8th International BioSC Symposium

Bioeconomy and sustainability – Opportunities, expectations, responsibilities"

BioSC
Bioeconomy Science Center

January 27-28, 2025

LVR Landesmuseum Bonn, Colmantstraße 14-16, 53115 Bonn, DE

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13:15	**Christian Patermann Award 2024** Laudatio by **Ingar JANZIK**, BioSC Awarding of the prize by **Thorsten MENNE**, MKW NRW
Keynote Lecture **Moderation: Ulrich SCHURR,** Forschungszentrum Jülich / BioSC	
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	Plant nutrition for sustainable plant production **Stanislav KOPRIVA**, Institute for Plant Sciences, University of Cologne
	Bio-based approaches for plant health **Sylvia SCHLEKER**, INRES – Molecular Phytomedicine, University of Bonn / BioSC
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15:30	**Poster Session & Coffee**
Moderation: Sandra VENGHAUS, RWTH Aachen University / BioSC	
16:30	**The role of bioeconomy for climate change mitigation and adaptation** **Daniela JACOB**, Climate Service Center Germany (GERICS), Helmholtz-Zentrum Hereon, Hamburg
	Integrated life cycle sustainability assessment as support for the development of sustainable bio-based products **Nils RETTENMAIER**, ifeu-Institut für Energie- und Umweltforschung, Heidelberg
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Evening discussion **Session II: Sustainablility perspectives of the generations** **Moderation: Ulrich SCHURR**, Forschungszentrum Jülich / BioSC	
17:30	The PRACC project: Practical Challenges of Climate Change - Intergenerational Justice and Freedom Dirk LANZERATH, German Reference Centre for Ethics in the Life Sciences (DRZE), Bonn
	Debate: Controversial sustainability perspectives of the generations **Sandra VENGHAUS**, Decision Analysis and Socio-economic Assessment, RWTH Aachen University / BioSC **Dirk LANZERATH**, German Reference Centre for Ethics in the Life Sciences (DRZE), Bonn **Anna VON MIKECZ,** Member Bioeconomy Council NRW, Vice Chair NABU NRW, Düsseldorf **Linda LÜTKES**, Office Bioeconomy Council NRW, Düsseldorf
18:30	**Networking Dinner** (The poster exhibition is open all evening)

January 28th, 2025	
08:30	**Welcome Coffee**
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Session III: Natural human needs - Food supply and health **Moderation: Georg GROTH,** Heinrich Heine University Düsseldorf / BioSC	
09:45	**Tasty futures – Accelerating system change through food** **Lee GREENE**, Food Horizons & Foodhub NRW e.V., Düsseldorf
	Fermenting a Sustainable Future: The Role of Micro- and Precision Fermentation in Achieving Global Sustainability Goals **Maria SCHARFE**, Formo, Berlin
	From Innovation to Acceptance: Shelf Life-Extending Technologies to Combat Food Waste **Jeanette KLINK-LEHMANN**, Institute for Food and Resource Economics, University of Bonn / BioSC **Florian BOURDEAUX**, Institute of Biotechnology, RWTH Aachen University / BioSC
	Questions & Answers
11:00	**Poster Session & Coffee**

Session IV: Beyond natural needs - Biomanufacturing and circular economy **Moderation: Dörte ROTHER,** Forschungszentrum Jülich / BioSC	
12:15	**Driving Bioeconomy Forward: From Biorefineries to Biomanufacturing** **Michel MANGION,** Bioeconomy for Change Network, France
	Integrated Bio-Process Development at the Center for Next Generation Processes and Products - Itaconic Acid Production as a Case Study **Katharina SAUR**, AVT - Process Engineering, RWTH Aachen University / BioSC
	The Jülich Biofoundry – Accelerated development of tailor-made catalysts and bioprocesses **Stephan NOACK**, IBG-1 Biotechