterization, data analysis, and troubleshooting, ultimately providing a clearer approach to selecting high-purity technical lignin for high-value uses.



What was the most challenging part of your PhD studies?

The most challenging part of my PhD was redirecting my research after the initial experiments did not produce the expected results. The heterogeneity of lignin made it difficult to establish clear structure–property relationships in lignin-based nanoparticles for biomedical applications. I therefore shifted to a more fundamental study of industrial kraft lignin. This required me to learn new analytical methods and redesign the project almost from the beginning. Although challenging, it taught me how to adapt to unexpected results and turn an initial setback into a coherent research project.

What is your plan for your personal career after PhD?

After completing my PhD, I began working as a university lecturer, combining teaching with research focused on understanding lignin chemistry and developing efficient strategies for its high-value utilization.

What do you like most about Åbo Akademi?

ÅAU offers excellent research facilities, supportive colleagues, valuable teaching opportunities, and a friendly international environment, all of which create a positive atmosphere for the academic and professional development of PhD candidates.

Interview with fresh Doctor Liqui Hu

What was your most important independent achievement during your PhD studies?

Successfully executing my proposed research strategies, which resulted in several first-author publications and patent applications. Specifically, developing barrier and coating formulations from wood-derived biopolymers has strong potential for the paper industry. Beyond the lab, I also independently co-supervised master's students, which taught me how to delegate, plan effectively, and optimize my time without compromising my own research output.

What was the most challenging part of your PhD studies?

The initial phase, where many experiments failed, was the hardest. This was compounded by external disruptions—first the pandemic, and later the laboratory relocation to Aurum, which caused significant downtime. However, overcoming the isolation and restarting my work in a new environment taught me resilience, systematic "fail-fast" testing, and ruthless time optimization. This period truly marked my shift from a student to an independent researcher.



What is your plan for your personal career after PhD?

Short-term, I aim for a postdoctoral position abroad to gain experience in either academic research or applied industrial R&D. Long-term, I aspire to lead my own research group at a university or national research institute, while actively maintaining collaboration with Åbo Akademi and the Finnish materials ecosystem.

What do you like most about Åbo Akademi?

The uniquely human-scale culture and the strong collaboration between industry and academia impressed me. Additionally, within the NMT group, I greatly valued the supportive team spirit and the analytical infrastructure. This combination created an encouraging environment that kept me grounded and focused on my research throughout my PhD, even during challenging times.

Interview with fresh Doctor Farzad Jafarionar

What was your most important independent achievement during your PhD studies?

Elementti! A software tool I developed for more professional processing and visualization of elemental maps. It became an important part of my work and made handling this type of data much more efficient and consistent.

What was the most challenging part of your PhD studies?

Laboratory experiments combining HCl(g) and water vapor. At low temperatures, this mixture is especially difficult to control and handle, which made the experiments technically very challenging.

What is your plan for your personal career after PhD?

I would like to continue in academia and further develop my research career.

What do you like most about Åbo Akademi?

Probably the freedom. At Åbo Akademi, I have been able to spend time on side ideas that eventually became useful parts of my research.

Interview with fresh Doctor German Araujo Barahona

What was your most important independent achievement during your PhD studies?

From a scientific perspective, my most important achievement was learning how to successfully combine classical chemical engineering knowledge (my original background) including reactor engineering and heat and mass transfer, with material synthesis and characterization and reaction kinetics. This has been a significant learning journey for me. Bridging these different areas was not always easy, but it allowed me to develop a much broader and more integrated knowledge. I am extremely grateful to my supervisors, colleagues, and friends at TKR, who taught me so much along the way, not only scientifically but also personally and professionally.



What was the most challenging part of your PhD studies?

One of the most challenging aspects of my PhD was learning and integrating knowledge from different scientific areas while maintaining the consistency and coherence of the overall research. Time management was another major challenge, particularly when balancing experimental work, data analysis, modelling, writing, and academic and immigration bureaucracy. Learning how to prioritize these different tasks and keep the research moving forward was an important part of my development during the PhD.

What is your plan for your personal career after PhD?

I would like to continue doing research and developing my own ideas, while further expanding my expertise in chemical engineering and catalysis. For me, continuous learning can sometimes be overwhelming, but at the same time, it is one of the most rewarding aspects of a research career.

In the future, I hope to continue working in an environment where I can remain curious, take on new scientific challenges, and gradually develop greater independence as a researcher.

What do you like most about Åbo Akademi?

What I like most about Åbo Akademi is its collaborative spirit, which I believe is one of its greatest strengths and has helped attract talented people from all over the world. There is always someone willing to help whenever you need support with your experiments or studies.

I also really appreciate the dynamism within the research teams and their willingness to explore new topics and develop new ideas. This is complemented by an outstanding research infrastructure, particularly in chemistry and chemical engineering, which I would consider among the best I have encountered in Europe. I think this combination of collaboration, expertise, openness and excellent facilities makes Åbo Akademi a very special environment for research and education.

Interview with fresh Doctor Maryam Hmoudah

What was your most important independent achievement during your PhD studies?

For me, one of the most important achievements of my PhD was becoming a more independent researcher and, at the same time, developing my confidence as a leader. My experience in the Laboratory of Industrial Chemistry and Reaction Engineering (TKR), played a very important role in this. I was given the freedom to develop my own ideas and take responsibility for my research, while always knowing that there was a supportive team around me whenever I needed advice or a different perspective. This taught me something that I now consider very important in academic leadership: people grow when they are trusted. During my PhD, I gradually learned to take ownership of my work, speak up about my ideas, and make decisions with confidence. I now try to create the same sense of trust and encouragement for the students and young researchers I work with.



What was the most challenging part of your PhD studies?

The most challenging part was probably learning to be comfortable with uncertainty. Research does not always give you the answer you expect, and there were certainly moments when an experiment failed or I had to rethink the direction I was taking.

My dual PhD journey also meant experiencing two different academic and cultural environments, in Finland and Italy, under the supervision of Professor Tapio Salmi, Professor Martino Di Serio, and Professor Vincenzo Russo. Moving between these environments was a very enriching experience, but it also required me to adapt to different ways of working, communicating, and approaching research. At times, this was challenging, but it taught me to be open-minded and to appreciate that there is often more than one way to approach a problem.

I have always believed that “where there is a will, there is a way.” Whenever I faced a difficulty, I tried to focus on finding a way forward rather than seeing the challenge as a reason to stop.

What made these experiences particularly valuable was the supportive environment at TKR. I never felt that I had to face a difficulty alone. There was always an open door for discussion, and I learned that seeking guidance does not take away from your independence. On the contrary, it can help you grow while still taking responsibility for your own decisions.

Looking back, the challenges of my PhD taught me much more than how to conduct research. They helped me become more adaptable and confident, and they shaped my understanding of leadership. I learned that a good leader does not need to have all the answers; sometimes, the most important thing is to create an environment where people feel supported enough to find their own way forward.

What is your plan for your personal career after PhD?

After my PhD, I am building my academic career at An-Najah National University in Palestine. I see my future as a combination of research, teaching, and mentorship, with a strong focus on water and wastewater treatment. But I also want to build something beyond my own research. My experience at TKR showed me how much a supportive research environment can influence a

young scientist. I would like to create that kind of environment for my own students, where they feel trusted to develop their ideas and confident enough to take their own steps.

The most rewarding parts of being an academic is seeing students grow. I want to help young people discover what they are capable of and eventually see them accomplish dreams that perhaps once seemed impossible to them.

In particular, I hope to encourage more young women to see science and engineering as a place where they can belong and become leaders. In that sense, my career is not only about the research I can do myself, but also about the people I can help grow along the way.

What do you like most about Åbo Akademi?

What I like most about Åbo Akademi is the people and the phenomenal research environment. During my time at TKR, I felt that research was very much a collective experience. Even though everyone had their own projects, there was always a willingness to discuss ideas and help one another.

I also really enjoyed the everyday academic life at Åbo Akademi. The coffee breaks became a special part of my experience. They were simple moments, but they created wonderful opportunities to meet colleagues, exchange ideas, and have conversations that sometimes continued long after the coffee was finished. I especially appreciated the academic conversations and the opportunity to learn from the experience of Professor Tapio Salmi, Professor Dmitry Murzin, and the whole TKR team. Their talks and discussions gave me a different perspective on research and reminded me how much we can learn from researchers who have spent many years building their expertise. I truly enjoy academia, and for me, this exchange of knowledge and experience was one of the best parts of being at Åbo Akademi.

The seminars that were regularly organized added a lot to my experience. I had the chance to engage with colleagues as well as researchers from different countries and backgrounds. These informal and formal interactions broadened my perspective and made me feel part of a truly international research community.

Professor Tapio Salmi's leadership also had a strong influence on me. He created an environment where you were encouraged to become independent rather than simply follow instructions. That gave me the confidence to take ownership of my research and to see myself not only as a PhD student, but as a researcher who could contribute something of my own.

I think that is what I will remember most about Åbo Akademi. I came there to complete my PhD, but I left with a much clearer understanding of the kind of researcher and academic leader I want to become.

Interview with fresh Doctor Federica Orabona

What was your most important independent achievement during your PhD studies?

I would say that one of my most important achievements was successfully bringing together the collaboration between three institutions: Åbo Akademi University, the University of Naples Federico II and the National Research Council of Italy (CNR). During my PhD, I travelled between Finland and Italy and conducted research in the different laboratories, learning to work across



different research environments and coordinate my work between the three institutions. I am particularly proud of having developed the independence and adaptability needed to make this collaboration work effectively.

What was the most challenging part of your PhD studies?

Perhaps the first year of my PhD was the most challenging. I had to establish and set up the analytical methods needed for my research while also defining the direction of my project and finding the right path for my PhD research.

What is your plan for your personal career after PhD?

I plan to continue working in research as a postdoctoral researcher at VITO, a leading Flemish research organization, with a particular focus on sustainable materials and processes. I would like to continue developing my expertise in this field and contribute to the transition towards green chemistry and more environmentally responsible technologies. In the longer term, I would like to develop my career towards a research management position, combining my scientific background with the coordination and management of research activities.

What do you like most about Åbo Akademi?

I particularly appreciate the working culture at Åbo Akademi, especially the efficiency and supportive working environment. It is a place where I have had the opportunity to work independently while also benefiting from a collaborative and stimulating atmosphere.

Interview with fresh Doctor Mouad Hachhach

What was your most important independent achievement during your PhD studies?

One of the most meaningful achievements for me was securing external funding from competitive Finnish foundations to support my research on biomass valorization and reactor modeling. I was awarded grants from the Finnish Cultural Foundation (SKR), Svenska Litteratursällskapet (SLS), and Svenska Kulturfonden among others, all of which have rigorous selection processes. This funding was crucial for keeping my research on track and gave me confidence in my ability to develop fundable research ideas.

What was the most challenging part of your PhD studies?

The most challenging part was finding a good balance between pursuing funding opportunities and advancing my research. Writing competitive grant applications to foundations such as SKR, SLS, and Kulturfonden required a lot of independent work—framing the research questions, preparing budgets, and aligning with each foundation's priorities—even with support from my supervisors. At the same time, I was working on complex three-phase reactor models and biorefinery analysis. Learning to manage my time and energy between these two demanding aspects was a steep but valuable learning curve between funding acquisition and research.

What is your plan for your personal career after PhD?

My plan is to build an academic career based in Morocco while maintaining strong research collaboration with Åbo Akademi. I have applied for a docent title at Åbo Akademi to formalize my role in supervising students and contributing to research projects. I hope to develop a research line on sustainable chemical engineering, use my dual affiliation to foster Finland–Morocco collaborations, and continue applying for external funding to support joint projects, teaching, and publications.

What do you like most about Åbo Akademi?

I really appreciate the academic freedom to explore independent research ideas, the international environment, and the supportive, collaborative culture within Åbo Akademi. Åbo Akademi offers a work environment that not only encourages cooperation and knowledge sharing, but also fosters deep friendships among colleagues. My supervisors offered important mentorship in grant writing and research design, which helped me successfully apply for funding from foundations such as SKR, SLS, and Kulturfonden. These aspects have played a big role in my growth as a researcher and especially as a person.



Interview with fresh Doctor Christoph Schmidt

What was your most important independent achievement during your PhD studies?

To be brave and step into the unknown. That step allowed me to create a novel concept in my research topic, which later turned out really successful.

What was the most challenging part of your PhD studies?

To keep on going when nothing worked and the amount of work was endless. But a strong motivation can bring you through the deepest valleys.

What is your plan for your personal career after PhD?

I already had a long while the goal to work in the industry as researcher and bring with my activities a positive contribution to the society.

What do you like most about Åbo Akademi?

The colleagues. Moving to another country and knowing only one person seemed difficult but the colleagues became central in my life and I am still happy that this amazing network existed.



Interview with fresh Doctor Sara Lund

What was your most important independent achievement during your PhD studies?

My most important independent achievement during my PhD was navigating a research project with an exceptionally broad scope. My work took me from mineralogy and graphite purification to graphene production, and finally to a functional application. Carrying out research with such a broad scope is not always easy, and luckily, being a researcher does not mean knowing how to do everything on your own. Learning to see the bigger picture, recognizing what needs to be investigated, and acquiring the necessary knowledge and skills are the key to moving the research forward.



What was the most challenging part of your PhD studies?

As I participated in a research project spanning several different fields, techniques, and research environments, working across these areas was sometimes challenging, especially in the beginning, when there was so much to learn. From the beginning, the aim was to go from a natural graphite-bearing raw material all the way to a graphene-based application. This meant not only learning a wide range of experimental techniques but also coordinating work between different laboratories and research groups, each with their own expertise, practices, and ways of working. Working across different research environments taught me a lot about communication, collaboration, and how different areas of expertise can complement each other.

What is your plan for your personal career after PhD?

I am currently working as a postdoctoral researcher in the Analytical Chemistry group on a project developing biodegradable electrodes for electrophysiological measurements. I see my new position as an exciting opportunity to learn new things while building on my previous experience. I hope to continue broadening my skills and knowledge, and to explore new research areas and collaborations along the way.

What do you like most about Åbo Akademi?

What I like most about Åbo Akademi is the people and the atmosphere. I have always enjoyed the friendly and open environment, not only within our research group but also between different laboratories. I have also appreciated the open-door policy of the professors and the emphasis Åbo Akademi places on work-life balance. Together, these things have created a supportive environment where I have felt comfortable learning, asking questions, and growing as a researcher.

Interview with fresh Doctor Ville Yrjänä

What was your most important independent achievement during your PhD studies?

It was not directly related to the topic of my PhD, but I was able to leverage my programming hobby to develop open-source software for processing results obtained with electrochemical impedance spectroscopy (EIS). Later, this work led me to improve upon an existing approach to validating impedance spectra. Thus far, this sidetrack related to EIS has resulted in two peer-reviewed publications of my own, new contacts both domestic and international, and opportunities to collaborate with others on topics unrelated to my PhD topic.



What was the most challenging part of your PhD studies?

Outside of complications related to the COVID pandemic and the move to Aurum, I found the process of learning how to network and collaborate while occupying different roles (doctoral student, colleague, and supervisor of MSc thesis) throughout the project to be challenging but rewarding.

What is your plan for your personal career after PhD?

I would like to continue with academic research due to the challenges and freedoms it entails. Teaching has also been a rewarding experience, and it would be nice to be able to continue doing that as well. However, I am open to the idea of working in some kind of industry.

What do you like most about Åbo Akademi?

The people I have been fortunate enough to work with or gotten to know along the journey.

Interview with fresh Doctor Ida Mattson

What was your most important independent achievement during your PhD studies?

Combining family life with two small children with the finalization of the thesis is something I'm very proud of.

What was the most challenging part of your PhD studies?

I think every PhD student experiences moments of self-doubt and uncertainty at some points during the studies. Not achieving the expected results in the lab during extended period of times were somewhat wrecking, but eventually you'd manage to get over also those hurdles. Fortunately, the stressful moments were outweighed by the nice ones.



What is your plan for your personal career after PhD?

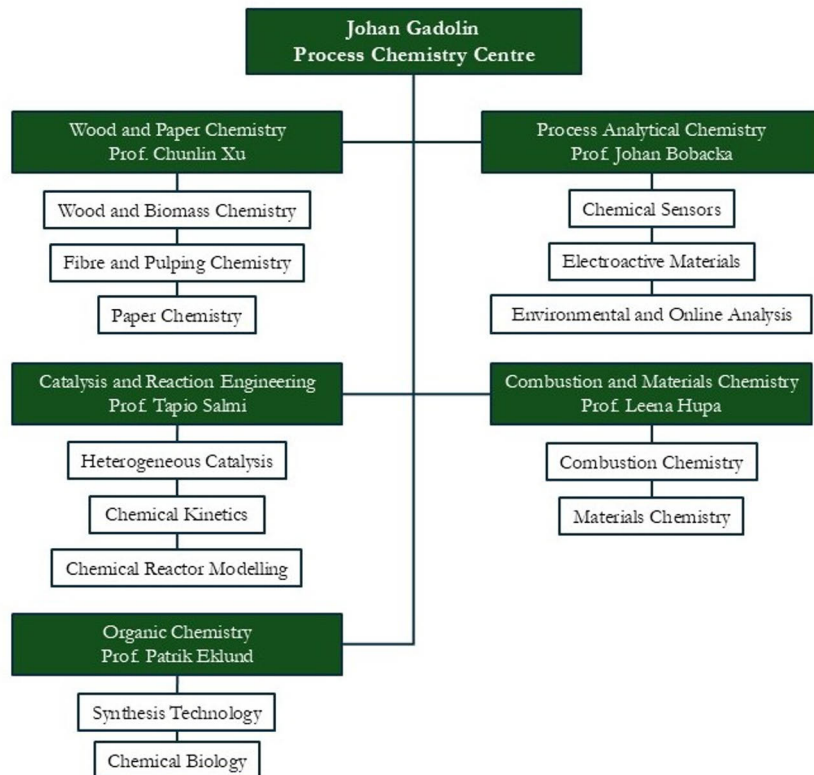
My plan is to pursue a career outside academia. I'm currently working as a Senior Engineer in the medtech business where I daily get to utilize the problem-solving skills and network that was formed during the PhD studies.

What do you like most about Åbo Akademi?

The people and warm and helpful atmosphere are something I'll always have with me from Åbo Akademi.

3. Our organization and who we are

3.1 Organization of *PCC*



Executive Board

- Professor Johan Bobacka (chairman)
- Professor Patrik Eklund
- Professor Henrik Grénman (vice chairman)
- Professor Leena Hupa (→ 08/25)
- Professor Daniel Lindberg (09/25 →)
- Academy Professor Tapio Salmi
- Professor Chunlin Xu

Scientific Advisory Board (SAB)

- Prof. Raimo Alén, University of Jyväskylä
- Prof. Tuomas Koiranen, LUT University
- Prof. Lars J. Pettersson, KTH Royal Institute of Technology, Stockholm, Sweden
- Dr. Sari Rautiainen, VTT
- Prof. Thomas Rosenau, BOKU
- Prof. Andreas Seidel-Morgenstern, Max-Planck-Institut Magdeburg, Germany
- Prof. Maija Tenkanen, University of Helsinki

Forum for Society (FS)

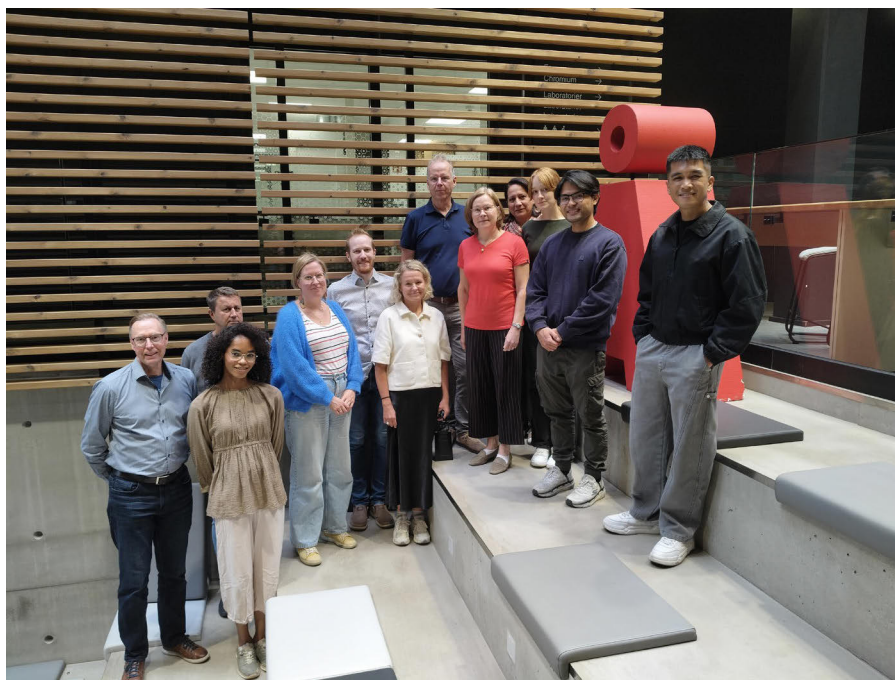
- Örjan Andersson (Novia)
- Ilmo Aronen (University of Helsinki)
- Maija Blomquist (Radiometer)
- Kenneth Ekman (Fortum Battery Recycling)
- Ann-Sofie Fonsen (Boreal bioproducts)
- Linda Fröberg-Niemi (Business Turku)
- Bertel Karlstedt (Karlstedt Consulting)
- Katariina Kemppainen (Metsä Group)
- Hanna Kinnunen (Gasgrid)
- Jonas Konn (Kemira)
- Björn Lax (Chemec)
- Juha Lehtonen (VTT)
- Lars Peter Lindfors (Neste)
- Aila Maijanen (CLIC Innovation)
- Pia Nilsson (UPM)
- Leena Paavilainen (Luke)
- Jarkko Partinen (Resand)
- Ismo Savallampi (Borealis Polymers)
- Mathias Snåre (Nordkalk)
- Tor Stendahl (Calogena)
- Mats Sundell (Mirka)
- Petri Vasara (AFRY)
- Heli Virkki (Gasgrid)
- Lari Vähäsalo (CH-Bioforce)

3.2 Process Analytical Chemistry

Continuous (on-line, in-line, non-invasive) chemical analysis is relevant for the chemical process industry, environmental monitoring, and personal health monitoring. Emerging analytical applications, such as distributed chemical analysis and non-invasive on-body chemical sensing, benefit greatly from calibration-free and maintenance-free chemical sensors and biosensors. This is an important driving force for our research. Our long-term development of solid-contact ion-selective electrodes and solid-state reference electrodes represent two important steps towards maintenance-free ion sensors. Another driving force is the green transition, which encourages us to utilize bio-based (non-fossil) materials in various electrochemical devices, including electrodes, sensors and batteries. These sustainability values are also influencing our teaching activities in the *Erasmus Mundus* joint master's degree program *Excellence in Analytical Chemistry* (EACH), which received continued funding from EU for several years ahead.

Our research on electrochemical sensors and biosensors continued in 2024-2025. Significant research efforts were also directed towards the development of solid-state sodium-ion batteries, which was funded by the Jane and Aatos Erkkö Foundation. A new project related to corrosion of medical instruments was initiated and funded by Business Finland. Furthermore, a new European M-ERA.NET project on the development of biodegradable ECG electrodes was initiated and funded by Business Finland. Research on wearable biosensors for non-invasive glucose monitoring continued successfully in collaboration with the start-up company GlucoModicum Oy that has over 60 employees today.

Our activities in analytical chemistry during 2024-2025 resulted in 3 Doctoral theses, 8 MSc theses, 19 peer-review articles, and several presentations at international conferences.



Personnel

Professors

Johan Bobacka

Tom Lindfors (Associate Professor)

Ari Ivaska (Emeritus)

Andrzej Lewenstam (Emeritus)

University lecturer

Rose-Marie Latonen (docent)

Docents

Zhanna Boeva (GlucModicum)

Adriana Ferancova (University of Oulu)

Leo Harju (Emeritus)

Carita Kvarnström (University of Turku)

Li Niu (Guangzhou University)

Di Wei (Beijing Institute of Nanoenergy and Nanosystems)

Anna Österholm (Georgia Institute of Technology)

Researchers

Sara Lund (post-doc)

Zekra Mousavi (docent)

Tomasz Sokalski (docent)

Ville Yrjänä (post-doc)

Muhammad Shajih Zafar (post-doc)

Visiting researchers

Sreenivasa Rao Amaraneni

Shiyu Gan

Christian Gosti

Rongning Liang

Manuel Miró

Sigrid Selberg

Eszter Supala

Lijie Zhong

Doctoral students

Luca Guagneli

Narender Joon

Jay Pee Oña (post-doc)

Hazzalea Elyse Reyes

Angelo Robiños

Rodney Salazar

Laboratory, financial and faculty support services

Tor Laurén (laboratory services manager)

Mia Mäkinen (secretary)

Karita Åberg (project controller)

3.3 Natural Materials Technology

The mission of the Laboratory of Natural Materials Technology (NMT) is to promote the sustainable and multipurpose use of biomass for high-value biomaterials, biochemicals, and fibre products. We generate and disseminate new scientific knowledge and equip students and researchers with expertise in biomass chemistry and materials technology, together with the creative problem-solving skills needed by forest-based and related bio-based industries.

Our research advances the resource-efficient use of wood and other renewable raw materials in bioproducts, including pulp, paper, fibres, and wood products, as well as emerging biomaterials, biocomposites, biochemicals, and bioenergy applications. Our activities encompass **four main areas: biomass fractionation** using new chemistries and processes; **lignin chemistry and valorisation** into nanoparticles, copolymers, resins, and composites; **bioproducts and functional materials** for coatings, energy storage and harvesting, and medical applications; and **analytical method development and industrial problem-solving**.

NMT's research environment is being strengthened through investments in infrastructure, doctoral education, and international collaboration. Through the [Printed Intelligence Infrastructure \(PII\)](#), Åbo Akademi's Functional Printing Center received an investment package of approximately €1.6 million from Research Council of Finland and the University. The investment expands capabilities in advanced printing, bioprinting, biomass processing, and materials characterisation.

Through the [Emission Free Pulping \(EFP\) programme](#) (2024–2028), NMT contributes to a joint initiative involving forest industry partners and research organisations in Finland and Sweden, to increase wood utilisation efficiency and reduce biomass burning, and CO₂ emissions in pulping. NMT's contribution focuses on developing a wood microanalysis toolbox to investigate the dissolution of wood components and their interactions within the cell wall. We also investigate how oxygen affects lignin and hemicellulose chemistry during treatment, providing fundamental knowledge to support new pulping processes that produce high-quality fibres at higher yields. The [Circular Materials Bioeconomy Network \(CIMANET\)](#), a national doctoral education pilot funded by the Ministry of Education and Culture, strengthens NMT's research training in the sustainable use of renewable resources for advanced materials with a strong focus on lignin. The network connects doctoral education with the competence needs of bio-based industries and broadens collaboration across Finnish universities. NMT also participates in [MADNESS](#), the Centre of Excellence in Materials-driven Solutions for Combatting Antimicrobial Resistance, funded by the Åbo Akademi University Foundation, contributing expertise in bio-based materials for biomedical applications.

More recently, NMT's international collaboration is further strengthened through the [Global Center for Sustainable Bioproducts \(GCSB\)](#). Its Finnish node, [Circular Bio-based Residues to Sustainable Bioproducts \(CirBReS\)](#), is funded by Business Finland for 2026–2029. The collaboration focuses on converting biomass residues into sustainable composites and plastics, connecting NMT's expertise in biomass chemistry and functional materials with an international research network and industrial partners.



During 2024–2025, NMT secured approximately €5 million in external funding from the Research Council of Finland, Business Finland, industrial partners, and foundations, including the Jane and Aatos Erkko Foundation. We maintain close collaboration with the Natural Resources Institute Finland (Luke) and VTT in Finland, Wallenberg Wood Science Center and KTH Royal Institute of Technology in Sweden, the Technical University of Denmark (DTU), and BOKU University in Austria through researcher exchanges, joint research, and teaching. Other active partners include Aalto University, Tampere University, the University of Helsinki, the University of Oulu, and research groups affiliated with the BioCity Turku research programmes.

Personnel

Professors

Martti Toivakka

Chunlin Xu

Bjarne Holmbom (Emeritus)

Lecturers

Jan Gustafsson

Mari Nurmi

Anna Sundberg (Docent)

Docents or group leaders

Andrey Pranovich (Docent in Wood Chemistry)

Xiaoju Wang (Head of Research and Docent in Sustainable Biomaterial Engineering, jointly with Pharmaceutical Sciences Laboratory)

Doctoral students and researchers

Marie Alopaeus

Minette Kvikant-Julin

Zonghong Lu

Tapani Nick

Ruijie Wu

Nizam P A

Julia Chrzastowska

Ellen Sundström

Shujun Liang

Wangfang Deng

Donya Arjmandi

Valter Georgs

Qi Nie

Tim Salomäki

Andreas Schröder

3. Our organization and who we are

Matilda Martin	Yongzheng Li	Jonatan Rönholm
Esmeralda Laurén	Adil Mehmood	Dumindu Peththa Wadu
Sai Hu	Ábris Szkladány	Johannes Bjarnason Hellnäs
Jiayun Xu	Watti Lehtimäki (MM Kotkamills Boards Oy)	
Zhiqiang Li (SAPPI)	Veronica Matamala (Arauco)	
Jarl Hemming	Jani Kniivilä	Ekaterina Korotkova
Oskar Backman	Dmitry Tarasov	Hao Zhang
Larissa Kessler	Hoyoung Yoon	Zhongqi Liu
Andre Mazega Fontes	Yidong Zhang	

Laboratory Managers

Teija Tirri	Kenneth Stenlund
-------------	------------------

Secretary

Annika Fougstedt	Karita Åberg
------------------	--------------

<https://www.abo.fi/en/natural-materials-technology-research-and-personnel/>

3.4 Industrial Chemistry and Reaction Engineering

The first chair at the new Faculty of Chemical Engineering (*Kemisk-tekniska fakulteten KTF*) was the Borgström professorship in general chemical technology starting in July 1st 1920 in Republic of Finland. This is the birth date of Industrial Chemistry and Reaction Engineering at Åbo Akademi (*Teknisk kemi och reaktionsteknik, TKR*). The focus of TKR today is in heterogeneous, homogeneous and enzymatic catalysis, chemical kinetics and thermodynamics, chemical reactor technology as well as exploring new reaction environments and development of green process technology. Process intensification (PI), particularly intensification of chemical reactions by unconventional forms of energy and new reactor and catalyst structures is our hard-core activity.

We have three full-time professors to lead and supervise the activities and to accomplish the strategic goals of the laboratory: Borgström professor in chemical technology (Dr Dr habil. Dmitry Murzin), professor in chemical reaction engineering (Dr Dr h.c. Tapio Salmi, Academy professor 1009-2013 and 2019-2023 appointed by Academy of Finland), and a new professorship in chemical process intensification (Dr Henrik Grénman). The active collaboration with our faithful partner in exotic reaction environments (Dr J.-P. Mikkola) from Umeå universitet is continuing.

The main applications of our research remain in the strongly methodological approach to the valorisation of molecules originating from biomass to fine and specialty chemicals as well as new fuel components. Heterogeneous and homogeneous catalysis combined to very detailed kinetic studies and avant-garde reactor technologies are the keys for success in the revolutionary green transition to sustainable chemical processes and products. In the development of the new technology, we are among the global pioneers. Our know-how is continuously developed on catalyst technology as well as new approaches to chemical kinetics and reactor structures. From green chemistry to green process technology is the long-term strategy of TKR. Several new projects have been initiated with our strategic domestic partners, such as VTT, Neste, Borealis, Wärtsilä as well as European enterprises, e.g. Evonik, Sanofi and UPM. Tens of internship students come every year to our laboratory, for scientific training and social interaction.

Green chemistry is transformed to green process technology progresses in many fields, particularly in the development of new continuous processes for sophisticated chemicals, such as biodegradable surfactants, platform chemicals, bio-lubricants and chemical intermediates. This is in many cases materialized by using micro- and milliscale reactors, which provide a real technology jump in catalyst development, kinetic screening and continuous production of chemicals in gas and liquid phases. By utilizing new technologies, a considerable process intensification is obtained, and the equipment size is minimized down to 5-10% of the size of conventional reactor equipment, such as packed beds or tank reactors. A revolution of the current reactor technology is necessary.

All the experimental efforts are coupled to advanced mathematical modelling of chemical and physical phenomena in batch, semi-batch and continuous systems. Several processes based on molecules originating from biomass are under investigation, for example epoxidation of fatty acids, fatty acid esters and alkenes, carbonation of epoxides, catalytic transformation of furfural, oxidation and hydrogenation of sugars originating from hemicelluloses, as well as selective catalytic oxidation of alcohols and depolymerization of lignin. Microwave and ultrasound technologies are used to enhance the epoxidation fatty acids and carbonation of fatty acid epoxides. Molecular oxygen and hydrogen peroxide are used as environmentally friendly oxidation agents. The research project devoted to catalytic destruction of pharmaceuticals in wastewaters by using ozone as the oxidation agent has been continued with Università di Napoli 'Federico II'. Novel catalyst structures, such

as 3D-printed structures and solid foams are under investigation to shift from traditional slurry and trickle bed technology to intensified reactor systems. Real collaboration is flourishing with several universities and research centres in Europe, e.g. Delft, Dresden, Napoli, Padova, Madrid, Prague, Rouen, Poitiers, Valladolid, Venice. We have been very successful in obtaining project financing from European Union, Finland's Akademi (Research Council of Finland, RCF), Business Finland and private foundations: several projects are in progress, e.g. projects devoted to 3D printed reactor elements, integrated reaction-separation processes, and utilization of carbon dioxide as an inexpensive reactant for chemical processes, such as production of green methane and carbonates. Two Academy Research Fellow positions have been granted to our scientists by FRC.

Many of the recent doctoral theses have been accepted with distinction. The prestigious national award for best doctoral thesis in catalysis (2021-2023) was given to Dr Mathias Alvear Cabezón who gave the award lecture at Young Scientist Forum of Finnish Catalysis at Helsinki Fair Centre.



Education of the young generation of scientists has been active, by organizing courses in reaction kinetics and computer-aided chemical engineering. We are active partners in European networks for chemical and engineering fields. IMATEC - Erasmus Mundus Joint Masters programme in Technology and Management for Circular Economy is a tailored Master's program for chemical engineering and INNOLAB is a German-Italian-Finnish network (Dresden-Napoli-Åbo) for development education methods in Chemical Engineering. New collaboration educational efforts have been started with Eötvös Lorand University in Budapest and Université de Montpellier.

Organizing international scientific conferences is our tradition and passion. We hosted the oldest and most prestigious conference in chemical reaction engineering, International symposium on Chemical Reaction Engineering, ISCRE28 in June 2024 in Turku/Åbo. The event gathered around 450 top scientists all over the world. In June 2025, we organized the Renewable Resources and Biomass (RRB) conference in our city. This strongly interdisciplinary event became a great success, particularly because it provides a relaxed forum for new encounters. June 24-26, 2026 it was time to organize the 4th International conference on Unconventional Catalysts, Reactors and Applications (www.ucra4.org) in Mariehamn, the picturesque capital of autonomous Åland Islands. The topics spanned from green mining to reactors in space technology and the discussions were very vivid.

Professors

Tapio Salmi (Professor in chemical reaction engineering, visiting professor Università di Napoli 'Federico II')

Dmitry Murzin (Borgström professor in chemical technology)

Johan Wärnå (professor in chemical reaction engineering 1.1.2019-31.12.2023)

Jyri-Pekka Mikkola (joint professor with Umeå University, technical chemistry, sustainable development)

Henrik Grénman (professor in chemical process intensification)

Päivi Mäki-Arvela (docent, associate professor in industrial chemistry)

Laboratory Manager Docent Kari Eränen

Docents

Atte Aho	Ikenna Anugwom	Adriana Freites Aguilera
Narendra Kumar	Juha Lehtonen	Sébastien Leveneur
Matti Reinikainen	Vincenzo Russo	Fredrik Sandelin
Pasi Tolvanen	Zuzana Vajglová	Pasi Virtanen

Senior Researchers

Matias Alvear Cabezon	German Araujo Barahona	Tommaso Coglianò
Luis Gallego Villada	Mouad Hachhach	Maryam Hmoudah
Mark Martínez Klimov	Najeeb Lashari	Lilia Longo
Luca Mastroianni	Jay Pee Oña	Federica Orabona
Wander Pérez Sena	Ole Reinsdorf	Francesco Sandri
Muhammad S. Zafar	Emiliano Salucci	Christoph Schmidt
Nataliya Shcherban	Irina Simakova	Glaydson Simões dos Reis

Doctoral students and researchers

Ahmed Adam	Saeedeh Afshar	Giuseppe Agovino	
Emila Aho		Éloise Andres	Bruna Arenhart
Emilia Ares		Ghasal Askari	Andres Barreiro
Rifet Bin Monsur		André Björkvik	Carl Brunberg
Pablo Cangotena		Florine Cantel	Salvatore Capasso
Miriam Cavaliere		Karla Culo	Antonio D'Angelo
Michele De Simone		Ethan Dautremont	Margot Deliat
Angelie Desgouliere		Ibrahima Diallo	Claudia Di Dinizio
Lucie Duperray Soriano		Shehasis Dutta	Esteban Duverger
Diseye Egberike		Jeremy Favier	Marine Flande
Cléa Fourreaux		Irene de la Fuente	Federico Floris
Mehdi Hassan Milu		Giulia Idri	Iqra Jaffar
Natalie Jaklová		Simon Jansen	Shey Jude Fale
Aminata Kaba		Eelis Ketola	Mario Khalil Zelada
Wayne Kipgeno Korir		Silondile Khumalo	Federica Lavino
Micol Lubian		Ramin Majidov	Said Manaa
Chinedu Mbanusi		Enrico Marchi	Ananias Medina Ferrer
Samuel Morizot		Stefano Napolitano	Stefano Ferrer
Ana Nuñez Nuñez		Temitayo Olatunde	Raushan Orazbegova
Jasmina Palo		Alessandro Perrucci	Kgothatso Phaahia
Micaiah Pitmang		Habibur Rahman	Anna Rejzková
Eva-Luise Röss		Tobias Ritola	Filippo De Rosso
Barbara Ruiz Bolado		Tayeb Sakhi	Nikita Sarkov
Mohideen Shanavas		Abdul Shahid	Uswa Shahid
Stanislav Stadnichenko		Christopher Stäglich	András Szabó
Shruti Vikram		Sabrina Vitiello	Sanja Vucetic
Olha Yevdokimova		Hao Xin	

<https://www.abo.fi/en/industrial-chemistry-and-reaction-engineering-research-and-personnel/>

3.5 High-Temperature Processes and Materials

High-Temperature Processes and Materials

Professor Leena Hupa retired as the professor in charge of the High-Temperature Processes and Materials (HTPM) research group in the summer of 2025. Prof. Hupa continues as professor emerita as well as head of research in the HTPM research group. Professor Daniel Lindberg started as a professor in high-temperature chemistry and technology in September 2025. Professor Lindberg acted as a professor in metallurgical thermodynamics at Aalto University 2018-2025 (visiting professor 2025-2026), but he has had a long background in the HTPM research group (DSc in 2007, postdoc/senior researcher 2010-2018).

Our research strategy is to provide expertise in detailed chemistry knowledge in high-temperature processes and high-temperature materials. Our primary research endeavours are foremost in bioenergy, inorganic materials and biomedicine. Management of material streams and emissions, as well as treatment and recycling of various waste and side streams in an energy-efficient and environmentally friendly manner, are essential topics in our research. These efforts aid adapting the industrial processes for the green transition, circular economy, and sustainability.

We explore challenges in the thermochemical conversion of biomasses and waste into energy, fuels, chemicals, and biochar. One distinctive attribute of our research is developing cleaner and more efficient combustion technologies using "difficult" but CO₂-neutral fuels. Our research includes laboratory-scale measurements, sampling campaigns in full-scale combustion processes and mathematical modelling. The laboratory experiments facilitate investigations in controlled conditions, providing a fundamental understanding of the relevant chemical details. The laboratory data is complemented by mathematical modelling. We utilise thermodynamic and kinetic modelling to describe the processes. For this, we develop databases of the high-temperature systems through thermal analysis in ambient and pressurised atmospheres. Our sub-models describing the chemistry in high-temperature processes, such as NO_x-formation reactions in various fuels, are designed to model the impact of new CO₂-neutral combustion processes with computational fluid dynamics.

Some of our core competence areas are exploring the high-temperature corrosion and erosion mechanisms of steam tubes and ceramic refractories induced by bed materials, melts/slugs, gases, and various ashes containing, e.g., alkalis and halogens. We develop new techniques to accurately measure and understand the corrosion and reaction mechanisms of the materials in their target environments. A new field has been the study of slag-refractory interactions in Direct Reduced Iron Smelting, mainly related to future fossil-free steel production.

We explore novel ways to reuse and recycle waste and industrial side streams and recover valuable elements or compounds for new applications.

In our biomedical materials research, we develop and explore devices and tissue-engineering scaffolds of bioactive glasses, biodegradable metals, and inorganic material-polymer composites for bone and soft tissue applications. We combine chemical engineering principles with material manufacture and in vitro characterisation to understand material behaviour in the dynamic body environment.

Our research, covering several fields of industry, is done in firm collaboration with universities, companies, and research centres. It is financed by Åbo Akademi, Business Finland, the Research Council of Finland, the EU, industry and small to medium-sized enterprises. In addition to novel

generic knowledge and competence, our research gives the industry partners new strategic scientific information and tools for innovations, new products and business concepts for the global market.



Personnel

Professors

Daniel Lindberg (professor in high-temperature chemistry and technology)

Leena Hupa (Emerita)

Mikko Hupa (Emeritus)

University lecturers

Johan Werkelin

Maria Zevenhoven (docent)

External docents

Sonja Enestam

Oskar Karlström

Fiseha Tesfaye

Senior researchers and postdoctoral researchers

Roland Balint

Farzad Jafarihonar

Minna Siekkinen

Meheretu Dirbeba

Thomas Kronberg

Polina Sinitsyna

Markus Engblom (docent)

Juho Lehmusto (docent)

Emil Vainio

Jan-Erik Eriksson

Jonne Niemi

Patrik Yrjas (docent)

Doctoral students

Johanna Clayhills

Sara Hagman

Alessandro Ruozzi

Rasmus Fagerlund

Ali Hasnain

Adrian Stiller

Aiman Fatima

Ali PourghasemiHanza

Manu Thankachan

MohammadReza Goodarzi

Viswamoorthy Raju

Laboratory, financial and faculty support services

Luis Bezerra

Tor Laurén (laboratory manager)

Susanna Lönnberg (economy)

Mia Mäkinen (secretary)

Jaana Paananen

Linus Silvander

3.6 Organic Chemistry

Organic Chemistry at Åbo Akademi University strives for excellence in research and education, training students and researchers on all levels for successful careers in industry and academia. The research group is part of the two main research profiling areas of Åbo Akademi University: Technologies for a Sustainable Future, focusing on chemical engineering and material aspects in bioeconomy, and Solutions for Health focusing on bioimaging, functional materials, health economics, IT in health and targeted therapies and diagnostics.

The research at organic chemistry is focused on the development of sustainable chemical synthesis technologies for the preparation of functional molecules and materials. Valorization and chemical modification of biomass (lignin, hemicelluloses) as well as the chemistry and synthesis of natural products and carbohydrate derived molecules play a big role in our research projects. Within the Johan Gadolin Process Chemistry Centre we have an active collaboration with Industrial Chemistry and Reaction Engineering as well as with Natural Materials Technology and several joint projects related to lignin chemistry.

Part of our activities are also related to drug discovery and development and are performed in collaboration with different research groups at Cell and Molecular Biosciences and Pharmacy at Åbo Akademi University. We are also part of the Biocity research programmes: SmartBio and BioMed. Organic chemistry also closely collaborates with several national and international partners and actively participates in research networks.

Other research activities range from energy research to environmental organic chemistry including studies on degradation of pharmaceuticals in waste-water treatment by advanced oxidation processes. Advanced characterization (structural analyses) of molecules and materials is essential for our research, and our core infrastructure is the NMR spectroscopy and mass spectrometry facilities provided by Turku Centre of Chemical and Molecular Analytics (<https://ccma.fi/>). We also offer analytical services (NMR and MS) for outside organizations and companies. Our research projects are mostly funded by Business Finland, Research Council of Finland, EU-networks and companies.



Personnel

Professors

Patrik Eklund
Reko Leino (Dean)
Jorma Mattinen (Emeritus)

Docents

Patrik Eklund
Tiina Saloranta-Simell (Senior lecturer)
Filip Ekholm (University of Helsinki)
Ari Rosling (Arctic Biomaterials)

Experienced Researchers (Lecturers)

Jan-Erik Lönnqvist
Robert Lassfolk

Early stage researchers

Abdelhakim Bayssine
Hamid Ardeshiri Lordejani
Rupali Rajendra Bhadane

Samira Cheshak
Ziba Fotouhichianeh
Marta Gäddnäs
Jaswinder Kaur
Ewelina Kortesmäki
Patrik Runeberg
Nikke Saarinen
Teddie Strandberg
Anton Örn

Laboratory engineer

Teija Tirri

Secretary

Rebecca Mattbäck

Economy secretary

Karita Åberg

<https://www.abo.fi/en/organic-chemistry-research-and-researchers/>

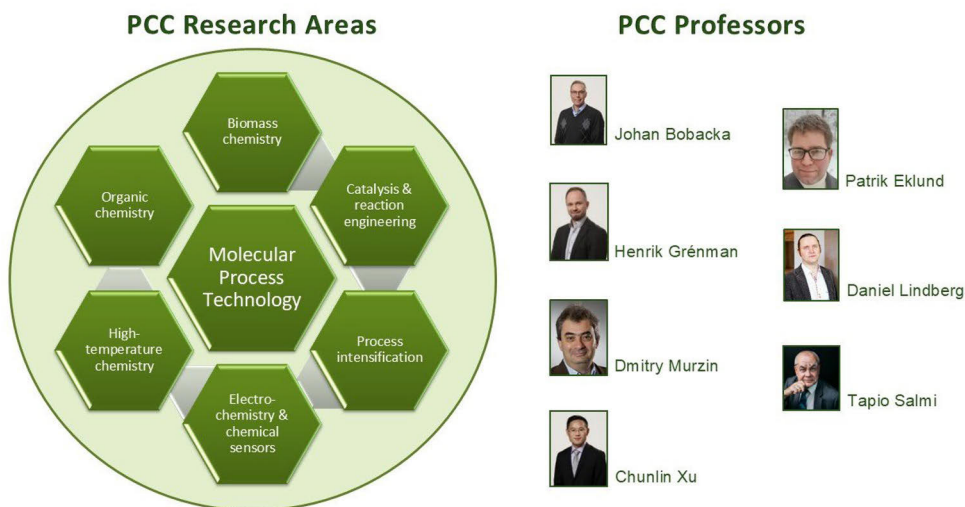
4. Current Research

The major research activities at **PCC** are in the core of the Finnish Bioeconomy, Circular Economy, Cleantech, and Green Energy areas. Finland can become one of the pioneers in a global perspective in the evolutionary development of forest biomass, because 70% of our territory consists of forest, which is rich in lignocellulosic biomass. Finland actually has the largest amount of forest per capita in the whole of Europe and this biomass has a yearly growth that is larger than what we utilize.

Forest biomass is potentially a very rich source of molecules, which can be further refined to new materials, chemicals and fuel components. The challenge is big, because the molecules appearing in biomass deviate substantially from those in fossil sources. Molecules from biomass have a high degree of functionality and high oxygen content compared to the molecules appearing in fossil sources. This implies that many of the current technology solutions cannot be applied directly to molecules originating from biomass and therefore new chemical technology is needed.

The development of new technologies should be based on a deep understanding of the underlying chemical and physical processes, which we call Molecular Process Technology. **PCC** merges chemistry and chemical engineering to provide industrially relevant solutions for the future. The goal is to develop new, sustainable technologies for making valuable chemicals, materials, and fuel, as well as novel devices for chemical sensing and electrical energy storage.

Our research is mainly focused on two important types of molecules appearing in forest biomass, namely polysaccharides (hemicelluloses and cellulose) and lignin. Additionally, our research includes multiple complementary research activities that support the green transition. Our main research areas are illustrated below, and specific research projects are highlighted further in the rest of this Chapter.



PCC research areas and professors

Ion Sensors Made of Natural Materials (BioISE)

Main funding: Åbo Akademi

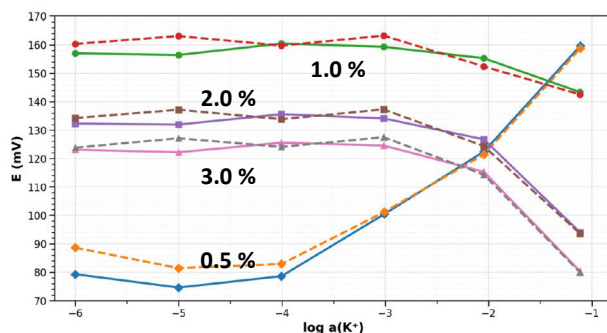
Ibtisam Haider Syed, Julia Kuczałak, Rupali Rajendra Bhadane, Rose-Marie Latonen, Patrik C. Eklund, Tom Lindfors

This work presents the first results of an ongoing effort to replace the widely used plasticized PVC-based ion-selective membranes with sustainable, biodegradable natural materials for application as sensing membranes in potentiometric ion-selective electrodes.

Replacing fossil fuel-based materials with more environmentally friendly and sustainable alternatives is becoming increasingly important, particularly as chemical sensors for wearable applications and various types of single-use sensors become more widespread. The use of sustainable sensor materials can reduce the environmental impact associated with end-of-life disposal and contribute to the ongoing green transition.

In the first phase of the project, we investigated linseed oil, a natural drying oil derived from flaxseed, as a sustainable alternative to plasticized PVC for the fabrication of ion-selective membranes. Because the curing of linseed oil is inherently slow, the membrane films were heated at 100 °C for 15 h to accelerate the drying process. Furthermore, methyl linoleate was incorporated into the membrane formulation to enhance bulk drying by promoting cross-linking within the linseed oil matrix. In addition, methyl linoleate acted as a plasticizer, thereby reducing the membrane resistance.

The incorporation of a small amount of multiwalled carbon nanotubes into the optimized linseed oil matrix further reduced its resistance, making the material suitable for potentiometric measurements. The results demonstrate that the linseed oil matrix inherently functions as a cation exchanger; however, this cationic response can be converted into an anionic response by incorporating small amounts of tridodecylmethylammonium chloride into the membrane. These findings highlight the versatility of the linseed oil matrix as a platform for ion-selective membrane development. Future work will focus on investigating the ion-selectivity of the linseed oil-based membranes and evaluating their applicability as membrane materials for solid-state reference electrodes.



The potentiometric response in 10^{-6} – 10^{-1} M KCl of linseed oil films containing methyl linoleate, multiwalled carbon nanotubes and different amounts of the anion exchanger tridodecylmethylammonium chloride (TDMACl). The amount of added TDMACl (% m/m) is given in the figure.

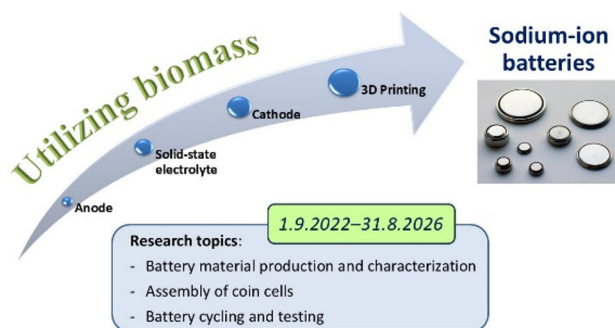
Cooperation: Warsaw University of Technology

Development of sustainable technologies for electrical energy storage based on biomaterials and 3D printing (SUSTEC)

Main funding: Jane and Aatos Erkko Foundation, Åbo Akademi University

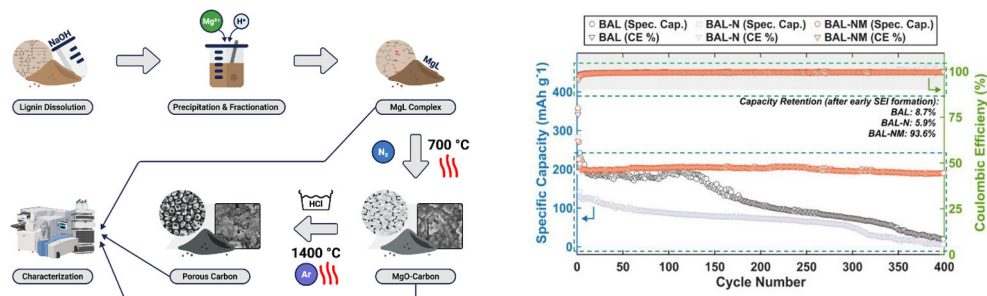
Angelo Robiños, Hazzalea Reyes, Hao Zhang, Zekra Mousavi, Ville Yrjänä, Muhammad Shajib Zafar, Zhichen Ba, Yongzheng Li, Ruijie Wu, Veronika Badažhikova, Amir Abbasi, Tor Laurén, Leena Hupa, Chunlin Xu, Johan Bobacka

The SUSTEC project addresses the escalating demand for electrical energy storage, driven by the increasing use of renewable energy sources and societal electrification. Within this project we develop sodium-ion batteries (SIBs) as a sustainable alternative to state-of-the-art lithium-ion batteries. SIBs utilizing solid-state electrolytes (SSEs) are developed to improve battery safety. Our research includes engineering wood-derived hard carbon (HC) precursors for battery anode designs, wood-derived templates for SSE development, and biomass-derived binders for cathode materials. The main research topics and results are presented below.



Lignin-derived hard carbon anode materials

Lignin-derived HCs were developed as anodes, and the effect of dopant materials on the structure of lignin before, during, and after pyrolysis was investigated. Our results show that metal-assisted lignin fractionation and processing can control lignin heterogeneity and direct carbonization. Recent data demonstrates that lignin chemistry, metal–lignin interactions, heteroatom-doping, and the role of free radicals critically shape the HC framework and the performance of HC-based anodes in sodium-ion half-cells. Complementary machine-learning analyses established quantitative relationships between precursor chemistry, processing conditions, and battery performance.



Synthesis of lignin-derived hard carbon (left), and cycling performance of SIB half-cells (right)

Solid-state electrolytes

A cellulose template for SSE design, and a cellulose-reinforced gel electrolyte were developed, respectively. A sodium super ionic conductor (NASICON) material was synthesized using cellulose nanofibrils (CNFs) as a templating agent. The CNF template both modified the crystal structure and improved the ionic conductivity of the resulting material. Additionally, cyanoethyl cellulose was introduced to reinforce polymerizable deep eutectic solvent gel electrolytes for high-energy-density SIBs.

Biomass-derived binders for cathodes

Biomass-derived binders were developed for cathodes. Traditional and commercially available binders such as polyvinylidene fluoride (PVDF) and carboxymethyl cellulose (CMC) were compared with other biomass-based alternatives, such as lignin, to investigate the influence of binder type and concentration on both the mechanical properties of the cathode and the electrochemical performance of the resulting half-cell.

3D printing of hydrogels and anodes

3D printing was applied to the design of electrode and hydrogel templates. Direct-ink-writing (DIW) printing was implemented to fabricate structured anode prototypes, and carbon-ink printing trials were performed to evaluate printability and structural integrity. In parallel, CNF-based hydrogel inks were engineered to be UV-curable, and high-fidelity printing was applied using DIW and digital light processing (DLP) printers. This was done to support the subsequent design of SSE templates.

Evaluation of electrochemical impedance data

An alternative approach was taken to deconvoluting the distribution of relaxation times from electrochemical impedance spectra. By combining linear Kramers-Kronig testing for the validation of impedance spectra with ideas from the multi-(RQ)-fit approach and Monte Carlo simulations, we were able to obtain a distribution function without the need for regularization. This new approach can resolve adjacent peaks that are challenging for other approaches, which will be useful for analyzing complex impedance data of batteries. With some modification, this approach can also be applied to deconvoluting the distribution of capacitive times from admittance spectra.

Outlook

The SUSTEC project has accelerated pioneering battery research activities at PCC. Importantly, SUSTEC has enabled strategic investments in training the project members and establishing the critical infrastructure that is required for conducting battery research. It has also facilitated the acquisition of complementary funding for recruitment and equipment. Together with establishing up-to-date research infrastructure, our researchers have gained valuable new skills in battery research at the interface between biomass chemistry, high-temperature chemistry and electrochemistry. Hence, SUSTEC has placed us in a good position to conduct impactful battery research at PCC.

Cooperation: Aalto University, Finland; Paul Scherrer Institute, Switzerland; Northeast Forestry University, China; Harbin Institute of Technology, China.

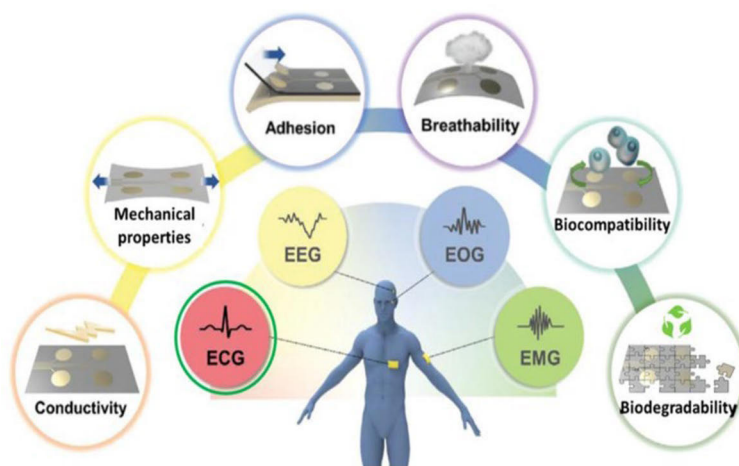
Biodegradable Electrodes as a Platform for Sustainable On-Skin Electrophysiology (Bio-Electro)

Main funding: Business Finland

Ellen Sundström, Pontus Lunabba, Sara Lund, Larissa Kessler, Chunlin Xu, Johan Bobacka

Non-invasive recording of the electrical activity of different body parts represents a fundamental technology in clinical diagnostics. This technology makes use of electrodes that are in contact with skin. However, the state-of-the-art electrodes show inherent drawbacks associated with current materials and technology, i.e. skin irritation, low signal quality, high electrode-skin impedance, plus big amounts of electronic waste. The electrode market is currently expanding, resulting in thousands of tons of annual electronic waste.

The Bio-Electro project aims to develop fully biodegradable electrodes for sustainable electrocardiogram (ECG) recordings. From an electrochemical point of view, the requirement of an efficient ion-to-electron transduction is considered in all phases of the project. By utilizing nanocelluloses and biodegradable conductive inks, the green ECG-electrodes will be flexible, conformable, wearable, breathable, biocompatible and fully biodegradable. Reduction of electronic waste with great benefits to the environment, society, and clinical users are expected. Monitoring of electrical activity from the eye (EOG), brain (EEG) or muscles (EMG) are other possible applications.



Technology platform of biodegradable electrodes for eco-sustainable electrophysiology

The Bio-Electro project is a European M-ERA.NET project coordinated by the University of Girona (Spain). The project consortium consists of three universities, two research institutes and three companies.

Cooperation: Universitat de Girona, Spain; Centro de Investigación Biomédica en Red, Spain; RHP Technology GmbH, Austria; Medical University of Vienna, Austria; Mirka Oy, Finland; CH-Bioforce Oy, Finland; National Research Institute for Agriculture, Food and Environment, France.

Utilization of AI for Optimization of the Production of Lignin-Carbohydrate Complexes with Targeted Properties (AI-4-LCC)

Main Funding: Research Council of Finland

Marie Alopaeus, Andrey Pranovich, Patrik Eklund, Chunlin Xu

Traditional biorefineries focus on cellulose production, whereas other biomass components, such as lignin and hemicelluloses, have mainly been regarded as low-value products. Both lignin and hemicellulose have potential as materials for high-value products, and the focus of biorefineries has therefore shifted toward exploiting all obtained fractions. Within our cross-disciplinary AI-4-LCC project, we proposed the AquaSolv Omni (AqSO) biorefinery, which is a hydrothermally based biorefinery that collects hemicellulose-, cellulose-, and lignin-rich fractions. Within the lignin-rich fraction, we obtained lignin-carbohydrate complexes (LCCs) in higher yields than previously reported. Due to the synergism between lignin and carbohydrates, LCCs have promising valorization potential for high-value products. Therefore, we performed AI-assisted optimization of AqSO with a focus on LCC production with specific properties. This was done using Bayesian Optimization to model process-structure-property-performance correlations. We found that the optimal process conditions for synthesizing these LCCs were a moderate P-factor and a medium-to-high temperature, and we observed a positive correlation between high carbohydrate content and low T_g and surface tension. These findings give LCCs the potential to be used in thermoplastic formulations and as emulsion stabilizers.

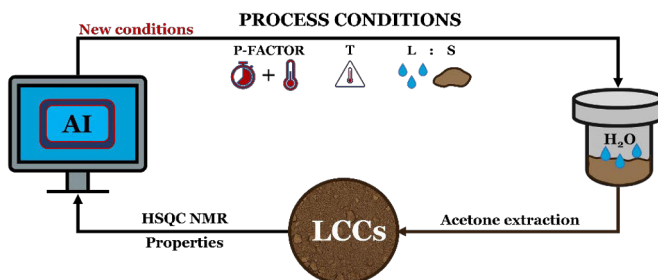


Figure 1. The workflow of the AI-assisted optimization of AqSO.

We continued the work on utilizing LCCs as fillers in thermoplastic polylactic acid (PLA) composites for 3D printing, with the aim of lowering PLA production costs and introducing attractive lignin properties. Preliminary results showed that LCCs isolated via ethanol-based reactive extraction performed better than those obtained through the traditional AqSO acetone extraction. Therefore, a background study on readily available hot water-extracted lignin was conducted, in which the reference lignin was modified in different ways, and its compatibility with PLA was compared. From this work, we concluded that modification with ethanol and sulfuric acid produced one of the best-performing fillers in PLA, with properties comparable to those of pristine PLA. In addition, this modified lignin demonstrated a stabilizing effect on PLA after several mechanical recycles. These results support continued investigation into using ethanol-based reactive-extracted lignin as a filler in PLA and demonstrate the promise of lignin in PLA composites for sustainable materials.



Figure 2. 3D printed object of lignin-PLA composite.

Cooperation: Aalto University, BOKU (Austria), Chalmers University of Technology (Sweden), St1 Oy, Kemira Oy

Emission Free Pulping (EFP)

Main funding: Business Finland

Donya Arjmandi, Julia Chrzastowska, André Mazzeo Fontes, Rodney Salazar, Kari Eränen, Dmitry Tarasov, Henrik Grénman, Anna Sundberg, Jan Gustafsson, Chunlin Xu

The Emission Free Pulping (EFP) project is an international collaboration among pulp producers, equipment suppliers, research institutions, and universities from Finland and Sweden. Its aim is to revolutionize traditional pulping methods by developing new approaches that significantly reduce CO₂ emissions and transform the pulp industry. The target of the EFP project is to challenge the chemistry and unit operations used in pulping processes to maximize product yield (i.e., fibre, lignin, and other wood components) while avoiding emissions (especially CO₂).

Task 1. Wood structure alteration by dissolution. Variation of middle lamella structure, properties in different wood species and dissolution kinetics.

To optimize the production of chemical wood pulp, it is necessary to gain a deep understanding of the chemical and physical modifications happening during fibre liberation on the micro- and nanoscale, in the cell wall layers and middle lamellae. In this work, we tested various microanalyses, imaging methods and surface analyses to investigate the differences in kinetics and mechanisms of fibre liberation from hardwoods and softwoods caused by peracetic acid delignification and kraft pulping. The untreated wood samples and the samples after partial or full fibre liberation were examined in terms of physical modification (electron microscopy, X-ray scattering), chemical composition change (Raman spectroscopy, pyrolysis GC-MS, sugar analysis, XPS) and distribution of wood polymers within the tissue (ToF-SIMS, CLSM).

The analytical methods provided complementary information on the dissolution of softwoods and hardwoods and revealed the mechanisms of fibre liberation caused by peracetic acid and by kraft cooking chemicals. During peracetic acid treatment the lignin removal is selective and proportional to the treatment duration, and the fibre separation happens mainly by dissolution and reactions within the middle lamellae. During kraft pulping, the hemicelluloses are partially removed, the lignin migrates to the surface and precipitates there, rather than being completely dissolved, with fibre separation happening at the cell wall-middle lamella interface. The hardwoods are significantly more susceptible to both treatments than the softwoods. This demonstrates the ability of the analytical toolbox to provide complementary information about the effects of various fibre liberation treatments on different biomass feedstocks. The detailed knowledge of the mechanisms behind these processes makes it possible to fine-tune their conditions to obtain desired product streams and minimize environmental impact.

Task 2. Chemistry of hemicellulose and lignin under mild and harsh pretreatment and their impact on fibre liberation

Releasing fibres from lignocellulosic biomass relies on chemical changes occurring in plant cell walls during pretreatment. While oxygen is known to impact the oxidation of lignin, hemicelluloses, and cellulose, its exact function in high-yield pulping is not well understood. This work explores how oxygen alters the chemistry of wood cell walls during hydrothermal treatment (HTT) and how these changes promote fibre release. The goal is to identify pretreatment methods that enhance fibre separation and quality, enabling more efficient, sustainable pulping with reduced chemical use and lower environmental impact. The effects of temperature, oxygen concentration, and residence time on the composition of hydrothermally treated biomass were systematically investigated (Figure 1). Increased temperature and oxygen levels, particularly at 160 °C, accelerated the degradation of hemicelluloses, decreasing its content from approximately 30% to 8% and increasing the relative proportions of cellulose and lignin. As hemicelluloses are less thermally stable than cellulose, they were preferentially degraded. These findings indicate that elevated temperature and oxygen facilitate selective hemicellulose removal and promote more efficient biomass fractionation.

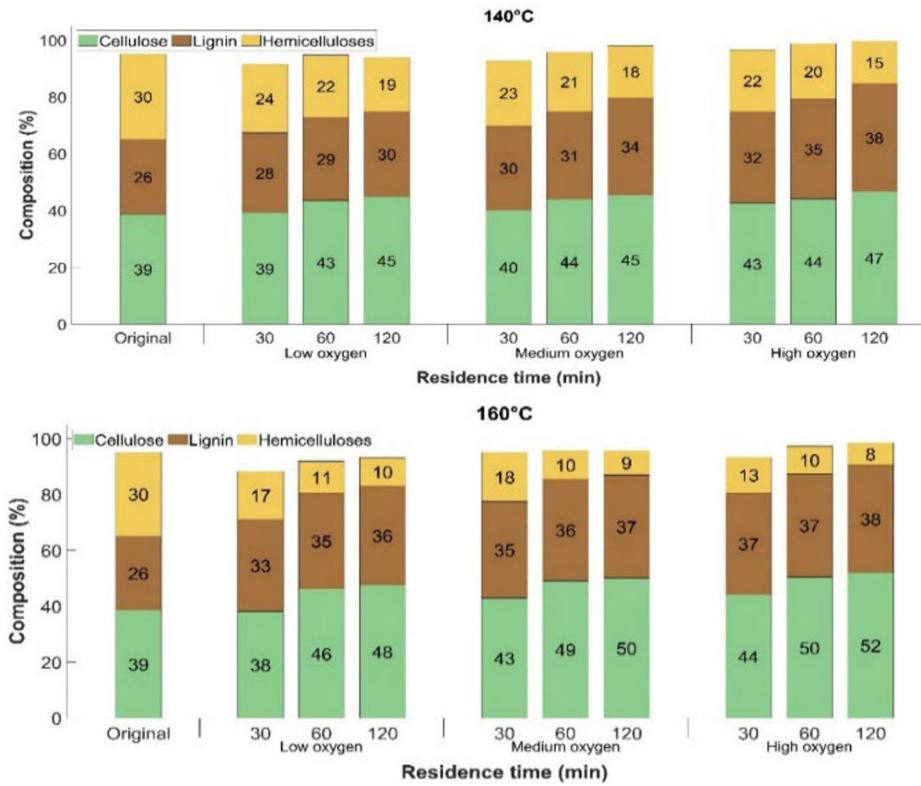


Figure 1. Compositional analysis of HTT-solids produced at 140 °C and 160 °C at different O₂ concentrations and residence times.

Pre-selected conditions were used as a starting point for the oxygen-assisted pulping stage. While the pretreatment aimed to partially modify the fibre wall by controlled removal or redistribution of lignin and hemicelluloses, the following oxygen-assisted pulping step evaluated whether these changes improved fibre liberation and delignification efficiency. In this way, the pretreatment results were directly connected to pulp recovery, screening yield, WRV, fibre morphology, and the identification of conditions suitable for high-yield fibre production.

More information can be found on the EFP website: www.emissionfreepulping.com

Cooperation: VTT Technical Research Centre, RISE Research Institutes of Sweden, KTH Royal University of Technology, Aalto University, LUT University, Oulu University, University of Helsinki, Mid Sweden University, Chalmers University of Technology

From Dust to Value: Circular Bio-based Residues (D2V)

Main funding: Business Finland

Qi Nie, Dumindu Peththa Wadu, Dmitry Tarasov, Andrey Pranovich, Rupali Rajendra Bhadane, Valter Georgs, Wangfang Deng, Pedram Fatehi, Patrik Eklund, Chunlin Xu

The D2V project aims to develop a sustainable value chain from wood-based industrial side streams to high-value bio-based products i.e. dispersants, wood adhesives, binders and coatings, thermoplastic biocomposites, and fiber-based insulation materials through integrated biorefinery approach. The main goal of the D2V project is to promote the transition of Finnish biorefinery to a sustainable circular bioeconomy. According to Eurostat records, the EU manufacturing sector produced approximately 17.5 million tons of wood waste in 2022, with approximately 1.9 million tons originating from Finland. Wood waste, such as wood dust, sawdust, and bark, once considered a byproduct; is a promising raw material for the manufacture of value-added products.

For further conversion into value-added materials, lignocellulosic biomass should be fractionated for further recovery of lignin and (non)cellulosic carbohydrates. Pressurized hot water extraction (PHWE) is a simple, green, and efficient method that avoids intensive instrument corrosion and waste liquid disposal due to the use of only water as a solvent. In this project, softwood and hardwood originated waste dust (particle size 20-100 μm), sawdust (100-1400 μm) and bark generated as a byproduct of the industrial process, were kindly provided by project partners. At the beginning, the effect of raw-material particle size on PHWE performance was studied. Dust and sawdust were subjected to PHWE at processing temperatures of 150-170 $^{\circ}\text{C}$, residence time 15-45 min and liquid to solid (L/S) ratio of 6 v/wt. After PHWE, two streams were obtained: solids dissolved in the water medium (hydrolysates) and post-treated wood (PHWE-solids). Non-cellulosic carbohydrates (hemicelluloses) presented in hydrolysates were recovered using organic solvents. The workflow of this hemicellulose recovery is shown in Figure 1.

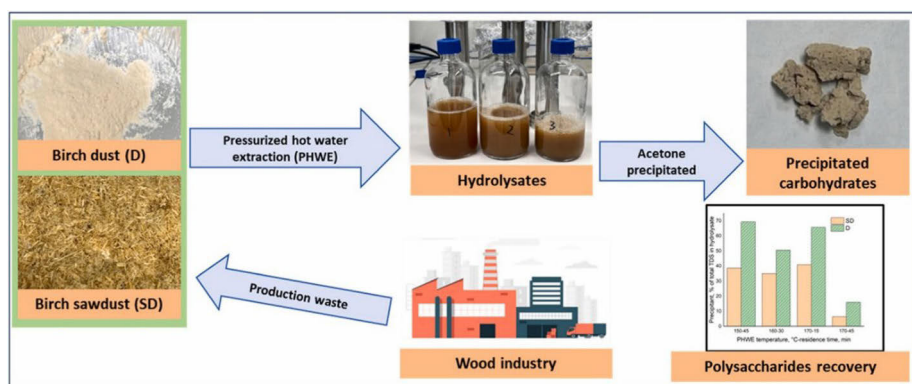


Figure 1. Workflow of hemicellulose recovery from industrial hardwood dust and sawdust materials

The analysis of raw material size showed that applying ultrafine dust was much more advantageous for the precipitation of carbohydrates with organic solvents. For instance, xylose content in the precipitates from dust-originated hydrolysate was 35% higher than that from hydrolysate produced after PHWE of sawdust at similar conditions. The molar mass (M_w) of dust-originated extracts and their precipitates obtained using acetone as an anti-solvent was generally twice as high as that of materials obtained after PHWE of sawdust. The study indicates that industrial hardwood dust could be a promising feedstock for hemicellulose recovery, and that the yield, properties, and composition of the recovered fractions could be adjusted by PHWE conditions applied.

In the other part of the study, alkaline-assisted PHWE was employed for lignin extraction from softwood sawdust (SSD). Two SSD samples, supplied, and industrial partner were tested: untreated (SSD) and PHWE-extracted (PHWE-SSD). PHWE treatment was performed at processing temperatures 150-175 $^{\circ}\text{C}$,

residence time of 60 min and 2-10 wt.% of NaOH were added as catalyst. After treatment, lignin was recovered from generated liquor via acidification and its properties and structure investigated. It was found that alkali concentration of 4 wt.% is optimal for lignin recovery. It was possible to obtain sulfur free lignin with moderate molecular weight and relatively high reactive functional groups content. Considering the properties of recovered lignin, several samples were implemented in an industrial UV-curable acrylic resin supplied by project partner. It was possible to substitute up to 20 wt.% of petroleum-based filler with lignin.

Lignins provided by industrial partners were also utilized for wood adhesive manufacture. In order to enhance the reactivity, softwood hydrolysis (HL) and Kraft (KL) lignin were subjected to fractionation by sequential solvent extraction. Selected lignin fractions were employed for lignin-based wood adhesive manufacture via a single-step process using glyoxal, phenol, and formaldehyde. Bonding strength results showed that fractionated lignin alone enhanced dry bonding strength for adhesives produced from both HL and KL. All lignin-containing systems delivered low formaldehyde emissions, meeting stringent interior-grade requirements and reducing reliance on fossil-derived components. Also, the application of lignin in 3D printing has been tested. Powder bed fusion (PBF) printable lignin-PLA and lignin-PHBH powders were prepared by an emulsion-solvent-evaporation approach. PBF printing was initiated with trials and optimization of printing settings utilizing a commercially available PLA powder. Sufficient powder characterization was conducted. Figure 2 presents the powder-based PBF printed samples.



Figure 2. Powder-based PBF printed samples with various lignin implementation contents.

The utilization of cellulose was also studied in this project. The PHWE-SSD materials supplied by industrial partners were screened and subjected to mechanical nanofabrication using a Masuko grinder or Prolab refiner equipment for microfibrillated cellulose production. Fiber analysis before and after grinding showed a clear reduction in fiber length and a strong increase in fines content, confirming successful fibrillation.

Overall, the D2V project provided an improved comprehension of the integrated biorefinery of industrial wood waste materials. The streams generated during various biorefinery approaches were carefully investigated and possible industrial applications were suggested and developed.

Cooperation: University of Helsinki, University of Turku, Lakehead University (Canada), KTH Royal Institute of Technology, Boreal Bioproducts, Fiberwood, Kiilto, GVK Coating Technology, Tonester, Cajo Technologies, Woodyly, Mirka

Green Adaptable Method for Refining Lignocellulosic Materials to High-Value Components (GRAM)

Main funding: Business Finland

Donya Arjmandi, Ruijie Wu, Dmitry Tarasov, Patrik C. Eklund, Chunlin Xu

The GRAM project developed a comprehensive understanding of lignocellulose fractionation and technical lignin processing, with particular emphasis on the quality, structure, and potential utilization of recovered lignin and fibre fractions. Different types of lignin samples were employed, comprising, lignins produced via treatment with choline chloride–thiolactic acid systems, acid hydrotropic fractionation, organosolv processing and commercial lignins. Softwood, hardwood and non-wood feedstocks were utilised for lignin recovery. Fiber samples were mainly obtained from softwood using delignification with choline chloride–thiolactic acid and phenol-based systems. The main objective of this project was to investigate and advance novel lignocellulose processing approaches. The main goal was comprehensive characterisation of extracted lignin and carbohydrate fractions to investigate the association between processing conditions and properties of obtained materials for identification of further potential applications. Lignin samples were subjected to composition analysis, examination of molar mass values and functional group content. In addition, the effect of fractionation methods on lignin structure was also investigated. Fiber samples were subjected to molar mass and polydispersity index (PDI) examination. Figure 1 presenting the analytical workflow of lignin and fibre characterization.

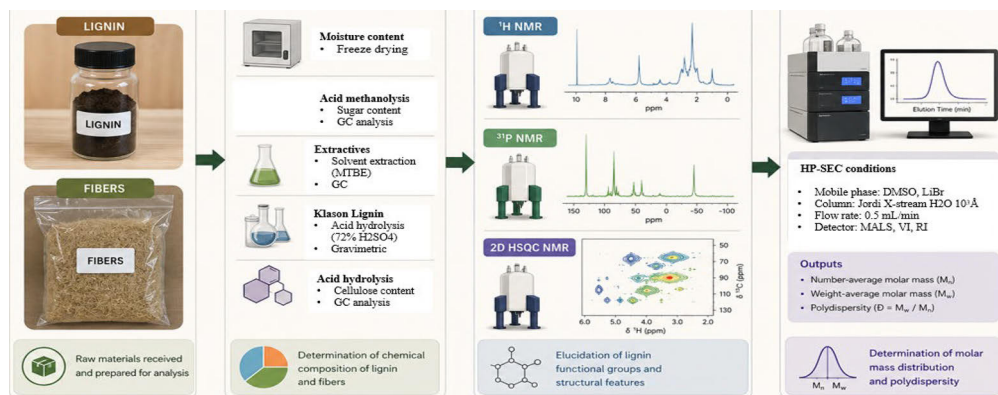


Figure 1. Analytical workflow of lignin and fibre characterization

In general, the examined lignin fractions showed relatively high purity, with generally low amounts of residual carbohydrates and extractives. The amount of Klason lignin in most of the examined lignin samples ranged from 80 to 90 wt.%. Furthermore, the total amount of hydroxyl groups ranged across a wide distribution from 1.6 to 9.3 mmol/g. It was found that key structural components, such as aryl-glycerol- β -aryl ether, phenylcoumaran and resinol inter-units, were significantly affected by fractionation technologies applied. Characterization of both lignin and fiber also revealed considerable variety in molar mass. The obtained knowledge advanced in the current understanding of the effect of lignin recovery technologies on its composition, structure, and functionality. The possible value-added applications of investigated lignins and fibers were suggested.

Cooperation: University of Oulu, Sherwin-Williams, UPM, Nordfuel, Fortum

Fate of Extractives in the Fiber Lines (DETEX)

Main funding: UPM

Julia Chrzastowska, Juyeon Seo, Tomasz Sokalski, Ekaterina Korotkova, Anna Sundberg, Johan Bobacka, Chunlin Xu

Extractives are various compounds which can be found in wood and other plant biomass but are not part of the plant structure. The presence of extractives, especially betulinol and other triterpenoids, in raw materials used for pulping and papermaking can cause process disturbances and spots on pulp and paper. Because of that it is vital to precisely monitor extractive content in all process steps of pulp and paper production. Conventional approach includes multiple steps: accelerated solvent extraction, silylation and GC-FID analysis followed by GC-MS. It is time-consuming, destructive, involves sophisticated equipment and big quantities of solvents. For these reasons a new, non-destructive, quick, and facile analytical method is needed.

Spectroscopic (near infrared and Raman spectroscopies) and electrochemical (ion-selective electrodes and voltammetry) methods were tested for their applicability to pulp extractive analysis. Machine learning was additionally used for tackling non-linear correlations and to extract chemical information from the spectral and electrochemical experimental data and to build classification and prediction models. Extractive analysis performed with GC was used as a reference method.

Correlation of NIR and Raman spectra of industrial conifer and birch pulps with the results of GC analysis resulted in successful estimation of various extractive types including fatty acids, triterpenoids or prenols. Both square wave voltammetry in neutral media and differential pulse voltammetry in non-aqueous media could non-selectively quantify the triterpenoid content in pre-concentrated pulp extracts, while the array of 8 ion-selective electrodes could semi-quantitatively predict betulinol content in simulated pulp extracts (Figure 1). These methods could be used by the fibre industry for process control of various stages of pulping and papermaking, for example to monitor the content of lipophilic extractives in the wet end of paper machine. Introduction of the novel methods to the pulp and paper mills could support and partially replace the costly quality control methods.

Predicted class	B	5	0	0	0
	L	2	7	0	0
	M	0	1	7	1
	H	1	0	1	7
		B	L	M	H
		Actual class			

Figure 1. Results of semi-quantitative prediction of betulinol content in simulated pulp extracts based on potentiometric data gathered by a sensor array consisting of 8 ion-selective electrodes. The solution classes included acidified acetone with no betulinol added (B), with low betulinol content (L), medium betulinol content (M), and high betulinol content (H). The classification was performed using linear supporting vector machines algorithm with 81% accuracy.

Cooperation: UPM

Demonstrating Value Chains in the Circular Economy (BioDemo)

Main funding: European Regional Development Fund (ERDF) as a part of the EU regional and structural policy funds 2021-2027

Jan-Erik Lönngqvist, Ekaterina Korotkova, Jiayun Xu, Meheretu Dirbeba, Ali Hosnain, Thomas Kronberg, Tapio Salmi, Chunlin Xu, Leena Hupa

The BioDemo project supports the development of bio- and circular-economy business operations on an industrial scale in the Turku region. It aims to assist companies in building value chains for the efficient valorization of material streams from the bio- and circular economies, thereby promoting regional biorefinery development and sustainable resource utilization.

The project collects information on the composition changes of reeds in the Turku region. The reed samples, which were collected from different areas and at various times of the year, were manually separated into three distinct parts: stems, leaves, and flowers. Both their structural and non-structural components were investigated. The detailed composition of main reeds components, i.e. cellulose, hemicellulose and lignin presented here will perfectly meet the industry's genuine needs and contribute to the development of biorefinery applications.

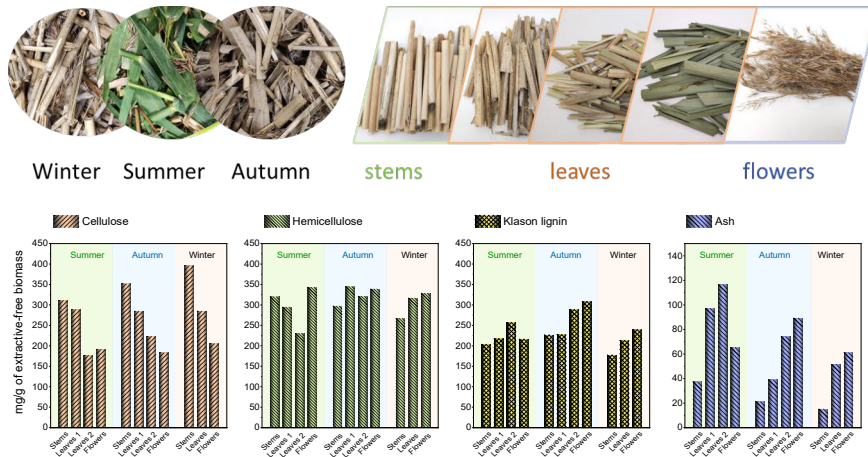


Figure 1. Composition of various reed samples (harvest region: Parainen, Fladan)

Cooperation: Business Turku,
Turku University of Applied Science



**Euroopan unionin
osarahoittama**



**Uudenmaan liitto
Nylands förbund**

Engineering Living Photosynthetic Materials for Energy and Chemicals: S2B; Photo-e-Mat; PhotoFactory

Main funding: European Union, Research Council of Finland, Jane and Aatos Erkko Foundation

Hoyoung Yoon, Jonatan Ronnbölm, Tim Salomäki, Larissa Kessler, Oskar Backman, Hao Zhang, Chunlin Xu

This research brings together three complementary projects: “Solar Butanol Production by Solid-state Photosynthetic Cell Factories” (**S2B**), “A Bio-inspired Generator of Green Electricity Using Photosynthetic Bacteria and Sustainable Materials” (**Photo-e-Mat**), and “The Next Generation Biohybrid Systems for Photosynthetic Fuel and Chemicals Production.” (**PhotoFactory**). Together, these projects develop engineered living photosynthetic materials that integrate photosynthetic microorganisms with advanced bio-based material platforms for the sustainable production of energy carriers and value-added chemicals.

The transition towards a sustainable bioeconomy requires technologies that utilise sunlight, carbon dioxide and renewable resources to produce fuels, chemicals and electricity with reduced dependence on fossil-based processes. The three projects address this challenge by developing photosynthetic cell factories (PCFs) in which photosynthetic microorganisms are incorporated into functional material matrices that support and regulate their activity. Their shared aim is to move beyond conventional suspended cultures towards immobilised, structured and material-integrated systems that can maintain high cell viability and productivity over extended operation. By controlling the immediate environment around the cells, these systems can improve light utilisation, CO₂ availability, nutrient transport and product recovery, while also enabling more robust and potentially scalable modes of continuous or repeated production.

A central concept is the integration of photosynthetic microorganisms with lignocellulose-based hydrogels and three-dimensional scaffolds. Cell immobilisation within hydrated matrices can improve cell retention, protect the microorganisms from mechanical stress and provide a more stable and controllable microenvironment for photosynthetic production. At the same time, the supporting materials must balance several interconnected properties, including water retention, mechanical stability, optical transparency and light scattering, porosity, gas exchange and the transport of CO₂, nutrients, substrates and metabolic products. Excessively dense or opaque materials may limit light penetration and diffusion, whereas highly open structures may compromise mechanical integrity or cell retention. The architecture of the material is therefore as important as its chemical composition, and both must be designed together to create favourable conditions for long-term photosynthetic activity and efficient conversion of solar energy into chemicals and electricity.

ÅAU develops functional biopolymers and fabrication methods for PCFs, linking material chemistry with scaffold design to support photosynthetic activity. The work combines amine-functionalised polysaccharides for CO₂ capture, nanocellulose hydrogels for light management, and photocurable bioinks for cell immobilisation and 3D printing. Chemical modification and formulation are used to tailor rheology, photocrosslinking and hydrogel stability in culture media, with biocompatibility as a key design criterion. Scaffold architectures are designed to control cell distribution and facilitate CO₂ supply, nutrient transport and product release while maintaining mechanical integrity and light accessibility. Conductive polymer coatings are also being investigated to provide pathways for electron collection, extending these platforms towards porous photosynthetic bioanodes for bioelectricity generation.

The research focuses on four specific tasks:

Task 1. Amine functionalisation of polysaccharides for CO₂ capture

Task 2. Optical control in nanocellulose hydrogels

Task 3. Cellulose-based biohybrid hydrogels for photosynthetic fuels and chemicals production

Task 4. Printed scaffolds for chemical production and bioelectricity

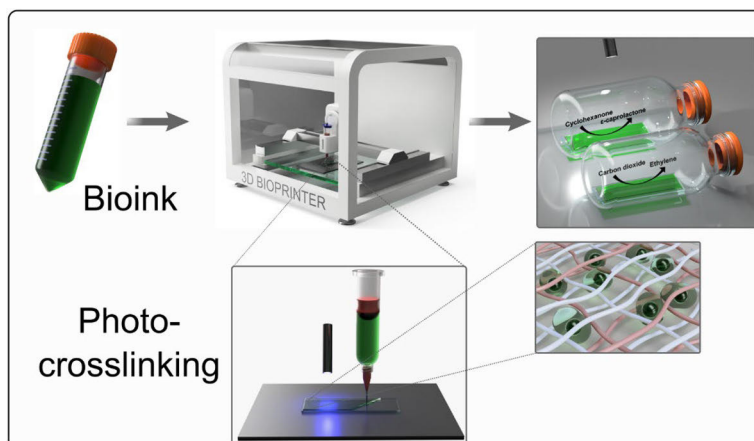


Figure 1. Schematic illustration of photocurable biopolymers engineered into 3D-printed photosynthetic living materials for chemical production.

As an example, we developed photocurable biopolymer-based hydrogels and printable bioinks for immobilisation of photosynthetic microorganisms. The work combines polysaccharide-based structural components with photocrosslinkable galactoglucomannan methacrylate (GGMMA) to create mechanically stable and biocompatible hydrogel matrices that can withstand cultivation conditions while maintaining photosynthetic cell activity. Material formulation and photocuring conditions are tailored to control rheology, printability, mechanical stability, water retention and mass transfer, while enabling efficient exchange of CO₂, nutrients, substrates and products. Compared with conventional ionically crosslinked alginate matrices, photocrosslinked networks provide improved structural stability, particularly under high-ionic-strength cultivation conditions.

3D printing is used to transform these photocurable bioinks into structured living biocatalysts, providing control over material thickness, surface area, porosity, diffusion distances and spatial distribution of cells. Thin, 3D-printed hydrogel structures facilitate light penetration and transport of gases, nutrients and products while retaining high densities of photosynthetic cells within the material. The concept has been demonstrated using engineered *Synechocystis* cell factories for ethylene production and engineered *Chlamydomonas reinhardtii* cell factories for the photosynthetic biotransformation of cyclohexanone to ϵ -caprolactone. The resulting materials maintained chemical production while providing improved mechanical robustness and opportunities for repeated or continuous operation. This platform establishes a basis for designing scalable, bio-based living materials in which hydrogel chemistry and 3D architecture are jointly engineered to improve photosynthetic chemical production.

Cooperation: University of Turku, Nantes Université, KTH, VU Amsterdam, University of Twente, LUT University, ERDYN.

Sustainable Coatings: SUSBINCO and COCOBIN

Main funding: Business Finland

Minette Kvikan, Nizam P.A., Matilda Martin, Tapani Nick, Jan Gustafsson, Nilusha Penabhatipola Mudiyanselage, Martti Toivakka and Chunlin Xu

The Sustainable Coatings activities at ÅAU during 2024–2025 represented a direct continuation from the Business Finland-funded SUSBINCO project (Sustainable Binders and Coatings, 2021–2024) into COCOBIN (Coatings and Composites from Novel Bio-Based Dispersions, 2024–2026). SUSBINCO established the basis for replacing fossil-derived binders, surfactants, and coating components with renewable, high-bio-content alternatives, while COCOBIN extended this work to multicomponent bio-based dispersions, composites, barrier packaging, and scale-up-oriented processing. The overall objective was to develop sustainable binders, dispersants, coatings and adhesives for fiber-based packaging and other applications, including textiles and abrasives. The work focused on valorizing underutilized forest-industry side streams, particularly galactoglucomannans (GGM), cellulose and suberin. These renewable materials were investigated as alternatives to fossil-based polymers and conventional surfactants, with emphasis on functionality, environmental safety, high bio-based content, recyclability, processability and industrial relevance.

ÅAU's contribution focused primarily on developing bio-based dispersants and binders, investigating two distinct approaches to hemicellulose modification. Firstly, the research continued with fatty acid-grafted-GGM produced in SUSBINCO, using C9, C14, and C18 fatty acids at three substitution levels to evaluate it as a suberin dispersant. The study investigated stability mechanisms and preferred dispersion techniques and concluded that melt dispersion produced the most stable systems. It also found that longer chains improved interfacial stability, while low to moderate substitution promoted steric stabilization and high substitution reduced compatibility through hydrophobic self-assembly. Furthermore, the utilization and performance of GGM-FA as a stabilizer in suberin–wax barrier coatings are currently being investigated to identify coatability and hydrophobic properties on fiber-based substrates.

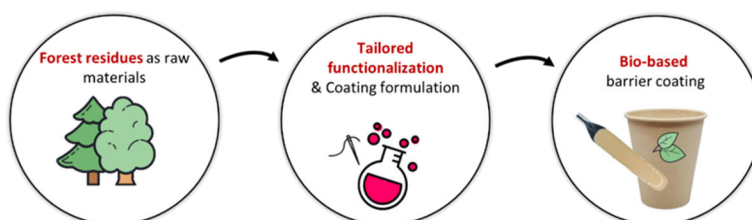


Figure 1. Project scheme for the development of bio-based barrier coatings.

The second approach utilized GGM functionalized through etherification and subsequently used as a comonomer with bio-based synthetic monomers, including butyl acrylate and lauryl acrylate. The resulting high-bio-content latexes were investigated for adhesive and barrier-binder applications. In the initial formulations developed within SUSBINCO, GGM replaced approximately 50% of the synthetic polymer component. In the subsequent COCOBIN project, the bio-based content was further increased, enabling up to 90% replacement of the synthetic component while maintaining properties comparable to those of the earlier 50% replacement systems. The work also explored the dual functionality of modified GGM, which acted both as a reactive co-monomer and as a stabilising surfactant, thereby replacing synthetic surfactants in the latex formulations. The developed GGM-based binders were combined with suberin hydrolysate for barrier-coating studies targeting fibre-based packaging applications. In parallel, separate investigations examined suberin-based Coatings formulated with carboxymethylated GGM to improve dispersion and coating performance. The resulting latex systems were also evaluated for adhesive applications, including their potential use with non-woven abrasive materials.

Micro-fibrillated cellulose (MFC) was also investigated using different fibrillation instruments and processing conditions. The study examined the effects of the degree of fibrillation and energy input on the

resulting material properties, with the aim of identifying more efficient processing routes and understanding the relationship between fibrillation intensity, energy consumption and performance.

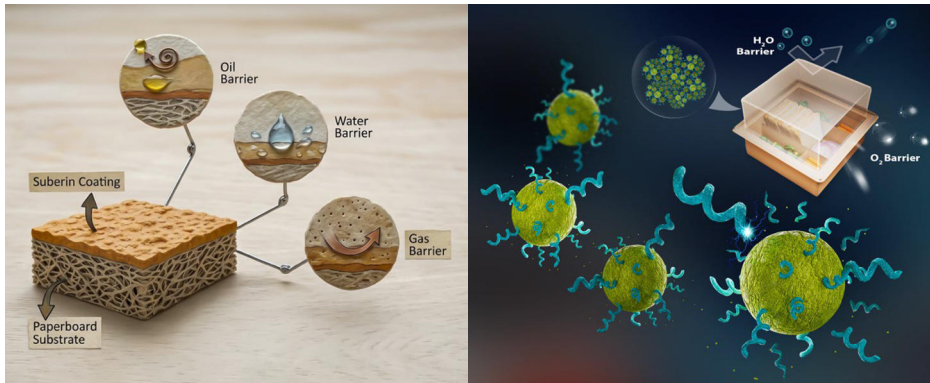


Figure 2. Bio-based coatings for multifunctional barrier packaging applications.

Cooperation: KCL, Metsä Board, Mirka, UPM-Kymmene, Valmet, Kemira, CH-Polymers, and CH-Bioforce. The research partners include University of Oulu, Tampere University, the University of Eastern Finland, LUT University, VTT Technical Research Centre, and the Natural Resources Institute Finland (LUKE).

The project is part of three Business Finland Veturi programs: Valmet's Beyond Circularity, Mirka's Shape, and Metsä Board's ExpandFibre programs.



Circular Materials Bioeconomy Doctoral Education Network (CIMANET)

Main funding: Ministry of Education and Culture, Finland

Sanja Vucetic, Teddie Strandberg, Samira Cheshak, Andreas Schröder, Esmeralda Laurén, Adil Mehmood, Hao Zhang, Robert Lassfolk, Tiina Saloranta-Simell, Lilia Longo, Xiaoju Wang, Martti Toivakka, Patrok Eklund, Henrik Grénman, Chunlin Xu

Circular Materials Bioeconomy Network: From Bio-based Resources to Advanced Materials (CIMANET) is a national doctoral education network within Finland's Doctoral Education Pilot, with its main funding provided by the Ministry of Education and Culture, Finland. The network brings together nine Finnish universities and many industrial partners to strengthen doctoral education and research in the circular materials bioeconomy. It aims to educate highly skilled researchers who can contribute to the sustainable utilization of biomass resources, the development of advanced bio-based materials and technologies, and the transition toward a circular and low-carbon economy.

ÅAU hosts six doctoral researchers within CIMANET, covering complementary research areas across lignocellulose chemistry, biomass fractionation, molecular characterization, functional materials, and sustainable electronics. Together, their projects span the value chain from biomass processing and structural characterization to advanced material design and high-value applications.

The six doctoral research projects at ÅAU are:

- Sanja Vucetic – Advanced aromatic platforms from lignocellulose for high-value materials production (AROMAP).
- Teddie Strandberg – Development of methods for biomass characterization based on NMR and MS techniques (BIOCHAT).
- Samira Cheshak – Novel technologies for chemical modification of biomass-derived molecules and materials (CHEMOD).
- Andreas Schröder – Reactive fractionation of biomass towards highly reactive lignin (REAFRAC).
- Esmeralda Laurén – Tailoring highly reactive lignin to 1D fibrillar nanostructures towards photo-/thermal-curable coating applications (1DLIGNIN).
- Adil Mehmood – Bio-based materials for sustainable electronics (BIOELEC).

In addition to the individual research projects, CIMANET provides a structured doctoral training environment through joint courses, research seminars, workshops, mobility activities, company visits, co-supervision and external mentoring. The doctoral researchers interact across disciplines and institutions, gaining access to complementary expertise, advanced research infrastructures and industrial perspectives. These activities strengthen both scientific competence and transferable skills and support career development in academia and industry.

More information can be found on the CIMANET website: www.cimanet.fi

Cooperation: UPM, Stora Enso, CH-Bioforce, Mirka, VTT Technical Research Centre, LUT University, University of Oulu, Aalto University, University of Jyväskylä, University of Eastern Finland

Printed Intelligence Infrastructure (PII)

Main funding: Research Council of Finland

Martti Toivakka, Chunlin Xu, Johan Bobacka, Jessica Rosenholm, Ronald Österbacka, Nicklas Anttu, Tan Phat Huynh, Jouko Peltonen, Xiaoju Wang, Hongbo Zhang

Printed Intelligence Infrastructure (PII) is a Finnish national research infrastructure that provides advanced facilities and expertise for the development, fabrication, characterization, and upscaling of printed functional materials, devices, and intelligent systems. PII brings together complementary expertise from ÅAU, Tampere University, the University of Oulu, and VTT Technical Research Centre of Finland. The infrastructure covers the full development chain from functional material and ink formulation to printing, additive manufacturing, characterization, prototyping, and pilot-scale manufacturing, supporting both academic research and industrial technology development.

At ÅAU, PII activities are coordinated through the Åbo Akademi Functional Printing Center (FUNPRINT). The infrastructure supports interdisciplinary research in sustainable materials, energy, biotechnology, pharmaceuticals, biomedical applications, sensors, and functional devices. The available manufacturing technologies include 2D functional printing, thin-film coating, direct ink writing (DIW), 3D printing, multimaterial printing, bioprinting, and high-resolution additive manufacturing. These technologies are complemented by facilities for material and ink preparation, rheological characterization, surface modification, structural analysis, and mechanical testing.

The ÅAU infrastructure has recently been significantly strengthened through new equipment investments. The XTPL Delta Printing System enables high-precision deposition and additive fabrication of functional micro- and nanoscale structures. Brinter ONE provides a modular platform for multimaterial 3D printing and bioprinting, while volumetric 3D bioprinting enables rapid fabrication of complex three-dimensional structures. Advanced characterization facilities include Piuma and Pavone nanoindentation systems for mechanical analysis of soft, polymeric, and biological materials, as well as an S Neox 3D optical profiler for detailed surface morphology and topographical characterization. Material-processing equipment, including a Masuko Grinder and LM20 Microfluidizer, supports the preparation and modification of nanocellulose, hydrogels, and other bio-based functional materials used as printable inks and matrices.

The combination of advanced material processing, printing technologies, and characterization makes PII particularly suitable for research on bio-based functional inks, nanocellulose materials, hydrogels, 3D-printed scaffolds, printed energy-storage components, sensors, and engineered biological systems. It provides an important platform for transferring new material concepts from laboratory-scale formulation to functional printed structures, devices, and demonstrators.

More information can be found on the Åbo Akademi University Functional Printing Center (FunPrint) website: www.abo.fi/funprint

Cooperation: Tampere University, University of Oulu, VTT Technical Research Centre

Process intensification I: Microreactors and 3D printed reactor structures

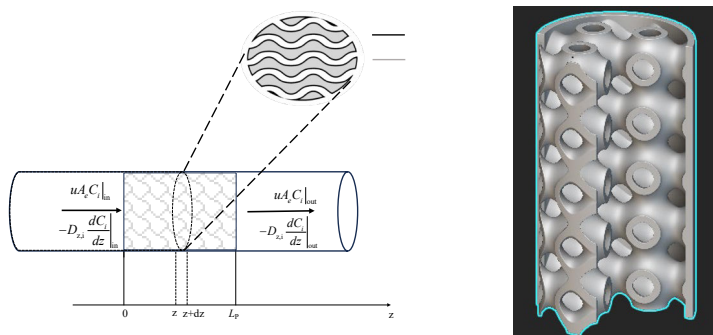
Main funding: Research Council of Finland, Åbo Akademi, Università di Napoli 'Federico II', università di Padova

Luca Mastroianni, Enrico Marchi, German Araujo Barabona, Carl Brunberg, Filippo Rosso, Kari Eränen, Vincenzo Russo, Johan Wärnå, Henrik Grénman, Dmitry Murzin, Tapio Salmi

Microreactors and 3D printed reactor structures are revolutionary trends of contemporary chemical reaction engineering and chemical reactor technology. Gas-phase microreactors provide a safe and efficient way to study the kinetics of rapid reactions, to screen catalysts and to produce chemicals even in large scale, on site. Gas-phase microreactors and 3D printed structures have been successfully implemented to prepare chemical intermediates, such as ethylene oxide, methyl chloride, ethyl chloride, acetaldehyde, ethyl acetate, ethylene and diethyl ether. In recent times, the project has focused on the use of microreactors, and 3D printed structures for hydrogenation, oxidation, dehydration, etherification reactions. The research activities comprise all the essential elements of microreactor and 3D printing technology, from coating and characterization of the reactor elements to catalyst screening, kinetic studies as well as reactor modelling.

Selective gas-phase oxidation of methanol, ethanol, 1-propanol and 1-butanol and their mixtures was conducted in a microreactor with Au/g-Al₂O₃ coated catalyst. Plausible kinetic equations were implemented in a pseudo-homogeneous plug flow model. The kinetics and catalyst stabilization was studied in for nitrobenzene hydrogenation to aniline on porous platinum layers in microchannels. A mechanistic model was applied to describe the catalyst behaviour.

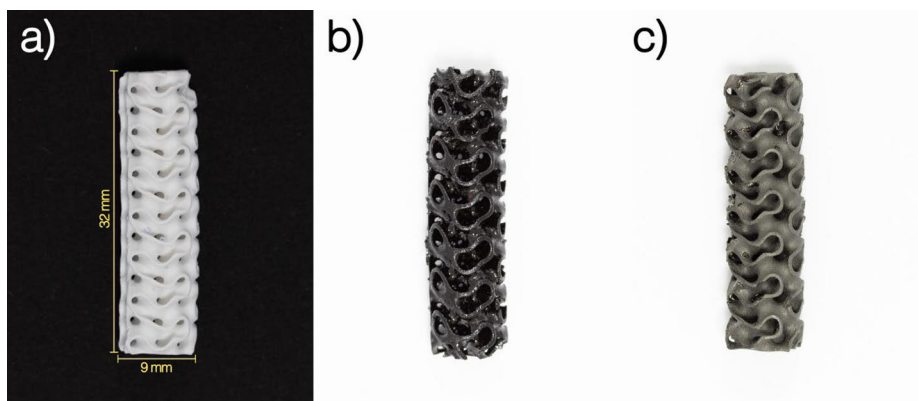
Additive manufacturing, i.e. 3D printing of catalyst elements was investigated by applying the Digital Light Processing (DLP) method, where the catalyst structures were printed layer by layer until the desired structure was obtained. Gold deposition with different (i.e., urea and ammonia) revealed different gold nanoparticle sizes and distributions along the alumina structure walls. The printed structure influenced significantly the catalyst performance. The different 3D printed catalytic systems were described with axial dispersion model.



Mathematical model and reality of a 3D-printed structure (Luca Mastroianni).

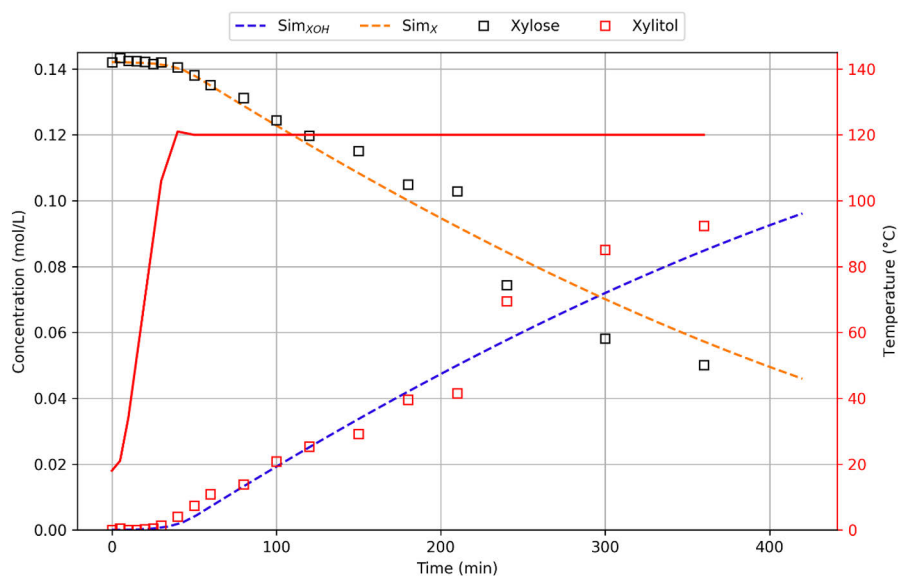
A Ru/C catalyst material was prepared on a 3D-printed alumina support to investigate how the catalyst performs on the new support. The new catalyst was studied with an extensive range of characterisation techniques, such as SEM, TEM, nitrogen physisorption, hydrogen TPR and ICP-OES, and used in batch experiments for the hydrogenation of xylose.

The synthesis preserved the open structure of the original alumina support while producing a thin, uniform carbon layer on the surface.



a) 3D-printed catalyst support b) support coated with PFA c) catalyst after pyrolysis (Carl Brunberg).

Temperatures between 90 and 120 °C and initial concentrations of xylose up to 1.0 mol/L were screened to enable modelling of the reaction kinetics and assess the influence of reaction parameters on the kinetics. An unconventional experimental approach, modelling of non-isothermal experiments, was briefly explored paving the way for future work utilizing structured catalysts.



Concentration and temperature profiles of a simulated and a real non-isothermal experiment (Carl Brunberg).

Cooperation: Università di Napoli 'Federico II', Università di Padova.

Process intensification II: Novel multiphase reactors

Main funding: Åbo Akademi, Research Council of Finland, Magnus Ehrnrooths stiftelse, Suomen kulttuurirahasto, Svenska kulturfonden, Svenska litteratursällskapet i Finland, Wihuri foundation

German Araujo Barabona, Luca Mastrianni, Tommaso Coglianò, Wander Perez Sena, Monad Hachbach, Carl Brunberg, Eva-Luis Ress, Arne Reinsdorf, Alberto Goicoechea Torres, Maria Ciaramella, Maria Cavaliere, Ananias Medina Ferrer, Javier Ibanez Abad, Juan Garcia Serna, Martino di Serio, Riccardo Tesser, Vincenzo Russo, Johan Wärnå, Dmitry Murzin, Tapio Salmi

Development and advanced modelling of multiphase reactors and structured catalysts, such as solid foams and 3D-printed structures is the topic of the project, involving various flow models in the bulk phases of the reactor as well as modelling of simultaneous reaction and diffusion in porous catalyst structures. Three-phase hydrogenation, oxidation, epoxidation and carbonation have been studied. The focus of the project is on the innovative discovery of new reactor structures and the shift from batch to continuous operation. Major breakthroughs were made in the catalytic oxidation and hydrogenation of sugars and epoxidation of vegetable oils; in all these cases, the power and the strength of continuous operation was demonstrated, and the results of the project were published in prestigious journals and presented in numerous international conferences.

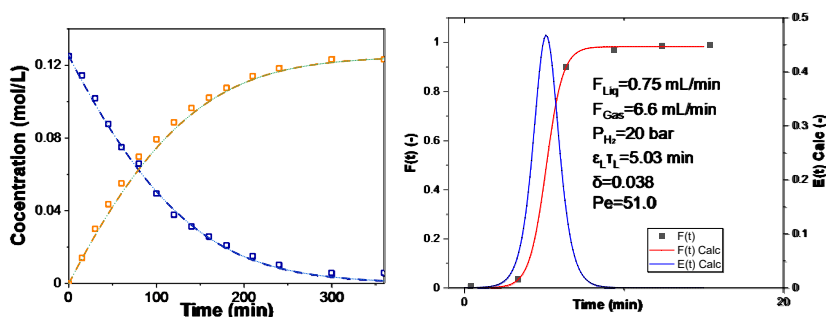
Solid foams are trendy materials as catalyst structures because they have two major benefits: thin catalyst layers guarantee a high effectiveness factor (suppressed internal mass transfer resistance in catalyst pores) and a low pressure drop. Raney-type solid nickel foams, with and without Mo promotion, were studied in batch and continuous operation. While active and selective, the typical stability issues of nickel catalysts were mitigated by addition of molybdenum, which doubled the activity and enhanced resistance to deactivation. Ru/C solid foams were synthesized via carbon coating of aluminium foams. These catalysts exhibited excellent activity, selectivity, and reusability, making them suitable for both semi-batch and continuous operation.

Sugar hydrogenation and oxidation on packed beds

Extensive kinetic experiments were performed in semi-batch reactors with monomeric sugars and their mixtures (xylose, arabinose, galactose). Mechanistic models based on non-competitive and semi-competitive adsorption provided excellent agreement with experimental data. The competitiveness factor ($\alpha \approx 0.74$) of the semi-competitive adsorption model supported the predominance of sugar adsorption while leaving interstitial sites accessible for hydrogen, consistent with molecular size differences. The rate expression for hydrogenation is shown below.

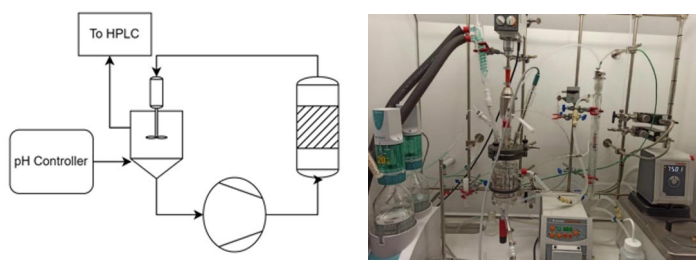
$$r_X = \frac{k_X \cdot \alpha \cdot (1 + (1 - \alpha) \cdot K_X \cdot C_X)^2 \cdot C_X \cdot P_{H_2}}{\left(1 + \sqrt{K_{H_2} \cdot P_{H_2}} + K_X \cdot C_X + (1 - \alpha) \cdot \sqrt{K_{H_2} \cdot P_{H_2}} \cdot K_X \cdot C_X\right)^3}$$

Continuous hydrogenation studies were conducted in a laboratory scale parallel screening reactor in trickle-bed regime. The effects of temperature, liquid flow rate, and concentration on conversion, selectivity, and space-time yield were quantified. Hydrodynamic measurements (residence-time distribution, liquid holdup) were coupled with kinetic modelling, demonstrating that gas-liquid and liquid-solid mass transfer resistances are of comparable magnitude under the low-interaction regime. At higher sugar concentrations and flow rates, liquid-solid hydrogen transfer emerged as the prevailing limitation. The project demonstrated that structured foam catalysts overcome the internal diffusion and pressure drop limitations of conventional catalyst particles, while maintaining excellent activity and selectivity in sugar hydrogenation. The combined insights from material development, intrinsic kinetics, and transport modelling provide a robust framework for designing efficient three-phase catalytic systems. Future research will be focused on reactor configurations and operating strategies that enhance wetting and interfacial mass transport, thereby unlocking the industrial potential of foam-based catalysts in biomass valorization.



The project demonstrated that structured foam catalysts overcome the internal diffusion and pressure drop limitations of conventional catalyst particles, while maintaining excellent activity and selectivity in sugar hydrogenation. The insights from material development, intrinsic kinetics, and transport modelling provide a framework for designing efficient three-phase catalytic systems. Future research will be focused on reactor configurations and operating strategies.

The catalytic oxidation of the monomeric sugars extracted from hemicellulose biomass (e.g. arabinose), is an attractive way to valorise wood-based biomass by producing bio-based chemicals with a high value and low environmental impact. From this perspective, the catalytic oxidation of the arabinose sugar, which is present in large amounts in hemicelluloses, was investigated in this work, with a focus on the impact of the effect of liquid flow rate on the arabinose conversion. The obtained results will also be used to ameliorate the developed continuous packed bed reactor model by improving the accuracy of mass transfer modelling. Experiments were performed in a continuous system under a constant volumetric flow rate of oxygen, which ensured a constant concentration of dissolved oxygen in the system. The catalyst used was a gold on alumina 3%, the temperature was kept constant at 70°C and the pH 8.



Photograph and simplified flowsheet of the experimental setup (Monad Hachbach)

The development of the mathematical model was based strictly on the mass and energy balances and well-established correlations for the reaction kinetics and flow-related phenomena. The experimental results revealed that complete conversion of arabinose to arabinonic acid was obtained in all cases, however it was achieved faster in case of higher liquid flows, which agrees well with our experimental findings, and this can be because the high flow suppresses the external mass transfer limitation in this case. Similarly, the simulation results confirmed that a complete arabinose conversion is obtained in all cases, however, it was achieved faster in case of a higher liquid flow rate.

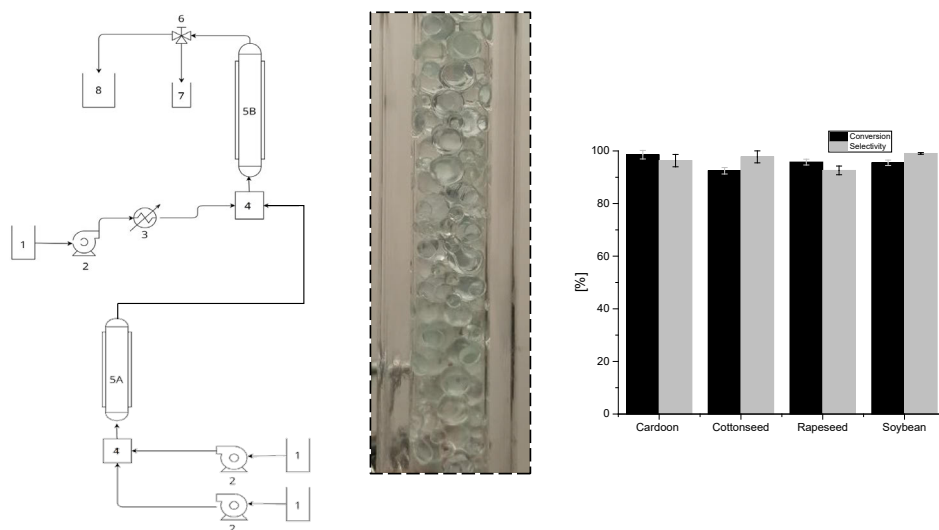
Fatty acid epoxidation and glycerol hydrochlorination in column reactors

A continuous reactor concept, a co-current packed column filled with glass bead elements was developed for the intensified and safe operation exothermic liquid-liquid reactions. Epoxidation of vegetable oils, such as cardoon oil was used as the raw material. The operative conditions of the reactor system ensured excellent results in terms of the double bond conversion and the epoxide selectivity as well as an efficient energy

transfer. Almost a complete double bond conversion with a selectivity to the target product, epoxide close to 95 % was obtained by working at very low and safe temperatures 40-45°C. The thermal profile inside the reactor under these conditions was recorded and the reactor had a very safe isothermal behaviour.

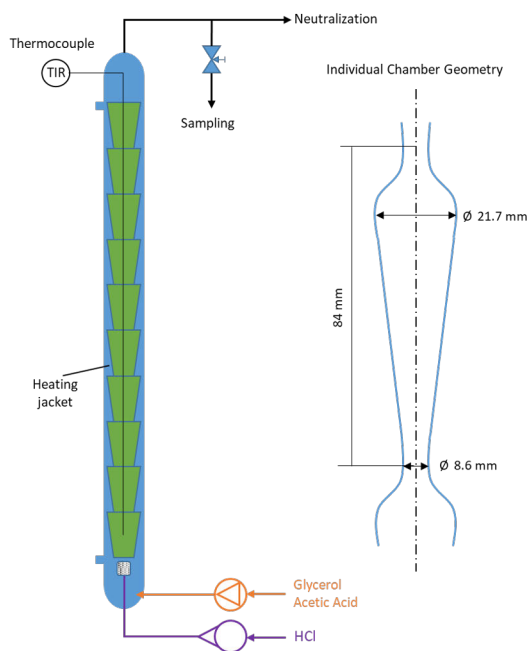
The fluid dynamics of the reactive system was studied by feeding both the oil and aqueous phases at the same time with inert tracers. Because of the complexity of the system, deeper studies concerning the fluid dynamics were performed to describe its behaviour in detail. Kinetic and reactor modelling efforts were conducted, where all the reactions involved in the system were considered and the partition coefficients of the components in aqueous and oil phases were determined experimentally in a Lewis cell.

Stationary and dynamic axial dispersion models were used to describe the behaviour of the reactor system and to seek for optimal operation conditions. The simulations of generic cases in Damköhler space and fatty acid epoxidation in time space showed that by improving the mass transfer characteristics of the bed, the limit case of rapid interfacial mass transfer, i.e. equilibria between the oil and aqueous phases are approached and a simplified mathematical model can be used. The novel continuous reactor concept, being superior to the prevailing slow and unsafe semi-batch technology was patented.



Development of continuous reactor technology for vegetable oils epoxidation (Tommaso Cogliano).

Glycerol has become an inexpensive and attractive raw material for the chemical industry, because large amounts of glycerol are released as stoichiometric co-products in the production of biodiesel. In the transesterification of triglycerides, three moles of fatty acid methyl esters and one mole glycerol are formed. Burning glycerol to get energy is an option, but for chemical industries several attractive but challenging alternatives exist for glycerol valorization, such as production of glycerol carbonate, acrolein, glycidol, epichlorohydrin, ethers, diols and syngas.



Variable-area bubble column reactor and detail of the variable diameter chamber.

A variable area pulsed flow reactor was constructed and the hydrochlorination of glycerol with gaseous HCl was investigated as a chemical model system. The hydrodynamics of the reactor was studied combining reaction experiments, residence time distribution experiments and automatized analysis of high-speed video recordings. This innovative reactor geometry presented a higher per volume productivity compared to a traditional bubble column, thanks to a 4.5x increase of the Péclet number and a 60% incremented range of operationally stable gas velocities. Experimental data were employed for the development of a fully transient gas-liquid reactor model based on the concept of axial dispersion. The model accounts for the dynamic behavior of both gas and liquid phases, describing the changes in the liquid flowrate and density due to the dilution of hydrogen chloride and the gas phase holdup over time and axial position, affording an excellent description of the experimental data. Overall, the productivity was greatly enhanced and the variable diameter reactor has proven to be a promising technology for gas-liquid reactions requiring high gas-to-liquid ratios.

Cooperation: Università di Napoli 'Federico II', Normandie Université INSA Rouen, Universidad de Valladolid, Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Evonik

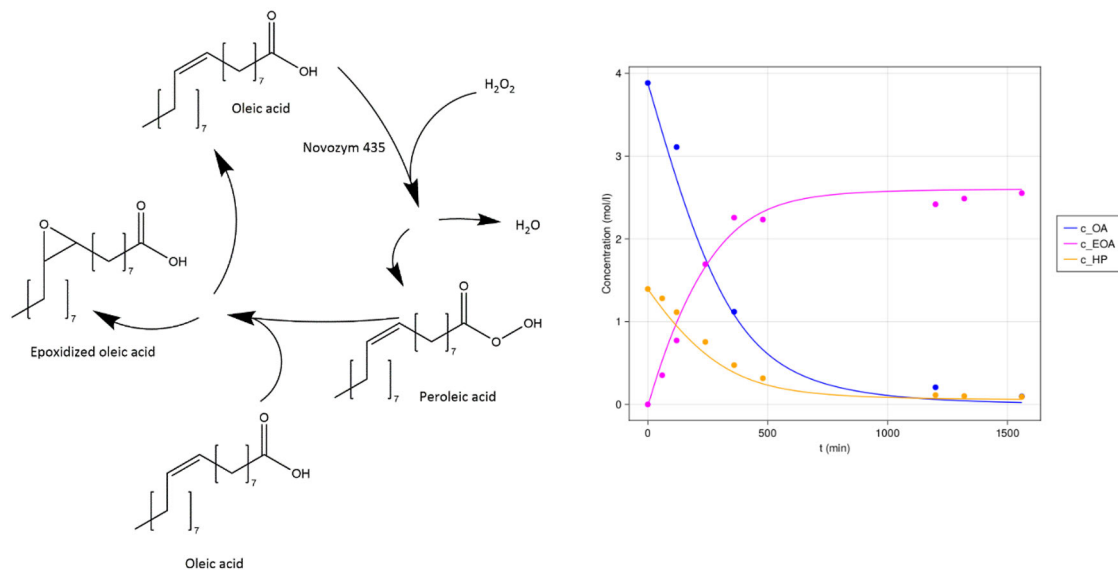
Process intensification III: Ultrasound as a process intensification method

Main funding: Åbo Akademi, Research Council of Finland

Adriana Freitas Aguilera, Pontus Lindroos, Wilhelm Wikström, Jani Rakkila, Mark Martinez Klimov, Pasi Tolvanen, Tapio Salmi

Epoxidized fatty acids are important green intermediates for chemical industry. This work was focused on the epoxidation of oleic acid using immobilized lipase Novozym® 435 as the catalyst and hydrogen peroxide as the epoxidation agent. Different reactant molar ratios, temperatures and stirring rates were evaluated. Acoustic irradiation was implemented for reaction intensification and different ultrasound amplitudes were tested. Novozym® 435 revealed to be an efficient and durable catalyst for fatty acid epoxidation. The experimental results showed that almost complete conversions of the double bonds in oleic acid are achievable in isothermal batch operation, with low concentrations of ring-opening by-products formed.

Ultrasound irradiation was successfully applied for enhancing the reaction rate, and higher conversions were reached compared to silent experiments. The catalyst preserved its activity and selectivity well, which was confirmed by catalyst recovery experiments conducted in the absence and presence of acoustic irradiation. Scanning electron microscope (SEM) images revealed that the cavitation caused by ultrasound has an impact on the catalyst morphology. The product distribution was studied with nuclear magnetic resonance (NMR) spectroscopy, confirming that the main ring-opening agent is the fatty acid itself, which resulted in the formation of esters. The kinetic data was modelled mathematically, based on molecular reaction mechanisms. The model explained all essential features of the data, as displayed below.



Reaction scheme of oleic acid epoxidation and example of model fit to experimental data.

One-pot epoxidation of alkenes

Main funding: Research Council of Finland, Neste-Fortum Foundation

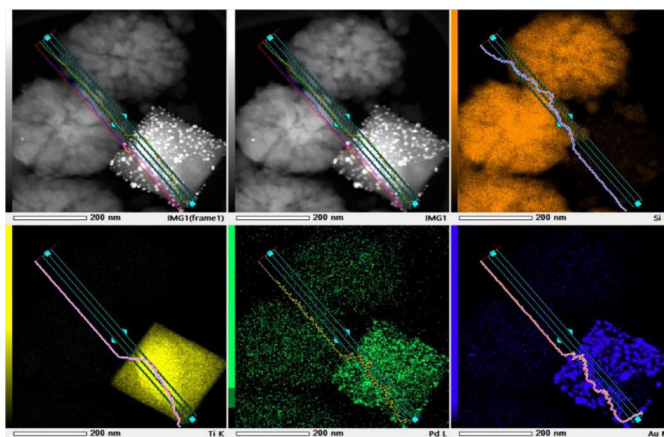
Christoph Schmidt, Matias Alvear Cabezón, Francesco Sandri, Christopher Stäglich, Alice Vidrequin, Jeremy Favier, Seo Mandon, Sari Granroth, Mika Lastusaari, Seo Mandon, Satu Ojala, Tiina Laitinen, Mika Lastusaari, Ilari Angervo, Stefan Haase, Tapio Salmi

Propene oxide (PO) is one of the most important building block molecules with a market volume of 21 billion euro in 2023. The current trend in PO production is heavily shifted to the environmentally friendly hydrogen peroxide (H_2O_2) to propylene oxide (HPPO) process. Titanium silicalite is an active catalyst in the epoxidation of alkenes. The advantage of the HPPO process is the absence of harmful by-products. The direct synthesis of H_2O_2 (DSHP) from hydrogen and oxygen on AuPd catalysts has been developed to maximize the H_2O_2 selectivity. A visionary aspect is to develop an integrated catalyst which would enable one-pot synthesis of PO starting from H_2 , O_2 and propene.

Bimetallic gold-palladium catalysts supported on titanium silicate 1 (TS-1) were prepared by impregnation and characterized. Screening and kinetic experiments were performed in a continuous laboratory-scale trickle bed reactor. The main reactions in the system are

DSHP& Epoxidation: $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}_2$; $\text{H}_2\text{O}_2 + \text{CH}_3\text{-CH=CH}_2 \rightarrow \text{PO} + \text{H}_2\text{O}$

The HR-TEM investigation of the catalyst structures revealed the diversification of the active sites. Commercial TS-1 included anatase as impurity and the metals (Pd and Au) where concentrated on the anatase phase, where the DSHP took place, after which H_2O_2 shifted to TS-1, to the epoxidation sites. The propene hydrogenation proceeded mainly on the metal nanoparticles on anatase. This separation of active sites was the key issue for successful one-pot operation. Transient experiments in the isothermal laboratory-scale trickle bed reactor were carried out by varying temperature, pressure and flow rate. The H_2O_2 response had an initial maximum which can be explained by the reaction scheme, since it is the primary product of the one-pot synthesis. The induction period observed in the epoxidation step is due to the activation of the framework titanium in TS-1 with H_2O and H_2O_2 , which changes its coordination and was proven by XPS results of spent catalysts.



STEM-EDS with line scans of fresh AuPd-TS1-10-3; a) and b) STEM image, c) Si, d) Ti, e) Pd and f) Au (Christoph Schmidt, Tiina Laitinen)

Cooperation: University of Turku, University of Oulu, Technische Universität Dresden, HTW-Dresden, Université de Poitiers, YnILaSalle Rennes, University Wisconsin-Madison

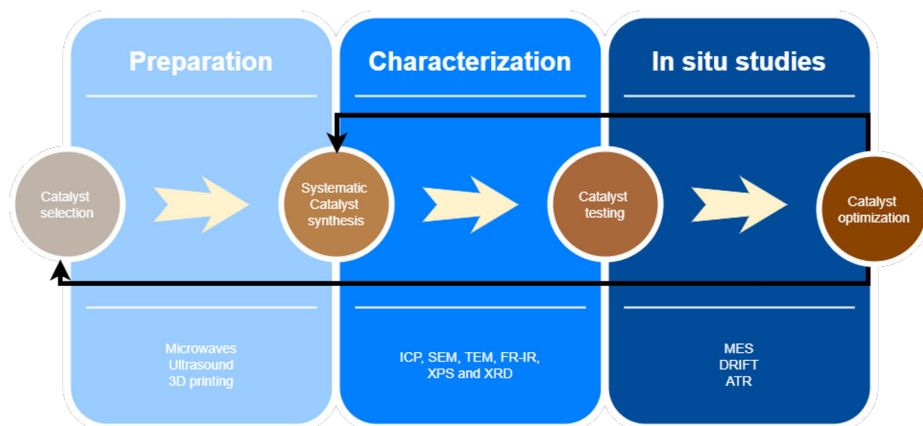
Multiscale techniques for production methods of industrial chemicals – new structures and mathematical modelling

Main funding: Research Council of Finland

German Araujo Barabona, Ethan Dautremont, Kari Eränen, Tapio Salmi

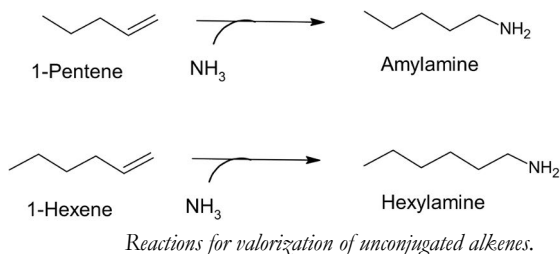
The project focuses on the development of new and improved chemical reactor structures for continuous production of selected industrially important chemicals. Ammonia is used as inorganic reactant, which is able to combine with organic molecules, such as alkenes and epoxides to make high-value products. This orientation towards applications is strongly coupled to deep-going investigation of process fundamentals, i.e. in situ spectroscopic studies of reaction mechanisms, kinetic and thermodynamic modelling as well as optimization of flow patterns in chemical reactor devices. This project aims to develop materials and solutions for the in situ production of ammonia and amination of unconjugated olefins, which is still a challenge.

The aim of the research effort is to create new process solutions based on fundamental understanding of the underlying chemical and physical phenomena. The research infrastructure (materials, chemicals, experimental reactor equipment as well as analytical techniques) is available at our university. Multiscale modelling approach will be applied, comprising DFT calculations, classical kinetic and flow modelling as well as flow visualization with a high-speed camera and CFD simulations. Schematic views on the approach are provided below.

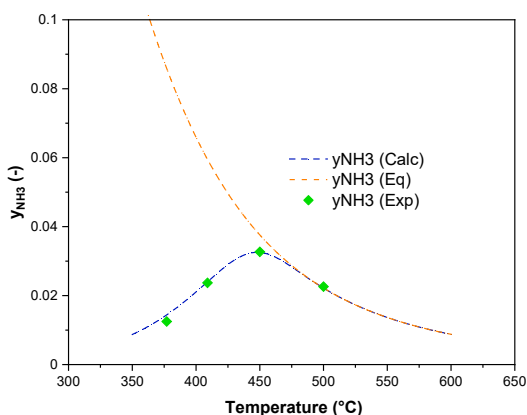


Pathway to new and exciting structures and materials.

The project will result in the implementation of new catalyst materials and structures for continuous and clean production of the inorganic reactant molecule (NH_3) and final products (amines). The chemical processes to be investigated are displayed in Figure 3. New fundamental insight will be provided on the underlying reaction mechanisms, unique kinetic data will be produced and the feasibility of the new process technology will be demonstrated by continuous operation in avant-garde reactors (micro- and millireactors, 3D-printed structures). The project implies a pronounced renewal in several aspects: shift to on site production of the gaseous reagent (NH_3) and utilisation of it in amination reactions, development of new structured reactor elements for continuous operation, new fundamental knowledge on underlying reaction mechanisms, new models for reactor design, based on a combination of DFT calculations, classical modelling approach and CFD. It is important to recognize the industrial interest in these molecules and to develop sustainable solutions for amination of unsaturated olefins.



Ruthenium-based ammonia synthesis catalysts have been prepared by using 3D-printing technology and characterized. The experimental equipment consists of a continuous gas-phase reactor, feeding system for hydrogen and nitrogen as well as an on line gas chromatograph (micro-GC). The experiments have demonstrated that this is a working concept, which can become competitive with the current ammonia synthesis process.



Effect of temperature on NH_3 outlet concentration at 30 bar, and a total feed flow rate of $50 \text{ mL NTP min}^{-1}$ on a 3D-printed Ru–Ba/C catalyst.

Cooperation: Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf, HTW-Dresden, Università di Napoli ‘Federico II’

Intensified catalysis through combined 3D printing and ALD (INCAT)

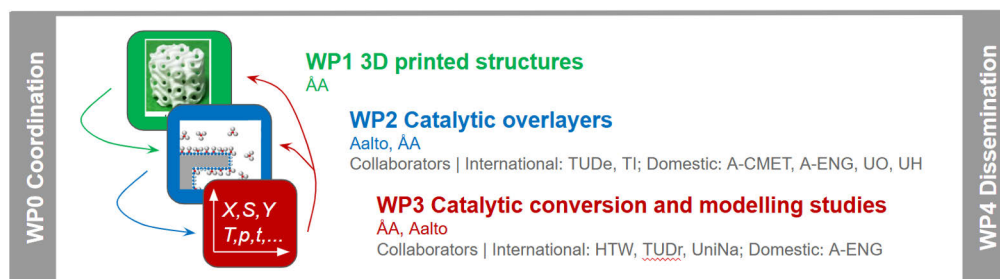
Main funding: Research Council of Finland

Ethan Dautremont, Jorge Velasco, German Araujo Barabona, Tapio Salmi, Kari Eränen, Riikka Puurunen

The key issue in most industrially applied chemical processes is the use of homogeneous, heterogeneous or enzymatic catalysts to enhance the rate of a chemical process and to provide a high selectivity of desired products. Among the different types of catalysts, solid materials are dominant (metals, metal oxides, micro- and mesoporous materials). Conventional, wet methods for catalyst preparation are well developed; they are mainly based on metal impregnation. To progress further to highly active and selective catalysts, more sophisticated methods should be introduced, which provide catalysts with well-defined active sites, i.e. optimal nanoparticle size for structure sensitive reactions as well as mono- bi- and multimetallic catalysts. It is evident that this goal cannot be achieved with conventional wet preparation methods only.

The very recent development of inexpensive 3D printing technology has opened a completely new perspective for the design of tailored chemical reactors and mimicking natural structures in reactor design. In recent years, intensive research has been initiated at Åbo Akademi within the research group of docent Kari Eränen, professor T. Salmi and collaborators on structured reactors and catalysts, focusing to the application of microreactor technology, solid foams and 3D-printed structures. The metal deposition work has been done with wet methods – now it is time to shift to more sophisticated approach based on atomic layer deposition (ALD) in close collaboration with professor Riikka Puurunen's group at Aalto University. Professor Puurunen is one of the leading experts in Europe in atomic layer deposition (ALD) technology.

The overarching hypothesis of INCAT is that the combination of 3D printing and ALD can be materialized and it is possible to reach a higher activity and selectivity of catalytic processes through it. The main objective is to obtain superior heterogeneous catalysts by combining 3D printing and atomic layer deposition (ALD) techniques. The performance of the catalysts will be demonstrated with scientifically and industrially relevant chemical reactions: sugar hydrogenation, direct synthesis of hydrogen peroxide and epoxidation of alkenes. The work package structure of the project is shown below.



Cooperation: Aalto University, University of Turku, University of Oulu, University of Helsinki, Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf, HTW-Dresden, Università di Napoli 'Federico II', TU-Delft

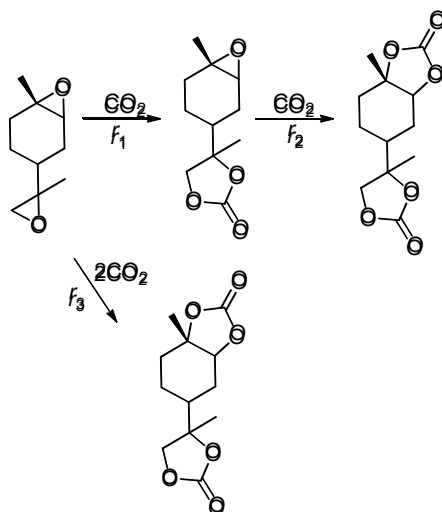
Green synthesis of non-isocyanate polyurethane foams from bio-based building blocks (NIPU)

Main funding: Åbo Akademi

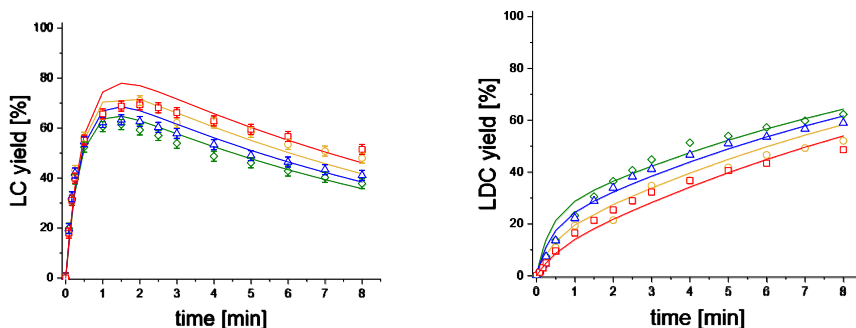
Federica Orabona, Wander Perez Sena, Stefano Napolitano, Clandia Di Finizio, Francesco Taddeo, G.C. Recupido, K. Lama, F. Polaczek, Kari Eränen, Letizia Verdolotti, Martino Di Serio, Vincenzo Russo, Dmitry Murzin, Tapio Salmi

Polyurethane foams are among the most important polymeric materials used in our modern society, with applications ranging from thermal and acoustic insulation to cushioning, packaging, automotive components and biomedical devices. However, conventional polyurethane production relies on the reaction between polyols and di-isocyanates, which are mainly derived from fossil resources and associated with significant health and environmental concerns. This doctoral thesis addresses this challenge by developing bio-based non-isocyanate polyurethane (NIPU) foams through the synthesis of renewable building blocks and their subsequent conversion into foamed NIPU materials.

Renewable feedstocks such as limonene diepoxide, epoxidized soybean oil and ethyl levulinate were investigated as starting materials for the preparation of bio-based NIPU precursors. Five-membered cyclic carbonates were synthesized through the catalyzed CO_2 cycloaddition to epoxides, a reaction achieving 100% atom economy while valorizing carbon dioxide as chemical feedstock. The kinetic and mass transfer aspects of the carbonation of limonene diepoxide were studied in detail under varying operating parameters. Heterogeneous catalysts based on ionic liquids grafted on solid supports were designed, characterized and tested. The influence of different grafting parameters was correlated with the catalytic activity. A second class of renewable building blocks was obtained from the acid-catalysed condensation of ethyl levulinate with phenol to produce diphenolic acid ethyl ester (DPE). The kinetics of this reaction was investigated using ion-exchange resins as heterogeneous Brønsted acid catalysts and a mathematical model was developed to describe the chemical system.

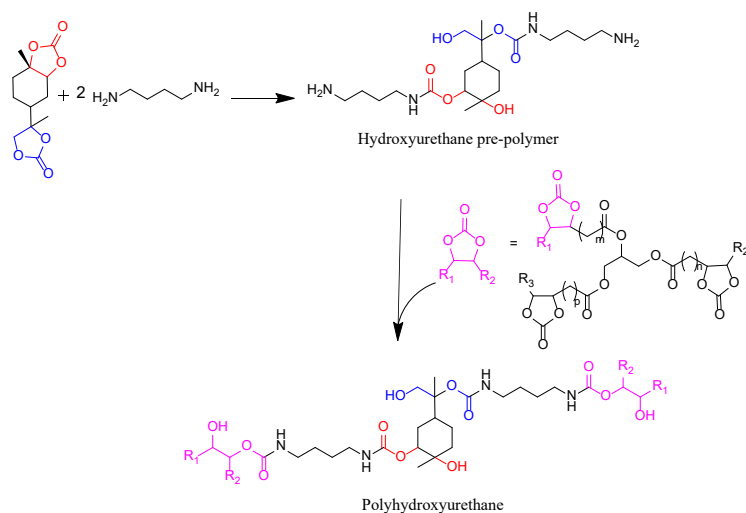


Reaction network for the CO_2 cycloaddition to limonene diepoxide.



Reaction kinetics of CO_2 cycloaddition to limonene diepoxide (LC=monocarbonate, LDC = decarbonate). Continuous lines represent model prediction.

The synthesized cyclic carbonates were applied in the preparation of NIPU foams with high bio-based content. Different formulations were developed by combining rigid and flexible cyclic carbonates with bio-based diamine, catalysts, fillers and blowing agents. Both self-blowing and non-self-blowing approaches were explored. The resulting materials were characterized in terms of chemical structure, morphology, thermal behaviour, mechanical properties and reprocessability. Particular focus was dedicated to the dynamic nature of polyhydroxyurethane networks, which enables the reprocessing of NIPU foams into new materials through temperature-controlled compression molding. The project demonstrated that renewable and waste feedstocks can be effectively combined to produce bio-based NIPU foams with tailored properties and reprocessability, providing a comprehensive contribution to the development of safer, isocyanate-free polyurethane technologies.



Reaction scheme of the synthesis of polyhydroxyurethanes (represented as one of the possible isomers) starting from limonene and soybean oil-based cyclic carbonates (simplified representation) and 1,4-butanediamine.

Cooperation: Università di Napoli 'Federico II', Consiglio Nazionale delle Ricerche (IT)

77

polyurethanes for sustainable bio-based innovation, 5 megaeuro), where Åbo Akademi is one of the central players in the development of carbonation processes.

The kinetics and selectivity of the epoxidation of renewable terpenes and vegetable oils are governed by the interplay between substrate molecular structure, catalyst properties, oxidant concentration, and competing reactions. A quantitative understanding of these effects will enable the development of kinetic models capable of predicting epoxide formation and selectivity across different renewable feedstocks. Continuous-flow operation, combined with controlled oxidant dosing and optimized heat and mass transfer, can improve epoxide selectivity, productivity, and process robustness compared with conventional batch or semibatch operation. The integration of intrinsic kinetics and transport phenomena into reactor models will enable rational process optimization and scale-up to produce renewable epoxide precursors suitable for cyclic carbonate and NIPU synthesis, subsequently. The project activities at Åbo Akademi consist of three scientific work packages (WP1-WP3).

WP1 Renewable feedstocks and catalytic epoxidation

Epoxidation of terpene-derived feedstocks. Pinene and limonene will be used as a representative bio-based terpene and epoxidized according to Green Chemistry principles using hydrogen peroxide as oxidant and γ - Al_2O_3 as heterogeneous catalyst. Experiments will initially be conducted in a jacketed semibatch reactor using ethyl acetate as solvent and controlled H_2O_2 feeding. The influence of temperature, catalyst loading, substrate-to-oxidant ratio, H_2O_2 feeding rate and mixing intensity on conversion and epoxide selectivity will be systematically investigated.

Epoxidation of vegetable oils. Cardoon and linseed oils will be investigated as renewable feedstocks with different degrees and distributions of unsaturation. Initial experiments will establish the effects of temperature, oxidant-to-double-bond ratio, catalyst concentration and reaction time on conversion and epoxide selectivity. The results will establish operating windows for the subsequent continuous experiments.

WP2 Continuous epoxidation and process intensification

Continuous epoxidation of vegetable oils. The epoxidation of cardoon and linseed oils will be transferred to continuous-flow operation. Continuous reactor configurations will be investigated by varying temperature, residence time, feed composition, oxidant ratio and flow rate. Particular attention will be given to controlling the local concentration of H_2O_2 and limiting secondary reactions. Batch, semibatch and continuous processes will be compared in terms of reactant conversion, product selectivity, productivity and catalyst stability. This task will build on the continuous and green vegetable-oil epoxidation approaches previously developed at Åbo Akademi within the EPOXY project in the doctoral thesis of Tommaso Cogliano.

Intensification of terpene epoxidation. Based on the kinetic results obtained in WP1, the feasibility of transferring limonene epoxidation from semibatch towards continuous operation will be evaluated. Reactor conditions will be designed to provide controlled contact between the organic substrate, aqueous hydrogen peroxide and heterogeneous catalyst. The effects of residence time, phase ratio, catalyst amount and hydrodynamic conditions will be investigated. Performance will be evaluated through epoxide yield and selectivity, H_2O_2 utilization and reactor productivity.

Catalyst stability and process robustness. The stability and reusability of the selected heterogeneous catalysts will be investigated under prolonged operation. Possible catalyst deactivation, changes in surface properties and loss of catalytic activity will be evaluated through spectrometric and surface characterization techniques. Reproducibility of the epoxide product composition and functionality will be determined, since consistent precursor quality is required for downstream cyclic carbonate production.

WP3 Reaction engineering, modelling and precursor validation

Modelling of kinetics and transport phenomena. The kinetic models developed in WP1 will be combined with reactor mass balances to describe semibatch and continuous epoxidation. Relevant gas-liquid, liquid-liquid and liquid-solid transport effects will be considered depending on the reaction system. Dedicated experiments at different mixing conditions and flow rates will be used to distinguish intrinsic

kinetics from mass-transfer limitations. Residence-time-distribution (RTD) experiments with inert tracers will be carried out where appropriate to characterize the flow pattern of continuous reactors. The resulting mathematical models, consisting of coupled mass balances and kinetic equations, will be implemented in MATLAB/Python/ModEst and validated against experimental data.

Reactor optimization and scale-up. Experimentally validated reactor models will be used to identify operating conditions that maximize epoxide yield, selectivity and productivity while minimizing secondary reactions. Dimensionless criteria and characteristic reaction and transport times will be used to assess changes in reactor scale and operating conditions. The models will provide a basis for rational process intensification and define operating windows for robust continuous production.

Validation of renewable epoxides as NIPU precursors. Selected epoxidized vegetable oils and terpene-derived epoxides produced under optimized conditions will be provided for subsequent CO₂ cycloaddition to five-membered cyclic carbonates in collaboration with the ReLION partners. ReLION specifically envisages long-chain cyclic carbonates derived from epoxidized vegetable oils, including linseed-type feedstocks, as building blocks for flexible NIPU systems. The relationship between epoxidation conditions, epoxide functionality and suitability for subsequent cyclic carbonate synthesis will be investigated. This task will establish the connection between reaction engineering of renewable epoxide production and the final application in bio-based NIPU materials.

Cooperation: Università di Napoli 'Federico II', Ritols SIA (LA), Consiglio Nazionale delle Ricerche (IT), Universidad de Castilla – la Mancha (ES), Geven SPA (IT), Centro de Nano-tecnología e Materiais Técnicos Funcionais e Inteligentes (PT), Fraunhofer Institute for Applied Polymer Sciences (DE), Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro (IT)

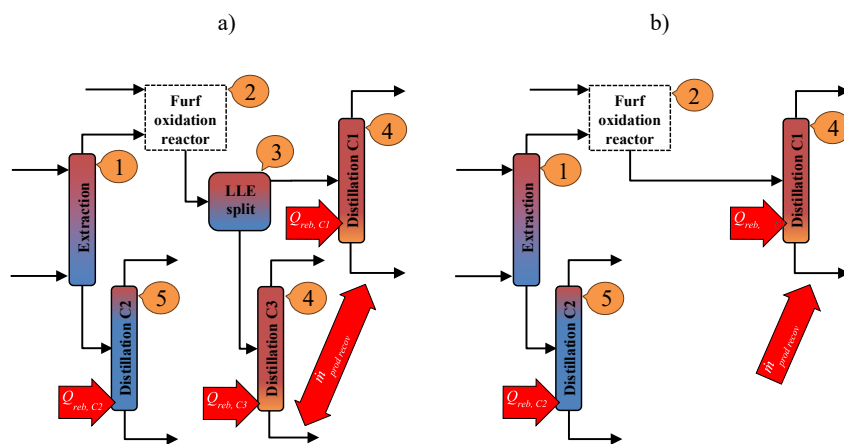
A conceptual process design approach: Exploring solvent effects in the oxidation of furfural with hydrogen peroxide to C4 intermediates

Main funding: Research Council of Finland, Åbo Akademi, University of Oulu

Wander Perez Sena, Olha Yendokimova, Ville Tuppurainen, Juba Abola, Juba Tanskanen, Johan Wärnå, Dmitry Murzin, Tapio Salmi

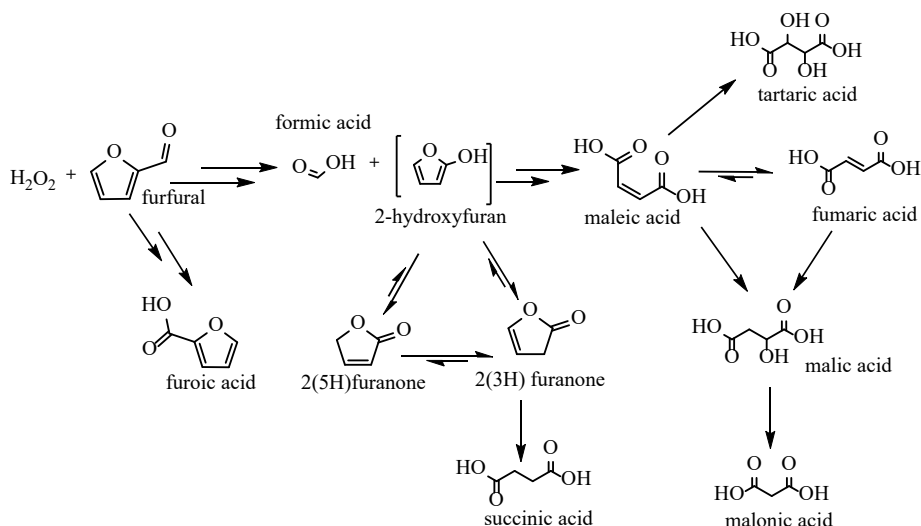
Furfural, obtained from the dehydration process of pentoses originating from the monomeric units of hemicelluloses, such as xylose and arabinose, is acknowledged as one of the top bio-based platform molecules, due to its high degree of functionality and versatility, allowing it to undergo diverse chemical transformations, including hydrogenation, amination, aldol condensation, oxidative esterification, and oxidation processes. Among these approaches, oxidation of furfural with hydrogen peroxide presents compelling transformation pathways, yielding a wide range of valuable C4 compounds. Notable products of furfural oxidation include dicarboxylic acids such as succinic, maleic acids, and fumaric acid, as well as lactones such as 2-(5H)-furanones, all with significant industrial utility. The main challenge is the selectivity of furfural transformations.

One of the key limitations of oxidizing furfural with hydrogen peroxide is the reduced solubility of furfural in the aqueous phase. To surmount this dilemma, utilization of organic solvents is explored in the collaborative project of Åbo Akademi and University of Oulu, by utilizing the top solvent candidates, where a conceptual process design for biphasic furfural oxidation using hydrogen peroxide was proposed, with thousands of solvents screened and ranked based on the process-level energy consumption in COSMO-RS based framework. The top solvent candidates were evaluated experimentally and compared in the oxidation of furfural with hydrogen peroxide using an acidic ion exchange-catalyst in a laboratory scale batch reactor.



Conceptual process design for furfural oxidation. a) biphasic system, b) monophasic system.

In the present project, the aim is to address the disadvantages of the aqueous-phase process by developing a novel conceptual process, where organic solvents are utilized in the oxidation of furfural targeting C4 lactones and diacids in a highly coupled manner. The energy-intensive distillation of furfural is avoided by solvent extraction, where the bulk of the water is removed. Furfural is oxidized in the presence of an organic solvent, thus avoiding a cumbersome intermediate separation of furfural from the organic extract. Furthermore, the presence of solvent in the separation section of the reaction products offers possibilities to exploit different affinities of products towards organic and aqueous phases.



Simplified reaction network for the oxidation of furfural with hydrogen peroxide over Amberlyst-15 catalyst

Biphasic oxidation of furfural with hydrogen peroxide was investigated in a batch reactor system utilizing the top-20 solvents candidates identified during the previous solvent screening study based on a conceptual process design, with the criteria being a process-level energy consumption evaluated in COSMO-RS based framework. During the biphasic oxidation experiments, it was observed that the activity and selectivity of the Amberlyst-15 catalyst remains unaffected as the system was operated in a biphasic mode compared to the monophasic system. The furfural consumption rate during oxidation was observed to be accelerated with increasing the organic-to-aqueous phase volume ratio and the initial furfural concentration, while the formation rate of the primary product was observed to proceed more slowly compared to the aqueous system.

It was proved that the utilization of organic solvents is advantageous from the viewpoint of product separation efficiency, as predicted in the process concept design and solvent screening study, since the two major products, i.e. 2-(5H)-furanone and succinic acid were observed to be mainly concentrated in the organic and aqueous phases, respectively. Among the various organic solvents screened, anisole was found to be the most efficient in term of 2-(5H)-furanone migration to the organic phase, with the partition coefficient values exceeding 2, which is more than twofold the values obtained for the rest of the investigated biphasic systems. The perspective of the new process is very good, thanks to the complementary competencies of the participating universities.

Cooperation: Chemical Process Engineering Research Unit, University of Oulu.

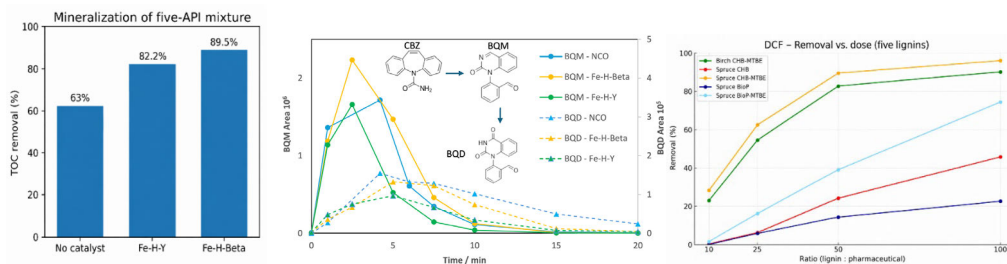
Advanced treatment of pharmaceuticals and other micropollutants in water

Main funding: Liedon Säästöpankkisäätiö, Svenska litteratursällskapet i Finland (SLS), Åbo Akademi University; IMATEC Erasmus Mundus (MSc thesis support); EU BAPUR project.

Pasi Tolvanen, Ana Fernanda Núñez Núñez, Estéban Duverger, Nikke Saarinen, Abdul Shabid, Shey Jude Fale, Soudabeh Saeid, Matilda Kråkström, Narendra Kumar, Kari Eränen, Patrik C. Eklund, Jyri-Pekka Mikkola, Dmitry Yu. Murzin, Tapio Salmi

Pharmaceutical residues are persistent micropollutants that are only partly removed in conventional wastewater treatment. Since 2015, the project has developed ozonation and heterogeneous catalytic ozonation for their removal, initially using individual pharmaceuticals in model water. Earlier work established reaction kinetics and transformation-product (TP) pathways and showed that catalyst structure strongly affects both degradation of the parent compounds and oxidation of persistent intermediates.

The latest study examined a five-pharmaceutical mixture containing ibuprofen (IBU), diclofenac (DCF), carbamazepine (CBZ), sulfadiazine (SDZ) and sulfamethoxazole (SFX). Fe-H-Y and Fe-H-Beta zeolites improved ozone utilization and mineralization: after 120 min, TOC removal increased from 63% without catalyst to 82.2% with Fe-H-Y and 89.5% with Fe-H-Beta. Fe-H-Y combined rapid degradation with better structural stability, whereas Fe-H-Beta gave the highest mineralization but more carbon deposition. The mixture experiments also highlighted competition between APIs, supporting the move toward more realistic multi-contaminant water matrices. LC-MS showed that catalytic ozonation accelerated the conversion of key intermediates, not only the removal of parent APIs. In the CBZ pathway, BQM formed rapidly whereas BQD was more persistent; Fe-zeolites, especially Fe-H-Y, shifted the maxima earlier and promoted further oxidation. For IBU, 1-oxo-IBU decayed faster with catalysts, and for DCF the accumulation of 4-OH-DCF was strongly suppressed. These results show that treatment performance must be evaluated through both API removal & TP fate.



Left: Catalytic ozonation increased mineralization of the five-API mixture; centre: the most significant TP degradation with catalysts (Tolvanen et al., Applied Catalysis B, 2026); right: lignin adsorption, where DCF removal increased strongly with lignin dose after MTBE treatment (N. Saarinen, MSc thesis, 2025).

In parallel with catalytic ozonation, Nikke Saarinen's work complements the ozonation studies by investigating adsorption of APIs and their transformation products using lignin-based materials. His MSc thesis, performed within the EU BAPUR project, demonstrated promising adsorption of several pharmaceuticals with technical lignins, and this work is now being continued in his doctoral research using lignin-based nanoparticles and solutions produced in the ozonation studies. A complementary study examined ozone-based degradation of urea, an important side-stream compound in pharmaceutical production. Ana Fernanda Núñez Núñez's MSc work was supported by the IMATEC Erasmus Mundus programme.

The current focus is on continuous catalytic ozonation, catalyst stability and regeneration, and the transition from model mixtures to real water matrices, including treated municipal wastewater from Kakolanmäki. The effects of water composition, ozone utilization and transformation-product formation are investigated, while lignin-based adsorption is explored as a complementary polishing step.

Cooperation: Laboratory of Molecular Science and Engineering, Åbo Akademi University / EU BAPUR project; Turku Bioscience Center; Turun seudun puhdistamo Oy / Kakolanmäki wastewater treatment plant; Umeå University; University of Naples Federico II; Novia University of Applied Sciences; IMATEC Erasmus Mundus.

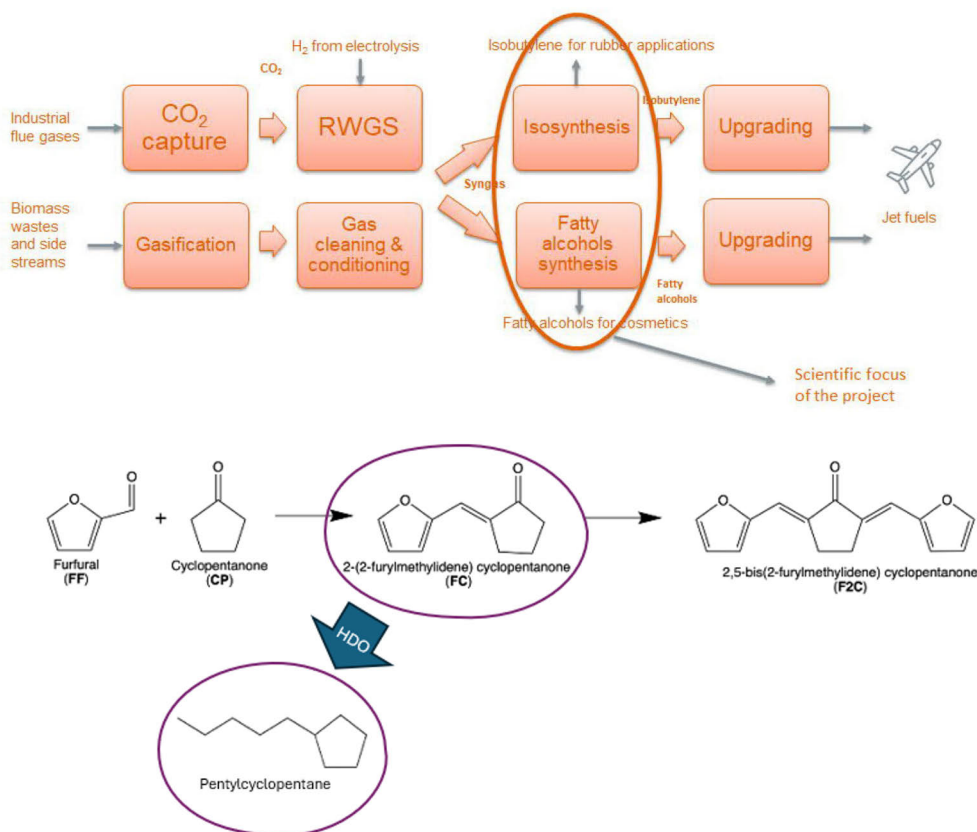
Catalytic Synthesis of Sustainable Aviation Fuels

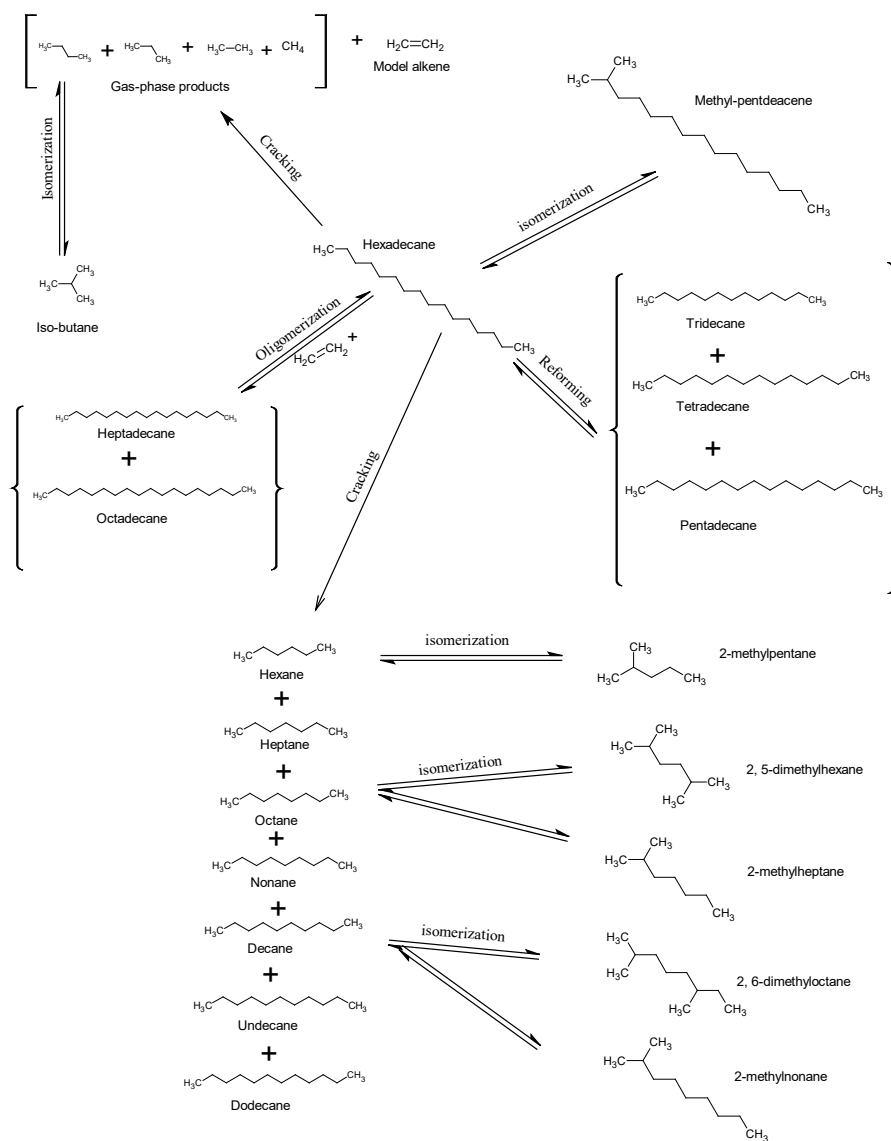
Main funding: Åbo Akademi, Neste and Fortum Foundation, EU DTN and EU MCSE

Olha Yevdokimova, Atte Aho, Stanislav Sadovnichenko, Eelis Ketola, Nikita Sarkov, Natalia Shcherban, Vincenzo Russo, Kari Eränen, Irina Simakova, Päivi Mäki-Arvela, Dmitry Yu. Murzin

Aviation turbine fuel (ATF) or jet fuel applied for commercial and military turbine engine aircrafts is conventionally based on petroleum as a feedstock being produced starting from crude oil distillation (205 - 260 °C). The composition is regulated as strict standards should be applied regarding energy and bulk density, clean combustion, low freezing point (needed for high altitude flights), flash point, viscosity, sulfur content and lubricity. The latter for example is provided by aromatic compounds, at the same time leading to poor combustion. Besides such aromatic compounds, jet fuel contains alkanes, alkenes and cycloalkane derivatives, constituting ca. 70-85% combined. A carbon number, an important parameter defining the desired fuel properties, is ranging from 8 to 16. A high hydrogen-to-carbon ratios provided by alkanes are essential for cleaner combustion.

Currently approved fuels containing normal and iso-alkanes originate from several sources: synthesis gas, lipids (fats, oils, greases), sugars, and alcohols (e.g. ethanol or isobutanol). Some potential synthesis routes of isoalkanes for sustainable aviation fuel (SAF) are given below.





Iso-alkane production routes

Our research activities are focused on different routes for production of SAF: hydrocracking of fatty acids with Ni-Fe catalysts, condensation of furfural with cyclopentanone using ceria and Zr containing metal-organic frameworks, with subsequent hydrodeoxygenation of mono- and di-condensation products; direct synthesis of isobutene from syngas using zirconia or synthesis of fatty alcohols on Cu-Fe-Co-K catalysts with subsequent dehydration and oligomerization and finally synthesis of dimethyl ether from carbon monoxide and hydrogen. DME can be converted catalytically to olefins.

Cooperation: Pisarzvesky Institute of Physical Chemistry and Taras Shevchenko National University Kyiv, IMDEA Energy, Newcastle University, University of Pretoria

Synthesis of methanol through partial oxidation of methane over biomimetic catalysts under mild conditions

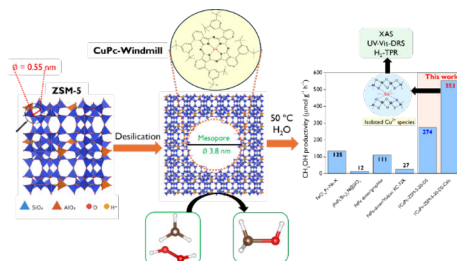
Main funding: Research Council of Finland (MEMBMCAT)

Luis A. Gallego-Villada, Päivi Mäki-Arvela, Mehdi Milu, Kari Eränen, Pasi Virtanen, Narendra Kumar, Sebastian Pütsch, Alexander Efimov, Dmitry Yu. Murzin

The direct conversion of methane into methanol has been a long-standing challenge in catalysis. Methane is abundant, but it is difficult to convert it selectively to methanol, as the latter is even easier to oxidize than methane, leading to formation of formaldehyde, formic acid, or CO₂, instead generating methanol as the target. Methanol is an important chemical and a convenient liquid fuel, therefore ability to produce it directly from methane could have important practical benefits. In particular, biogas or stranded natural gas can be converted into a useful liquid, without relying on the conventional and energy-intensive route through synthesis gas. For about two decades, one of the main approaches has used copper-containing zeolites in the gas phase oxidation. These catalysts are first heated in oxygen at high temperature to form reactive copper–oxygen sites followed by cooling, exposure to methane, and finally treatment with steam to recover the methanol. Although this approach works, the process involves several heating and cooling steps, methanol yields are still relatively low, and the overall process is not yet truly catalytic.

Our project at Åbo Akademi University explores a different approach: methane oxidation in the liquid phase at only 50 °C and water as the solvent. We use copper-containing catalysts and hydrogen peroxide to generate the reactive oxygen species required for methane activation. This approach avoids the high-temperature activation step and the need for steam extraction. In practice, methane is simply introduced into an aqueous suspension containing the catalyst and hydrogen peroxide. So far, this work has led to three publications. In the first study (10.1016/j.jcat.2026.116924), we looked at how the copper species and acidity of the zeolites affect methane oxidation. It was found that good performance depends on finding the right balance between copper dispersion and the zeolite acidity including the ratio between the Brønsted and Lewis sites. In the second study (Scheme 1, 10.1016/j.apcatb.2026.126987), copper phthalocyanine was used to control the distribution of copper in the zeolite. After thermal treatment, phthalocyanine decomposes forming highly dispersed copper species. These catalysts displayed particularly good performance when specific activity per copper atom was compared. The third study (10.1016/j.rechem.2026.103821) focused on understanding the reaction and improving the analysis of the products. We have developed reliable methods to quantify the different products formed during the reaction and used them to study the reaction pathway. Our results indicate that methanol formation involves the reaction of methyl and hydroxyl radicals.

We are now extending this work to bimetallic copper–iron catalysts. The first results are promising, as combining the two metals gives better performance than the single-metal catalysts. We are currently working on understanding the reasons of such synergy and subsequent improvement of the catalytic performance



Scheme 1. Taken from Gallego-Villada et al., Applied Catalysis B: Environment and Energy (2026), 126987.

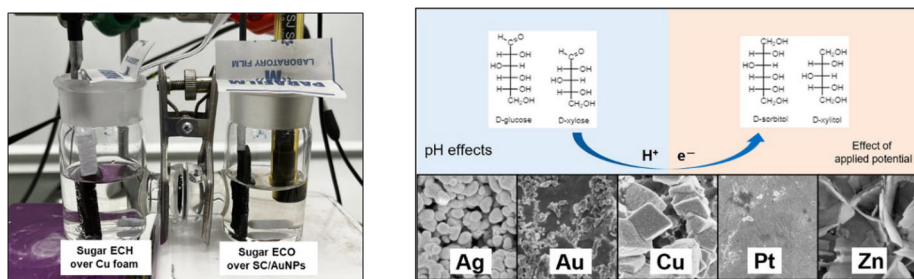
Cooperation: Tampere University

Electrocatalytic conversion of glucose and xylose into value-added chemicals

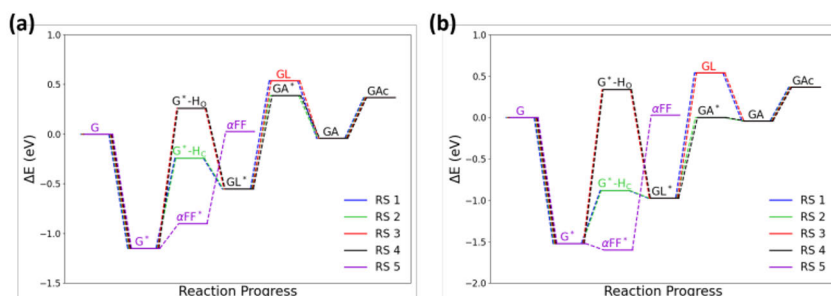
Main funding: Tiina and Antti Herlin Foundation

Jay Pee Oña, Narendra Kumar, Laura Laverdure, Karoliina Honkala, Rose-Marie Latonen, Henrik Grénman

Catalytic conversion of biomass into fuels and value-added chemicals offers a sustainable, environmentally friendly alternative to fossil-based processes. Electrochemical routes for biomass valorization allow aqueous processing of biomass feedstocks under milder reaction conditions than conventional catalytic processes, without the need for costly and possibly toxic reductive and oxidative reagents. Renewable electricity (e.g., solar, wind) can supply the energy required for electrochemical conversions, and a major advantage is that the required hydrogen and oxygen are produced in situ. In this work, we studied the electrocatalytic valorization of glucose and xylose, the main components of wood hemicellulose. In the electrocatalytic hydrogenation (ECH) of the sugars over different roughened metal surfaces (Ag, Au, Cu, Pt, and Zn), the Cu catalyst showed the highest glucose and xylose conversion with selectivity towards sorbitol of 21.1 % and towards xylitol of 67.1 %. ECH of sugars over carbon-supported Au nanocatalysts revealed that metal-cluster size influences ECH rates. On the other hand, the electrocatalytic oxidation (ECO) of glucose and xylose over mesoporous Sibunit carbon-supported Au nanocatalyst showed high turnover frequencies for glucose (4300 h⁻¹) and xylose (1897 h⁻¹) at 25 °C and 0.1 M NaOH supporting electrolyte (pH~12.5), with gluconic and xylonic acid selectivity of 81.5 % and 87.8 %, respectively. From DFT calculations, the presence of co-adsorbed OH⁻ on the Au surface facilitates the formation of and selectivity towards sugar acid products. The optimal activity of the rough Cu and SC/Au catalysts towards sugar ECH and ECO, respectively, enables simultaneous ECH and ECO of sugars through paired electrolysis. This work provides a basis for catalyst development and ideal reaction conditions for the electrocatalytic hydrogenation and oxidation of sugars, with insights into reaction mechanisms and substrate reactivity from DFT calculations.



Simultaneous ECH and ECO of sugars through paired electrolysis (left). Activity screening of different metal catalysts for the ECH of glucose and xylose (right).



Thermodynamic profile for the ECO of (a) glucose on a clean Au(111) surface and (b) with co-adsorbed -OH. Adsorbed species are labelled with an asterisk. G, GL, GA, GAc, and aFF correspond to glucose, gluconolactone, gluconate, gluconic acid, and α-fructofuranose, respectively. H₂O and H_C indicate the atom from which the first hydrogen is removed.

Cooperation: University of Jyväskylä

Towards sustainable steel production – an experimental and mathematical study on the intrinsic kinetics of iron oxides reduction

Main funding: RCF (IronH2), Business Finland project (FFS), Horizon Europe (MaxH2)

Emiliano Salucci, Antonio D'Angelo, Vincenzo Russo, Henrik Grénman, Henrik Saxén

Modern steel production, exceeding 1.8 billion tons per year, is responsible for approximately 7% of global anthropogenic CO₂ emissions. Decarbonizing this sector is therefore one of the major challenges of the coming decades. A significant share of these emissions comes from reducing iron oxides in iron ore to metallic iron, traditionally using coal-derived carbon monoxide as the main reducing agent (Blast Furnace technology, BF). Hydrogen is the most promising alternative reducing agent; however, implementing it requires a substantial transformation of the conventional production route, replacing the BF with direct reduction (DR) technologies to produce direct reduced iron (DRI).

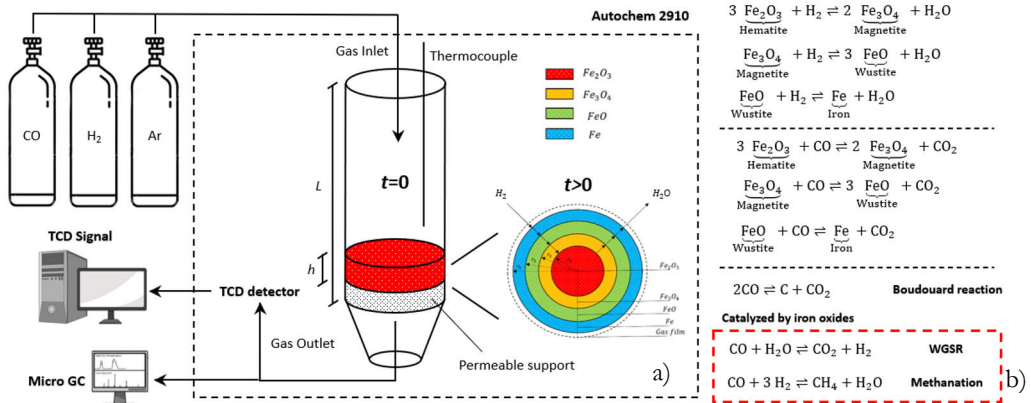


Figure 1. Scheme of the reactor and triple-front reaction in the particle (a), Reduction reaction of iron ore with H₂ and CO (b).

This research focuses on developing accurate models of the reduction kinetics of iron oxides to support process-model studies for hydrogen-based DRI production. Particular attention is devoted to the coupling between reaction kinetics, thermodynamics, mass transfer, and the evolving morphology of the reacting solid. The research combines experimental measurements, mathematical modeling, and physicochemical characterization of both high-purity and commercially available iron oxides.

Reduction experiments were performed using an Autochem 2910 and a dedicated reactor for gas-mixture experiments. Both setups enable fixed-bed reduction with a reductant-containing gas, while the effluent is continuously analyzed by a Thermal Conductivity Detector (TCD) and MicroGC. Experiments were conducted using high-purity hematite and magnetite powders and powders obtained by crushing and sieving commercial pellets. Isothermal tests were performed under controlled H₂/Ar, CO/He, and H₂+CO/He ratios and different temperatures and flow rates.

Mathematical models were developed in MATLAB, starting with a critical analysis of the shrinking-core and pore-volume approaches, to describe the sequential reduction of hematite to magnetite, wüstite, and metallic iron. The model couples gas-phase mass balances for H₂ and H₂O with equations describing the conversion of the three solid phases. A key development in recent years has been refining the interpretation of the TCD signal, allowing the experimental response to be directly related to gas composition and solid-phase conversion. This enabled a more rigorous comparison between experiments and model predictions (Figure 2).

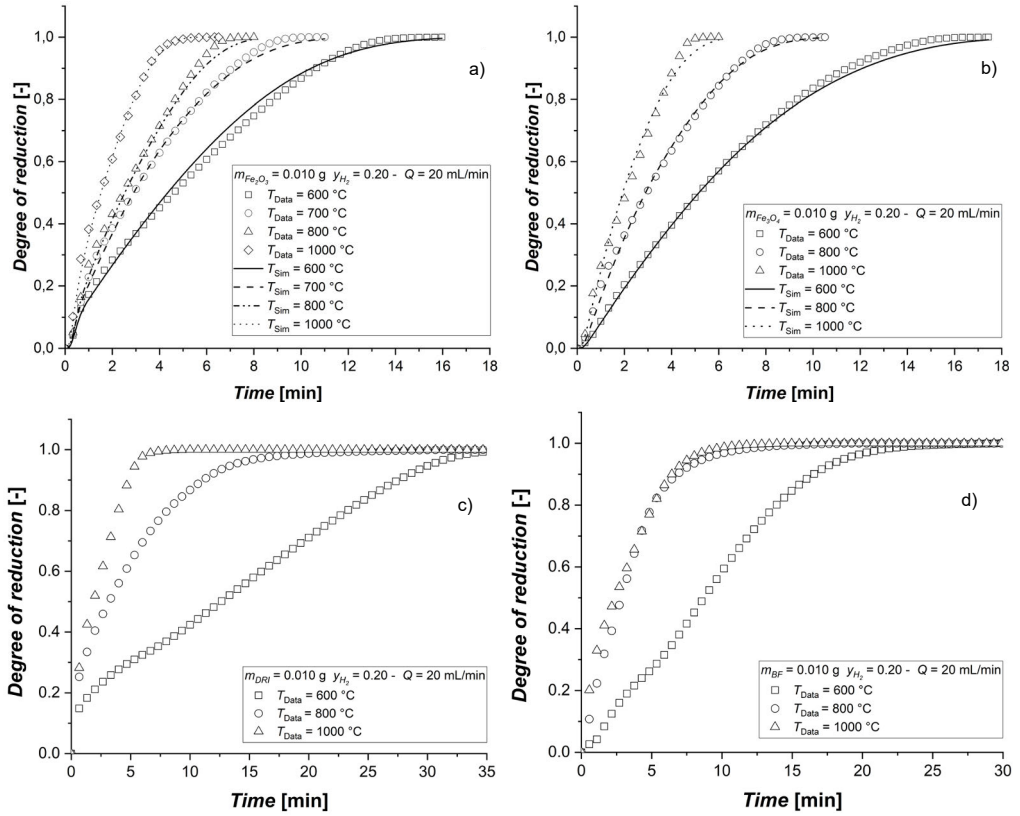


Figure 2. Effect of temperature on pure a) Fe_2O_3 and b) Fe_3O_4 and commercial powder from c) DRI and d) BF plants. Experimental results are indicated by markers; simulated results, where present, are shown by solid, dashed, dashed-dotted, and dotted lines.

The simulations reproduce the main features of the experimental TCD profiles, including the effects of temperature and the sequential reduction steps, demonstrating the models' ability to describe the overall reaction dynamics. Morphological and physicochemical characterization of starting and transient materials further supported the interpretation of the reaction fronts and the assessment of the model assumptions.

The project is now moving towards more complex reducing systems, particularly mixed $CO-H_2$ atmospheres, where carbon deposition during reduction becomes a key factor controlling the final quality of the reduced material. The ongoing work therefore aims to extend the kinetic understanding and modeling approach to these more complex systems.

Cooperation: University of Naples Federico II

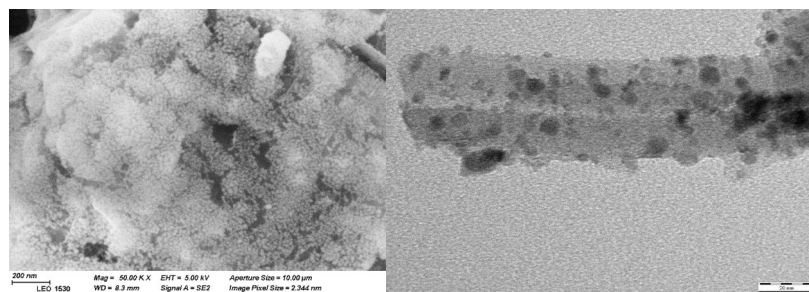
High purity methane from CO₂ utilizing a bi-functional material. From catalyst optimization to industrial modeling.

Main funding: Research Council of Finland

Enrico Marchi, Salvatore Capasso, Pablo Gangotena, Saeedeh Afshar, Christian Frilund, Tapio Salmi, Pekka Simell, Henrik Grénman.

Methane is the main component of natural gas and benefits from an existing infrastructure for transport, storage, and end use. Producing it from renewable hydrogen and captured CO₂ via the Sabatier reaction ($\text{CO}_2 + 4 \text{H}_2 \rightarrow \text{CH}_4 + 2 \text{H}_2\text{O}$, $\Delta H^\circ_{298} = -165 \text{ kJ/mol}$, typically over Ni catalysts) is therefore an attractive route to store surplus electricity in a renewable fuel. Because the reaction is exothermic and mole-reducing, it is equilibrium-limited, so conventional plants require high pressure, several cooled reactors in series, and downstream separation to meet grid-injection specifications. Sorption-enhanced methanation removes the water in situ with a zeolite sorbent, shifting the equilibrium towards the products. The close proximity of catalytically active and water-adsorption sites enables complete CO₂ conversion and a dry, high-purity methane stream in a single stage under milder conditions.

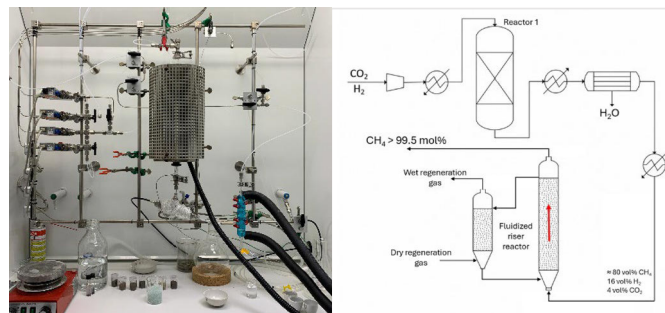
Catalyst synthesis was investigated and optimized employing a series of different precursors. The resulting bifunctional material yielded four times higher catalytic activity than the industrial equivalent and about 50% higher than the previously developed material at ÅAU.



Nickel-based zeolite bifunctional catalyst successfully employed in the production of high purity methane. SEM image (left), TEM image (right).

Catalytic and adsorption experiments were conducted in a laboratory packed-bed reactor between 180 and 300 °C at 1 atm. Mathematical modeling yielded kinetic parameters for the bifunctional catalyst, which can be used in scale-up design.

For industrial application, the process is modeled in a circulating fluidized riser bed reactor, where the bifunctional material is entrained by the H₂/CO₂ mixture and continuously recirculated through an external regenerator that desorbs water, making the inherently cyclic operation continuous. Intense solid-gas mixing and convective transport are essential for controlling the heat released by the reaction and adsorption. The outlet provides high-purity methane, without the need for further gas-gas separation.



Laboratory reactor system employed for experimental testing in Åbo Akademi University (left). Simplified process diagram of the industrial plant for sorption enhanced methanation, including a first high temperature reactor, followed by the circulating riser reactor to achieve high purity methane (right).

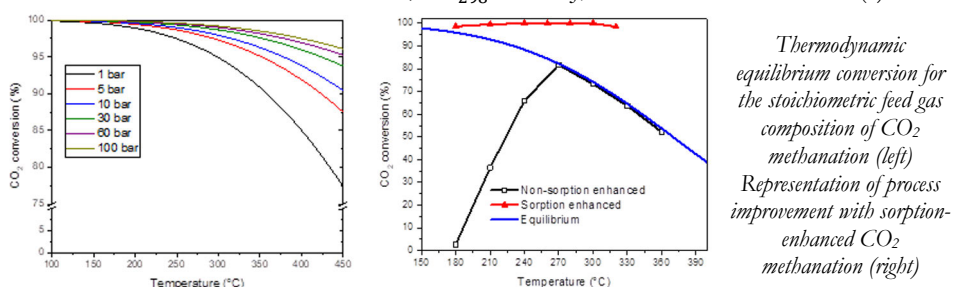
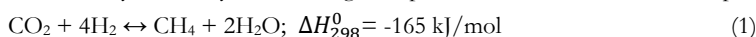
Cooperation: VTT, Delft University of Technology

Pure methane from CO₂ utilizing a structured radial flow reactor system employing a novel bi-functional material

Main funding: Academy of Finland

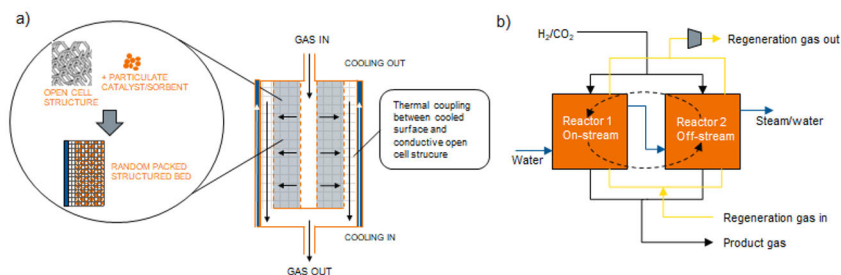
Enrico Marchi, Pablo Gangotena Palacios, Christian Frilund, Vincenzo Russo, Tapio Salmi, Pekka Simell, Henrik Gr nman

The importance of natural gas for industry and society has become increasingly evident in Europe after the brutal attack of Russia on Ukraine. Methanation, i.e., the Sabatier reaction, is a potential large-scale option for producing synthetic natural gas from CO₂ and sustainably produced hydrogen, and it is one of the solutions for decreasing carbon emissions. One of the advantages is that the needed infrastructure and large utilization of methane already exist, which makes market implementation of the product easy. However, the CO₂ conversion is limited by thermodynamics at high temperatures and kinetics at low temperatures.



According to Le Chatelier's principle, high catalytic activity at rather low temperature combined with the removal of one of the reaction products, namely water, would be required to increase the conversion. The aim of the project is to utilize a catalytic material, e.g., consisting of 13X-supported Ni-ceria previously developed in our group (Fig. 1), where these two functions are efficiently combined.

The methanation reaction (eq. 1) is highly exothermic, which makes large-scale operation at lower temperatures a challenge, e.g. in a traditional fixed bed reactor, as efficient heat transfer from inside the large bed is not feasible. The efficient heat transfer from the catalyst bed and management in the overall system calls for innovative reactor system development. The current project focuses on combining the benefits of structured reactors with the radial gas flow configuration to achieve a quasi-isothermal radial flow reactor. This could be accomplished by improving the thermal coupling between the packed bed and the cooling medium, e.g., by introducing interconnected heat-conducting structures to the bed, made possible by 3D printing.



a) Schematic representation of the catalyst packing strategy in a radial flow reactor b) Concept for a dynamically operating alternating bed methanation reactor system with energy integration between the exothermic methanation and desorption sequences in operation.

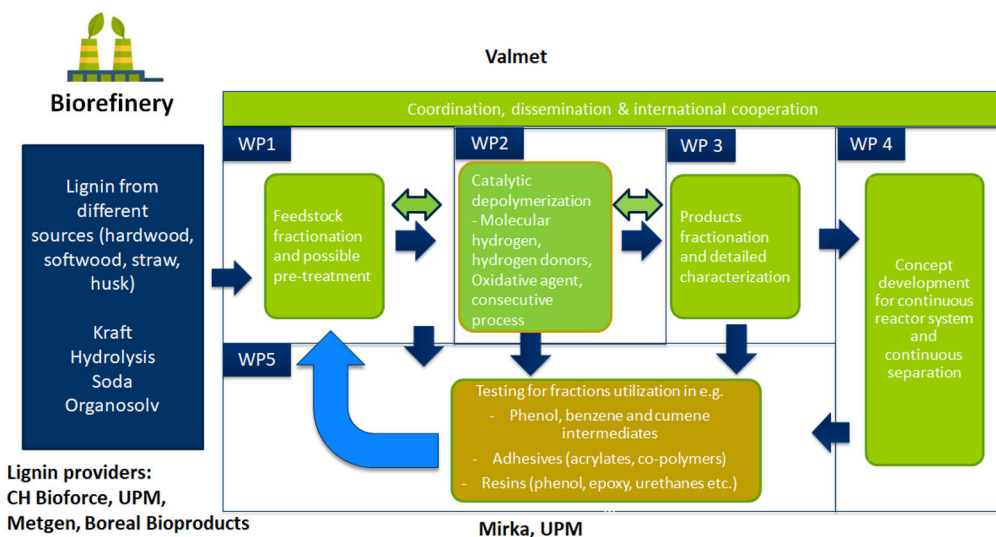
Cooperation: VTT, University of Naples Federico II, Delft University of Technology

Tailored polyphenols and polyols from fractionation and depolymerization of biorefinery lignins (Depoly2ols)

Main funding: Business Finland Co-Research Project

Sanja Vucetic, Lilia Longo, Dmitry Tarasov, Jarvinder Kaur, Samira Chesbak, Teddie Strandberg, Mark Martinez-Klimov, Rupali Bhadane, Yoon Ho Young, Ruijie Wu, Linyao Wang, Dumindu Peththa Wadu, Usma Shahid, Zhongqi Lin, Shao-Fei Sun, Robert Lassfolk, Chunlin Xu, Patrik Eklund, Henrik Grénman

Aromatic compounds are widely used in industry, e.g., as raw materials for polymers and adhesives. About a third of wood is lignin, which binds the wood fibers together, and lignin consists of precisely these valuable aromatic molecules. However, the aromatic compounds used today are fossil-derived, mainly from oil, and most lignin is burned for energy in industry. There are many different types of technical lignin, depending on the origin of the biomass, e.g., tree species, and how lignin is separated from other biomass, i.e., from cellulose and hemicellulose. The research project aims to first fractionate lignin from different biorefineries, then chemically characterize them. The fractions are further processed by partial catalytic depolymerization, after which the obtained products are again precisely characterized. The suitability of the products for different uses, e.g., producing polymers and adhesives, is investigated with standardized tests. The obtained fractions can also be further processed to improve the properties if necessary. Moreover, the aim is to develop a methodology for performing the partial depolymerization in a continuous reactor.



Schematic illustration of work packages and their connections

We successfully pre-fractionated the lignins by liquid-liquid extraction and developed a simplified, well-functioning one-step process. Lignin structure influences processing and fractionation outcomes. Most depolymerization results have been obtained in a batch reactor setup, where different catalysts, solvents, hydrogen pressure, temperature, mixing rates, and practical experimental procedures were tested. The results show that partial depolymerization from the original 20 kDa-30 kDa range (Fig 1) is feasible, yielding oligomers and short polymers with an average molar mass in the range of 1000 – 4000 Da with a degree of polymerization of about 5-20). Moreover, the functionality of the obtained fractions is increased during the processing by addition of -OH groups to the structure, and the solubility of the lignin is improved, which enables its better use in polyols substitution in general.

The decrease in molar mass and the increased functionality both contribute positively to the end-use properties. The currently investigated applications include preparing epoxy resins, lignin-based adhesives, and UV-curable acrylic latex from functionalized lignin. Very promising results have been obtained, with the depolymerized fractions outperforming the non-depolymerized ones as well as the raw lignin.

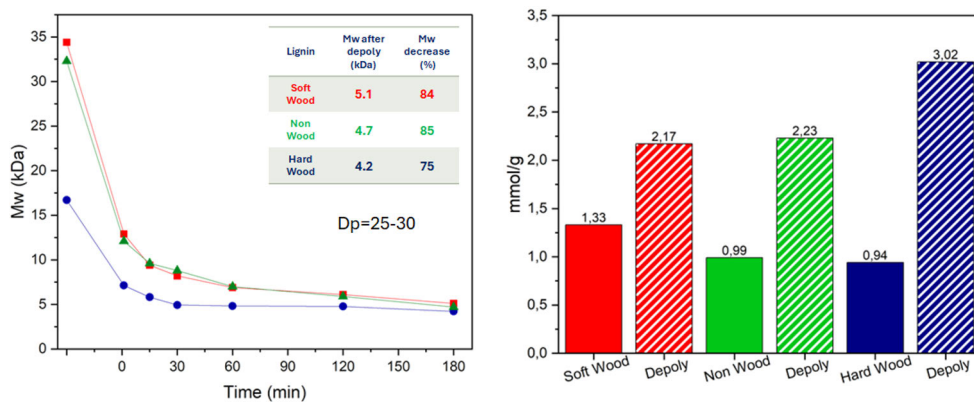


Figure 1. Examples of the partial depolymerization of lignins and the increase in -OH groups in the corresponding lignin fractions.

Cooperation: VITO (Belgium), BOKU (Austria), University of Stockholm, Mirka, Valmet, UPM, Boreal bioproduct, CH-Bioforce, MetGen

BIO4ALL

Main funding: Business Finland Co-Innovation Project

Diseye Egberike, Hamid Ardesbiri, Meheretu Dirbeba, Iqra Jaffar, Johanna Ingman, Chinedu Mbanusi, Leena Hupa, Patrik Eklund, Henrik Grénman

Mitigating climate change will require rapid transformation of critical value chains in the energy, transportation, and chemicals sectors through the development and implementation of sustainable, fossil-free technologies. For example, organic chemicals and polymers are produced today almost entirely from fossil crude oil. Furthermore, in addition to the electrification of light road transport, there is increasing demand for sustainable fuels, especially in aviation and marine transport in Europe until 2050.

The Bio4all project aims to develop a value chain from challenging forest and agricultural biomass residues through liquefaction technologies into aviation and marine fuels, as well as selected chemical products. To improve the process's economic viability, the project pretreats the biomass prior to pyrolysis. The approach aims to facilitate integrated biomass valorization by producing both a cellulose- and lignin-rich solid fraction, suitable for bio-oil production via fast pyrolysis, and a hemicellulose-rich hydrolysate that can be further processed into high-value bio-based chemicals. Three biomass feedstocks—wheat straw, forest residue, and pine wood—were investigated at laboratory scale under varying HWE conditions.

The most effective pretreatment conditions (160 °C, 120 min, and a biomass-to-water ratio of 1:18) resulted in substantial hemicellulose removal (60–80%) while largely preserving the cellulose and lignin fractions. Simultaneously, high removal efficiencies were achieved for potassium ($\geq 95\%$) and magnesium (90–95%), whereas calcium removal was more moderate (40–60%), likely due to the presence of water-insoluble calcium species. To assess scalability, the selected HWE conditions were validated at pilot scale using the forest residue. Excellent agreement between laboratory- and pilot-scale results ($R^2 = 0.99$) confirmed the robustness and scalability of the process. Compared with conventional mineral-acid leaching, the single-step HWE approach avoids the use of hazardous chemicals while effectively removing AAEMs and recovering hemicelluloses. Figure 1 displays the removal of alkali and alkaline earth metals from the biomass with the pre-treatment, and Figure 2 shows the yields obtained from the original biomass in the pre-treatment and pyrolysis.

Pyrolysis experiments show that CO₂ and CO formation decrease with pretreatment and that bio-oil yield increases. Besides yield, the chemical composition of the bio-oil is important, and we performed detailed analysis after fractionation using NMR and chromatographic methods. Method development has also been a crucial part of the development work, as simpler but accurate ways of analyzing the main aspects of the oils would be very valuable.

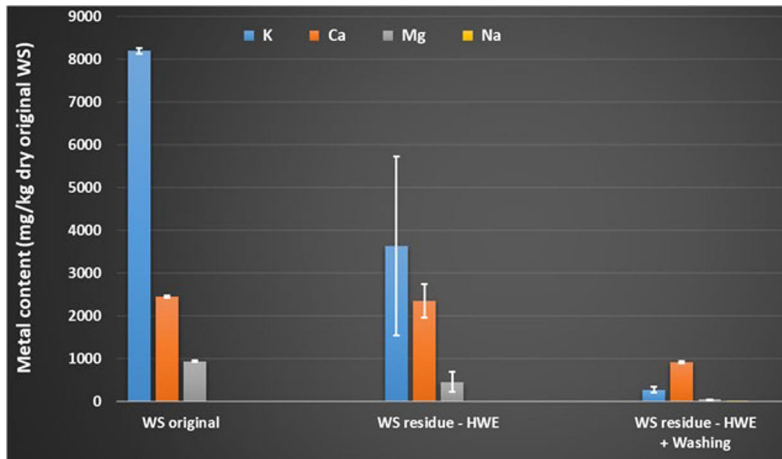


Figure 1. Removal of alkali and alkaline earth metals from wheat straw with pre-treatment

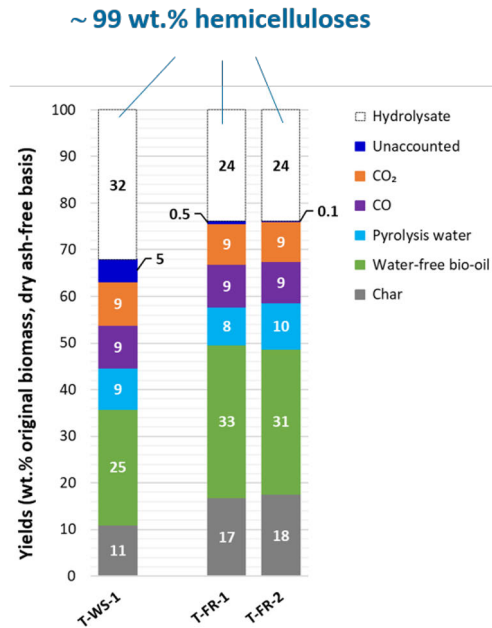


Figure 2. Yields obtained for wheat straw and forest biomass from the original biomass in the pre-treatment and pyrolysis.

The work continues with comparing and developing laboratory- and pilot-scale fractionation and pyrolysis.

Cooperation: VTT, Tampere University, Tampere University of Applied Science, Lappeenranta University of Technology, Fifth Innovation, Green Fuel Nordic, Dieffenbacher, Meriaura and Montinutra and large companies: BASF, Borealis, Neste and Valmet. VITO (Belgium), BOKU (Austria), University of Stockholm, Mirka, Valmet, UPM, Boreal bioproduct, CH-Bioforce, MetGen

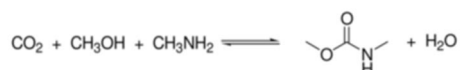
Carbamate Synthesis from CO₂, Amines, and Alcohols: Integrating Catalysis and Process Systems Engineering

Main funding: Åbo Akademi

Hao Xin, Atte Aho, Kari Eränen, Chengfian Cui, Dmitry Yu. Murzin

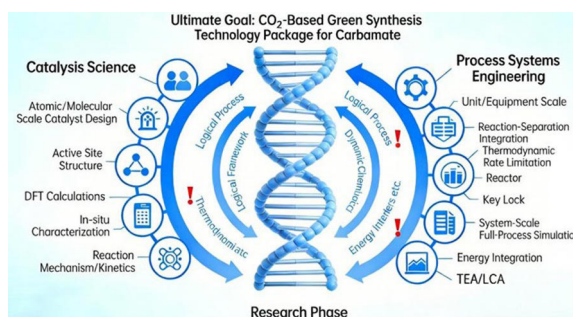
The escalating challenge of climate change, driven by anthropogenic CO₂ emissions, necessitates urgent action, aligning with Sustainable Development Goals (SDGs). Concurrently, the chemical industry faces a pressing need to replace hazardous feedstocks with safer, more sustainable alternatives. Carbamates are a class of high-value chemicals widely used as precursors in the production of polyurethanes, pharmaceuticals, and agrochemicals. For decades, their industrial synthesis has relied almost exclusively on phosgene, a highly toxic and corrosive gas. This conventional route poses severe and persistent risks to human health, safety, and the environment.

A transformative green alternative is the direct synthesis of carbamates from CO₂, amines, and alcohols



This atom-economical route not only valorizes a waste greenhouse gas but also eliminates the use of phosgene. Despite its immense potential, this reaction is hampered by significant scientific barriers: (i) thermodynamic equilibrium limitations due to water co-production, which caps the maximum achievable yield, and (ii) kinetic challenges that demand highly active and selective catalysts, which are often deactivated by the very water produced.

This project aims to develop a commercially viable and inherently safer process for carbamate synthesis by co-designing a robust catalyst and an intensified process. The project is structured around four primary objectives: a) to synthesize and optimize a water-tolerant, highly active heterogeneous catalyst for direct carbamate synthesis from CO₂, amines, and alcohols, with a focus on long-term stability and reusability, b) to elucidate the reaction mechanism and identify primary deactivation pathways using advanced in-situ spectroscopic techniques and kinetic analysis; c) to experimentally overcome thermodynamic equilibrium limitations by designing and testing an intensified reactor concept (e.g., reactive distillation) that continuously removes co-produced water, d) to develop a validated process model in Aspen Plus integrating intrinsic kinetics with reactor design, and perform techno-economic analysis and life cycle assessment to benchmark against the conventional phosgene route. A multi-scale integrated research framework for carbamate synthesis is shown below



Cooperation: Tohoku University, Nanjing Tech.

Aftertreatment catalysis for zero-carbon shipping by long-distance vessels

Main funding: EU H4PERION

Atte Aho, Kari Eränen, Dmitry Yu. Murzin

The aim of the EU project is to develop and demonstrate a safe, reliable and economically viable internal combustion engine (ICE) capable of running on the zero-carbon fuels hydrogen and biomethane, with the potential for up to 100% hydrogen operation, while retaining ICE robustness and operability. The engine will be demonstrated in an open-sea environment by deploying it on a large commercial vessel. In parallel, the project will also develop a modern fuel blending and supply system enabling flexible use of zero-carbon fuels, and a new exhaust aftertreatment approach for reducing emissions across all operating conditions. The project also produces multiple supporting outcomes, including scalability studies, training programs, and contributions to safety guidelines and regulatory development.

H4PERION brings together 16 partners from seven European countries, representing the maritime value chain from ship design and engine development to vessel operation, training, safety and academic research. In addition to the University of Vaasa and Wärtsilä, project partners include WEGEMT, NTUA, TalTech, the American Bureau of Shipping, Deltamarin, the University of Oulu, Åbo Akademi University, Meric Wave Computanics, DLR, BALance Technology Consulting, MEYER WERFT and Wasaline. Their combined expertise will help ensure that the technologies developed in the project can be brought into practical use quickly and safely.

The aim of our team is to develop and test the exhaust aftertreatment solutions.



Experimental set-up

We are focusing on development of monometallic and bimetallic Pt catalysts as well as nonprecious metals catalysts on various zeolitic supports. In particular, the effects of the cluster size, Pt/Pd ratio, metal nature, the zeolite type, silica to alumina ratio, crystal size, metal introduction and support preparation methods will be explored. Testing is done in lab-scale experiments in realistic $\text{H}_2\text{-CH}_4$ exhaust conditions.

Cooperation: University of Vaasa, University of Oulu, Wärtsilä

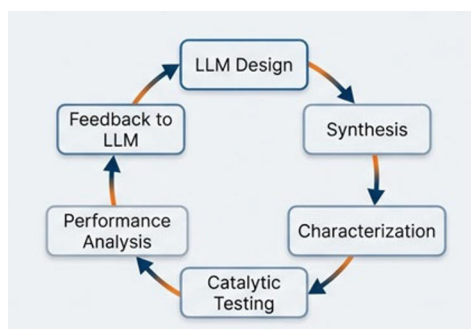
AI in development of catalytic materials

Main funding: Erasmus-Mundus IMATEC program

Wayne Korir, Atte Abo, Eeelis Ketola, Päivi Mäki-Arvela, Eugene Mourgine, Dmitry Yu. Murzin

The field of artificial intelligence has evolved from narrow statistical tools towards systems capable of general-purpose reasoning, a shift that requires precise distinctions between AI, machine learning, and large language models. Artificial intelligence (AI) broadly refers to computational systems designed to perform tasks requiring human intelligence, including perceiving, reasoning, learning, and planning. Machine learning (ML), a subfield of AI, encompasses statistical algorithms that learn patterns from data to generate predictions. Large language models (LLMs) are a specialised class of ML trained on massive bodies of text; through this training, they acquire the ability to comprehend and generate language and develop capabilities that extend beyond pattern recognition, including reasoning across disciplines and synthesising knowledge from unstructured text.

In this work we are not aiming to elucidate if AI can replace a chemist; instead, we explore how AI and the chemist can collaborate more effectively, and what happens when they do. The work is a demonstration grounded in an experimental case study documenting how a researcher works alongside an LLM at every stage of the catalyst development cycle, the problems that arise, and how they are managed. The primary contribution of this work is a documented end-to-end LLM-assisted catalyst design workflow that integrates AI-driven reasoning across the full development lifecycle with human execution authority and formalised expert oversight. The workflow includes a feedback loop in which catalyst characterisation data and experimental results are fed back into the LLM to inform iterative redesign.



The secondary contribution is experimental: the catalyst synthesis, characterisation, and catalytic testing of candidates generated by the workflow, using CO₂-to-DME conversion as the case study through which the methodology is demonstrated and evaluated.

Beyond the workflow itself, this project makes several specific methodological contributions. First, it introduces a tiered, risk-stratified approach to recipe generation that organises catalyst candidates by novelty and the synthesis risk, a structure absent from prior AI-assisted catalysis workflows. Second, it provides systematic documentation of operational failure modes encountered during workflow execution, an aspect of AI-assisted research that the literature consistently under-reports. Third, it proposes repeated prompting with convergence assessment as a designed protocol for managing non-determinism in LLM outputs, though formal validation of this approach remains future work. Like all first demonstrations, this work is limited to one reaction system, one model family, and one research group's experience of running the workflow. The value lies not in its generality but rather in the transparency and completeness of what it reports.

Conceptualization of Biomass-based Materials for Environmental and Energy Storage Systems (Bio-Adsorb&Energy)

Main funding: Research Council of Finland, Åbo Akademi

Glaydson Simoes dos Reis, Najeeb ur Rehman Lashari

The use of biomass for the production of sustainable multi-functional materials for environmental and energy storage systems is environmentally and economically advantageous. In a Finnish context, forest industry by-products constitute a large raw material resource, which, if it can be used in high-value production systems, is of great economic/environmental/scientific importance. This project approaches the idea of efficient and targeted utilization of forest industry side-streams for the production of valuable, sustainable and greener materials for water decontamination and energy storage systems. The implementation is characterized by a systematic approach through a comprehensive analysis program (raw material characteristics and composition, structured biobased carbon material properties and water decontamination/electrochemical performances), and a model and simulation building that can provide fundamental data for future studies, and has a clear goal to identify the production paths in the form of raw material and process combinations with the highest potential for producing high-performance materials for water decontamination and energy storage applications.

From biomass, two types of carbon structures can be produced using different thermochemical treatments, crystalline carbon (graphitic) and amorphous carbon (non-graphitic hard and soft carbons) (**Figure 1**). However, the current state-of-the-art presents many large gaps between methods to produce different carbon materials from biomasses and how their properties are connected to the resulting carbon performances in adsorbing pollutants from waters, as well as used as electrodes in batteries and supercapacitors. This research project intends to tackle this gap by explicitly focusing on the minute correlation of soft and hard carbon properties and the resulting material properties/performances on the intended end application. Another important gap that international literature faces is how soft and hard carbon structures are formed from the same starting biomass precursor regardless of synthesis preparation. This project will deeply address this gap by focusing on aspects related to biomass type and composition that are properties that influence the soft and hard carbon structures together with the heating process and activation.

Figure 1a shows the basic structure of Graphite, soft, and hard carbons. Hard carbons are extensively studied for application as anode materials in sodium-ion batteries, but only recently a great interest has been focused on the understanding of the sodium storage mechanism and the comprehension of the structure–function correlation. In contrast, soft carbons are more suitable for lithium-ion batteries as well as supercapacitors. For adsorption applications, there are no representative works dedicated to the influence of soft and hard carbons regarding their adsorptive performances and we will be the first ones to study the application of soft and hard carbons on the removal of pollutants from polluted waste waters and how their microstructures and physicochemical properties are correlated to their performances.

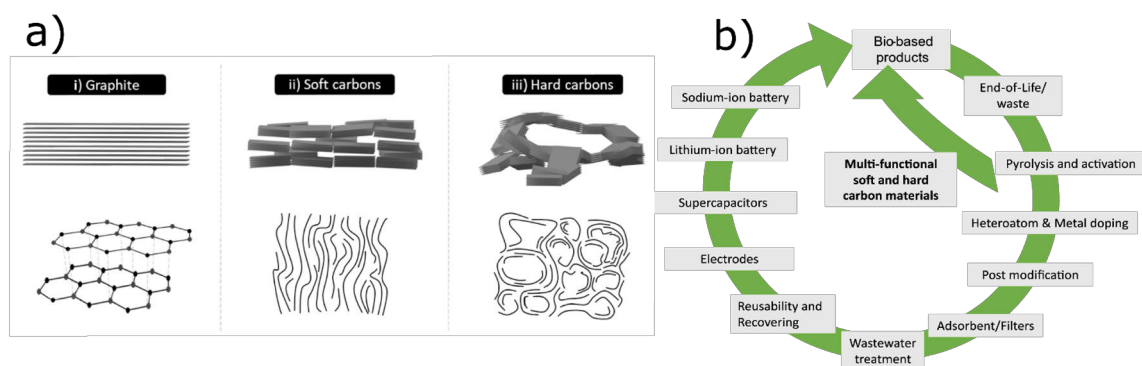


Figure 1 a) Basic structure of Graphite, soft, and hard carbons; b) Project concept's scheme.

What particularly distinguishes the project, is the systematic way of working, the strong industrial connection, the combined competence among the project partners and the specific focus on raw materials with high relevance to the Finnish society and industry. Moreover, this project is also expected to improve the knowledge of the chemistry of biomass-derived carbon anodes: how the pyrolysis conditions and impregnation methods can affect the electrochemical capacity of SCs and batteries. Therefore, there are several areas in which scientific breakthroughs can be achieved with the penultimate project goal to enable forest residuals in modern-day SCs/batteries while improving the energy density, safety, and life expectancy of biomass-based energy devices.

Advancing chemical-looping combustion of domestic fuels (ACLOUD)

Main funding: EU (CETP), Business Finland, Swedish Energy Agency, and Forschungszentrum Jülich GmbH (BMWK) - FZJ/PtJ

Patrik Yrjas, Emil Vainio, Maria Zevenhoven, Jonne Niemi, Aiman Fatima, Topias Mannisto, Edward Efratuei, Francisca Onuoka, Jaana Paananen, Leena Hupa, Daniel Lindberg

ACLOUD develops climate-negative solutions by rational and efficient methods for the utilisation of waste-derived fuels and biomass, in a process with inherent CO_2 capture. The process is called chemical-looping combustion (CLC), which is a Fluidised Bed Combustion (FBC) technology that avoids the mixing of fuel and air. This achieves:

- Inherent CO_2 capture - as the produced CO_2 is not diluted by N_2 .
- Milder corrosion conditions - as ash species are separated from heat-transferring surfaces in the air reactor.

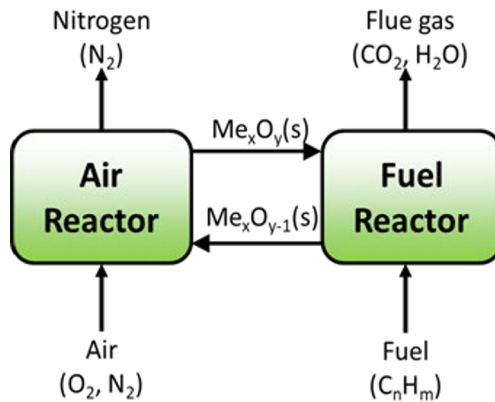


Figure 1. Chemical-Looping Combustion (CLC)

Me_xO_y = oxidised oxygen carrier, $\text{Me}_x\text{O}_{y-1}$ = reduced oxygen carrier.

The project is realised in six work packages (Figure 2).

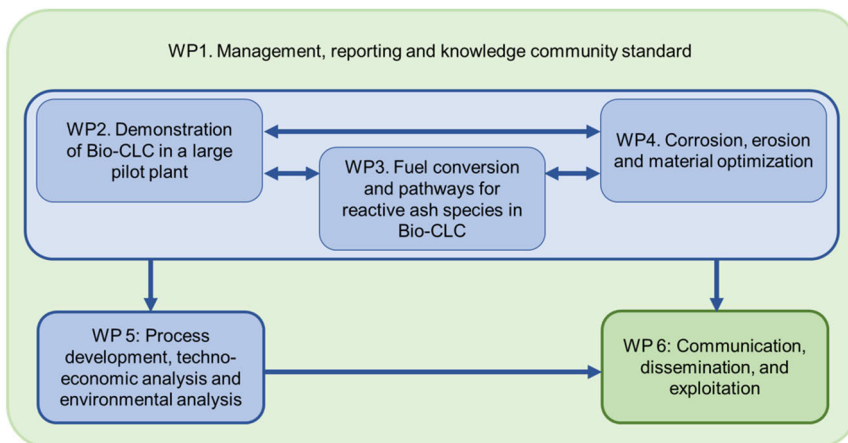


Figure 2. The ACLOUD project work package structure.

Although the project includes dedicated efforts on life-cycle assessment (LCA) and techno-economic analysis (TEA), the research is mainly experimentally oriented and involves:

- Corrosion and material studies.
- Ash chemistry and alkali measurements.
- CLC demonstration in a larger pilot (1 MW).
- CLC development in a smaller pilot (10 kW).
- Process, impact and environmental studies.

Åbo Akademi is mainly involved in work packages 2 and 4. WP4 involves laboratory work on material degradation (corrosion and erosion) and thermodynamic modelling, while WP2 involves a measurement campaign in the 1 MW CLC pilot plant (Figure 3) at the Tech. Uni. Darmstadt.

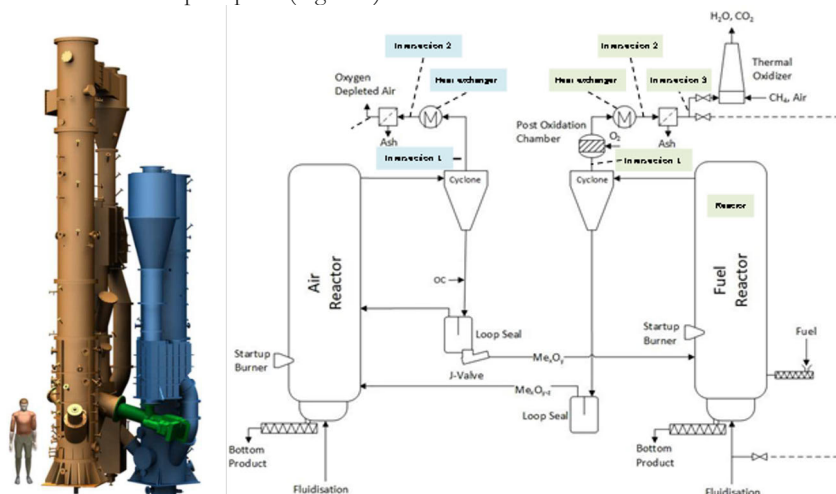


Figure 3. The 1 MW CLC pilot plant at the Techn. Uni. Darmstadt.

Cooperation: Chalmers (Sweden, coordinator), Åbo Akademi (Finland), Technical University of Darmstadt (Germany), Sumitomo SHI FW Energia Oy (Finland), Alleima Ab (Sweden), CheMin GmbH (Germany), Stockholm Exergi (Sweden), Skövde Energi (Sweden), RISE - Research Institute of Sweden (Sweden)

Clean and efficient utilization of demanding fuels (CLUE)

Main funding: ANDRITZ, UPM-Kymmene, Metsä Fibre, International Paper, Valmet Technologies, Graduate School at Åbo Akademi, PostDocs in Companies Program, Finnish Recovery Boiler Committee, Svenska Kulturfonden

Meberetu Dirbeba, Markus Engblom, Jan-Erik Eriksson, Rasmus Fagerlund, Leena Hupa, Mikko Hupa, Farzad Jafaribonar, Thomas Kronqvist, Tor Laurén, Juba Lehmusto, Amirreza Mottaghitalab, Jonne Niemi, Viswamoorthy Raju, Alessandro Ruozzi, Paulo Santochi Pereira da Silva, Ali PourghasemiHanza, Daniel Schmid, Emil Vainio, Johan Werkelin, Patrik Yrjas, Maria Zevenhoven

CLUE is an industry-academia consortium project that covers several research topics connected to the conversion of renewable and challenging fuels to energy (Figure 1). The current consortium period CLUE 2023-2025 continues the long-term academia-industry collaboration between Åbo Akademi and the CLUE companies. The research within the project is industrially relevant and based on a fundamental understanding of detailed chemistry. Low-grade biomasses and waste-derived fuels bring challenges to process design and operation. The work aims to provide industry with better tools to handle the impacts of fuel impurities, minimize fouling and corrosion, meet tightening emission limits, and find new approaches to the utilization of ashes and other waste streams. Research methods include laboratory experiments and analyses, full-scale boiler measurements, and mathematical modeling. The work is carried out in close collaboration with industry.

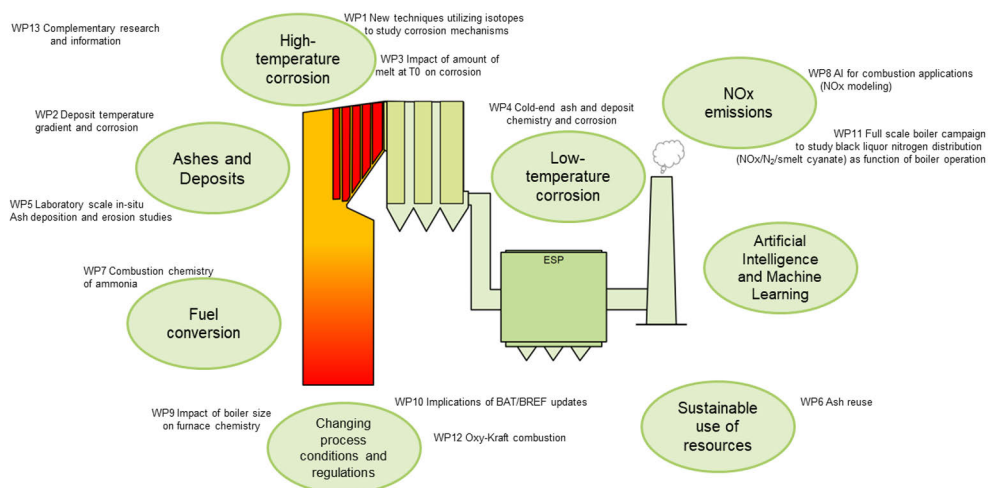


Figure 1. CLUE 2023-2025 research topics and work packages

Cooperation: Aalto University, University of Toronto (Canada)

Properties and behavior of deliquescent salts and deposits in biomass and waste thermal conversion – Towards improved efficiency and reliability

Main funding: Research Council of Finland

Emil Vainio (PI), Alessandro Ruozzi, Farzad Jafaribonar, Leena Hupa

Clean and efficient utilization of biomass and waste fuels as energy sources for the production of heat and electricity is of great importance. Utilizing biomass and waste streams for energy production is one alternative for reducing the use of fossil fuels and increasing self-sufficiency in energy. Biomass based fuels are the most important renewable fuels in Finland. In 2022, 68% of the renewable energy and 29% of the total energy consumption in Finland originated from biomass (stat.fi). Biomass conversion for the production of heat and electricity is conducted in large industrial combustors, such as fluidized bed boilers, black liquor recovery boilers, biomass gasifiers, and grate-fired boilers. Research and development of these technologies have been of great importance for Finnish industry, since many of the boiler manufacturers and developers have activities in Finland.

The qualities and properties of different biomasses vary a lot, and the ash forming elements may lead to several challenges in their use. The ash forming elements can form hygroscopic and corrosive deposits in the cold-end of power boilers. Recently, it has been shown that challenges related to corrosion and operational issues in the cold-end, e.g., deposit build-up, decrease in heat transfer, corrosion in various parts, and plugging of flue gas cleaning equipment, are mainly caused by hygroscopic salts and deposits. These challenges are mainly related to chlorine rather than sulfur chemistry (Figure 1).

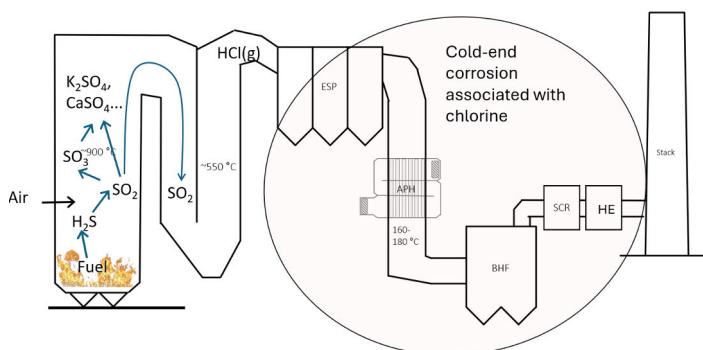


Figure 1. Challenges and corrosion in the cold-end of industrial boilers caused by the presence of $HCl(g)$ and the formation of hygroscopic and deliquescent salts/deposits rather than sulfuric acid induced corrosion.

In the research, innovative solutions were developed to improve energy efficiency while avoiding operational challenges and corrosion in thermal conversion of sustainable biomass and waste fuels. This research explained the properties, formation, behavior of hygroscopic salts and deposits, and determined their influence on corrosion and operational performance. Based on this, new understanding of the formation of hygroscopic salts was gained, the lower limits of heat exchangers for various fuels mapped, and new strategies for preventing corrosion and deposit build-up were developed. Understanding the root cause is key when devising viable strategies to avoid problems related to corrosion and deposit build-up while improving efficiency.

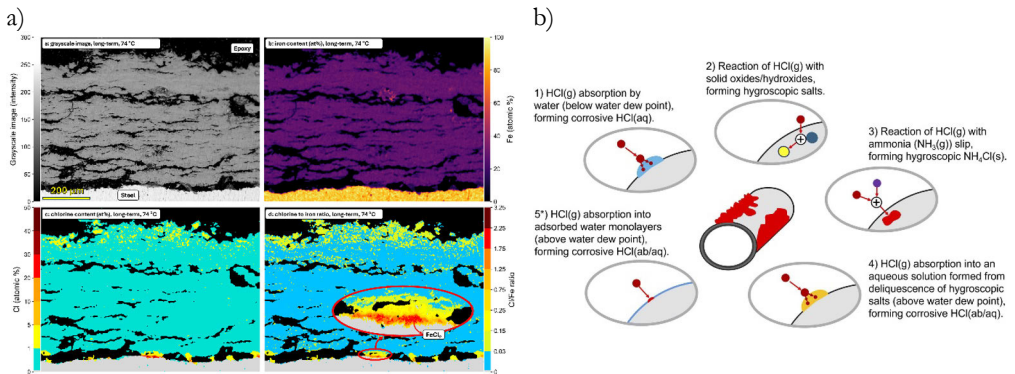


Figure 2. a) Formation FeCl_2 in the cold-end of a BFB boiler firing biomass and waste. b) HCl -induced corrosion mechanisms. (Jafaribonar et al. Corrosion Science 2026)

Cooperation: Valmet Technologies Oy, Andritz Oy, Sumitomo FW SHI Energia Oy, University of Toronto

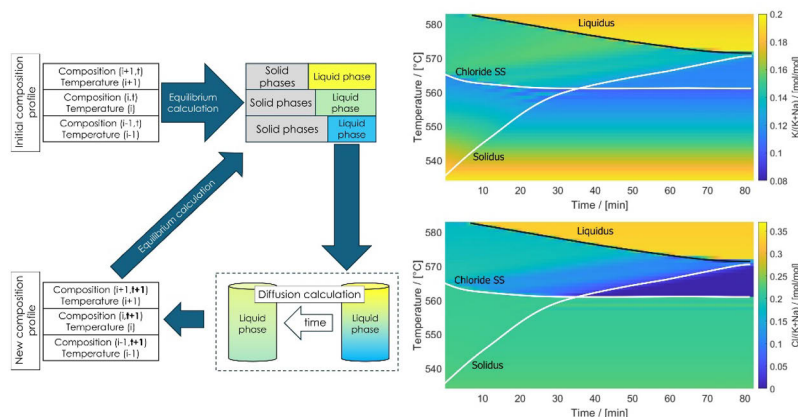
New insights on the effects of temperature gradients on high-temperature corrosion

Main funding: Research Council of Finland

Jonne Niemi (PI), Roland Balint, Juho Lehmusto, Markus Engholm, Daniel Lindberg

Heat and power boilers firing low-grade fuels, such as biomass and waste, frequently suffer from severe fouling and slagging on heat exchanger surfaces. Ash deposits in these systems often contain high concentrations of alkali and heavy-metal salts that accelerate corrosion and degrade heat exchanger materials. While the influence of temperature gradients on deposit chemistry and corrosion has been recognized previously, the underlying mechanisms have remained largely elusive. This project resolved these mechanisms by investigating the coupled effects of thermal gradients on deposit aging, corrosion product formation, and alloy degradation through laboratory exposures integrated with mathematical modelling. Together, the experimental and computational findings provide deeper insight into the fundamental physical and chemical phenomena governing intra-deposit mass transport.

A key achievement of the project is a new modelling framework developed to predict the redistribution and enrichment of potassium (K) and chlorine (Cl) via melt percolation in kraft recovery boiler deposits. The approach couples thermodynamic phase equilibrium calculations with mass transfer inside an iterative calculation loop. Model predictions show strong agreement with compositional profiles from operating boiler deposits, clarifying the driving forces behind melt migration and deposit sintering. Applying this model yields significantly more accurate estimates of local first-melting temperatures, providing an engineering basis to optimize material selection and steam parameters in current and future boilers. In addition, the project successfully modelled Temperature Gradient Zone Melting (TGZM)-type melt migration within the reciprocal K–Na–Cl–SO₄ system, establishing a quantitative understanding of dynamic salt transport under steep thermal gradients.



Schematic of the iterative calculation loop and the resulting time-dependent K and Cl concentration profiles across a thermal gradient. [Niemi et al. 2025]

Cooperation: Aalto University, Hokkaido University (Japan)

Initiation and propagation of high-temperature corrosion reactions in complex oxygen-containing environments

Main funding: Research Council of Finland

Roland Balint, Juho Lehmusto, Ali PourghasemiHanzga

Growing interest in technologies based on the use of more sustainable and ecological fuels, such as waste-derived fuels and biomass, necessitates improved power production efficiencies through higher operation temperatures. So far, the main obstacle to increasing the temperatures when using the aforementioned fuels has been their corrosivity, which leads to material degradation. To decipher the current challenges, factors initiating and sustaining high-temperature corrosion have to be identified, and their influence understood better. The objective of this project is to complement high-temperature corrosion mechanisms by providing new and unique information on separate steps of corrosion and ultimately, link these steps to a coherent description of high-temperature corrosion processes. Research questions related to high-temperature corrosion will be addressed with entirely new approaches, such as positron emission tomography (PET); collinear photofragmentation and atomic absorption spectroscopy (CPFAAS) coupled with an ultra-high-speed camera, and high-temperature electrochemical measurements (Figure 1). These novel methods, together with studies involving both stable and radioactive isotopes, will provide valuable information regarding, for example, intra-deposit diffusion, the role of various oxygen-bearing species in high-temperature corrosion, and gas-phase chemistry and kinetics of high-temperature corrosion reactions.

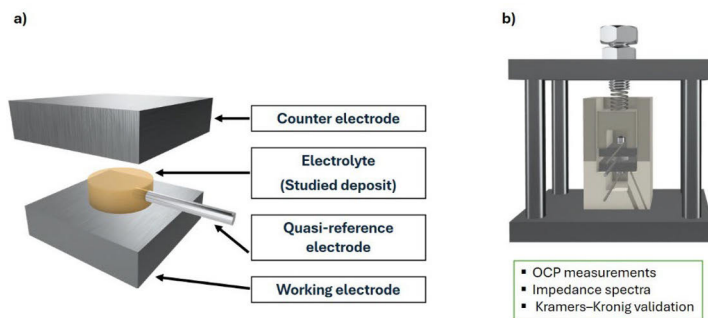


Figure 1. Schematic illustration of the design developed for monitoring the high-temperature melting behavior of a chemically complex synthetic deposit. The electrochemical circuit consists of inert electrodes, while the studied deposit acts as a solid electrolyte (a). The circuit is mounted to a non-conductive rig, placed in a furnace. The setup enables in-situ measurements, allowing real-time detection of, for example, the first melting temperature of the deposit or the initiation of corrosion.

On a general level, the outcome of the project is expected to manifest itself in novel technical solutions regarding materials for increased power production efficiency in various industrial applications, profiting both scientific and societal communities. For the scientific community, the key deliverables are 1) a more comprehensive understanding of high-temperature phenomena through the utilization of isotopic tracers and 2) the introduction of new combinatorial methods to study socially relevant issues on thermal energy conversion from a completely new perspective. From a societal point of view, the value of the project lies in the possibility of enhancing power production efficiency, increasing the use of sustainable fuels, and lowering plant maintenance costs through a reduced need for shutdown and cleaning procedures. This would partly answer the incremental power demand without proposing more voluminous use of carbon-based fuels.

Cooperation: Bundesanstalt für Materialforschung und -prüfung (Germany), Oak Ridge National Laboratory (USA), Tampere University

Intelligent medical devices for global market (IMD1)

Main funding: Business Finland, Åbo Akademi, Svenska Kulturfonden

Minna Siekkinen, Polina Sinitsyna, Adrian Stiller, Emma Lillsund, Denise Eriksson, Markus Rosenblad, Mikael Bergelin, Markus Engblom, Emil Vainio, Daniel Lindberg, Leena Hupa

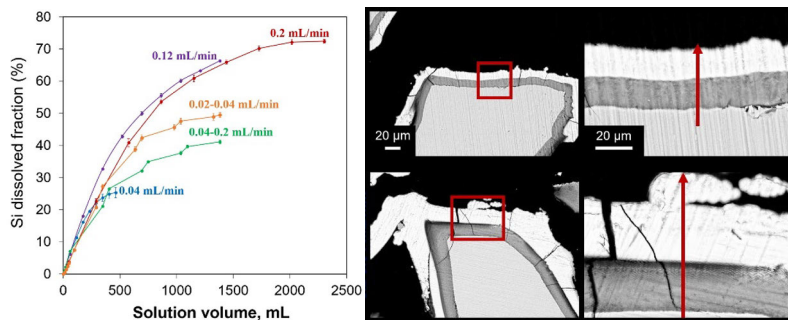
This Business Finland Co-Innovation project develops intelligent multifunctional biomaterials for personalized medical devices. The research combines bio-based materials, bioactive glasses, and biodegradable metals to create advanced implant solutions with tailored biological and mechanical performance. Several complementary projects funded by Svenska Kulturfonden have supported the research.

At Åbo Akademi, the research focuses on understanding the degradation and biomineralization mechanisms of bioactive-glass, biodegradable-metal, and composite implants. Particular emphasis has been placed on developing manufacturing methods for producing bioactive glasses as microspheres, porous implants, and fibres for biomedical applications.

We have also developed microreactor platforms for studying degradation and biomineralization under dynamic conditions that better mimic the physiological environment. By combining experimental methods with chemical engineering and modelling approaches, we quantify ion-release kinetics and establish links between material composition, processing, degradation behaviour, and biological response.

These insights provide the scientific basis for tailoring biomaterials and manufacturing processes, enabling medical devices with predictable performance, controlled degradation, and application-specific functionality.

The figure illustrates how different flow conditions affect Si release from bioactive glass S53P4 particles in a microreactor over 192 h. Constant flow resulted in the highest Si release, whereas varying flow rates slowed dissolution. The observed differences were linked to the formation of a hydroxyapatite layer that retards dissolution, as shown in the SEM cross-sections.



Influence of dynamic flow conditions on Si dissolution from bioactive glass S53P4 in simulated body fluid (left) and SEM cross-sections showing the formation of silica-rich and hydroxyapatite surface layers after 192 h of exposure (right). Adapted from Sinitsyna, et al., Journal of Non-Crystalline Solids (2026).

Cooperation: University of Turku, Aalto University, University of Helsinki, Bonalive, StickTech, Mirka, Bioretec, KiiTo and CH-Bioforce (Finland); Friedrich Schiller University Jena and Friedrich-Alexander University Erlangen-Nürnberg (Germany), University of Amsterdam, Maastricht University (the Netherlands).

Oxy-Kraft recovery boiler - Towards novel integrated green energy parks (Oxy-Kraft RB)

Main funding: EU (CETP), Business Finland, Swedish Energy Agency, and Agencia Estatal de Investigación

Patrik Yrjas, Emil Vainio, Markus Engblom, Rasmus Fagerlund, Aiman Fatima, Sara Hagman, Leena Huhta, Luis Beçerra

In pulp production, a pre-product for, e.g. cardboard and paper, a by-product called ‘black liquor’ (BL) is produced. The BL is utilised in Kraft recovery boilers (RB), which are multipurpose units, as they generate both electricity and heat while recovering the pulping chemicals (Na and S). The RB is critical for the feasibility of the process. Yearly, about 700 boilers burn around 220 million tonnes of BL, which is the largest biomass-based energy source in the world. This project aims to pave the road to the operation of Kraft recovery boilers in oxy-combustion mode. Oxy-combustion is a known technology to concentrate CO₂ for further capture; however, applying oxy-combustion in Kraft recovery boilers has, so far, not been studied. The Kraft recovery boiler is an extremely complex device, with the recovery of pulping chemicals as an essential part of the boiler design and operation. In this project, we explore in detail the technical and economic feasibility of such a technology.

By changing the operation of a Kraft recovery boiler to oxy-combustion, several processes will be affected in the boiler; e.g., to recover the chemicals in the right form, any changes in the chemical recovery process and the sulphur reduction in the bed have to be carefully studied. In addition, operational issues may change, such as the liquor feed into the boiler. The liquor spray and the droplet size are of importance for the operation of the process to minimise fuming and carryover (escape of droplets and chemicals to the freeboard and further) and to keep a steady char bed at the boiler bottom. Changes in carryover and fume chemistry will induce changes in the heat exchanger corrosion behaviour, which directly mirrors back on the boiler availability and thus on the economy of the whole pulp mill. Further, any process changes can cause changes to critical gaseous emissions (NO_x and SO_x) that must be controlled. A detailed understanding of the potential changes in these processes is crucial when devising new design and operation solutions for the novel Oxy-Kraft process.

An Oxy-Kraft recovery boiler would allow for the utilisation of integrated green technologies, such as bioenergy with carbon capture and storage (BECCS) or bioenergy with carbon capture and use (BECCU), liquid biofuel production, green ammonia production in combination with the oxygen separation process, and smart/dynamic usage of the bioenergy depending on the energy market. The total fossil CO₂ emissions in Finland were around 37 million tonnes in 2025. Consequently, capture and storage of all black liquor flue gas CO₂ produced in Finland would compensate for a decrease in total fossil CO₂ emissions by about 40%-50% just with a single technology. An average-size recovery boiler in Finland burns 1.0 million tonnes of dry black liquor per year. Capturing the CO₂ from ONE average Finnish recovery boiler (1.32 Mt CO₂/year) equals roughly the emissions caused by about 250 000 Finns (5.3 tonne/capita and year, 2024). This carbon capture would, in fact, be a net negative emission, as the carbon in black liquor is biogenic. This would greatly support the EU’s commitment to net-zero greenhouse gas emissions by 2050.

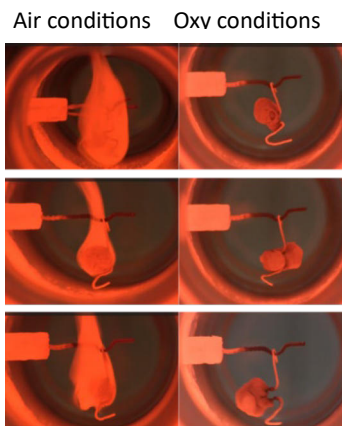


Figure 1. Photos from the char-burning stage of three qualities of black liquor at 900 °C. Fume formation is detected under air combustion conditions, while there is essentially no fume formation under oxy-combustion conditions. Uppermost: Spanish liquor; middle: Nordic liquor; lowest: American liquor.



Figure 2. Oxy-Kraft presenters at the International Chemical Recovery Conference (ICRC) in Toronto, 2025. Front row, from left: Sara Hagman (ÅA), Emil Vainio (ÅA), and Aiman Fatima (ÅA). Back row, from left: Michael Greencorn (KTH), Patrik Yrjas (ÅA), Fernando Leo (Uni. Zaragoza), Rasmus Fagerlund (ÅA), and Markus Engblom (ÅA). The next ICRC will be arranged by ÅA in Turku in 2028.

Cooperation: Åbo Akademi (Finland, coordinator), KTH Royal Institute of Technology (Sweden), University of Zaragoza (Spain), Valmet Oy (Finland), Valmet Ab (Sweden), ANDRITZ Oy (Finland), International Paper Inc. (USA)

From waste to value – recycling mineral side streams (REMIS)

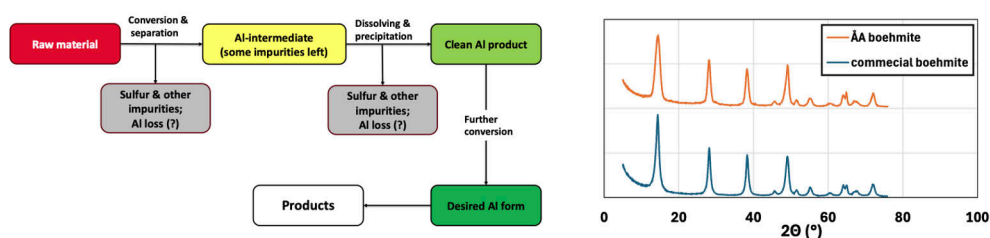
Main funding: Business Finland, Åbo Akademi

Thomas Kronberg, Jan-Erik Eriksson, Daniel Schmid, Johan Werkelin, Ali Hasnain, Edwin Okafor, Jan-Henrik Smått, Tan Phat Huynh, Bastian Drapchoen, Waji Kiani, Evelina Koivisto, Nico Häggqvist, Ron Zevenhoven, Cataldo de Blasio, Sharma Urvi, Daniel Lindberg, Leena Huja

The REMIS project addresses a major sustainability challenge: the underutilization of mineral waste generated by the construction sector and aluminium industry. Large volumes of these materials are currently disposed of despite containing valuable resources that could replace virgin raw materials in industrial applications. REMIS aims to develop sustainable value chains that transform mineral waste into useful secondary raw materials and high-value products.

The project investigates both bulk and advanced applications for mineral side streams. Construction-related mineral residues can be incorporated into building materials, while purified aluminium-based side streams are being developed for higher-value applications, including ceramic abrasive grains, supplementary cementitious materials and advanced 3D-printed products. By evaluating the entire value chain, from material collection and characterization to processing and end-use applications, REMIS seeks to identify solutions that are technically feasible, environmentally beneficial and economically competitive. By creating new value from industrial and construction side streams, REMIS contributes to reducing waste generation, decreasing the consumption of virgin raw materials and advancing Finland's transition towards a circular and resource-efficient economy.

A key research focus at the HTPM group during the reporting period has been the valorisation of aluminium anodization waste. This waste stream contains significant amounts of aluminium compounds but also impurities that must be removed before further processing. Purification routes to convert the waste into boehmite, a valuable aluminium oxyhydroxide widely used as a precursor for advanced ceramic materials, were developed and evaluated. Particular attention was given to removing residual sodium and sulfur compounds that can negatively affect subsequent processing and product quality. Especially the sulfur cannot be removed with traditional cleaning routes. The newly developed purification strategy has yielded promising results. XRD measurements, as well as other characterization methods such as FTIR, NMR and SEM-EDS, show strong agreement of the ÅA boehmite with commercial boehmite, also regarding morphology and purity. The purified material can serve as a feedstock for sol-gel processing, additive manufacturing and thermal treatment routes aimed at producing value-added ceramic products.



Processing route for purification of aluminium anodization waste into boehmite suitable for advanced ceramic processing. The XRD spectrum of the purified product shows close correspondence with commercial grade boehmite, indicating successful removal of critical impurities and suitability for further valorisation (Daniel Schmid).

Cooperation: University of Oulu, Mirka, Paroc, Vektorio, Levanto, Kierto Ympäristöpalvelut, Suomen Erityisjäte, (Finland), University of Cardiff (UK), Aarhus University (Denmark)

The use of domestic clay as a sustainable building material (SARA)

Main funding: European Regional Development Fund (ERDF) as part of the EU regional and structural policy funds 2021-2027

Thomas Kronberg, Jan-Erik Eriksson, Johan Werkelin, Leena Hupa

The SARA project explored new ways to utilise the large volumes of clay excavated from construction and civil engineering projects in Finland. Instead of treating surplus clay as waste and transporting it to landfills or other disposal sites, the project investigated how locally available, previously deposited clay masses could be characterised, processed and incorporated into new products and construction applications. The work aimed to support the transition towards a more circular use of materials by replacing virgin raw materials with locally available secondary resources.

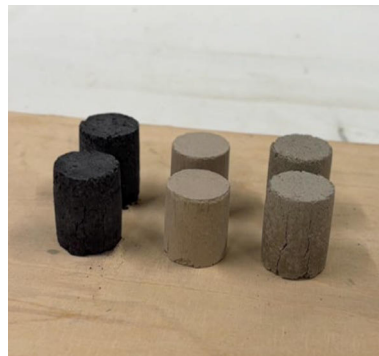
A particular focus was on developing unfired clay products, including tiles and bricks suitable for construction applications. Avoiding firing can significantly reduce the energy demand associated with clay-based products. The project also investigated recycled and renewable additives, including textile fibres, natural fibres and fibrous waste streams from the forest industry, to improve the mechanical performance of unfired clay products while simultaneously increasing the utilisation of other waste streams.

The project also addressed the potential of using surplus clay in larger-scale infrastructure applications. Excavated clay has traditionally been used, for example, in noise barriers and ground stabilisation. SARA investigated the use in broader applications, including flood protection structures and other prefabricated construction elements. In these applications, industrial by-products such as ashes and slags were considered as potential alternatives to conventional cement, further reducing the reliance on virgin materials and supporting resource-efficient construction.

A key outcome of SARA was the generation of new knowledge on the characterisation, processing and practical utilisation of domestic clay resources. The results provide a basis for companies and other stakeholders to develop new products, applications and green-growth business opportunities based on locally available clay and other secondary material streams. More broadly, the project demonstrated how materials currently regarded as surplus or waste can be brought back into productive use alongside, or as substitutes for, virgin natural resources.



Clay sampling



Compressed earth blocks

Towards carbon-neutral metals 2 (TOCANEM2)

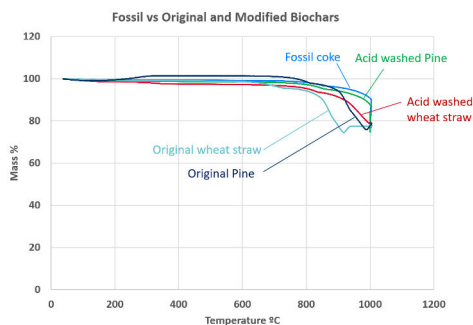
Main funding: Business Finland, Åbo Akademi University

Johanna Clayhills, Markus Engblom, Juho Lehmusto, Jonne Niemi, Emil Vainio, Kent Bergman, Daniel Lindberg, Leena Hupa

Åbo Akademi contributes to three research tasks within the Business Finland Co-Innovation project Towards Carbon-Neutral Metals 2 (TOCANEM2). The activities focus on: (1) characterization and pre-treatment of biomasses for metallurgical biocarbon production, (2) refractory degradation mechanisms in direct reduced iron (DRI) smelting furnaces, and (3) removal of impurities from complex raw materials and industrial side streams. Although the three tasks address different scientific and technological challenges, they share the common goal of enabling low-carbon metal production. The work is closely integrated with activities carried out by the project's industrial partners and collaborating universities.

Characterization and pre-treatment of biomasses for metallurgical biocarbon

Modified biomasses were produced by removing ash-forming elements through leaching treatments. In addition, selected biomasses were doped with potassium to investigate its effect on char reactivity. Biochars produced from the modified feedstocks were characterized through thermogravimetric analysis, providing new insights into the role of ash-forming elements in controlling biochar reactivity. A particularly significant finding was that biochar produced from leached pine exhibited a reactivity comparable to that of fossil coke, highlighting its potential as a sustainable metallurgical reductant.

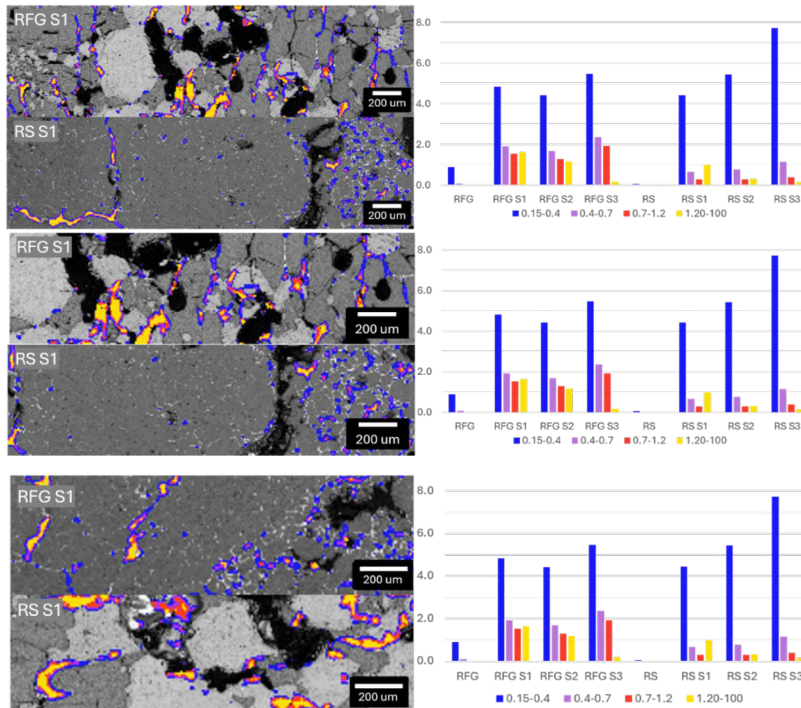


TGA mass curves showing effect of biomass pre-treatment on biochar reactivity. The lower the temperature at which significant mass loss occurs, the higher the char reactivity. Leaching of pine biomass reduced the influence of ash-forming elements and produced a biochar with reactivity characteristics approaching those of fossil coke.

Main refractory degradation mechanisms in DRI smelting furnaces

The influence of slag- and gas-phase species on refractory degradation in a pilot-scale DRI smelting furnace has been investigated and compared with laboratory-scale experiments using synthetic slags. The work aims to identify the species responsible for refractory wear, establish the dominant degradation mechanisms, and support the selection of more durable refractory materials. A major development during the project has been the creation of an in-house computational tool based on SEM-EDS analyses, enabling quantitative assessment of slag-refractory interactions.

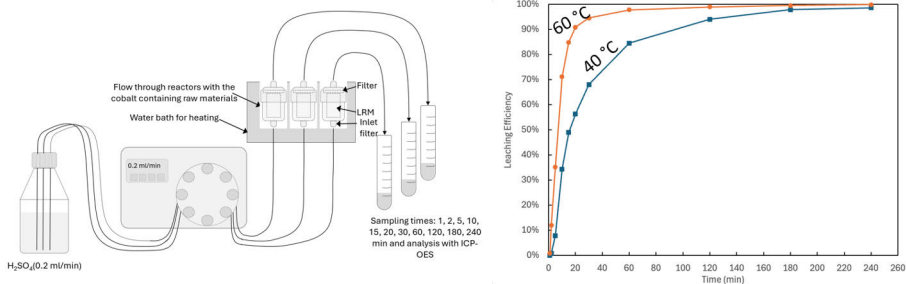
Quantitative analysis of slag-refractory interactions has improved understanding of the mechanisms responsible for refractory wear and identified opportunities to optimise slag chemistry, refractory selection, and furnace operation. Future work will focus on validating the findings through comparison of laboratory and pilot-scale experiments.



Si/Mg ratio before and after slag exposure in slag cups in magnesia-chromite (RFG) and magnesia (RS) refractories with three different slags.

Dissolution kinetics and modelling of challenging recycled materials using laboratory experiments

Studies on the purification of industrial side streams have been conducted using laboratory reactors designed in-house. The work has focused on sulfate removal from metal-bearing sludges and the recovery of valuable metals such as copper, nickel, and cobalt from complex secondary resources. The effects of key processing variables, including leaching conditions and reactor operation parameters, have been evaluated to optimize impurity removal and maximize resource recovery. The results contribute to the development of more circular and sustainable routes for metal production.



Leaching setup using flow-through reactors (left). Effect of temperature on cobalt leaching efficiency from industrial side streams (right).

Cooperation: University of Oulu, Aalto University, VTT Technical Research Centre of Finland Ltd, Metso Metals Oy, Fortum Battery Recycling Oy, Jervois Finland Oy.

Substituent Migration in Glycans: From Molecular Mechanism to Molecular Recognition

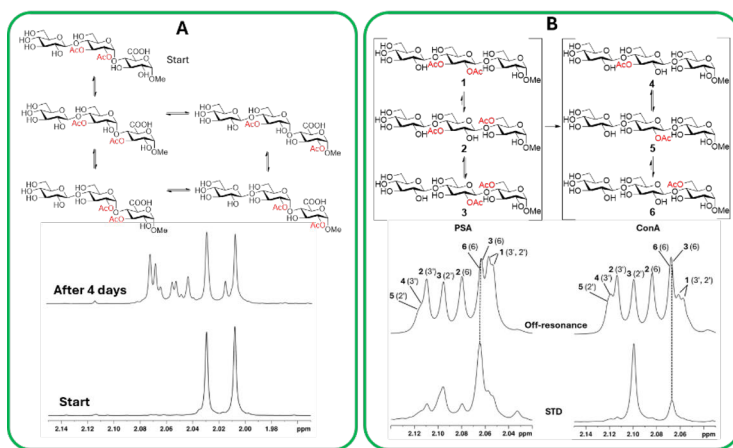
Robert Laszfolk

Carbohydrate-based vaccines have become important tools for preventing infectious diseases and are increasingly being explored for new therapeutic applications. These vaccines rely on specific carbohydrate structures, known as glycans, to trigger protective immune responses. Traditionally, glycans have been viewed as static molecules with fixed chemical structures. However, recent findings from our research suggest that some chemical groups attached to glycans can migrate within and even between sugar units, generating previously unrecognised structural diversity.

This project investigates how such substituent rearrangements influence the structure and function of vaccine-relevant carbohydrates. Building on our discovery that acetyl groups can migrate across glycosidic linkages in complex carbohydrates, we will explore whether similar processes occur in glycans used in vaccines and other biomedical applications. We will also examine whether phosphoryl groups, which are important components of many bacterial carbohydrate antigens, exhibit comparable behaviour.

By combining synthetic chemistry, advanced spectroscopy, computational modelling, and biological studies, we aim to determine when these structural changes occur, what drives them, and how they affect immune recognition. The results will provide fundamental insights into glycan structural dynamics and may challenge the conventional view of vaccine carbohydrates as single, well-defined molecular entities.

In the long term, this research will improve our understanding of carbohydrate structure and function and contribute to the development of safer, more effective, and more predictable carbohydrate-based vaccines and therapeutics.



A) Migration in *Streptococcus pneumoniae* type 9V model compound under optimal acetyl group migration conditions; B) STD of the glucotrisaccharide with the proteins PSA and ConA after migration occurred

Cooperation: CIC bioGUNE (Spain), University of Zaragoza (Spain), Tampere University (Finland)

5. PCC publications and reports 1.1.2024-31.12.2024

5.1 Theses 2024

5.1.1 Doctoral Theses

1. *Balint Roland*, Impacts of time and temperature gradient on the morphology and chemical composition of superheater ash deposits
2. *Cogliano, Tommaso*, Vegetable oils epoxidation: from batch to continuous process, *Acta technologiae chemicae Aboensia* 2023 A/4 ISSN 2669-8315 (double degree with Università di Napoli 'Federico II')
3. *Hachbach, Monad*, Development of new technologies for valorization of forest resources – from molecules to plant, *Acta technologiae chemicae Aboensia* 2024 A/2 ISSN 2669-8315
4. *Hmoudab, Maryam*, Innovative materials for water purification, (double degree with Università di Napoli 'Federico II'), *Acta technologiae chemicae Aboensia* 2024 A/1 ISSN 2669-8315
5. *Koppolu, Rajesh*, High-throughput Processing of Nanocelluloses into Barrier Coatings
6. *Liu, Rui*, Heterogeneity of Softwood Kraft Lignin: Effects on Fractionation and Nanoparticles Formation
7. *Lund, Sara*, From exfoliation of graphite to graphene-based electrodes for a biophotoelectrochemical application
8. *Martinez Klimov, Mark*, Hydrodeoxygenation of lignin-derived model compound for sustainable aviation fuel production using bifunctional catalysts, *Acta technologiae chemicae Aboensia* 2023 A/5 ISSN 2669-8315
9. *Mattsson, Ida*, Smart Materials from Sweet Molecules : Exploration of Monosaccharide-Derived Polyols in Material Applications
10. *Ona, Jay Pee* Permego, Electrocatalytic conversion of glucose and xylose into value-added chemicals, *Acta technologiae chemicae Aboensia* 2024 A/3 ISSN 2669-8315
11. *Saadabadi, Atefeh*, An Investigation into the Molecular Interactions and Biological Effect of Natural Stilbenoids at the TRPA1 and TRPV4 Ion Channels
12. *Siekkinen Minna*, The impact of dissolution products and solution pH on in vitro behaviour of the bioactive glasses 45S5 and S53P4
13. *Sinitsyna Polina*, In vitro dissolution of bioactive glasses with the focus on S53P4-derived products
14. *Wang, Qingbo*, Wood-Derived Functional Biomaterials towards 3D Bioprinting

5.1.2 Masters's theses

1. *Andersson Max*, On-site production of hydrogen peroxide for hydrometallurgical leaching of black mass
2. *Bergman Kent*, Converting gypsum into more valuable materials with the use of salts
3. *Claybills Johanna*, Leaching of phosphorus from biomass ash and model chemicals
4. *Fayyaz, Faiza*, Steam-induced melt infiltration method for all oxide Co₃O₄ based solar cells
5. *Hakalax, Ann-Louise*, Lignin i UV-härdningsbara akrylater
6. *Herrlin, Mathias*, Synthesis attempt of a novel β -O-4' lignin model compound and the study of a thiourea-based lignin fractionation process using a β -O-4' lignin model compound
7. *Karlström, Anton*, Direct ink writing of dense pastes containing macroparticles
8. *Laurén, Esmeralda*, Characterization of hemicellulose-based latices for coating applications
9. *Lazø, Angelo Bryan*, Synthesis and characterization of hydromagnesite-templated and lignin-derived porous carbon for supercapacitor electrode application
10. *Lubian Micol*, Synthesis of menthol from citronellal over polymer supported catalyst
11. *Nyberg, Robin*, Fri radikal sampolymerisation av lignin och butylakrylat
12. *Nygård Alex*, Commissioning and qualification of process equipment for the manufacturing of advanced therapy medicinal products,
13. *Rehrmann, Jonas*, Experimental characterization of catalysts for combined reforming of methane in respect to carbon deposition
14. *Rönneholm, Jonatan*, Lignin-based polyol synthesis for polyurethane applications

15. *Salomäki, Tim*, AI-guided design of compatible composites of birch lignin and polylactic acid for 3D printing
16. *Sjöqvist, Niklas*, Production technologies for microfibrillated cellulose
17. *Strandberg, Teddie*, LC-MS-analys av omvandlingsprodukter av ibuprofen

5.2 Publications 2024

5.2.1 Articles in refereed international scientific journals and series

1. Adeniyi, K. O., Osmanaj, B., Manavalan, G., Mikkola, J.-P., Berisha, A., Tesfalidet, S. **Reagentless impedimetric immunosensor for monitoring of methotrexate in human blood serum using multiwalled carbon nanotube@ polypyrrole/polytyramine film electrode**, *Talanta* 268 (2024) 125316.
2. Adeniyi, K.O, Manavalan, G., Zainelabdin, A., Mikkola, J.-P., Tesfalidet, S., **Scalable synthesis of two dimensional few atomic-layered bismuthene nanosheets as a sustainable electrocatalytic material for sensing applications: voltammetric detection of heavy metal ions**, *ACS Applied Nano Materials* 7 (2024), 20217–20228.
3. Aho, A., Lind, N., Virtanen, P., Mäki-Arvela, P., Eränen, K., Granroth, S., Korpelin, V., Honkala, K., Russo, V., Simakova, I., Murzin, D. Y. **Influence of Cu: Fe ratio in synthesis of higher alcohols from syngas over CuFeCoK/attapulgite catalysts**, *Applied Catalysis O: Open*, 193 (2024) 206972.
4. Aho, A., Mäki-Arvela, P., Kumar, N., Angervo, I., Eränen, K., Wärnå, J., Salmi, T., Murzin, D. Y. **Synthesis of acrylic acid from methyl lactate over calcium phosphate catalysts in a fixed bed reactor: time-on-stream behavior and kinetic analysis**, *Chemical Engineering Communications* 211 (2024) 1300-1318.
5. Alvear, M., Fortunato, M., Eränen, K., Lehtonen, J., Rautiainen, S., Di Serio, M., Russo, V., Salmi, T. **Epoxidation of light olefin mixtures with hydrogen peroxide on TS-1 catalyst**, *Catalysis Letters* 154(5) (2024) 2101-2111.
6. Alvear, M., Schmidt, C., Reinsdorf, O., Lebron-Rodriguez, E., Al Abdulghani, A., Hermans, I., Peurla, M., Lastusaari, M., Eränen, K., Murzin, D. Yu., Kumar, N., Salmi, T., **Ti-MWW catalysts for propylene oxide production: Influence of Si/Ti ratio and calcination conditions**, *Catalysis Letters* 154 (2024) 834-845.
7. Alvear, M., Lopez-Gonzalez, J., Stäglich, C., Al Abdulghani, A. J., Eränen, K., Haase, S., Salmi, T., Hermans, I. **Ammonia: A Vital additive in the epoxidation of propylene over TS-1 extrudates**, *Available at SSRN 5034936* (2024).
8. Araujo-Barahona, G., Shcherban, N., Eränen, K., Kopa, I., Bezverkhyy, I., Martínez-Klimov, M., Vajglová, Z., Aho, A., García-Serna, J., Salmi, T. Murzin, D. Yu., **Ruthenium supported on silicate and aluminosilicate mesoporous materials applied to selective sugar hydrogenation: Xylose to xylitol**, *Chemical Engineering Journal* 485 (2024) 150019.
9. Badazhkova, V. D., Savela, R., Wärnå, J., Murzin, D. Y. Leino, R., **Reaction kinetics of the Shvo-catalyzed dehydrogenation of 1-phenyl-1,3-propanediol-derived lignin model compound**, *Molecular Catalysis* 553 (2024) 113780.
10. Badazhkova, V. D., Savela, R., Wärnå, J., Murzin, D. Y., Leino, R., **Reaction kinetics of the Shvo-catalyzed dehydrogenation of 1-phenyl-1,3-propanediol-derived lignin model compound**. *Molecular Catalysis* 553 (2024) 113780.
11. Bobacka, J., **Perspective on the coulometric transduction principle for ion-selective electrodes**, *Sensors and Actuators B: Chemical* 410 (2024) 135674.
12. Boeva, Z., Mousavi, Z., Sokalski, T. & Bobacka, J., **Recent trends in non-invasive on-body chemical sensing**, *Trends in Analytical Chemistry* 172 (2024) 117542.
13. Cao, Ji, Larasati, S., Yabushita, M., Nakagawa, Y., Wärnå, J., Murzinm D. Yu., Daiki Asada, D., Nakayama, A., Tomishige, K., **Kinetic modeling of erythritol deoxydehydration and consecutive hydrogenation over the ReO x-Pd/CeO₂ catalyst**, *ACS Catalysis* 14 (2024) 1663-1677.
14. Cogliano, T., Russo, V, Eränen, K., Tesser, R., Di Serio, M., Salmi, T., **Epoxidation of vegetable oils in continuous device: kinetics, mass transfer and reactor modelling**, *Chemical Engineering Science* 294 (2024) 120079.

15. Cogliano, T., Desgouliere, A., Perez-Sena, W. Y., Eränen, K., D'Angelo, A., Aho, A., Kumar, N., Pirault-Roy, L., Murzin, D. Yu., Salmi, T., **Tall oil epoxidation in the presence of non-noble metal oxide-modified heterogeneous catalysts**, *Industrial & Engineering Chemistry Research* 63 (2024) 21214–21226 (Prof. M. DiSerio *Festschrift*).
16. Demuth, P., Gallego-Villada, L. A., Mäki-Arvela, P., Majidov, R., Vajglová, Z., Kumar, N., Angervo, I., Lastusaari, M., Eränen, K., Murzin, D. Yu., **Micro and mesoporous materials based on zeolite Y for the Florol synthesis via the Prins cyclization of isoprenol**, *Catalysis Today* 433 (2024) 114695.
17. dos Reis, G. S., de Oliveira, H. P., Candido, I. C. M., Freire, A. L., Molaiyan, P., Dotto, G. L., Grimm, A., Mikkola, J.-P., **Supercapacitors and triboelectric nanogenerators based on electrodes of greener iron nanoparticles/carbon nanotubes composites**, *Scientific Reports* 14 (2024) 11555.
18. dos Reis, G.S., de Oliveira, H.P., Candido, I.C.M., Freire, A.L., Molaiyan, P., Dotto, G.L., Grimm, A., Mikkola, J.-P., **Supercapacitors and triboelectric nanogenerators based on electrodes of greener iron nanoparticles/carbon nanotubes composites**, *Scientific Reports* 14 (2024) 11555.
19. dos Reis, G.S., Iakunkov, A., Shakya, J., Sahoo, D., Grimm, A., de Oliveira, H.P., Mikkola, J.-P., Björk, E.M., Hamed, M.M., **Nanostructured sulfur-doped carbon from biomass and its layer-by-layer self-assembly for high-performance supercapacitor electrodes**, *ACS Sustainable Resource Management* (2024).
20. Dotto, G. L., Pinto, D., Silva, L. F. O., Grimm, A., Khan, M. R., Ahmad, N., de Brum, I. A. S., Mikkola, J.-P., dos Reis, G. S., **Adsorption of rare earth elements (Ce³⁺, La³⁺, and Nd³⁺) and recovery from phosphogypsum leachate using a novel ZSM-5 zeolite**, *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 698 (2024) 134549.
21. Eichin, D., Rakkila, J., Li, X.-G., Ekambaram, R., Lassfolk, R., Leino, R., Savolainen, J. **Mannose receptor independent uptake of transmembrane glycocluster immunostimulant TADM by macrophages**. *Carbohydrate Research* 541 (2024) 109166.
22. Fotsing, P. N., Vieillard, J., Bouazizi, N., Samir, B., Cosme, J., Marquis, V. Le Derf, F., Ngueagni, P. T., Pakade, V., Woumfo, E. D., Dotto, G. L., dos Reis, G. S., Khan, M. R., Manoharadas, S., **Adsorption of Cr(VI) and phosphate anions by amino-functionalized palm oil fibers**, *Environmental Science and Pollution Research* 31 (2024) 60247–60259.
23. Gallego Villada, L. A., Mäki-Arvela, P., Kumar, N., Alarcón, E. A., Vajglova, Z., Tirri, T., Angervo, I., Lassfolk, R., Lastusaari, M., Murzin, D., **Zeolite Y-based catalysts for efficient epoxidation of R-(+)-Limonene: Insights into the structure-activity relationship**. *Microporous and Mesoporous Materials* 372 (2024) 113098.
24. Gallego-Villada, L. A., Mäki-Arvela, P., Kumar, N., Alarcón, E. A., Vajglová, Z., Tirri, T., Angervo, I., Lassfolk, R., Lastusaari, M., Murzin, D. Yu., **Zeolite Y-based catalysts for efficient epoxidation of R-(+)-Limonene: Insights into the structure-activity relationship**, *Microporous and Mesoporous Materials* 372 (2024) 113098.
25. Gallego-Villada, L. A., Cueto, J., del Mar Alonso-Doncel, M., Mäki-Arvela, P., Alarcón, E. A., Serrano, D. P., Murzin, D. Yu., **Dendritic ZSM-5 zeolites as highly active catalysts for the valorization of monoterpene epoxides**, *Green Chemistry* 26 (2024) 10512–10528.
26. Gallego-Villada, L. A., Perez-Sena, W. Y., Sánchez-Velandia, J. E., Cueto, J., del Mar Alonso-Doncel, M., Wärnä, J., Mäki-Arvela, P., Alarcon, E. A., Serrano, D. P., Murzin, D. Yu. **Synthesis of dihydrocarvone over dendritic ZSM-5 Zeolite: A comprehensive study of experimental, kinetics, and computational insights**, *Chemical Engineering Journal* 498 (2024) 155377.
27. Gericke, M., Amaral, A. J. R., Budtova, T., De Wever, P., Groth, T., Heinze, T., Höfte, H., Huber, A., Ikkala, O., Kapuśniak, J., Kargl, R., Mano, J. F., Måsson, M., Matricardi, P., Medronho, B., Norgren, M., Nypelö, T., Nyström, L., Roig, A., Sauer, M., Schols, H., van der Linden, J., Wrodnigg, T., Xu, C., Yakubov, G., Kleinschek, K. S., Fardim, P., **The European Polysaccharide Network of Excellence (EPNOE) research roadmap 2040: Advanced strategies for exploiting the vast potential of polysaccharides as renewable bioresources**. *Carbohydrate Polymers* 326 (2024) 121633.
28. Grimm, A., dos Reis, G. S., Dinh, V. M., Larsson, S. H., Mikkola, J.-P., Lima, E. C., Xiong, S. **Hardwood spent mushroom substrate-based activated biochar as a sustainable bioresource for removal of emerging pollutants from wastewater**, *Biomass Conversion and Biorefinery* 14 (2024) 2293–2309.
29. Guo, X., Wang, Z., Gao, Y., Zhang, C., Zhang, S., Sang, S., Ma, J., Sun, S., Murzin, D., Low, J., Shao, T., Xiong, Y., **Highly stable perovskite oxides for electrocatalytic acidic NO_x-reduction streamlining ammonia synthesis from air**, *Angewandte Chemie International Edition* 63 (2024) e202410517.

30. Hachhach, M. Russo, V., Simakova, I., Eränen, K., Murzin, D. Yu., Salmi, T., **Continuous recycled packed bed in sugar oxidation**, *Chemical Engineering Science*, GLS16 Special Issue (2024).
31. Honkanen, M., Narvi, E., Ojala, V. K., Jokilampi, A., Rantakari, P., Kronqvist, P., Kähäri, V. M., Veräjänkorva, E., Kurppa, K. J., Rahkila, J., Savolainen, J., Ekambaram, R., Leino, R., Elenius, K., **Immunomodulatory Synthetic Glycocluster Molecule Prevents Melanoma Growth In Vivo**, *ChemBioChem* 25 (2024) e202400264.
32. Howaili, F., Saadabadi, A., Mäkilä, E., Korotkova, E., Eklund, P. C., Salo-Ahen, O. M. H., Rosenholm, J. M., **Investigating the Effectiveness of Different Porous Nanoparticles as Drug Carriers for Retaining the Photostability of Pinosylvic Derivative**, *Pharmaceutics* 16 (2024) 2, 276.
33. Howaili, F., Saadabadi, A., Mäkilä, E., Korotkova, E., Eklund, P. C., Salo-Ahen, O. M. H., Rosenholm, J. M., **Investigating the Effectiveness of Different Porous Nanoparticles as Drug Carriers for Retaining the Photostability of Pinosylvic Derivative**, *Pharmaceutics* 16 (2024) 276.
34. Hu, L., Koppolu, R., Hämäläinen, R., Kanerva, H., Nick, T., Toivakka, M., Korpinen, R., Saranpää, P., Qasim, U., Liimatainen, H., Xu, C., Anghelescu-Hakala, A., **Suberin-Based Aqueous Dispersions for Barrier Packaging Applications**, *ACS Sustainable Chemistry & Engineering* 12 (2024) 23, 8902–8912.
35. Ibrahim, H. H., Weckman, T., Murzin, D. Yu., Honkala, K., **Understanding selective hydrogenation of phenylacetylene on PdAg single atom alloy: DFT insights on molecule size and surface ensemble effects**, *Journal of Catalysis* 434 (2024) 115523.
36. Jablonski, P., Irgum, K., Mikkola, J.-P., Wärnä, J., Khokarale, S. G., **Brønsted acid ionic liquid catalyzed depolymerization of poly-(3-hydroxybutyrate) to 3-hydroxybutyric acid: highly selective and sustainable transformation in methyl isobutyl ketone and water-containing phase-Separable reaction media**, *ACS Sustainable Chemistry & Engineering* 12 (2024) 13946–13959.
37. Järvinen, T., Vucetic, N., Palvölgyi, P., Pitkänen, O., Siponkoski, T., Cabaud, H., Vajtai, R., Mikkola, J.-P., Kordas, K., **An energy harvester based on UV-polymerized short-alkyl-chain-modified [DBU][TFSI] ionic liquid electrets**, *Journal of Materials Chemistry A* 12 (2024) 1746–1752.
38. Jha, P. K., Kochrekar, S., Jadhav, A., Lassfolk, R., Salomäki, M., Mäkilä, E., Kvarnström, C., **Wide Electrochemical Stability Window of NaClO₄ Water-in-Salt Electrolyte Elevates the Supercapacitive Performance of Poly(3,4-ethylenedioxythiophene)**, *Energy Storage Materials* 72 (2024) 103758.
39. Jogi, R., Samikannu, A., Mäki-Arvela, P., Virtanen, P., Hemming, J., Smeds, A., Mukesh, C., Lestander, T. A., Xu, C., Mikkola, J.-P., **Liquefaction of lignocellulosic biomass into phenolic monomers and dimers over multifunctional Pd/NbOPO₄ catalyst**, *Renewable Energy* 233 (2024) 121148.
40. Kadam, G. G., Nayak, S. K., Samikannu, A., Mikkola, J.-P. and Konwar, L. J., **Environmentally benign and continuous 5-hydroxymethylfurfural (HMF) production from concentrated sugars over NbOPO₄ supported TiO₂ catalyst in a dimethyl carbonate-water biphasic system**, *Applied Catalysis A: General* 691 (2024) 120087.
41. Khokarale, S. G., May, P. O., Sparrman, T., Irgum, K., Mikkola, J.-P., **Ionic liquid strategy for chitosan production from chitin and molecular insights**, *RSC Sustainability* 2 (2024) 1154–1164.
42. Kopa, I., Yevdokimova, O., Martínez-Klimov, M. E., Kurmach, M., Murzin, D., Shcherban, N., **Furfural acetalization with ethanol over hierarchical vs. conventional Beta zeolites**, *ChemistrySelect* 9 (2024) e202304754.
43. Korabkova, E., Boeva, Z., Radaszkiewicz, K. A., Skopalova, K., Kasparkova, V., Xu, W., Wang, X., Pachernik, J., Minarik, A., Lindfors, T. & Humpolicek, P., **Stimuli-responsive thin film composites of conducting polymers and cellulose nanocrystals for tissue engineering**, *International Journal of Biological Macromolecules* 265 (2024) 131036.
44. Laisné, E., Thivet, J., Manavalan, G., Petnikota, S., Mikkola, J.-P., Thyrel, M., Hu, T., Lima, E. C., Naushad, M., Lassi, U., dos Reis, G. S., **Box-Behnken design for the synthesis optimization of mesoporous sulfur-doped carbon-based materials from birch waste: Promising candidates for environmental and energy storage application**, *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 692 (2024) 133899.
45. Lempiäinen, H., Bergna, D., Heponiemi, A., Hu, T., dos Reis, G. S., Sliz, R., Lassi, U., **Fe-based catalytic modification of a birch sawdust-based carbon structure: The effect of process parameters on the final product using an experimental design**, *Carbon Trends* 17 (2024) 100428.
46. Lind, N., Aho, A., Eränen, K., Virtanen, P., Simakova, I., Mäki-Arvela, P., Murzin, D. Yu., **Transformation of syngas to valuable oxygenated products over Rh-MnOx/SiO₂, Rh-Co/ZrO₂ and Rh-Cu/ZrO₂ catalysts**, *Applied Catalysis A: General* 683 (2024) 119852.

47. Liu, R., Willför, S., Xu, C., **New insights into the effects of structural and constituent heterogeneities in lignin on the formation of nanoparticles.** *Industrial Crops and Products* 220 (2024) 119149.
48. Liu, R., Smeds, A., Willför, S., Xu, C., **Structural properties of softwood lignin fractions: Revealed by NMR and Py-GC/MS.** *Industrial Crops and Products* 209 (2024) 118055.
49. Long, J., Zhou, G., Yu, X., Xu, J., Hu, L., Pranovich, A., Yong, Q., Xie, Z.-H., Xu, C., **Harnessing chemical functionality of xylan hemicellulose towards carbohydrate polymer-based pH/magnetic dual-responsive nanocomposite hydrogel for drug delivery.** *Carbohydrate Polymers* 343 (2024) 122461.
50. Lu, Z., Tienaho, J., Kilpeläinen, P., Wang, L., Zhang, H., Hu, L., Liu, R., Brännström, H., Halmemies, E., Wang, X., Toivakka, M., Xu, C. **Laccase-Catalyzed Copolymerization of Tannin and Technical Lignin: Polymerization Kinetics and Enhanced Properties of Polyphenols.** *ACS Sustainable Chemistry & Engineering* 12 (2024) 23, 8765–8779.
51. Lund, S., Wey, L. T., Peltonen, J., Bobacka, J., Latonen, R.-M. & Allahverdiyeva, Y., **Graphene and graphene–cellulose nanocrystal composite films for sustainable anodes in biophotovoltaic devices,** *Sustainable Energy & Fuels* 8 (2024) 210–224.
52. Manabayeva, A. M., Mäki-Arvela, P., Vajglová, Z., Martinez-Klimov, M., Yevdokimova, O., Peuronen, A., Lastusaari, M., Tirri, T., Baizhumanova, T. S., Kassymkan, K., Kaumenova, G. N., Brodskiy, A. R., Sarsenova, R. O., Shorayeva, K. A., Murzin, D., Tungatarova, S. A., **Dry reforming of methane over Mn-modified Ni-based catalysts,** *Catalysis Letters* 154 (2024) 4780–1794.
53. Manandhar, S., Yrjänä, V., Leito, I. & Bobacka, J., **Determination of benzoate in cranberry and lingonberry by using a solid-contact benzoate-selective electrode,** *Talanta* 274 (2024) 125996.
54. Mandjoukov, B. & Lindfors, T., **Planar, low-cost, flexible, and fully laminated graphene paper pseudo-reference and potassium-selective electrodes,** *Sensors and Actuators B: Chemical* 403 (2024) 135190.
55. Maradesa, A., Py, B., Huang, J., Lu, Y., Iurilli, P., Mroziński, A., Law, H. M., Wang, Y., Wang, Z., Li, J., Xu, S., Meyer, Q., Liu, J., Brivio, C., Gavriluk, A., Kobayashi, K., Bertei, A., Williams, N. J., Zhao, C. & Danzer, M., Žic, M., Wu, P., Yrjänä, V., Pereverzyev, S., Chen, Y., Weber, A., Kalinin, S. V., Schmidt, J. P., Tsur, Y., Boukamp, B. A., Zhang, Q., Gaberšček, M., O'Hayre, R. & Ciucci, F., **Advancing electrochemical impedance analysis through innovations in the distribution of relaxation times method,** *Joule* 8 (2024) 1958–1981.
56. Marchi, E., Perez-Sena, W. Y., Eränen, K., Wärnå, J., Murzin, D. Y., Salmi, T., **Application of a loop reactor in the investigation of furfural oxidation kinetics on an acidic ion exchange catalyst,** *Industrial & Engineering Chemistry Research* 63 (2024) 14567–14581.
57. Mariyaselvakumar, M., Kadam, G. G., Saha, A., Samikannu, A., Mikkola, J.-P., Ganguly, B., Srinivasan, K., Konwar, L. J., **Halogenated melamine formaldehyde polymers: Efficient, robust and cost-effective bifunctional catalysts for continuous production of cyclic carbonates via CO₂-epoxide cycloaddition,** *Applied Catalysis A: General* 675 (2024) 119634.
58. Martínez-Klimov, M. E., Yevdokimova, O., Mäki-Arvela, P., Cueto, J., Shcherban, N., Vajglová, Z., Eränen, K., Murzin, D. Y., **Hydrodeoxygenation of isoeugenol in continuous mode using bifunctional Pt-Beta 25-binder catalysts for renewable jet fuel production,** *Sustainable Energy & Fuels* 8 (2024) 90–102.
59. Mastroianni, L., Russo, V., Eränen, K., Di Serio, M., Murzin, D. Y., Salmi, T., **Towards unconstrained catalyst shaping: high accuracy DLP printing of porous γ -Al₂O₃-based catalysts.** *Catalysis Science & Technology* 14 (2024) 1336–1348.
60. Mastroianni, L., De Jesus Medina Ferrer, A., De Domenico, A. M., Eränen, K., Di Serio, M., Murzin, D., Russo, V., Salmi, T., **DLP 3D printing of alumina catalyst architectures: Design, kinetics and modeling of structure effects on catalyst performance,** *Chemical Engineering Journal* 501 (2024) 157691.
61. Michelson, J., Mäki-Arvela, P., Rajala, P., Hallapuro, M., Schmid, D., Karlström, O., Wärnå, J., Murzin, D. Y. (2024). **Modeling of a bubble column for CO₂ removal by absorption with NaOH,** *Chemical Engineering Communications* 211 (2024) 571–581.
62. Murzin, D. Yu., **Catalytic kinetics in nanoconfined space of acidic micro/mesoporous materials,** *Chemical Engineering Science* 294 (2024) 120078.
63. Murzin, D. Yu., **Kinetics of enantioselective heterogeneous nanocatalysis with limited cluster occupancy: Beyond the coverage concept,** *Chemical Engineering Journal* 497 (2024) 154570.

64. Murzin, Dmitry Yu. **Synergy between heterogeneous catalysis and homogeneous radical reactions for pharmaceutical waste destruction: Perspective**, *Chinese Journal of Catalysis* 58 (2024) 7-14.
65. Oña, J. P., Laverdure, L., Latonen, R.-M., Kumar, N., Peurla, M., Angervo, I., Honkala, K. & Grénman, H., **Influence of Reaction Parameters on Nanogold-Catalyzed Glucose and Xylose Oxidation: A Joint Experimental and DFT Study**, *ACS Catalysis* 14 (2024) 1532-1544.
66. Orabona, F., Capasso, S., Perez-Sena, W. Y., Taddeo, F., Eränen, K., Verdolotti, L., Tesser, R., Di Serio, M., Murzin, D., Russo, V., Salmi, T. **Solvent-free condensation of ethyl levulinate with phenol promoted by Amberlyst-15: Kinetics and modeling**, *Chemical Engineering Journal* 493 (2024) 152677.
67. Perez-Sena, W. Y., Paya, M., Eränen, K., Lassfolk, R., Lagerquist, L., Kumar, N., Aho, A., D'Angelo, A., Salmi, T., Wärnå, J., Murzin, D. Yu., **Heterogeneous catalytic oxidation of furfural with hydrogen peroxide over a niobia catalyst**, *Catalysis Science & Technology* 14 (2024) 1942-1957.
68. Perez-Sena, W. Y., Tuppurainen, V., Gautier, A., Eränen, K., Ahola, J., Tanskanen, J., Salmi, T., Wärnå, J., Murzin, D. Yu. **Biphasic furfural oxidation with hydrogen peroxide: Process-level solvent screening and solvent effect on catalytic activity**. *Industrial & Engineering Chemistry Research* 63 (2024) 15809-15822.2024.
69. Perez-Sena, W. Y., Paya, M., Eränen, K., Lassfolk, R., Lagerquist, L., Kumar, N., Aho, A., D'Angelo, A., Salmi, T., Wärnå, J., Murzin, D. Y., **Heterogeneous catalytic oxidation of furfural with hydrogen peroxide over a niobia catalyst**. *Catalysis Science and Technology* 14 (2024) 1942-1957.
70. Pitkänen, O., Vucetic, N., Cabaud, H., Bozo, E., Järvinen, T., Mikkola, J. P., Kordas, K., **Evaluation of short alkyl chain modified [DBU][TFSI] based ionic liquids as supercapacitor electrolytes**. *Electrochimica Acta* 475 (2024) 143659.
71. Qasim, U., Sirviö, J. A., Suopajarvi, T., Hu, L., Pratiwi, F. W., Lin, M. K. T. H., Anghelescu-Hakala, A., Ronkainen, V.-P., Xu, C., Liimatainen, H. **A multifunctional biogenic films and coatings from synergistic aqueous dispersion of wood-derived suberin and cellulose nanofibers**. *Carbohydrate Polymers* 338 (2024) 122218.
72. Rajendran, K., Samikannu, A., Kanchan, D.R., i Rovira, A.M., Li, Z., Tingelstad, P., Mikkola, J.-P., Banerjee, A., Rout, K.R. and Chen, D., **Carbon-carbon coupling and hydrodeoxygenation during beechwood hydropyrolysis gas upgrading on TiO₂: Oxygen vacancies, Lewis acidity and basicity**, *Chemical Engineering Journal* 501 (2024) 157568.
73. Ramos-Andrés, M., Hu, L., Grénman, H., Xu, C., García-Serna, J., **Upcycling of carrot waste into pectin-arabinogalactan and lignin-cellulose films via hydrothermal treatment, ultrafiltration/diafiltration, and casting**. *Journal of Environmental Chemical Engineering* 12 (2024) 3, 112645.
74. Rauhameri, A., Robiños, A., Anttalainen, O., Salpavaara, T., Rantala, J., Surakka, V., Kallio, P., Vehkaoja, A. & Müller, P., **Classification of Volatile Organic Compounds by Differential Mobility Spectrometry Based on Continuity of Alpha Curves**, *IEEE Access* 12 (2024) 130571-130582.
75. Ristinmaa, A. S., Korotkova, E., Arntzen, M. Ø., Eijsink, V. G. H., Xu, C., Sundberg, A., Hasani, M., Larsbrink, J. **Analyses of long-term fungal degradation of spruce bark reveals varying potential for catabolism of polysaccharides and extractive compounds**. *Bioresource Technology* 402 (2024) 130768.
76. Ruiz, D., Morales, K., Mäki-Arvela, P., Chimentão, R. J., Murzin, D. Y. **Direct Reductive amination of HMF to 5-(aminomethyl)-2-furanmethanol using supported iridium-based catalysts**. *ChemPlusChem* (2024) e202400453.
77. Saadabadi, A., Korotkova, E., Eklund, P. C. **Isolation of stilbenoids from fresh knotwood of Scots pine using a high yield method**. *Holzforschung* 78 (2024) 363-370.
78. Salmi, T., Freites Aguilera, A., Russo, V. **Shallow beds are not plug flow reactors—analysis of kinetic data in the presence of axial dispersion effects**, *Chemical Engineering Research and Design* 207 (2024) 133-141.
79. Salmi, T., Flory, T., Perez-Sena, W., Eränen, K., Schmidt, C., Wärnå, J. **Determination of effective liquid-phase diffusion coefficients by tracer method in continuous packed columns**, *Chemical Engineering Science* 296 (2024) 120239.
80. Salmi, T., Perez-Sena, W. Y., Ciccarelli, F., Eränen, K., Medina, A., Cogliano, T., Di Serio, M., Wärnå, J., Leveneur, S., Russo, V. **Kinetics and reactor modelling of a complex three-phase system: Carbonation of epoxides on grafted catalysts**, *Chemical Engineering Science* 285 (2024) 119578.
81. Salmi, T., Araujo Barahona, G., Najarneshadmarshhadi, A., Braz, C., Goicoechea Torres, A., Ciamarella, M., Ares, E., Russo, V., García Serna, J., Eränen, K., Wärnå, J., Matos, H., Murzin, D., **Process**

- intensification via structured catalysts: Production of sugar alcohols, *Chemie-Ingenieur Technik* 96 (2024) 1642-1656 (Prof. A. Seidel-Morgenstern *Festschrift*).
82. Salucci, E., D'Angelo, A., Russo, V., Grénman, H., Saxén, H., **Modelling of iron oxide reduction with hydrogen in a small fixed bed**, *Chemical Engineering Science* 292 (2024) 119934.
 83. Salucci, E., D'Angelo, A., Fabozzi, A., Senneca, O., Bellucci, F., Francesca, R., Grénman, H., Saxén, H., Di Serio, M., Russo, V., **Valorization of iron (II) oxalate dihydrate coming from pickling processes through thermal conversion**, *Materials* 17 (2024) 4630.
 84. Samikannu, A., Mikkola, J.-P., Tirsoaga, A., Tofan, V., Fierascu, R. C., Richel, A., Verziu, M. N., **The activation of C–O bonds in lignin Miscanthus over acidic heterogeneous catalysts: towards lignin depolymerisation to monomer units**, *Biomass Conversion and Biorefinery* 14 (2024) 9723-9737.
 85. Sánchez-Velandia, J. E., Kurmach, M., Shvets, O., García Baldoví, H., García-Verdugo, E., Murzin, D. Yu., Shcherban, N., **Fine-tuning of acidity in hierarchical zeolites for the efficient Prins cyclization yielding Florol**, *ACS Sustainable Chemistry & Engineering* 12 (2024) 16283-16296.
 86. Sandri, F., Danieli, M., Guarise, M., Marelli, M., Zorzi, F., Franco L., Zecca, M., Centomo, P., **Radical reactivity of mesoporous sulfonic polydivinylbenzene as the catalytic support in the direct synthesis of hydrogen peroxide and its role in the formation of palladium hydrides**, *Applied Catalysis A: General* 675 (2024) 119630.
 87. Sarmad, S., Nikjoo, D., Mikkola, J.-P., **Innovative CO₂ capture technologies: Exploring the potential of porous liquids containing deep eutectic solvents and hypercrosslinked polymers**, *Separation and Purification Technology* 352 (2024) 128189.
 88. Shcherban, N. D., Kholkina, E., Sergiienko, S., Kovalevsky, A. V., Bezverkhyy, I., Murzin, D. Yu., **Carboxymethylation of cinnamyl alcohol with dimethyl carbonate over graphitic carbon nitrides**, *ChemPlusChem* 89 (2024) e202300600.
 89. Sidorenko, A. Yu., Khalimonyuk, T. V., Mamatkodiroy, B. D., Yakubov, Y. Y., Aho, A., Sviridova, T. V., Kouznetsova, T. F., Adizov, B. Z., Ibragomov, A. B., Murzin, D. Yu., Gu, Y., Agabekov, V. E., **Preparation, acid modification and catalytic activity of kaolinite nanotubes in α -pinene oxide isomerization**, *RSC Advances* 14 (2024) 25079-25092.
 90. Sidorenko, A. Yu., Khalimonyuk, T. V., Kurban, Y. M., Ilyina, I. V., Li-Zhulanov, N. S., Patrusheva, O. S., Aho, A., Heinmaa, I., Volcho, K. P., Salakhutdinov, N. F., Murzin, D. Yu., Agabekov, V. E., **Catalytic synthesis of heterocyclic compounds with a cineole moiety based on α -pinene**, *Applied Catalysis A: General* 691 (2024) 120070.
 91. Sidorenko A.Yu., Yu.M. Kurban, I.V. Il'ina, N.S. Li-Zhulanov, O.S. Patrusheva, V.V. Goltsova, M.P. Bei, A. Aho, J. Wärmä, I. Heinmaa, T.F. Kouznetsova, K.P. Volcho, N.F. Salakhutdinov, D.Yu. Murzin, V.E. Agabekov, **Catalytic condensation of α -pinene with formaldehyde**, *Journal of Catalysis*, 430 (2024) 115306.
 92. Thue, P. S., Wamba, A.G.N., Mello, B.L., Machado, F.M., Petroman, K.F., Nadaleti, W.C., Andreatza, R., dos Reis, G.S., Abatal, M., Lima, E.C., **Magnetic Composite Carbon from Microcrystalline Cellulose to Tackle Paracetamol Contamination: Kinetics, Mass Transfer, Equilibrium and Thermodynamic Studies**, *Polymers* 16 (2024) 3538.
 93. Toivakka, M., Schröder, A., Kukkamö, V., **Orifice geometry as a tool for evaluating extensional flow resistance of barrier coating colors**, *TAPPI Journal* 23 (2024) 11, 625–631.
 94. Tóth, G. S., Backman, O., Siivola, T., Xu, W., Kosourov, S., Siitonen, V., Xu, C., Allahverdiyeva, Y., **Employing photocurable biopolymers to engineer photosynthetic 3D-printed living materials for production of chemicals**, *Green Chemistry* 26 (2024) 7, 4032–4042.
 95. Wang, Q., Karadas, Ö., Rosenholm, J. M., Xu, C., Näreoja, T., Wang, X., **Bioprinting Macroporous Hydrogel with Aqueous Two-Phase Emulsion-Based Bioink: In Vitro Mineralization and Differentiation Empowered by Phosphorylated Cellulose Nanofibrils**, *Advanced Functional Materials* 34 (2024) 29, 2400431.
 96. Wang, L., Wu, R., Wang, Q., Backman, O., Eklund, P. C., Wang, X., Xu, C., **Evolution of Self-Assembled Lignin Nanostructure into Dendritic Fiber in Aqueous Biphasic Photocurable Resin for DLP-Printing**, *Advanced Functional Materials* 34 (2024) 29, 2315679.
 97. Yilmaz, B., Deniz, I., Fazli, H., Bekircan, O., Gültekin, E., Pranovich, A., **Development of biobased, sustainable and environmentally friendly glycerol ester rosins for the production of thermoplastic road marking paint**, *Journal of Applied Polymer Science* 141 (2024) 38, e55961.
 98. Yilmaz, B., Deniz, I., Fazli, H., Bekircan, O., Pranovich, A., Karaogul, E., **Sustainable thermoplastic road marking paint production from natural modified rosins**, *BioResources* 19 (2024) 2, 2160–2178.

99. Yrjänä, V. & Bobacka, J., **Methods for automating and improving the robustness of linear Kramers–Kronig tests for the purposes of validating immittance spectra**, *Electrochimica Acta* 504 (2024) 144951.
100. Zergane, H., Abdi, S., Wang, Q., Wang, L., Uppstu, P., Sundberg, A., Xu, C., Wang, X., **Compatibilization of poly(methyl methacrylate) and cellulose nanocrystals through co-continuous phase to enhance the thermomechanical properties**, *Journal of Applied Polymer Science* 141 (2024) 17, e55273.
101. Zhang, Y., Deng, W., Wu, M., Liu, C., Yu, G., Cui, Q., Fatehi, P., Xu, C., Li, B., **A dual-functional lignin containing pulp foam for solar evaporation and contaminant adsorption**, *Desalination* 573 (2024) 117153.
102. Zhang, Y., Wang, L., Zhang, H., Rosqvist, E., Lastusaari, M., Peltonen, J., Vähäsalo, L., Xu, C., Wang, X., Pranovich, A., **Crystalline nanoxylan from hot water extracted wood xylan at multi-length scale: Molecular assembly from nanocluster hydrocolloids to submicron spheroids**, *Carbohydrate Polymers* 335 (2024) 122089.

5.2.2. Review articles in refereed international scientific journals and series

1. Coglianò, T., Turco, R., Di Serio, M., Salmi, T., Tesser, R., Russo, V. **Epoxidation of vegetable oils via the Prilezhaev reaction method: A review of the transition from batch to continuous processes**, *Industrial & Engineering Chemistry Research* 63 (2024) 11231-11262
2. Lebendig, F., Schmid, D., Karlström, O., Yrjas, P., Müller, M. **Influence of pre-treatment of straw biomass and additives on the release of nitrogen species during combustion and gasification**, *Renewable and Sustainable Energy Reviews* 189 (2024) 114033.
3. Lehmusto, J., Karlström, O., Tesfaye, F., Hupa, L. **Ashes from challenging fuels in the circular economy. A review**, *Waste Management* 177 (2024) 211-231.
4. Lu, Z., Zhang, H., Toivakka, M., Xu, C. **Current progress in functionalization of cellulose nanofibers (CNFs) for active food packaging**, *International Journal of Biological Macromolecules* 267 (2024) 131490.
5. Sánchez-Velandia, J. E., Gallego-Villada, L. A., Mäki-Arvela, P., Sidorenko, A., Murzin, D. Yu., **Upgrading biomass to high-added value chemicals: synthesis of monoterpenes-based compounds using catalytic green chemical pathways**, *Catalysis Reviews: Science and Engineering* (2024) 1-126.
6. Uysal-Unalan, I., Sogut, E., Realini, C. E., Cakmak, H., Oz, E., Espinosa, E., Morcillo-Martín, R., Oz, F., Nurmi, M., Cerqueira, M. A., Perera, K. Y., Ayhan, Z., Arserim-Ucar, D. K., Kanakaki, C., Chrysochou, P., Marcos, B., Corredig, M. **Bioplastic packaging for fresh meat and fish: Current status and future direction on mitigating food and packaging waste**, *Trends in Food Science & Technology* 152 (2024) 104660.

5.2.3. Books

Murzin, D. Yu, *Formulation Product Technology*, Mouton De Gruyter (2024), Berlin, 374 p.

5.2.4 Articles in refereed international edited volumes and conference proceedings

1. Lehmusto, J., Söyrinki, S., Lagerbom, J., Jokiaho, T., Que, Z., Määttä, J., Hupa, L., Huttunen-Saarivirta E., Lindgren, M. **Characterization of a Nickel Flash Smelter Refractory Material—The Effect of Thermal Gradient**. *Advances in Pyrometallurgy – Furnace Containment, Minerals, Metals and Materials Series* (2024) pp. 81–88.
2. Moroz, M., Tesfaye, F., Demchenko, P., Prokhorenko, M., Rudyk, B., Pereviznyk, O., Mastronardo, E., Lindberg, D., Hupa, L., Reshetnyak, O. **Phase Equilibria and Thermodynamic Properties of Selected Compounds in the Ag–Ga–S–AgBr System for Modern Application in Energy Conversion Devices**. *Energy Technology 2024: Carbon Dioxide Management and Other Technologies, Minerals, Metals and Materials Series* (2024) pp. 257–268
3. Nick, T., Kvikant, M., P.A., N., Hu, L., Preston, J., Xu, C., Toivakka, M. **Modified hemicelluloses as stabilizers for talc slurries for paper coating applications**. In: *TAPPI Advanced Coating Symposium Proceedings*, TAPPI Press (2024), pp. 74–87.
4. Schröder, A., Toivakka, M., Kukkamo, V. **Evaluation of extensional flow resistance of barrier coating colors with orifice geometry**. In: *Proceedings of 2024 TAPPICon*, TAPPI Press (2024), pp. 1080–1084.

5.2.5 Other

1. Ivaska, A., Harju, L., Huldén, S.-G., Larnesjö, P., Wichardt, C., Bergstrand, L., Henrich, A., Österholm, L.-H. & Eriksson, R., **Kvantitativ vätkemisk analys inom stålindustrin, Del A. Kemiskt laboratoriearbete**. Jernkontorets forskning. Rapport TO 45-47 (även D 893:A), Jernkontoret, 2024, ISSN 0280-249X
2. Salmi, T., Dmitry Murzin *Festschrift* Editorial. *Industrial & Engineering Chemistry Research* 63(11) (2024) 4743-4745.

5.3 Edited conference proceedings and reports

Bobacka, J., Latonen, R.-M., Mäki-Arvela, P., Saloranta-Simell, T., Sundberg, A., Tolvanen, P., Werkelin, J. (eds.) **Johan Gadolin Process Chemistry Centre at Åbo Akademi University: annual report 2022-2023**, Åbo Akademi University, 2024, ISSN: 2984-1003 (print), 2984-1011 (online)

5.4 Patents and invention disclosures

5.5 Awards granted 2024

Tapio Salmi, Doctor *honoris causa*, University of Oulu, May 2024

5.6 Editorials

Leveneur, S., Tolvanen, P., Russo, V., **Catalytic epoxidation reaction**, Editorial *Catalysts* 14 (2024) 285.

6. PCC publications 1.1.2025-31.12.2025

6.1 Theses 2025

6.1.1 Doctoral Theses

1. *Aalto-Setälä Laura*, Long-term in vitro and in vivo dissolution of bioactive glasses
2. *Aranjo Barabona, German Rodrigo*, New technology for hydrogenation processes in the alimentary industry, *Acta technologiae chemicae Aboensia* 2025 A/1 ISSN 2669-8315 (double degree with Universidad de Valladolid)
3. *Badazhkova, Veronika*, Lignin valorization via catalytic modification: Ruthenium-catalyzed hydrogen transfer approach for modification of lignin model compounds and lignin
4. *Eriksson Jan-Erik*, Identifying and measuring corrosion of boiler materials in various combustion environments
5. *Hu, Liqiu*, Aqueous dispersions from wood-derived biopolymers for barrier and packaging applications
6. *Jaiswal, Aayush Kumar*, Novel value-added applications for cellulose nanomaterials: Towards optics and electronics applications
7. *Mastroianni, Luca*, Avantgarde structured catalysts and reactors, *Acta technologiae chemicae Aboensia* 2025 A/2 ISSN 2669-8315 (double degree with Università di Napoli 'Federico II')
8. *Pereira da Silva Paulo Santochi*, Envelope flame and thermal NO in black liquor combustion – experimental and modelling studies
9. *Sevonius Christoffer*, Agglomeration mechanisms of fluidized beds during biomass combustion
10. *Yrjänä, Ville*, Solid-contact potentiometric anion-selective electrodes – receptors, challenges, and applications

6.1.2 Masters's theses

1. *Adam, Ahmed*, Hydrodeoxygenation of furfural-cyclopentanone aldol condensation products for sustainable aviation fuel production
2. *Adil Mahmood, ,* MFC-bound mineral composites
3. *Agovino, Giuseppe*, Structured catalysts by 3D printing: synthesis, catalytic activity and mathematical modeling (collaboration with Università di Napoli 'Federico II')
4. *Alvarez Paguay, Jocelyne Carolina*, Applying electrochemistry in re-passivation of medical instruments
5. *Andersson, Eleonora*, Graphene electrode platform for electrochemical detection of glucose
6. *Arenhart Bruna*, Study of wastewater pretreatment plant: An industrial park case study
7. *Blomberg, Malin*, Determination and control of acid group distribution in emulsion polymerization
8. *Cadiç, Jeric Paul*, Different constructions of the working electrode used in the novel coulometric signal transduction setup

9. *Cavaliere, Miriam*, Study of lactose hydrogenation reaction using a Ru/c solid foam catalyst in a trickle-bed reactors (TBR) (collaboration with Università di Napoli 'Federico II')
10. *De Simone, Michele*, Raney-type Ni foam catalyst for sugar hydrogenation: kinetics, reactor design and xylitol production in a continuous system (collaboration with Università di Napoli 'Federico II')
11. *Dumindu Peththa Wadu, ,* Lignin-glyoxal-formaldehyde resin towards formaldehyde-reduced wood adhesives
12. *Efretuei Edward, ,* Low temperature corrosion study with KOH and K₂CO₃, 2025
13. *Eriksson Denise*, Development of in vitro analysis methods using a continuous flow reactor to study the dissolution of biomaterials, 2025
14. *Floris, Federico*, Sorption-enhanced carbon dioxide methanation: characterization and kinetic modelling of a zeolite-based catalyst (system (collaboration with Università di Padova)
15. *Guevara Garza, Juan Angel*, Carbon nanomaterials as additives in cement
16. *Hagman Sara*, Black liquor oxy-combustion : A laboratory study on droplet burning, 2025
17. *Heikola, Niklas*, Hemicelluloses in the lyocell fibre-spinning process for eucalyptus bleached kraft pulp
18. *Herrlin, Mathias*, Synthesis attempt of a novel β -O-4' lignin model compound and the study of a thiourea-based lignin fractionation process using a β -O-4' lignin model compound
19. *Levi Francesco*: Kinetic and morphological study of the reduction of pure iron oxide powder in the presence of CO and H₂/CO
20. *Lillsund Emma*, Development of reinforcing bioactive glass fibers for glass-ionomer cement
21. *Manu Thankachan*, Sawdust composites bound by microfibrillated cellulose
22. *Mbanusi Chinedu Francis*, Developing biomass pretreatment for improving pyrolysis product yield and composition
23. *Napolitano, Stefano*, Carbonation of epoxidized limonene: catalytic and kinetic aspects (collaboration with Università di Napoli 'Federico II')
24. *Nordgren, Sofia* Valorisation of phosphogypsum via leaching: Evaluating phosphorus and calcium separation
25. *Nuñez Nuñez, Ana*, Ozonation of pharmaceuticals: From single active pharmaceutical ingredients to complex mixtures
26. *Olatunde, Temitayo*, Biphasic furfural oxidation with hydrogen peroxide: Effect of solvent on reaction kinetics
27. *Pabustan, Conrado IV*, Electrochemical rust removal on medical-grade stainless steel instruments
28. *Rahman, Habibur*, Direct catalytic decomposition of N₂O over Cu- and Fe-modified ZSM-5, beta, and USY zeolite catalysts
29. *Ritola, Tobias*, Pressurized thermocatalytic decomposition of hydrocarbons using the Hycamite catalyst
30. *Rosabal Quiros, Gloriana Maria*, Effect of the electrode body material on the potentiometric response of solid-contact anion- and cation-selective electrodes
31. *Saarinen, Nikke*, Utvärdering av olika liginers förmåga att adsorbera läkemedelsrester från vatten
32. *Snäfs Fredrika*, Inhibition of sulfite oxidation in a laboratory-scale NO₂ scrubber
33. *Suominen, Kerttu*, Pressurized hot water extraction of spruce and birch barks: kinetics and properties of recovered materials

34. *Svedberg, Rickard*, Hemicelluloses modification in thermoplastic polymer for further industrial applications
35. *Tagbo Victor*, Role of ash-forming elements in the reactivity of biochar relevant for metallurgical applications
36. *Vesentini Davide*, SpruceSugar™ applications in barrier coating and film formation for sustainable packaging

6.2 Publications 1.1.2025-31.12.2025

6.2.1 Articles in refereed international scientific journals and series

1. Aalto-Setälä, L., Strömberg, G., Uppstu, P., Björkenheim, R., Pajarinen, J., Lindfors, N.C., Hupa, L. **Image and numerical analysis for understanding the in vivo dissolution of partially crystalline bioactive glass S53P4 scaffolds.** *Open Ceramics* 22 (2025) 100757.
2. Abushaba, F., Stiller, A., Mohamad, S.A., Areid, N., Hupa, L., Heino, T.J., Vallittu, P.K., Närhi, T.O. **Exploring the reactions induced by bioactive glass air abrasion of titanium and their effects on osteoblast cellular responses.** *Journal of Biomedical Materials Research: Part A* 113 (2025) e37949.
3. Ahmed, H., dos Reis, G. S., Molaiyan, P., Lähde, A., Lassi, U., **Silicon/carbon composite anode materials for lithium-ion batteries: materials design and synthesis, current state, progress, and future perspectives,** *Progress in Energy* 7(2) (2025) 022003.
4. Ahmed, M., Bhakta, S., Sarmad, S., Faiz Ullah Shah, F. U., Mikkola, J.-P., **Halogen-Free Deep Eutectic Solvents as Ambient Temperature Supercapacitor Electrolytes,** *Journal of Power Sources* 664 (2025/2026).
5. Aho, A., Rahman, H., Yevdokimova, O., Murzin, D. Y., Rebrov, E., **Synthesis of higher alcohols over K-promoted CuFe/SiO₂ catalysts,** *Catalysis Today* (2025) 115485.
6. Aho, A., Suomalainen, M., Peuronen, A., Mikkonen, H., Heikkinen, N., Mäki-Arvela, P., Simakova, I., Eränen, K., Lastusaari, M., Lehtonen, J., Murzin, D. Yu., **Synthesis of higher alcohols from syngas: exploring the parameter space and conceptual process design,** *Chemical Engineering Research and Design* 222 (2025) 1-14.
7. Alopaeus, M., Stosiek, M., Diment, D., Löfgren, J., Cho, M., Hemming, J., Tirri, T., Pranovich, A., Eklund, P. C., Rigo, D., Balakshin, M., Xu, C., Rinke, P., **SP-LCC — a dataset on the structure and properties of lignin-carbohydrate complexes from hardwood.** *Scientific Data* 12 (2025) 996.
8. Alshehri, B. M., Elshimy, A. S., Salah, A. M., Al-Ahmed, Z. A. M., Lima, E. C., dos Reis, G. S., .Selim, A. Q., Badawy, A. M., Mobarak, M., Seliem, M. K., Bendary, H. I., **Sodium alginate-modified activated binder derived from TiO₂ nanoparticles and carbon-rich limestone: A new bio-based composite for methylene blue adsorption,** *International Journal of Biological Macromolecules* (2025) 143848.
9. Alvear, M., Lopez-Gonzalez, J., Stäglich, C., Al Abdulghani, A.J., Eränen, K., Haase, S., Salmi, T., Hermans, I., **Ammonia: A vital additive in the epoxidation of propylene over TS-1 extrudates,** *Chemical Engineering Journal* 506 (2025) 160229.
10. Araujo-Barahona, G., De Simone, M., Brunberg, C., Eränen, K., Reinsdorf, A., Roos, M., Garcia-Serna, J., Russo, V., Murzin, D. Yu., Salmi, T., **Solid Raney-type Ni foam catalysts for xylitol production: Continuous and batch operation,** *Applied Catalysis A: General* 701 (2025) 120324.
11. Ba, Z., Shi, Y., Zhang, H., Robiños, A., Zafar, M. S., Li, Y., Yu, F., Bobacka, J., Liang, D., Wang, Y., Xie, Y., Xu, C. **Machine learning to predict electrochemical performance of biomass carbon electrodes in lithium/sodium ion batteries.** *Applied Energy* 401 (2025) 126845.
12. Badazhkova, V., Leino, R., Savela, R., **Introduction of amino groups into lignin and lignin model compounds: recent advances.** *RSC Advances* 15 (2025) 46413-46424.
13. Badazhkova, V., Savela, R., Lassfolk, R., Leino, R. **Ruthenium-catalyzed bond cleavage in lignin model compounds containing β-O-4 linkages.** *Holzforschung* 79 (2025) 507-516.
14. Balint, R., Niemi, J., Hayashi, S., Lehmusto, J. **Laboratory studies on the ageing behaviour of waste incineration superheater ash deposits.** *Energy* 320 (2025) 135359.

15. Bertini, M., Ferrante, F., Gueci, L., Prestianni, A., Duca, D., Arena, F., Murzin, D. Y. **Alternative algebraic perspectives on CO/H₂ PROX over MnO₂ composite catalysts**, *Journal of Chemical Information and Modeling* 65(10) (2025) 4952-4967.
16. Bertini, M., Palella, A., Lisuzzo, L., Ferrante, F., Aho, A., Spadaro, L., Murzin, D. Yu., Duca, D., **Synergistic approaches to the acidic activation of Halloysite nanotubes for unlocking their potential in sustainable catalysis**, *Surfaces and Interfaces* 72 (2025) 107118.
17. Bhadane, R. R., Vähäsalo, L., Xu, C., Eklund, P. C., **Characterization of oat husk soda lignin from a Finnish biorefinery process**, *Biomass and Bioenergy* 205 (2025) 108490.
18. Bhadane, R., Backman, O., Uppstu, P., Smått, J.-H., Xu, C., Eklund, P. C. **Lignin-Grafted Poly(n-Butyl Acrylate) Copolymers as Soft Materials for Adhesive Applications: A Comparison of Hardwood, Softwood, and Straw Lignin**, *Biomacromolecules* 26 (2025) 4095-4107.
19. Bhattarai, M., Al-Terke, H., Liu, K., Wan, Z., Kilpeläinen, P., King, A. W. T., Khakalo, A., Xu, J., Xu, C., Ras, R. H. A., Mattos, B. D., Rojas, O. J. **Wood Biomolecules as Agricultural Adjuvants for Effective Suppression of Droplet Rebound from Plant Foliage**, *Advanced Science* 12 (2025) 17, 2416686.
20. Celma, A., Skrobonja, A., Khokarale, S. G., Mikkola, J. P., Sørmo, E., Cornelissen, G., Wiberg, K., Ahrens, L., **Using biochar in static and dynamic flow systems to remediate per-and polyfluoroalkyl substances from contaminated stormwater runoff**, *Remediation Journal* 36(1) (2025) e70041.
21. Chrastowska, J., Sokalski, T., Korotkova, E., Bobacka, J., Sundberg, A., Xu, C. **Machine learning-assisted spectrometric method for pulp extractive analysis based on model pulps**, *Holzforschung* 79 (2025) 9, 453–464.
22. Cogliano, T., Russo, Eränen, K., Tesser, R., Di Serio, M., Salmi, T., **Comparison of continuous technologies for vegetable oils epoxidation**, *Chemical Engineering Science* 301 (2025) 120726.
23. D'Angelo, A., Salucci, E., Russo, V., Grénman, H., Saxén, H., **Hydrogen reduction of iron oxide powder in thin layers**, *Industrial and Engineering Chemistry Research* 64 (2025) 158–170 (Professor M. DiSerio Festschrift).
24. da Silva Bruckmann, F., Vieira, Y., Bender, C. R., dos Reis, G. S., Silva, L. F. O., Crissien, T., Sellaoui, L., Dotto, G. L., **Occurrence, toxicity, ecological aspects, and environmental removal of ciprofloxacin, levofloxacin, and other fluoroquinolones excreted in urine**, *Journal of Water Process Engineering* 77 (2025) 108593.
25. Da Silva, P.S.P., Engblom, M., Brink, A., Hupa, M., Hupa, L. **An ignition delay time based criterion for the presence of envelope flame during black liquor droplet combustion**, *Fuel* 388 (2025) 134473.
26. D'Angelo, A., Salucci, E., Russo, V., Grénman, H., Saxén, H., **Reduction kinetics of pure and industrial hematite samples with hydrogen in a small fixed bed system**, *Available at SSRN* 5104362 (2025).
27. Deng, W., Zhang, Y., Hu, L., Azeez, N. P., Xu, C., Toivakka, M. **Lignocellulosic nanofibrils isolate via laccase/TEMPO-mediated oxidation for stabilizing pickering emulsions**, *Cellulose* 32 (2025) 9, 5407–5424.
28. Diment, D., Löfgren, J., Alopaeus, M., Stosiek, M., Cho, M. J., Xu, C., Hummel, M., Rigo, D., Rinke, P., Balakshin, M. **Enhancing Lignin-Carbohydrate Complexes Production and Properties with Machine Learning**, *ChemSusChem* 18 (2025) 8, e202401711.
29. dos Reis, G. S., Iakunkov, A., Shakya, J., Sahoo, D., Grimm, A., de Oliveira, H., Mikkola, J.-P., Björk, E.M., Hamed, M.M., **Nanostructured sulfur-doped carbon from biomass, and its layer-by-layer self-assembly for high-performance supercapacitor electrodes**, *ACS Sustainable Research and Manufacturing* (2025) 2, 50-61.
30. dos Reis, G. S., Subramaniam, C. M., Grimm, A., Hamed, M. M., Molaiyan, P., García-Alvarado, F., Lassi, U., Gocian, J., Petnikota, S., **Biomass-derived macroporous carbon–tin oxide composites as stable and high-capacity anodes for lithium-ion and sodium-ion batteries: experimental study and GFN1-xTB calculations**, *Physical Chemistry Chemical Physics* 27 (2025) 14000-14014.
31. Eriksson, J.E., Mori, S., Silvander, L., Hupa, L., Lehmusto, J. **Comparison of Laboratory-Scale Methods for Assessing Deposit-Induced Corrosion of Boiler Materials in Biomass Combustion and Recovery Boilers**, *High Temperature Corrosion of Materials* 102 (2025) 19.
32. Fagerlund, R., Engblom, M. **Modeling NO formation in CFD black liquor recovery boiler models part 1: Development of global reaction mechanism**, *Fuel* 409 (2025) 137840.

33. Fagerlund, R., Engblom, M. **Modeling NO formation in CFD black liquor recovery boiler models part 2: Impacts of nitrogen model parameters.** *Fuel* 404 (2025) 136214.
34. Fuhr, A. C. F. P., Raupp, I. N., Silva, L. F. O., Crissien, T. J., Philippi, V. P., Alomar, S. Y., dos Reis, G., S., Dotto, G. L., **Chitosan/clay adsorbent for dye removal: Statistical mechanics and thermodynamic insights,** *Journal of Molecular Liquids* 435 (2025) 128153.
35. Gallego-Villada, L. A., **Green chemistry metrics: Insights from case studies in fine chemical processes,** *Sustainable Chemistry and Pharmacy* 46 (2025) 102062.
36. Garoushi, S., Peltola, T., Siekkinen, M., Hupa, L. Vallittu, P.K., Lassila, L., Säilynoja, E. **Retention of strength and ion release of some restorative materials.** *Odontology* 113 (2025) 714-723.
37. Gorza, G., Samikannu, A., Konwar, L. J., Tesfalidet, S., Sarmad, S., Canu, P., Mikkola, J. P., **Synergistic catalyst Ru/NbOPO₄/TiO₂ for selective hydrodeoxygenation of phenolics towards unlocking lignin's potential,** *Molecular Catalysis* 582 (2025) 115177.
38. Gosti, C., Mousavi, Z., Fiore, L., Mazzaracchio, V., Olivieri, F., Gentile, G., Arduini, F. & Bobacka, J., **Carbon Black and PEDOT:PSS in a Synergistic Solid Contact for Reliable Printed Potentiometric Sensors,** *ACS Sensors* 10 (2025) 7820-7831.
39. Grimm, A., Conrad, S., Gentili, F.G., Mikkola, J.P., Hu, T., Lassi, U., Silva, L.F., Lima, E.C. dos Reis, G.S., **Highly efficient boron/sulfur-modified activated biochar for removal of reactive dyes from water: Kinetics, isotherms, thermodynamics, and regeneration studies,** *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 713 (2025) 136486.
40. Grimm, A., Dotto, G. L., da Boit Martinello, K., Silva, L. F., Lima, É. C., Khan, M. R., Ahmas, N., de Brum, I. A. S., dos Reis, G. S., **Recovery and concentration of Eu (III) from phosphogypsum leachate using ouricuri endocarp,** *Journal of Rare Earths* 43 (2025) 1728-1735.
41. Gui, T., Zou, S.-L., Dou, H.-Z., Ren, W.-F., Shao, C.-Y., Xu, C.-L., Xiao, L.-P., Sun, R.-C. **P-N synergy with lignocellulosic biomimetic flame-retardant aerogels for effective fire-safe and thermal insulation.** *Green Chemistry* 27 (2025) 16, 4308–4319.
42. Hachhach, M., Russo, V., Simakova, I., Eränen, K., Murzin, D. Y., Salmi, T., **Packed bed reactor technology in sugar oxidation,** *Chemical Engineering Science* 311 (2025) 121580.
43. Hachhach, M., Simakova, I., Eränen, K., Murzin, D.Y., Salmi, T., **Continuous recycled packed bed reactor technology: effect of liquid flowrate on arabinose oxidation,** *Chemical and Process Engineering: New Frontiers* (2025) e85-e85.
44. Han, T., Chen, S., Song, T., Lin, X., Han, D., Bobacka, J., Niu, L., **Low-frequency capacitance and mass-change of un-conditioned Nafion-coated electrodes - towards calibration-free Ag(I) ion sensing in pure water,** *Electrochemistry Communications* 175 (2025) 107911.
45. Han, T., Chen, S., Yang, S., Song, T., Lin, X., Yu, Q., Han, D., Bobacka, J. & Niu, L., **Determination of silver ions in distilled water by stripping voltammetry at a Nafion-coated gold electrode in combination with quartz crystal microbalance and electrochemical impedance spectroscopy,** *Talanta* 282 (2025) 127006.
46. Hegazy, S., Ghannami, A., dos Reis, G. S., Hu, T., Brahmi, R., Tuomikoski, S., Lassi, U., Srivastava, V., **Activation and Zr precursor influence on UiO-66-NH₂ composites for efficient cationic and anionic dye removal,** *Chemical Engineering Science* 302 (2025) 120785.
47. Hmoudah, M., Paparo, R., Chianese, C., El-Qanni, A., Salmi, T., Tesser, R., Russo, V., Di Serio, M., **Ibuprofen photodegradation promoted by ZnO and TiO₂-P25 nanoparticles: A comprehensive kinetic, reaction mechanisms, and thermodynamic investigation,** *Journal of Water Process Engineering* 69 (2025) 106598.
48. Hossain, A. S., Salah, A. M., Hasanuzzam, M., Salama, Y. F., Rudayni, H. A., Lima, E. C., dos Reis, G. S., Selim, A. Q., Seliem, M. K., **Chitosan–diatom hybrid beads embedding zero-valent iron nanoparticles as a bio-based adsorbent for Cr (VI) removal: Experimental characterization and statistical physics interpretation.** *International Journal of Biological Macromolecules* 332 (2025) 148615.
49. Hu, L., Wang, L., Xu, W., Wang, X., Toivakka, M., Gustafsson, J., Xu, C. **In situ polymerization of lignin in cellulose nanofibrils aqueous dispersion for fully bio-based barrier coating in packaging.** *Cellulose* 32 (2025) 9, 5389–5405.
50. Jafarihonar, F., Ruozzi, A., Kinnunen, H., Hupa, L., Vainio, E. **New insights into HCl-induced low-temperature corrosion in biomass- and waste-fired boilers.** *Corrosion Science* 262 (2025) 113587.
51. Kadam, G.G., Nayak, S.K., Samikannu, A., Mikkola, J.P., Konwar, L.J., **Environmentally benign and continuous 5-hydroxymethylfurfural (HMF) production from concentrated sugars over NbOPO₄ supported TiO₂ catalyst in a dimethyl carbonate-water biphasic system,** *Applied Catalysis A: General* 691 (2025) 120087.

52. Kassaun, B. B., Wang, L., Backman, O., Xu, C., Fatehi, P. **3D printable lignin-caprolactone material.** *Green Chemistry* 27 (2025) 13, 3451–3464.
53. Kassaun, B. B., Wang, L., Backman, O., Xu, C., Fatehi, P. **Lignin Caprolactone-Derived Wood Coatings.** *ACS Applied Polymer Materials* 7 (2025) 16, 10657–10673.
54. Kayakool, F. A., Pant, H., Paul, M., dos Reis, G. S., Manavalan, G., Srikanth, V. V. S. S., Thyrel, M., Petnikota, S., **Mesoporous carbon derived from lignin sulfonate as a sustainable cathode for high-performance aluminium batteries,** *Carbon Resources Conversion* 8 (2025) 100301.
55. Khan, S., Rauber, D., Veerabagu, U., Wu, R., Kay, C. W. M., Xu, C., Shanmugam, S., Kikas, T. **Tailored Lignin Fractions via Ionic Liquid Pretreatment for Sustainable Polymer Systems.** *Molecules* 30 (2025) 12, 2630.
56. Khan, S., Rauber, D., Wang, L., Veerabagu, U., Kay, C. W. M., Xu, C., Shanmugam, S., Kikas, T. **Lignin depolymerization from softwood biomass using integrated protic ionic liquid-enzyme pretreatment.** *RSC Sustainability* 3 (2025) 10, 4466–4477.
57. Konwar, L. J., Samikannu, A., Mikkola, J. P., **Continuous hydrogenation of aqueous levulinic acid to γ -valerolactone under mild conditions with a highly efficient multifunctional Ru/carbon catalyst,** *Applied Catalysis A: General* 706 (2025) 120494.
58. Kurmach, M., Poliakov, S. Kopa, I., Lytiuha, O., Diakun, K., Martinez-Klimov, M., Shvets, O., Murzin, D., Shcherban, N., **Efficient synthesis of methyl lactate from glucose over post-synthesized Sn-Beta zeolites: switching selectivity by tuning surface acidity,** *ACS Applied Materials & Interfaces* 17 (2025) 50639-50649.
59. Kvikant, M., Dax, D., Toivakka, M., Filonenko, S., Xu, C. **Amphiphilic hemicellulose derivatives as stabilizers in oil-in-water emulsions.** *International Journal of Biological Macromolecules* 309 (2025) 143094.
60. L'Huissier, M., Wärnå, J., Salmi, T., **Modelling of gas–liquid and gas–liquid–solid reactors for water treatment chemicals–From ferrous sulfate to ferric sulfate,** *Chemical Engineering Science* 309 (2025) 121497.
61. Lee, Y., Yoon, H. Y., Kim, J., Phong, N. T., Joe, E.-N., Tag, M., Oh, M. S., Moon, J. Y., Jeon, J.-R. **Synthesis of melanoidin-like polymers for non-roasted coffee brewing.** *Food Bioscience* 73 (2025) 107707.
62. Lehmusto, J., Ievlev, A., Kurley, J., Pint, B.A. **High-Temperature Oxidation Study in a Multi-Oxidant Environment Using 18O Tracer.** *High Temperature Corrosion of Materials* 102 (2025) 1–18.
63. Lehmusto, J., Söyrintki, S., Lagerbom, J., Jokiaho, T., Que, Z., Määttä, J., Hupa, L., Huttunen-Saarivirta, E., Lindgren, M. **Interactions of sulfur-containing gas with magnesia-chromite refractory in nickel flash smelting furnace.** *Ceramics International* 51 (2025) 11363-11371.
64. Lehrhofer, A. F., Yoneda, Y., Tran, T. H., Melikhov, I., Gille, L., Hettegger, H., Böhmendorfer, S., Potthast, A., Schottenberger, H., Rosenau, T. **Negative effect and removal of trace amounts of 1,3-dialkylimidazolium ionic liquids in samples from biorefineries.** *Cellulose* 32 (2025) 1, 147–163.
65. Li, C., Ren, Q., Song, J., Lyu, X., Liu, L., Cheng, Z., Zhang, H., Liu, H., An, X. **High-Value Valorization of Agricultural Waste Biomass into Lignin-Based Magnetic Nanocomposites: Multifunctional Catalytic Systems with Near-Infrared-Responsive Liquid Marbles for Controllable and Sustainable Dye Removal.** *Langmuir* 41 (2025) 44, 29913–29923.
66. Liang, S., Wang, Q., Xu, C., Rosenholm, J. M., Wang, X. **Photocurable cellulose nanofibers and its copolymer with polyacrylamide as microgels to support 3D cell cultivation.** *Nanoscale* 17 (2025) 23, 14394–14407.
67. Lu, Z., Zhang, H., Wang, Q., Toivakka, M., Xu, C., Wang, X. **Hierarchical Assembly of Cellulose Fibrils and Tannin in Biocomposite Foam: Scalable Production via Oven Drying and Customizable Metal Ions Release for Antimicrobial Activity.** *Small* 21 (2025) 23, e2501776.
68. Majidov, R., Aho, A., Vajglova, Z., Kumar, N., Lassfolk, R., Angervo, I., Tirri, T., Lastusaari, M., Eränen, K., Mäki-Arvela, P., Hietala, J., Murzin, D. Y., **Synthesis of Methyl Lactate from Glucose over Alkali-Modified Sn-H-Y Catalysts.** *Waste and Biomass Valorization* 16 (2025) 5069-5087.
69. Manabayeva, A.M., Mäki-Arvela, P., Vajglová, Z., Martínéz-Klimov, M., Yevdokimova, O., Peuronen, A., Lastusaari, M., Tirri, T., Tungatarova, S.A., Baizhumanova, T.S., Kassymkan, K., Kaumenova, N. Zhumabek, M., Zhumadullaev, D. A., Shoganbek, D., Murzin, D. Yu., **Mg-modified Ni-based catalysts prepared by the solution combustion synthesis for dry reforming of methane,** *Catalysis Today* 453 (2025) 115261.
70. Mastroianni, L., Agovino, G., Sandri, F., Aho, A., Eränen, K., Cassese, S., Mungiterra, S. Di Serio, M., Murzin, D. Yu., Russo, V., Salmi, T., **Digital Light Processing (DLP) 3D-Printed Pd/Al₂O₃**

- catalysts for H_2O_2 decomposition: towards efficient green thrusters, *Applied Catalysis A: General* 706 (2025) 120466.
71. Mello, B. L., Thue, P. S., Hamid, A., Usama, M., Machado, F. M., Seliem, M. K., Dehmani, Y., dos Reis, G. S., Salam, M. A., Khan, H., Silva, L. E. O., Lima, E. C., **Adsorption of 4-bromophenol from simulated wastewater using magnetic carbon-based composites: Kinetics, equilibrium, thermodynamics, and density functional theory analysis.** *Journal of Water Process Engineering* 76 (2025) 108250.
 72. Mikkola, J.-P., Wärnå J., **Human Body as an Efficient Chemical Reactor: Modelling the Long Term Phosphatidylethanol 16:0/18:1 and 16:0/18:2 Peth Concentrations in Population**, Available at SSRN 5253199 (2025).
 73. Molaiyan, P., Boz, B., dos Reis, G. S., Sliz, R., Wang, S., Borsari, M., Lassi, U., Paoletta, A., **Paving the path toward silicon as anode material for future solid-state batteries**, *Transportation e23* (2025) 100391.
 74. Molaiyan, P., Jin, T., Wang, S., dos Reis, G. S., Petnikota, S., Lassi, U., Paoletta, A., **The chemistry of halide-based solid electrolytes: unlocking advances in solid-state Li-ion batteries**, *Chemical Communications* 61 (2025) 2846-2857.
 75. Murzin, D. Y., **On active site density in heterogenous catalysis: Implications for kinetics**, *Chemical Engineering Science* 317 (2025) 122056.
 76. Murzin, D. Yu., **From isotherms to modern kinetics: Kinetic analysis**, *Nature Catalysis* 8 (2025) 861-862.
 77. Niemi, J., Balint, R., Engblom, M., Lindberg, D. **Modeling of Temperature Gradient-Induced Melt Movement within Kraft Recovery Boiler Ash Deposits.** *Energy & Fuels* 39 (2025) 454–464.
 78. Niemi, J., Balint, R., Lehmusto J. **Laboratory-scale method for high-temperature gas-to-solid deposition and corrosion studies – P235GH and AISI316 exposed to PbCl_2 and KCl .** *Chemical Engineering Science* 313 (2025) 121726.
 79. Nizam, P. A., Hu, L., Hemming, J., Rosqvist, E., Peltonen, J., Toivakka, M., Xu, C. **Dual function galactoglucomannan derivative for emulsion polymerization towards barrier coating applications.** *Chemical Engineering Journal* 511 (2025) 162183.
 80. Nowicki, J., Zgoda, M. M., Muszyński, M., Mikkola, J. P., Kołodziejczyk, M., **API-ILs ionic adducts: Solubility and surface activity properties—En route to new paradigm in drug development** *ChemMedChem* (2025) e202500404.
 81. Nygård, M., Wärnå, J., Russo, V., Torrkulla, J., Murzin, D. Yu., **Kinetic modelling of catalytic N_2O removal**, *Scientific Reports-Nature* (2025).
 82. Orabona, F., Napolitano, S., Badazhkova, V. D., Perez-Sena, W., Eränen, K., Tesser, R., Di Serio, M., Russo, V., Salmi, T. **CO_2 cycloaddition to limonene diepoxide: Kinetic and mass transfer analysis**, *Chemical Engineering Journal* 523 (2025) 168292.
 83. Palo, J., Reinikainen, M., Rautiainen, S., Pasanen, A. T., Baudouin, D., Grénman, H., Lehtonen, J. **Aqueous-phase reforming of methanol, acetic acid, 4-methylcatechol, and phenol over supported nickel and platinum catalysts**, *Applied Catalysis A: General* 699 (2025) 120172.
 84. Partyka, J., Kronberg, T., Pasiut, K., Kaczmarczyk, K., Kozien, D. **The impact of nano-quartz and the CaO/MgO ratio on the surface and mechanical properties of transparent glazes.** *Ceramics International* 51 (2025) 39983-39991.
 85. Paul, M., Grimm, A., Simões dos Reis, G., Manavalan, G., ES, S., Thyrel, M., Petnikota, S., **Activated carbon from birch wood as an electrode material for aluminum batteries and supercapacitors**, *ChemElectroChem* 12 (2025) e202400549.
 86. Perez-Sena, W.Y., Ciccarelli, F., Eränen, K., Di Serio, M., Russo, V., Salmi, T., **A pathway to cyclic carbonates: Cycloaddition of carbon dioxide to epoxidized methyl oleate on grafted heterogeneous catalysts**, *Journal of CO_2 Utilization* 91 (2025) 103005.
 87. Phong, N. T., Kim, J., Joe, E.-N., Tag, M., Lee, J.-G., Choi, M., Jang, K.-S., Yoon, H. Y., Jeon, J.-R. **Crop root exudate-responsive fertilizers fabricated by structural conversion of wastewater activated sludges into phenolic polymer-incorporated mineral-like particles.** *Chemical Engineering Journal* 507 (2025) 160536.
 88. Preston, J., Gaskin, E., Toivakka, M. **Pre-damping effects on water absorption and drying dynamics in flexographic printing.** *TAPPI Journal* 24 (2025) 11, 563–570.
 89. Quintana-Arturo, S. V., Gallego-Villada, L. A., Alarcón, E. A., Murzin, D. Yu., **One-pot transformation of R-(+)-limonene over Sr-and Sn-Modified hierarchical Y zeolite catalysts: Toward sustainable conversion routes**, *ACS Sustainable Chemistry & Engineering* 13(45) (2025).

90. Rajendran, K., Kanchan, D. R., Samikannu, A., Tingelstad, P., Li, Z., i Rovira, A. M., Banerjee, A., Mikkola, J.-P., Rout, K. R., Chen, D. **Lewis acid-base interactions of oxide support for enhanced C–C coupling and deoxygenation reactions**, *Journal of Catalysis* 452 (2025) 116435.
91. Rebane, R., Teearu, A., Helm, I., Bobacka, J., Randon, J., Bergquist, J. & Leito, I., **EACH Erasmus Mundus programme: Advancing excellence in analytical chemistry education and industry impact**, *Analytical and Bioanalytical Chemistry* 417 (2025) 1035-1047.
92. Rehman, L. N., Zhou, Y., Saleem, A., Mehmood, T., dos Reis, G. S., **Development of a Janus cellulose separator with dielectric effect modulation using 2D perforated titania nanosheet for zinc batteries**, *Journal of Power Sources* 660 (2025) 238412.
93. Riccio, L., Di Serio, M., Russo, V., Salmi, T., **Modelling of transient kinetics in trickle bed reactors: Butene oxide production via hydrogen peroxide**, *Chemical Engineering Research and Design* 218 (2025) 133-146.
94. Rigo, D., Fechter, T., Capanema, E., Diment, D., Alopaeus, M., Tarasov, D., Cantero, D., Balakshin, M. **Isolation of β -O-4-Rich Lignin From Birch in High Yields Enabled by Continuous-Flow Supercritical Water Treatment**. *ChemSusChem* 18 (2025) 1, e202401683.
95. Roa, K., Boulett, A., Cantero-López, P., Oyarce, E., Yáñez, O., Bruna, J., Pizarro, G., Hu, L., Xu, C., Sánchez, J. **Amoxicillin adsorptive hydrogels based on quaternary ammonium polymer and carboxylated cellulose nanocrystals**. *International Journal of Biological Macromolecules* 320 (2025) 146040.
96. Roa, K., Boulett, A., Santander, P., Bruna, J., Salfate, G., Pizarro, G. D. C., Hu, L., Xu, C., Sánchez, J. **Carboxylated cellulose nanocrystals in semi-interpenetrated network hydrogels and its application in water absorption and antibiotic removal**. *International Journal of Biological Macromolecules* 305 (2025) 141154.
97. Robiños, A., Zhang, H., Mousavi, Z., Laurén, T., Smått, J.-H., Hupa, L., Xu, C. & Bobacka, J., **Integrated Fractionation and Templating of Lignin Using Magnesium for Sustainable and Tailored Porous Carbon**, *RSC Sustainability* 3 (2025) 2883-2898.
98. Rosenau, T., Potthast, A., Zhang, J., Barbini, S., Koide, M., Rinner, U., Hettegger, H. **Cellulosic fibers spun from stabilized imidazolium ionic liquids: identification of chromophores in the fibers after accelerated ageing**. *Monatshefte für Chemie - Chemical Monthly* 156 (2025) 1, 77–90.
99. Rosqvist, E., Niemelä, E., Liang, S., Eriksson, J. E., Wang, X., Peltonen, J. **Proliferation of Human Cervical Cancer Cells Responds to Surface Properties of Bicomponent Polymer Coatings**. *Nanomaterials* 15 (2025) 10, 716.
100. Saadabadi, A., Rantanen, M., Marimuthu, P., Koivisto, A.-P., Eklund, P. C. , Salo-Ahen, O. M. H., **Insights Into Molecular Interactions and Biological Effect of Natural Stilbenoids at The TRPA1 Ion Channel**. *ChemMedChem* 20 (2025) e202400501.
101. Sarmad, S., Nikjoo, D. and Mikkola, J.P., **Innovative CO₂ capture technologies: Exploring the potential of porous liquids containing deep eutectic solvents and hypercrosslinked polymers**, *Separation and Purification Technology* 352 (2025) 128189.
102. Sathicq, Á. G., Gallego-Villada, L. A., Alarcón, E., Monroy, A. F., Martínez, J. J., & Romanelli, G. P. **Microwave-Assisted One-Pot Synthesis of Alkyl Levulinates From Post-Harvest Vegetable Waste**, *Advanced Sustainable Systems*, e00378 (2025).
103. Schimanofsky, C., Petritz, A., Ban, B., Irimia, C. V., D’Orsi, R., Yumusak, C., Mayr, F., Kanbur, Y., Kim, S., Operamolla, A., Saller, K., Schiek, M., Salinas, Y., Brüggemann, O., Teichert, C., Xu, C., Shim, B. S., Schwarzing, C., Stadlober, B., Sariciftci, N. S., Irimia-Vladu, M. **Natural dielectrics for organic field effect transistors: a study on resins derived from larch, spruce and Atlas cedar Pinaceae trees**. *Materials Advances* 6 (2025) 18, 6269–6290.
104. Schmid, D., Lidman Olsson, E., Vainio, E., Wu, H., Karlström, O., Hupa, L. **Fate of phosphorus and potassium in gasification of wheat bran and sunflower seed shells**. *Fuel* 384 (2025) 133950.
105. Shezad, N., Samikannu, A., Safdar, M., Arellano-García, H., Mikkola, J. P., Seo, D. K., Akhtar, F., **Nickel supported over hierarchical zeolite 13X catalysts for enhanced conversion of carbon dioxide into methane**, *International Journal of Energy Research* 2025(1) 4728304.
106. Shoganbek, D., Martínez-Klimov, M., Yevdokimova, O., Peuronen, A., Lastusaari, M., Aho, A., Tungatarova, S.A., Baizhumanova, T.S., Zhumadullaev, D.A., Zhumabek, M., Aubakirov, Y.A., Manabayeva, A., Mäki-Arvela, P., Murzin, D. Yu., **Dry methane reforming over lanthanide-doped Co–Al catalysts prepared via a solution combustion method**, *Materials Advances* 6 (2025) 1173-1190.
107. Sidorenko, A.Y., Khalimonyuk, T.V., Kurban, Y.M., Ilyina, I.V., Li-Zhulanov, N.S., Patrusheva, O.S., Aho, A., Heinmaa, I., Volcho, K.P., Salakhutdinov, N.F., Murzin, D.Y., **Catalytic synthesis of**

- heterocyclic compounds with a cineole moiety based on α -pinene, *Applied Catalysis A: General* 691 (2025) 120070.
108. Siekkinen, M., Stiller, A., Wang, X., Hupa, L. **Impact of bovine serum albumin in simulated body fluid on the dynamic dissolution behavior of bioactive glass S53P4.** *Open Ceramics* 21 (2025) 100747.
 109. Sruthy, S., Grimm, A., Paul, M., Cherian, C. T., Thyrel, M., Molaiyan, P., Lassi, U., Petnikota, S., dos Reis, G. S., **Low-temperature highly graphitized porous biomass-based carbon as an efficient and stable electrode for lithium-ion batteries and supercapacitors,** *Chemical Engineering Journal Advances* 22 (2025) 100762.
 110. Stäglich, C., Alvear, M., Schmidt, C., Angervo, I., Russo, V., Haase, S., Salmi, T., **Trickle bed reactor technology for propylene epoxidation with extrudates–Catalyst characterization, kinetic studies and modelling,** *Chemical Engineering Science* 310 (2025) 121570.
 111. Suárez-Méndez, A., Mendoza-Cruz, R., Martínez-Klimov, M. E., Wärnå, J., Albuquerque, J.S., Murzin, D. Yu., Klimova, T. E., **NiPt supported on zeolite Y and SBA-15 composites as efficient catalysts for the hydrodeoxygenation of anisole under mild conditions,** *Fuel* 400 (2025) 135793.
 112. Taddeo, F., Ortona, O., Ciccarelli, D., Tesser, R., Grénman, H., Di Serio, M., Russo, V., Paduano, L., **The importance of measuring diffusion coefficients in reactor design and simulation,** *RSC Advances* 15(20) (2025) 15701-15711.
 113. Tiwari, M., Dirbeba, M.J., Lehmusto, J., Yrjas, P., Vinu, R. **Kinetic evaluation of high-pressure pyrolysis of biomass using distributed activation energy model.** *Journal of Environmental Chemical Engineering* 12 (2025) 119049.
 114. Vahdatiyehta, P., Yrjänä, V., Rosqvist, E., Cetó, X., del Valle, M. & Huynh, T. P., **Electrochemical Behavior of Glassy Carbon Electrodes Modified with Electropolymerized Film of N,N'-bis (2-thienylmethylene)-1,X-diaminobenzene toward Homovanillic Acid and 4-Hydroxyphenylacetic Acid,** *Bioelectrochemistry* 165 (2025) 108944.
 115. Vajgllová, Z., Mäki-Arvela, P., Yevdokimova, O., Martinez-Klimov, M., Simakova, I., Eränen, K., Tirri, T., van Hoeven, J.E., Peuronen, A., Huš, M., Likozar, B., Lastusaari, M., Lindén, J., Doronkin, D.E., Murzin, D.Yu., **Effect of catalyst support on dihydroeugenol hydrodeoxygenation on low cost FeNi catalyst to produce renewable alkane fuel,** *Applied Catalysis A: General* 701 (2025) 120307.
 116. Vikram, S., Aho, A., Mäki-Arvela, P., Murzin, D. Yu., **Process optimization and techno-economic assessment of commercial scale synthesis of fatty alcohols from biomass-based syngas,** *Chemical Engineering Research and Design* 219 (2025) 34-42.
 117. Wang, X., Wu, R., Zhang, Y., Fu, Y., Qin, M., Xu, C. **Direct conversion of hemicellulose in biomass to functional diformylxylose with a recyclable organic co-solvent.** *Industrial Crops and Products* 238 (2025) 122363.
 118. Wärnå, J., Mikkola, J. P. **Long-Term phosphatidylethanol (PEth) in humans: The truth,** *Available at SSRN 5304114* (2025).
 119. Wei, L., Kumar, N., Haije, W., Peltonen, J., Peurla, M., Grénman, H., de Jong, W., **Effect of synthesis methods on the physico-chemical and catalytic properties of Ni 13X and Ni 5A zeolite catalysts in CO₂ methanation,** *Catalysis Today* 452 (2025) 115239.
 120. Wu, R., Liu, C., Zhang, Y., Xu, J., Pranovich, A., Hemming, J., Tirri, T., Wang, X., Xu, C. **In situ amino-lignin production via biomass fractionation for high-efficacy CO₂ capture.** *Green Chemistry* 27 (2025) 23, 6764–6775.
 121. Xu, C., Hasani, M., Ek, M. **The 17th European Workshop on Lignocellulosics and Pulp (EWLP) in Turku/Åbo, Finland (August 26–30, 2024).** *Holzforschung* 79 (2025) 9, 419.
 122. Xu, C., Hettegger, H., Rosenau, T. **Special Issue in “Cellulose”: Editorial Highlights from the EWLP 2024 and the EPNOE Junior 2024 Conferences.** *Cellulose* 32 (2025) 9, 5167–5169.
 123. Xu, J., Backman, O., Zhang, Y., Zhang, H., Smätt, J.-H., Hemming, J., Pranovich, A., Xu, C. **Direct dissolution and regeneration of cellulose-rich solid fractions from microwave-assisted deep eutectic solvent-treated spruce wood into cellulose fibers via DMAc/LiCl.** *Chemical Engineering Journal* 525 (2025) 169922.
 124. Xu, J., Si, C., Dai, L., Hemming, J., Pranovich, A., Xu, C. **Microwave-assisted deep eutectic solvent extraction of lignin from spruce heartwood and sapwood, targeting the comparison of different biorefinery concepts.** *Chemical Engineering Journal* 505 (2025) 159232.
 125. Xu, R., Doskaliuk, N., Pang, B., Xu, J., Xu, W., Xu, C., Antonietti, M., Filonenko, S. **Hemicellulose from mild extraction of biomass: Revealing structural insights and advancing potential value.** *Carbohydrate Polymer Technologies and Applications* 10 (2025) 100843.

126. Xu, Y.-C., Zou, S.-L., Xu, C.-L., Xiao, L.-P., Sun, R.-C. **Dual-Network Cellulose Adhesives via Copper Coordination: Bridging Ultrahigh Adhesive Performance and Environmental Stability.** *Advanced Functional Materials* 35 (2025) 50, e11048.
127. Yacoub, S. I., Saber, S. G., Ali, R. A., Lima, E. C., dos Reis, G. S., Al-Olayan, E., Salama, Y. F., Mobarak, M., Seliem, M. K., **CTAB-modified alkali-activated binder derived from Favia corals and glass waste: A novel bio-based adsorbent for effective removal of Mn (VII) ions from aqueous solutions,** *Journal of Industrial and Engineering Chemistry* 147 (2025) 406-421.
128. Ye, G., Yong, Q., Hu, L., Rosqvist, E., Peltonen, J., Hu, Y., Xu, W., Xu, C. **Molecular engineering of nanocellulose-poly(lactic acid) bio-nanocomposite interface by reactive surface grafting from copolymerization.** *International Journal of Biological Macromolecules* 306 (2025) Part 1, 141371.
129. Ye, G., Yu, Y., Wu, C., Zhang, H., Zhao, Y., Bi, H., Xu, C. **Molecular engineering of nanocellulose copolymer by grafting from homopolymerization of caprolactone: A revisit to temperature condition.** *Industrial Crops and Products* 235 (2025) 121699.
130. Yevdokimova, O., Shcherban, N., Martinez-Klimov, M., Weydisch, R., Cueto, J., Giner, E. A., Eränen, K., Peuronen, A., Lastusaari, M., Russo, V., Mäki-Arvela, P., Murzin, D. Y. **Synthesis of jet-fuel precursors from renewable biomass through aldol condensation of cyclopentanone and furfural on base catalysts,** *Catalysis Today* 443 (2025) 114962.
131. Yoneda, Y., Hettegger, H., Böhmendorfer, S., Potthast, A., Rosenau, T. **Cellulose acylation in aged 1-ethyl-3-methyl-imidazolium carboxylate ionic liquids upon fiber spinning.** *Cellulose* 32 (2025) 9, 5171–5178.
132. Yrjänä, V., Mousavi, Z., Sokalski, T., Joon, N., Leito, I. & Bobacka, J., **Influence of electrode body material on the analytical behaviour of solid-contact ion-selective electrodes,** *Talanta* 287 (2025) 127651.
133. Zhang, H., Wu, R., Chen, X., Ni, S., Xu, C., Fu, Y., Qin, M., Zhang, Y. **High-efficient fractionation of poplar chips by ternary deep eutectic solvents system for elevating enzymatic hydrolysis.** *Industrial Crops and Products* 225 (2025) 120489.
134. Zhang, Y., Deng, W., Lu, Z., Xu, C., Li, B., Wang, X. **Formic acid-directed spinning of closed-loop recyclable cellulose/chitosan filaments with moisture response and antimicrobial performance.** *Journal of Cleaner Production* 534 (2025) 147008.
135. Zhang, Y., Deng, W., Wang, Z., Wu, M., Liu, C., Yu, G., Li, Q., Xu, C., Li, B. **A Green Cellulose Dissolution System for Producing Tunable Regenerated Nanocellulose Formate.** *ACS Nano* 19 (2025) 23, 21243–21259.
136. Zhang, Y., Wang, Q., Deng, W., Hazer, S., Luukkonen, A., Pranovich, A., Salo-Ahen, O. M. H., Österbacka, R., Xu, C., Wang, X. **“Grafting-to” Polymers of Xylan-g-allyl Glycidyl Ether Toughen PEG Hydrogel via Microphase Separation: Thermoresponsive and Photoreactive Molecular Assembly in DLP 3D Printing.** *Small* 21 (2025) 34, e2502129.
137. Zhang, Y., Wu, R., Ni, S., Chen, X., Wang, Z., Li, Z., Fu, Y., Qin, M., Xu, C. **One-Step Extreme Delignification to Simultaneously Produce High-Purity Cellulose and Phenolated Lignin.** *ChemSusChem* 18 (2025) 23, e202501445.
138. Zhou, X., Zhang, Y., Murzin, D. Y., **Correcting misconceptions on thermodynamic calculations using the Freundlich model,** *Journal of Environmental Chemical Engineering* 13 (2025) 116993.

6.2.2. Review articles in refereed international scientific journals and series (9)

1. Gallego-Villada, L., Garcia-Sanchez, J. T., Lauer, G., Mäki-Arvela, P., Sanchez-Velandia, J. E., Murzin, D. Yu., **Physicochemical characterization of solid catalysts: Morphological, structural, textural, reducibility, and acid-base insights**, *ChemCatChem* (2025) e00974.
2. Hachhach, M., Bayou, S., El Kasmi, A., Zoubair Said, M., Akram, H., Hanafi, M., Ouafae Achak O., Chaouki, El Moujahid, C., Chafik, T., **Towards Sustainable Scaling-Up of Nanomaterials Fabrication: Current Situation, Challenges, and Future Perspectives**, *Eng* 6 (2025) 149.2025
3. Jafarihonar, F., Vainio, E., Hupa, L., Hupa, M. **Low-temperature corrosion in large-scale biomass boilers**. *Npj Materials Degradation* 9 (2025) 108.
4. Mäki-Arvela, P., Simakova, I., Cueto, J., Murzin, D. Yu., **Biomass transformation to value-added chemicals and fuels over zeolite catalysts**, *Zeolites: From fundamentals to emerging applications*, Chapter 11, 408-452, Eds D. P. Serrano, J. Čejka, *The Royal Society of Chemistry* (2025).
5. Marchi, E., Gangotena, P., Frilund, C., Salmi, T., Simell, P., Grénman, H. **Review on sorption-enhanced methanation of renewable hydrogen and carbon dioxide**, *International Journal of Hydrogen Energy* 177 (2025) 151628.
6. Orabona, F., Recupido, F., Lama, G. C., Polaczek, K., Taddeo, F., Salmi, T. Di Serio, M., Verdolotti, L., Russo, V. **Cutting-edge development of non-isocyanate polyurethane (NIPU) foams: From sustainable precursors to environmental impact evaluation**, *Green Chemistry* 25 (2025) 7403-7444.
7. Salucci, E., D'Angelo, A., Russo, V., Grénman, H., Saxén, H. **Review on the Reduction Kinetics of Iron Oxides with Hydrogen-Rich Gas: Experimental Investigation and Modeling Approaches**, *Industrial & Engineering Chemistry Research* 64 (2025) 1-35.
8. Samikannu, A., Mani, M., Konwar, L. J., Mäki-Arvela, P., Virtanen, P., Mikkola, J.-P., **Hydrodeoxygenation of triglycerides into renewable diesel**, *Green Chemistry Series* No. 89, Biorefining of Renewable Diesel: From Production to Market, Chapter 6, 96-137, Eds M. Aslam, S. Mishra, J. Aburto, *The Royal Society of Chemistry* (2025).
9. Sánchez-Velandia, J. E., Gallego-Villada, L. A., Mäki-Arvela, P., Sidorenko, A., Murzin, D. Yu., **Upgrading biomass to high-added value chemicals: synthesis of monoterpenes-based compounds using catalytic green chemical pathways**, *Catalysis Reviews* 67(2) (2025) 371-496.

6.2.3 Books

Murzin, D. Yu, *Engineering Catalysis*, 3rd Edition, FeGruyter, Berlin (2025)

6.2.4 Articles in refereed international edited volumes and conference proceedings

1. German Araujo-Barahona, Juan García-Serna, Tapio Salmi, German Araujo-Barahona, Juan García-Serna, Tapio Salmi, **Valorization of Banana Waste through Hydrothermal Extractions: Polyphenolic Compounds, Sugars and Sugar Alcohols**, ERASMUS+ BIP ESS-HPT 2025 The European Summer School in High Pressure Technology, Graz 6-19.7.2025
2. Hachhach, M., Murzin, D. Yu., Salmi, T., **Environmental assessment of the catalytic reaction**, **System & Control Transactions**, Peer reviewed conference proceedings ESCAPE 35- European Symposium on Computer Aided Process Engineering, Gent 6-9.7.2025, Van Impe, J. F. M., Leonard, G., Bhonsale, S. S., Polanska, M. E., Logist, F. (Eds.)
3. Kronberg, T., Eriksson, J.-E., Hupa, L. **Stabilization of sulfide-rich sediments with industrial side streams**. Nordic Geotechnical Meeting 2024, Linköping: Svenska Geotekniska Föreningen 2 (2025), pp. 355-358.
4. Moroz, M., Demchenko, P., Prokhorenko, M., Rudyk, B., Garashchenko, O., Prokhorenko, S., Lazarenko, O., Reshetnyak, O., Tesfaye, F., Hupa, L. **Low-temperature synthesis and thermodynamic properties of the AgGaGeS₄ compound for potential applications in optoelectronics and gas sensors**. *Energy Technology* (2025): Carbon Dioxide Management and Other Technologies. Tesfaye, F. (red.). 1 red. Switzerland: Springer, Cham. Vol. 1. pp. 111

5. Preston, J., Toivakka, M., Gaskin, E., **Pre-Damping Effects on Water Absorption and Drying Dynamics in Flexographic Printing**. In: *Proceedings of TAPPICon 2025*, TAPPI Press (2025), pp. 1053–1056.
6. Toivakka, M., Xu, C., Anghelescu-Hakala, A., Hu, L., Koppolu, R., Hämäläinen, R., Kanerva, H., Nick, T., Korpinen, R., Saranpää, P., Qasim, U., Liimatainen, H., **Suberin-based dispersions for barrier coating**. In: *Proceedings of TAPPICon 2025*, TAPPI Press (2025), pp. 788–792.

6.3 Patents and disclosures

1. Cogliano, T., Russo, V., Eränen, K., Di Serio, M., Tesser, R., Salmi, T., Continuous operation technology for epoxidation of organic unsaturated compounds, WO 2025/08334 A1 (2025).
2. Orabona, F., Taddeo, F., Di Serio, M., Russo, V., Salmi, T., Sintesi dell’etil estere dell’acido difenolico promossa da catalizzatori acidi, Italian Patent 102023000003057, C07C67 (2025)
3. Rautiainen, S., Lehtonen, J., Salmi, T., Alvear, T., Fortunato, M., Epoxidation of olefin mixture, International Patent Application, US18/708,732 (2025)

6.4 Awards granted

Tapio Salmi, Doctor *honoris causa*, Tallinn Technical University, September 2025

7. External interactions 2024

7.1 Organization of conferences/courses/meetings 2024

ISCRE , International symposium in Chemical Reaction Engineering, Logomo, Turku, *Tapio Salmi*

WWSC Academy Course 2: “Wood Cell Walls, Their Components and How to Study Them”, Umeå, Sweden, 15–19.4.2024, *Chunlin Xu*

Lignin Seminar Day 2024 (LigninReSurf Public Seminar), Aurum, Turku, Finland, 6.2.2024, *Chunlin Xu*

17th European Workshop on Lignocellulosics and Pulp (EWLP 2024), Sigyn Hall, Turku, Finland, 26–30.8.2024, *Chunlin Xu, Anna Sundberg, Mari Nurmi, Maritti Toivakka, Jan Gustafsson, Mia Mäkinen*

Towards new catalysts and reactor structures, Università di Napoli, October 2024 (Erasmus course), *Tapio Salmi (visiting professor)*

ISCRE28 International Symposium in Chemical Reaction Engineering, Logomo, Turku, 16-19.6.2024 (450 participants), *Tapio Salmi*

7.2 Visits and visitors

Visits

Araujo Barabona, German, Universidad de Valladolid, Spain, 1.10-31.12.2024

Mastroianni, Luca, Università di Napoli 'Federico II', Italy, 1.11-31.12.2024

Orabona, Federica, Università di Napoli 'Federico II', Italy, 1.11-31.12.2024

Salmi, Tapio, Università di Padova & Università di Napoli 'Federico II', Italy, 30.4-9.5.2024, 12.11-28.11.2024 (two visits)

Tolvanen, Pasi, visit to Lappeenranta LUT, University, Lappeenranta, lecturing in the Erasmus Mundus SBBE programme 26-28.08 2024.

Dirbeba, Meberetu Jaleta, Indian Institute of Technology Madras, India, 24.2.2024–3.3.2024

Lehmusto, Juho, Oak Ridge National Laboratory, USA, 2.1.2024-31.7.2024

Salmi, Tapio, Università di Napoli 'Federico II', May 2024 (2 weeks)

Visitors

Agorino, Giuseppe, Università di Napoli 'Federico II', Italy, 3.4-30.9.24

Baizhumanova, Tolken, Kazakh-British Technical University, Kazakhstan, 27.5-24.6.24

Bastard, Daphne, Université Le Havre Normandie, France, 19.4-4.8.24

Bricault, Guillaume, Université de Poitiers, France, 8.4-8.7.24

De Simone, Michele, Università di Napoli 'Federico II', Italy, 3.4-30.9.24

Fale, Shy Jude, Novia, University of Applied Sciences, Finland, 7.10-31.12.24

Gallego Garcia, Daniel, University of the Basque Country UPV/EHU, Spain, 1.3-1.7.24

Jaklová, Natalie, Charles University in Prague, Czech Republic 2.5-1.11.24

Longo, Lilia, Università Ca' Foscari Venezia, Italy, 1.1-24.6.24
Lubian, Micol, Università di Padova, Italy, 29.1-11.8.24, 1.11-31.12.24
Manabaeva, Alua, Kazakh-British Technical University, Kazakhstan, 27.5-24.6.24
Moradi, Neshat, University of Oulu, Finland, 1.1-31.12.24
Napolitano, Stefano, Università di Napoli 'Federico II', Italy, 3.4-30.9.24
Paget, Lexane, Université de Poitiers, France, 8.4-8.7.24
Shoganbek, Dinmukhamed, Kazakh-British Technical University, Kazakhstan, 12.3-25.4.24
Stäglich, Christopher, Technische Universität Dresden (TUD), Germany, 1.1-7.4.24
Than, Anaïs, Ecole Nationale Supérieure des Ingénieurs en Arts Chimiques et Technologiques (Toulouse INP-ENSIACET), France, 2.5-9.8.24
Vidrequin, Alice, Université de Poitiers, France, 8.4-8.7.24
Vikram, Shruti, Indian Institute of Technology Bombay, India, 1.3-31.12.24
Zakeri, Talat, Charles University, Czech Republic, 5.8-15.11.24
Naidu, Balaji Muthusamy, Indian Institute of Technology Madras, India, 19.2.2024–31.12. 2024
Shivolo, Magano, University of Namibia, Namibia, 13.10.2024–31.3.2025
Vinu, Ravikrishnan, Indian Institute of Technology Madras, India, 11.6.2024–15.6.2024
Tiwari, Mahendra, Indian Institute of Technology Madras, India, 1.4.2024–30.6.2024
Yoon, Ho Young, Gyeongsang National University, Republic of Korea, 26.1-1.4.24
Roa, Karina, University of Santiago de Chile, Chile, 28.3-23.6.24
Aubry, Anna, SIGMA Clermont, France, 20.5-30.8.24
Hilaire, Lauriane, SIGMA Clermont, France, 20.5-30.8.24
Nusbaum, Cécile, SIGMA Clermont, France, 20.5-30.8.24
Menegalli, Marie, Toulouse INP, France, 6.5-31.8.24
Brahimi, Salim, University of Messina, Italy, 7.8-30.11.24
Shafaei, Mahdis, Tarbiat Modares University, Iran, 23.9.24-1.3.25
Selberg, Sigrid, University of Tartu, Estonia, 1.1.-16.4.2024
Supala, Eszter, Budapest University of Technology and Economics, Hungary, 1.1.-30.9.2024
Gosti, Christian, University of Rome "Tor Vergata", 1.4.-30.9.2024
Amaraneni, Sreenivasa Rao, East Point College of Engineering & Technology, India, 8.-19.4.2024
Zhong, Lijie, Guangzhou University, China, 1.12.-31.12.2024

7.3 Evaluation of candidates

Committé member for recruitment of candidates for the doctoral education pilot, Innovative Doctoral Education Ecosystem for Photonics, I-DEEP, *Rose-Marie Latonen*

Committé member for recruitment of a professor in computer engineering at Åbo Akademi University, *Johan Bobacka*

Committé member for recruitment of a professor in high-temperature chemistry and technology at Åbo Akademi University, *Johan Bobacka*

7.4 External evaluations and reviews 2024

External evaluations

Evaluation of proposal in Horizon Europe Projects (2021-2027), European Union, *Päivi Mäki-Arvela*

Quality checks of reports, HORIZON-EIC-2024-PATHFINDEROPEN-01, *Rose-Marie Latonen*

Doctoral thesis evaluations

Christophliemk, Mika, University of Oulu, 19.04.2024, opponent, *Pasi Tolvanen*

Li, Fangfang, Luleå University of Technology, 12.12.2024, *Päivi Mäki-Arvela*, opponent

Li, Huisi, KTH Royal Institute of Technology, Sweden, 12.12.2024, Examination committee member, *Chunlin Xu*

Dahiya, Deepika, Aalto University, Finland, 17.12.2024, Opponent, *Chunlin Xu*

Truncali, Alessio, KTH Royal Institute of Technology, Sweden, 18.10.2024, Opponent, *Chunlin Xu*

Frasca, Serena, Uppsala University, Sweden, 04.10.2024, Examination committee member, *Chunlin Xu*

Mustafa, Rawand, Åbo Akademi University, Finland, 31.05.2024, Examination committee member, *Chunlin Xu*

Asta, Nadia, KTH Royal Institute of Technology, 3.5.2024, Examination committee member, *Anna Sundberg*

Zaar, Felicia, Uppsala University, 27.09.2024, Sweden, opponent, *Johan Bobacka*

Golbarg, Sara, Danmarks Tekniske Universitet (DTU), Lyngby, Danmark, 21.2.2024, opponent *Tapio Salmi*

Bijok, Nicolaos, Aalto University, Finland, 20.8.2024 opponent *Tapio Salmi*

Cardenas Ramirez, Juliana, Université de Lille, Villeneuve d'Ascq, France & Universidad Nacional de Colombia, Bogota, Colombia, 18.12.2024, opponent and jury member *Tapio Salmi*

7.5 Editorial Boards

Frontiers in Chemistry, Green and Environmental Chemistry, 2013-, Editorial board member *Jyri-Pekka Mikkola*

Topic in Catalysis, Guest Editor, *Henrik Grénman*

ChemEngineering, Guest Editor, *Henrik Grénman*

Frontiers of Science, Chemical Reaction Engineering, Associate Editor, *Henrik Grénman*

Nordic Pulp and Paper Research Journal, Member of editorial board, *Anna Sundberg*

Frontiers in Chemical Engineering, Chemical Reaction Engineering, Associate Editor, *Henrik Grénman, Pasi Tolvanen*

Industrial Crops and Products (Journal), Associate Editor, *Chunlin Xu*

ACS Sustainable Chemistry and Engineering (Journal), Member of editorial board, *Chunlin Xu*

Journal of Bioresources and Bioproducts, Editorial Board Member, *Chunlin Xu*

Journal of Korea TAPPI, Member of Editorial Board, *Martti Toivakka*

Sensors and Actuators B: Chemical, Editor, *Johan Bobacka*

Electrochimica Acta, Editorial advisory board member, *Johan Bobacka*

Journal of Solid State Electrochemistry, Editorial board member, *Johan Bobacka*

Current topics in electrochemistry, Editorial board member, *Johan Bobacka*

Biomedical Technology, Editorial board member, *Johan Bobacka*

Sensing and Bio-Sensing Research, Editorial advisory board member, *Tom Lindfors*

7.6 Member of committees and boards

ACA Systems Oy, Board Member, *Martti Toivakka*

Advanced Bioresources and Smart Bioproducts (SmartBio), BioCity Turku Research Program, Chairman of the board, *Henrik Grénman*

Baltic University Program (BUP), board member, *Tapio Salmi*

British Zeolite Association, *Narendra Kumar*

Combustion Institute, the Scandinavian-Nordic Section, president, *Patrik Yrjas*

Division of Analytical Chemistry (DAC) of the European Chemical Society (EuChemS), Representative of Finland, *Johan Bobacka*

Erasmus Mundus joint master's programme, EACH – Excellence in Analytical Chemistry, Academic board member, *Johan Bobacka*

European Federation of Chemical Engineering, (EFCE), Working Party of Chemical Reaction Engineering (WP-CRE), Representative of Finland, *Tapio Salmi*

European Federation of Chemical Engineering (EFCE), Working Party of High Pressure Technologies (WP-HPT), Representative of Finland, *Tapio Salmi*

European Federation of Chemical Engineers, *Narendra Kumar*

European Federation of Corrosion; Working Party 3, Vice-Chair, *Juho Lehmusto*

European Ceramic Society, Council member, *Thomas Kronberg*

Faculty of Science and Engineering (ÅAU), Member of faculty council, *Henrik Grénman*

Faculty of Science and Engineering, Åbo Akademi University, Deputy Dean, *Johan Bobacka*

Finnish Association for Graduate Engineers, *Narendra Kumar*

Finnish Catalysis Society, vice chairman, *Pasi Tolvanen 2022–*

Finnish Corrosion Society, board member, *Juho Lehmusto*

Finnish NMR society, board member, *Robert Lassfolke*

Finnish Thermal Energy Research Association, board member, *Patrik Yrjas*

Finnish Ceramic Society, Chair, *Thomas Kronberg*

GlucModicum Oy, Board member, *Johan Bobacka*

International Conference on the Impact of Fuel Quality on Power Production and the Environment, Executive committee member, *Jonne Niemi*

International Corrosion Council, National contact point, *Juho Lehmusto*

International Zeolite Association, *Narendra Kumar*

International Energy Agency – FBC, board member, *Patrik Yrjas*

International Commission of Glass, Council member, *Leena Hupa*

9th International Conference on Engineering for Waste and Biomass Valorisation, 27-30 June 2022, Copenhagen, Denmark, Member of Scientific Committee, Evaluation of conference abstracts, *Narendra Kumar*

Johan Gadolin Process Chemistry Centre, Åbo Akademi University, Chairman, *Johan Bobacka*

Johan Gadolin Process Chemistry Centre, Åbo Akademi University, Executive Board Member, *Patrik Eklund, Henrik Grénman, Leena Hupa, Tapio Salmi, Chunlin Xu*

Oil Shale, editorial board member, *Tapio Salmi*

Publication Forum (JUFO) Panel 4 (Chemistry), Panel member, *Johan Bobacka*

Pulp and Paper Fundamental Research Society, Fundamental Research Committee, Committee Member, *Martti Toivakka*

Raisio Research Foundation, scientific expert and board member, *Tapio Salmi*

Sigrid Jusélius Foundation, Board member, *Leena Hupa*

Sigrid Jusélius Foundation, Board member, *Johan Bobacka*

Societas Scientiarum Fennica, (The Finnish Society of Sciences and Letters, Finska Vetenskaps-Societeten, Suomen Tiedeseura), invited member, *J-P Mikkola*

Svenska Tekniska Vetenskapsakademien, Board member, *Leena Hupa*

Technologies for a Sustainable Future, Åbo Akademi University, Member of the Board, *Henrik Grénman*

Technologies for a Sustainable Future, Åbo Akademi University, Board member, *Johan Bobacka*

Young Academy Finland, Member 2023-2027, *Jonne Niemi*

Walter Ahlström Foundation, Board Member, *Anna Sundberg*

8 External interactions 2025

8.1 Organization of conferences/courses/meetings 2025

CIMAPRO Intensive Course: Circular Materials and Processes, CIMANET Doctoral Education Network, Vierumäki, Finland, 4-7.3.2025, *Chunlin Xu, Hao Zhang*

Lignin Workshop 2025: “Lignin to X – Challenges and Potential”, Aurum, Åbo Akademi University, Turku, Finland, 20–21.8.2025, *Chunlin Xu, Henrik Grénman, Patrik Eklund, Hao Zhang*

Modern Analytical Tools for Pulp, Paper, and Biorefinery, Agora, Åbo Akademi University, Turku, Finland, 8–12.12.2025, *Chunlin Xu, Anna Sundburg*

Computer-Aided Chemical Reaction Engineering (CACRE2025), two-week intensive course for postgraduate students, May 2025, Åbo Akademi, *Tapio Salmi, Johan Wärnå, Heikki Haario, Rüdiger Lange, Tuomo Sainio, Adriana Freites Aguilera, Tommaso Coglianò, Emiliano Salucci, German Aranjó Barabona*

Renewable Resources and Biofineries (RRB2025) - Moving Beyond Carbon Neutral, June 2-4, 2025, Turku-Åbo, *Henrik Grénman, Chair of local organizing committee, Member of Scientific Board*

8.2 Visits and visitors

Visits

Lehmusto, Juho, Bundesanstalt für Materialforschung und -prüfung, Germany, 3.11.2025-

Alopaeus, Marie, Chalmers University of Technology, Sweden, 10.2-31.5.2025 & 5.8-29.8.2025

Chrzastowska, Julia, Chalmers University of Technology, Sweden, 24.11-31.12.2025

Martin, Matilda, The University of Edinburgh, Scotland, 1.9.2025-27.2.2026

Nie, Qi, KTH Royal Institute of Technology, Sweden, 17.2-15.8.2025

Wang, Xiaojun, Tsinghua University, China, 01.4-31.7. 2025

Visitors

Askari, Ghazal, University of Garmsar, 30.11.2025-31.12.2025

Bendalabcen, Oumaima, Mohammed VI Polytechnic University, Morocco, 1.9.25-28.2.26

Cantel, Florine, Université Savoie Mont Blanc, France, 2.5-31.7.2025

Chen, Jinghuan, China National Pulp and Paper Research Institute, China, 12.3-5.9.25

Concetta Lavino, Federica, Università di Naples, Italy, 20.3-30.9.2025

Dautremont, Ethan, Université de Poitiers, France, 14.4-18.7.2025

De Rosso, Filippo, Università di Padova, Italy, 20.2-31.8.2025

Di Finizio, Claudia, Università di Padova, Italy, 6.3-31.8.2025

Dutta, Snehasis, University of Chemistry and Technology, Prague, Czech Republic, 1.6-31.8.2025

Duverger, Esteban, Université de Poitiers, France, 14.4-11.7.2025

Fale, Shbey, Jude, Novia, Turku, Finland, 1.1-28.2.2025
Favier, Jeremy, Université de Poitiers, France, 14.4-11.7.2025
Floris, Federico, Università di Padova, Italy, 19.2-7.9.2025
Fourreaux, Clea, Université Savoie Mont Blanc, France, 2.5-31.7.2025
François, Louis, SIGMA Clermont, France, 21.5-19.9.25
Gan, Shiyu, Guangzhou University, China, 1.6.-31.8.2025
Hao, Xiao, Nanjing Forestry University, China, 22.10.25-30.10.26
Huang, Mengle, South China University of Technology, China, 17.3.25-31.3.26
Itri, Giulia, Università di Reggio Calabria, Italy, 1.5.-15.11.2025
Liang, Rongning, Yantai Institute of Coastal Zone Research, China, 1.8-31.10.2025
Lubian, Micol, Università di Padova, Italy, 6.3.25
Miró, Manuel, University of the Balearic Islands, Spain, 31.3.-3.4.2025
Nataliia Smyk, 19.9-1.10.2025
Oksana Tatanaiko, 10-15.11.2025
Orazbekova, Raushan, Al-Farabi Kazakh National University, D. V. Sokolsky Institute of Fuel, Catalysis and Electrochemistry, 8.8-19.10.2025
Perrucci, Alessandro, Ålberg Universitet, Denmark, 4.2-3.8.2025
Rejzková, Anna, University of Chemistry and Technology, Prague, Czech Republic, 1.4-31.8.2025, 1.10-31.11.2025
Sandri, Francesco, Università di Padova, Italy, 30.6.2025 - 31.10.25
Sun, Shaofei, Dalian Polytechnic University, China, 13.2.25-31.1.26
Vikram, Shruti, IIT Bombay, India, 1.6.2025-31.12.2025
Vitiello, Sabrina, Università di Padova, Italy, 6.3-31.8.2025
Xie, Zhaoyong, Tianjin University of Science and Technology, China, 22.10.25-30.10.26
Zhong, Lijie, Guangzhou University, China, 1.1.-30.12.2025

8.3. Evaluation of candidates

Committee member for recruitment of a professor in high-temperature chemistry and technology at Åbo Akademi University, *Johan Bobacka*

8.4 External evaluations and reviews 2025

External evaluations

Evaluation of ERC Starting Grants, *Dmitry Murzin*

Evaluation of proposals, Horizon Europe, *Päivi Mäki-Arvela*

Evaluator of Qatar National Research Fund, *Jyri-Pekka Mikkola*

Install, Joseph, University of Helsinki, 15.3.2025, *Päivi Mäki-Arvela*, reviewer

Shao, Jieling, Chalmers University of Technology, 25.8.2025, Päivi Mäki-Arvela, member of examination committee

Verkama, Emma, Aalto University, 29.1.2025, reviewer

Quality checks of reports, HORIZON-EIC-2025-PATHFINDERCHALLENGES-01, *Rose-Marie Latonen*

Quality checks of reports, HORIZON-EIC-2025-PATHFINDEROPEN, *Rose-Marie Latonen*

Doctoral thesis evaluation

Ssentenza, Vicent, Chalmers University of Technology, 28.3.2025, opponent, *Lehmusto, Jubo*

Hanbikoski, Saara, Aalto University, Finland, 28.05.2025, preliminary examiner, *Chunlin Xu*

Bas, Yagmur, Luleå University of Technology, Sweden, 20.11.2025, opponent, *Chunlin Xu*

Siivonen, Joonas, University of Turku, Finland, pre-examiner, *Johan Bobacka*

Jacob, Ana, University of Nova Gorica & Kemijski Institut, Ljubljana, Slovenia, 18.5.2025, jury member *Tapio Salmi*

Scotto di Perta, Michele, Laboratoire de Génie Chimique Toulouse, Institut National Polytechnique de Toulouse et de l'Université Toulouse, France, 16.6.2025, opponent and jury member *Tapio Salmi*

8.5 Editorial boards

Academic Editor Catalysts, MDPI Publisher, Basel, Switzerland, *Narendra Kumar*

ACS Sustainable Chemistry and Engineering (Journal), Member of editorial board, *Chunlin Xu*

Catalysis in Petroleum Refinery Processes, Frontiers in Chemical Engineering, Topic Editor *Narendra Kumar*

Catalysis Research, Lidsen Publisher, *Narendra Kumar*

ChemEngineering, Guest Editor *Henrik Grénman* Current Catalysis, Bentham Science Publisher, *Narendra Kumar*

Exclusive Papers of the Editorial Board Members and Topical Advisory Panel Members of catalysts in Section Catalytic Materials, MDPI, Editor in Special Issue *Narendra Kumar*

Frontiers in Chemical Engineering, Associate Editor *Narendra Kumar*

Frontiers in Chemical Engineering, Chemical Reaction Engineering, Associate Editor, *Henrik Grénman, Pasi Tolvanen*

Frontiers in Chemistry, Green and Environmental Chemistry, 2013- Editorial board member *Jyri-Pekka Mikkola*

Frontiers of Science, Chemical Reaction Engineering, Associate editor *Henrik Grénman*

Guest Editor Special Issues, MDPI Publisher, Basel, Switzerland, *Narendra Kumar*

Industrial Crops and Products (Journal), associate editor, *Chunlin Xu*

Innovators in Chemical Reaction Engineering, Frontiers in Chemical Engineering, Lausanne, Switzerland, Topic Editor *Narendra Kumar*

Journal Catalysts, MDPI, Multi Disciplinary Publishing Institute, Publisher, *Narendra Kumar*

Journal of American Chemical Engineering, Science Publishers, *Narendra Kumar*

Journal of American Chemical Engineering, Science Publishers, *Narendra Kumar*

Journal of Bioresources and Bioproducts, Editorial Board Member, *Chunlin Xu*

Journal of Korea TAPPI, Member of Editorial Board, *Martti Toivakka*

Metal Modified and Acidic Mesoporous Catalytic Materials for Valorization of Lignocellulosic Biomass, Synthesis of Speciality, Fine Chemicals and Pharmaceuticals, MDPI, Editor in Special Issue *Narendra Kumar*

Microporous and Mesoporous Materials for Application in Catalysis, MDPI, Editor in Special Issue *Narendra Kumar*

Microporous Zeolites and Related Nanoporous Materials: Synthesis, Characterization and Application in Catalysis, Catalysts, MDPI, Editor in Special Issue *Narendra Kumar*

Nordic Pulp and Paper Research Journal, member of editorial board, *Anna Sundberg*

Oil Shale, editorial board member, *Tapio Salmi*

State of the Art and Future Challenges in Zeolite Catalysts, MDPI, Editor in Special Issue *Narendra Kumar*

Supported Metal Nanoparticles for synthesis of value added products, Frontiers in Chemical Engineering, Topic Editor *Narendra Kumar*

Topic in Catalysis, Guest Editor *Henrik Grénman*

Universal Journal of Catalysis Science, Universal Wiser Publisher, Current Catalysis, Bentham Science Publisher, *Narendra Kumar*

Universal Journal of Catalysis, Universal Wiser Publisher, *Narendra Kumar*

Waste and Biomass Valorization, Springer Nature Publisher, *Narendra Kumar*

Electrochimica Acta, Editorial advisory board member, *Johan Bobacka*

Journal of Solid State Electrochemistry, Editorial board member, *Johan Bobacka*

Current topics in electrochemistry, Editorial board member, *Johan Bobacka*

Biomedical Technology, Editorial board member, *Johan Bobacka*

Iontronics, Associate Editor, *Tom Lindfors*

Sensing and Bio-Sensing Research, Editorial Advisory Board, *Tom Lindfors*

Chemical Engineering Journal, ISCRE28 Special issue, Guest editor, *Tapio Salmi*

8.6 Member of committees and boards

ACA Systems Oy, Board Member, *Martti Toivakka*

Academia Scientiarum Fennica (Suomalainen Tiedekatemia, Finnish Academy of Science and Letters), invited member, 2023, *J-P Mikkola*

Advanced Bioresources and Smart Bioproducts (SmartBio), BioCity Turku Research Program, Chairman of the board, *Henrik Grénman*

Baltic University Program (BUP), board member, *Tapio Salmi*

Combustion Institute, the Scandinavian-Nordic Section, president, *Patrik Yrjas*

Division of Analytical Chemistry (DAC) of the European Chemical Society (EuChemS), Representative of Finland, *Johan Bobacka*

EFCATS Board member (2023-2025), *Dmitry Murzin*

Erasmus Mundus joint master's programme, EACH – Excellence in Analytical Chemistry, Academic board member, *Johan Bobacka*

ESEAC 2024 conference, Member of the scientific advisory board, *Ari Ivaska*

EPNOE 2025, Scientific Committee member, *Chunlin Xu*

European Ceramic Society, Council member, *Thomas Kronberg*

European Federation of Chemical Engineering, (EFCE), Working Party of Chemical Reaction Engineering (WP-CRE), Representative of Finland, *Tapio Salmi*

European Federation of Chemical Engineering (EFCE), Working Party of High-Pressure Technologies (WP-HPT), Representative of Finland, *Tapio Salmi*

European Federation of Corrosion; Working Party 3, Vice-Chair, *Juho Lehmusto*

Evaluation of Conference Abstracts: 18th International Congress Catalysis, 19-24 July, Lyon, France, *Narendra Kumar, Dmitry Murzin, Tapio Salmi*

Evaluation of Conference Abstracts: 19 th Nordic Symposium on Catalysis, 6-8 June 2022, Espoo, Finland. *Narendra Kumar*

Faculty of Science and Engineering, Åbo Akademi University, Deputy Dean 15.11.2022–31.12.2026, *Johan Bobacka*

Finnish Catalysis Society, Vice Chairman, *Pasi Tolvanen 2022–*

Finnish Ceramic Society, Chair, *Thomas Kronberg*

Finnish Corrosion Society, board member, *Juho Lehmusto*

Finnish NMR society, Chairman, *Robert Lassfolk*

GlucModicum Oy, Board member 2018—, *Johan Bobacka*

International Commission of Glass, Council member, *Leena Hupa*

International Conference on the Impact of Fuel Quality on Power Production and the Environment, Executive committee member, *Jonne Niemi*

International Corrosion Council, National contact point, *Juho Lehmusto*

International Energy Agency – FBC, board member, *Patrik Yrjas*

International Symposium on Chemical Reaction Engineering (ISCRE28), chair of scientific and organization committees, *Tapio Salmi*

International Symposium on Wood, Fiber and Pulping Chemistry (ISWFPC 2025), Scientific Committee Member, *Anna Sundberg*

Johan Gadolin Process Chemistry Centre, Åbo Akademi University, Chairman, *Johan Bobacka*

Johan Gadolin Process Chemistry Centre, Åbo Akademi University, Executive Board Member, *Patrik Eklund, Henrik Grénman, Daniel Lindberg, Tapio Salmi, Chunlin Xu*

NAM, Providence, RI, 2023, Session chairman, *Dmitry Murzin*

Publication Forum (JUFO) Panel 10 (Chemical engineering, materials engineering and environmental engineering), *Jonne Niemi*

Pulp and Paper Fundamental Research Society, Fundamental Research Committee, Committee Member, *Martti Toivakka*

Raisio Research Foundation, scientific expert and board member, *Tapio Salmi*

Research Council of Finland, Scientific Council for Natural Sciences and Engineering, Member, *Johan Bobacka*

Sigrid Jusélius Foundation, Board member 1.1.2022–, *Johan Bobacka*

Sigrid Juselius Foundation, Board member, *Leena Hupa*

Svenska Tekniska Vetenskapsakademien, Board member, *Leena Hupa*

Technologies for a Sustainable Future, Åbo Akademi University, Chairman of the Board, *Henrik Grénman*

Technologies for a Sustainable Future, Åbo Akademi University, Board member, *Johan Bobacka*

Walter Ahlström Foundation, board member, *Anna Sundberg*

Young Academy Finland, Member 2023-2027, *Jonne Niemi*

Europacat-15, 2023, Prague, Session chairman, *Dmitry Murzin, Tapio Salmi*

Universidad de Valladolid, Scientific Advisory Board, *Tapio Salmi*

10 th International Conference on Engineering for Waste and Biomass Valorisation, 19-24 August 2024, Sendai, Japan. Member of Scientific Committee, Evaluation of Conference Abstracts, *Narendra Kumar*

9. Doctoral Theses in Progress at PCC

1. *Alopaeus, Marie* (MSc 2022, Åbo Akademi University), Performance of lignin and lignin-derivatives in polylactic acid composites, FINLAND
2. *Aranjo Barabona, German* (MSc 2021, Universidad de Valladolid), New technology for hydrogenation processes in alimentary industry (double degree with Universidad de Valladolid), EL SALVADOR , *defended 24.10.2025*
3. *Arjmandi, Donya* (MSc 2018, Imam Khomeini International University), Advanced spectrometric and spectroscopic methodology for elucidation lignin structure, IRAN
4. *Badazhkova, Veronika* (MSc 2020, Saint-Petersburg State Chemical Pharmaceutical University), From forest industry waste streams to new chemicals and materials: value from lignin degradation, RUSSIAN FEDERATION, *defended 28.11.2025*
5. *Bayssine, Abdelhakim* (MSc 2024, Cadi Ayyad University) Lignin-Based Non-Isocyanate Polyurethanes and Polyesters for Sustainable and Functional Materials and Coatings, MAROCKO
6. *Barreiro Pérez, Andrés* (ChemEng 2024, Universidad Metropolitana, Caracas), Sustainable of cyclic carbonates from CO₂ and bioresources, VENEZUELA
7. *Bhadane, Rupali* (M. Pharm. 2009, MGV's Pharmacy college, Panchavati), Wood waste valorization: lignin isolation, characterization and role in sustainable adhesive and coatings, INDIA *defended 28.08.2026*
8. *Bjarnason Hellnäs, Johannes* (MSc 2026, Åbo Akademi University), Development of novel fractionation approaches for bio-based residues towards cascade utilization, FINLAND
9. *Brunberg, Carl* (MSc 2026, Åbo Akademi), Multiscale investigation of structured raney-type foam catalysts for continuous sugar hydrogenation FINLAND
10. *Cheshak, Samira* (MSc 2022, Hakim sabzevari University), Novel Technologies for Chemical Modification of Biomass-Derived Molecules and Materials, IRAN
11. *Claybills, Johanna* (MSc 2024, Åbo Akademi), Main refractory degradation mechanisms in DRI smelting furnaces, FINLAND
12. *Cogliano, Tommaso* (MSc 2019, Università di Napoli 'Federico II' 2019), Vegetable Oils Epoxidation: From Batch to Continuous Process, double-degree with Università di Napoli 'Federico II', ITALY, *defended 02.02.2024*
13. *Chrzastowska, Julia* (MSc 2021, Lodz University of Technology), Development of novel analytical methods for wood biorefineries, POLAND
14. *Dautremont, Ethan* (MSc 2026, Université de Poitiers), Intensified catalysis through combined 3D printing and atomic layer deposition, FRANCE
15. *De Angelo, Antonio*, (MSc 2020, Università di Napoli 'Federico II') Detailed experimental investigation of hydrogen-based steel production – from chemical kinetics to pellet scale, ITALY
16. *Delgado Liriano, Jose Emilio* (MSc 2019, INSA-Rouen), Production of γ -Valerolactone – a Green Platform Molecule, double-degree with INSA-Rouen, DOMINIC REPUBLIC, *defended 28.06.2023*
17. *Deng, Wangfang* (MSc 2022, Zhejiang Sci-Tech University), Harnessing lignin-containing nanocellulose for Pickering emulsions: from fundamentals to functional materials, CHINA
18. *Fagerlund, Rasmus* (MSc 2021, Åbo Akademi), Machine learning assisted modeling of chemical kinetics for use in computational fluid dynamics, FINLAND
19. *Fotonbichianeh, Ziba* (MSc 2025, University of Turku), Low-molecular-weight lignins and investigating their antimicrobial effects, IRAN
20. *Gangotena Palacios, Pablo*, (MSc 2023, Lappeenranta-Lahti University of Technology LUT), Pure methane from CO₂ utilizing a structured radial flow reactor system employing a novel bi-functional material, ECUADOR
21. *Georgs, Valter* (MSc 2023, Åbo Akademi University), Lignin-based materials for powder bed fusion additive manufacturing: from feedstock design to functional components, FINLAND
22. *Guagneli, Luca* (MSc 2021, University of Tartu & Åbo Akademi University), Improvement of the performance of chemical sensors and biosensors for on-body monitoring, ITALY
23. *Gäddnäs, Marta* (MSc 2026, Åbo Akademi University), Phosphoryl group migration in carbohydrates, FINLAND
24. *Hachbach, Monad* (MSc 2016, ENSA Agadir) Techno-economic and environmental analysis of hemicellulose valorization, ROYAUME DU MAROC, *defended 29.11.2024*

25. *Hagman, Sara* (MSc 2025, Åbo Akademi), Oxy-combustion in black liquor recovery boilers - Towards CO₂-negative emissions and carbon-neutral products, FINLAND
26. *Hasnain, Ali* (MSc 2109, Oulu University), Lightweight composites from industrial inorganic side streams, PAKISTAN
27. *Heberlein, Stefan* (MSc 2020, Technische Universität München), Energy and Resource Recovery from Waste Using High-Temperature Slagging Gasification, GERMANY
28. *Hu, Sai* (MSc 2025, Qilu University of Technology, China), Lignin-based elastomers for 3D printing, CHINA
29. *Joon, Narender* (MSc 2016, Åbo Akademi), Continuous Dynamic Extraction and On-Line Determination of Metals from Solid Environmental Samples, INDIA
30. *Kaka Khel, Taimoor A.* (MSc 2019, Åbo Akademi), A comprehensive catalytic study for the production of diesel range cycloalkanes from biomass molecules, PAKISTAN
31. *Kaur, Jasvinder* (MSc 2022, Punjab Agricultural University) Fractionation and Depolymerization of Biorefinery Lignin for Sustainable Epoxy Applications : Structural Characterization and Structure-Property Relationship. INDIA
32. *Khalil Zeleda, Mario Ernesto* (MSc 2025, Universidad Centroamericana José Simeón Cañas), Renewable non-isocyanate polyurethanes of sustainable bio-based innovation) EL SALVADOR
33. *Kholkina, Ekaterina* (MSc 2017, Åbo Akademi), Synthesis of Value-Added Products from Residual Materials: A Green Approach for the Sustainable Development of Novel Catalytic Materials for Biomass Valorization, RUSSIAN FEDERATION
34. *Kummala, Ruut* (MSc 2015, Åbo Akademi), Cellulosic materials at biological interfaces, FINLAND
35. *Kvikant-Julin, Minette* (MSc 2022, Åbo Akademi University), Hemicellulose stabilizers for aqueous dispersion coatings, FINLAND
36. *Laurén, Esmeralda* (MSc 2024, Åbo Akademi University), Tailoring highly reactive lignin towards thermal-/photo-curable coating applications, FINLAND
37. *Lehtimäki, Watti* (MSc 2021, Åbo Akademi University), Functional fibre-based packaging materials engineered for various end-of-life Scenarios, FINLAND
38. *Li, Na* (MSc 2007, Åbo Akademi University), High-Temperature Corrosion of Ceramics in Biomass Combustion, CHINA
39. *Li, Yongzheng* (MSc 2024, Qilu University of Technology), Lignin-based hard carbon as the anode for sodium-ion batteries, CHINA
40. *Li, Zhiqiang* (MSc 2013, Åbo Akademi University), Dissolving Pulp, CHINA
41. *Liang, Shujun* (MSc 2022, Åbo Akademi University), Wood-derived nanomaterial engineering for multifunctional biointerfaces, CHINA
42. *Lordejani, Hamid Ardesbiri* (MSc 2013, Azad University), Development and Application of Advanced Analytical Techniques for Biomass-Derived Bio-Oils, IRAN
43. *Lund, Sara* (MSc 2013, Åbo Akademi), From exfoliation of graphite to graphene-nanocellulose composites for bioelectrochemical applications, FINLAND, *defended 5.12.2024*
44. *Lu, Zonghong* (MSc 2020, Tianjin University of Science & Technology), Multiscale engineering of antibacterial polyphenolic materials: from molecular design to functional interfaces, CHINA
45. *Marchi, Enrico* (MSc 2023, University of Padova), Pure methane from CO₂ utilizing a structured radial flow reactor system employing a novel bi-functional material, ITALY
46. *Martínez Klimov, Mark* (MSc 2018, Universidad Nacional Autónoma de México), Selective hydroconversion of renewable feedstock into aviation fuel, MEXICO, *defended 26.01.2024*
47. *Mastroianni, Luca* (MSc 2021, Università di Napoli 'Federico II') Transient and stationary studies of avant-garde catalysts and reactors (double degree with Università di Napoli 'Federico II'), ITALY, *defended 11.12.2025*
48. *Matamala, Veronica* (MSc 2014, Åbo Akademi University), The effect of wood species on dissolving pulp processes and product quality, CHILE
49. *Martin, Matilda* (MSc 2023, Åbo Akademi University), Biopolymer-based composites and adhesives, FINLAND
50. *Mattsson, Ida* (MSc 2015, Åbo Akademi University), Smart Materials from Sweet Molecules: Self-Assembling Polyols Derived from Mannose, FINLAND, *defended 15.12.2024*
51. *Mehmood, Adil* (MSc 2025, Åbo Akademi University), Biobased materials in sustainable electronics, PAKISTAN
52. *Nick, Tapani* (MSc 2021, Åbo Akademi University), Sustainable coating formulations: harnessing modified hemicelluloses for suberin and pigment dispersions, FINLAND

53. *Nie, Qi* (MSc 2023, Åbo Akademi University), Fractionation, modification, and application of biopolymers from wood residues, CHINA
54. *Medina Ferrer, Ananias* (MSc 2015, Simon Bolivar University), Development of New Gas-Liquid Reactor Technology, VENEZUELA
55. *Oña, Jay Pee* (MSc 2018, Åbo Akademi University), Electrocatalytic oxidation and hydrogenation of carbohydrates, PHILIPPINES, *defended 20.12.2024*
56. *Orabona, Federica* (MSc 2022, Università di Napoli 'Federico II'), Synthesis of non-isocyanate polyurethane foams: catalysis, formulation and product characterization, ITALY, *defended 21.08.2026*
57. *Palo, Jasmiina* (MSc 2020, Aalto University), Aqueous-phase reforming of biorefinery effluents, FINLAND
58. *Peththa Wadu, Dumindu* (MSc 2025, Åbo Akademi University; MSc 2017, Poznan University of Technology), Lignin functionalization for bio-based coatings and adhesives, SRI LANKA
59. *Pourghasemi Hanza, Ali* (MSc 2015, Amirkabir University of Technology), Utilizing electrochemical measurements to study high-temperature corrosion of materials in contact with multicomponent molten salt mixtures present in different sustainable energy facilities, IRAN
60. *P. A, Nizam* (MSc 2019, Mahatma Gandhi University, Kerala) Valorisation of softwood galactoglucomannan for bio-based barrier coating applications, INDIA
61. *Rendon, Sabine* (MSc 2011, Åbo Akademi University), Dyes in Dye-Sensitized Solar Cells, FINLAND
62. *Reyes, Hazzalea Elyse* (MSc 2023, University of Tartu & Åbo Akademi University) Biotemplating Approach to Solid-State Electrolyte Preparation for Sodium-Ion Battery Applications, PHILIPPINES/UNITED KINGDOM
63. *Robiños, Angelo* (MSc 2022, University of Tartu & Åbo Akademi University), Development of 3D Printed Lignocellulosic Anode for Sodium-Ion Batteries, PHILIPPINES
64. *Runeberg, Patrik* (MSc 2014, Åbo Akademi University), Selective Oxidation of Unprotected Carbohydrates, Polyols and Phenolic Compounds from the Biorefinery Feedstock, FINLAND
65. *Ruozzi, Alessandro* (MSc 2020, Università degli Studi di Modena e Reggio Emilia), The role of deliquescent deposits on low and high temperature corrosion in the thermal conversion of biomass and waste, ITALY
66. *Rutanen, Anne* (MSc, Lappeenranta-Lahti University of Technology), Size segregation in high-speed paper coating processes, FINLAND
67. *Rönholm, Jonatan* (MSc 2025, Åbo Akademi University), Mitigating bacterial self-shading in bioreactors through nanocellulose hydrogel material development and additive manufacturing design, FINLAND
68. *Saarinen, Nikke* (MSc 2025, Åbo Akademi University), Bio-Based Materials for the adsorption and filtration of Pharmaceutical Residues from Water
69. *Salazar, Rodney* (MSc 2023, University of Tartu & Åbo Akademi University), Electrochemical TEMPO-mediated oxidation of biomass molecules and production of hydrogen-a sustainable route towards value-added chemicals, PHILIPPINES
70. *Salomäki, Tim* (MSc 2024, Åbo Akademi University), Wood-derived 3D printed scaffolds towards bio-photovoltaic devices, FINLAND
71. *Salucci, Emiliano* (MSc 2018, Università di Napoli 'Federico II'), Mathematical modeling of hydrogen-based steel production – chemical kinetics and mass transfer phenomena, ITALY, *defended 20.03.2026*
72. *Schmidt, Christoph* (MSc 2019, Rostock Universität LIKAT), Transient Studies of Catalytic Three-Phase Reactions, GERMANY, *defended 27.03.2026*
73. *Schröder, Andreas* (MSc 2023, Åbo Akademi University), Reactive fractionation of biomass towards highly reactive lignin, FINLAND
74. *Stiller, Adrian* (MSc 2019, Universität Ulm), The Impact of Fluid-Flow Rate of Dissolution of Bioactive Glasses, GERMANY
75. *Strandberg, Teddie* (MSc 2024, Åbo Akademi University), Development of methods for biomass characterization based on NMR and MS techniques, FINLAND
76. *Sundström, Ellen* (MSc 2023, Åbo Akademi University), Towards functional bio-based materials from cellulose and hemicellulose, FINLAND.
77. *Szkladányi, Ábris* (MSc 2026, Åbo Akademi University-Eötvös Loránd University), Fractionation and valorisation of forest residues from environmental stress using supercritical carbon dioxide and deep eutectic solvents, HUNGARY
78. *Thankachan, Manu* (MSc 2025, Åbo Akademi), Towards Negative CO₂ Emissions - Combined NO_x-SO_x Pre-Scrubbing and CO₂ Capture, INDIA

79. *Vierttö, Tyko* (MSc 2019, Aalto University) Catalytic Hydrodeoxygenation of Bio-Oil Feed to Transportation fuel FINLAND
80. *Viswamoorthy, Raju* (MSc 2004, Annamalai University), CFD-Modelling of Fly Ash Deposition and Deposit Build-Up Dynamics in Upper Furnaces of Black Liquor Recovery Boilers, INDIA
81. *Vučetić, Sanja* (MSc 2020, University of Belgrade), Partial depolymerization of industrial lignins to materials platforms, SERBIA
82. *Wu, Ruijie* (MSc 2022, Tianjin University of Science and Technology), Aromatic monomers-mediated stabilization of lignin via biomass fractionation, CHINA
83. *Xu, Jiayun* (MSc 2019, Qilu University of Technology), Fractionation of spruce for lignin characterization and cellulose-rich solids valorization, CHINA
84. *Yevdokimova, Olha* (MSc 2022, Taras Shevchenko National University of Kyiv), Jet fuel range cycloalkanes from renewable feedstock, UKRAINE
85. *Yrjänä, Ville* (MSc 2018, Åbo Akademi University), Developing Potentiometric Ion-Selective Electrodes for Anions, FINLAND, *defended 17.6.2025*
86. *Yidong Zhang* (MSc 2021, Qingdao University of Science and Technology), Hydrogen bond reconfiguration in wood polysaccharides towards functional materials, CHINA, *defended 30.1.2026*
87. *Örn, Anton* (MSc 2019, Åbo Akademi University), Synthesis of rare sugars through site-selective epimerization, FINLAND

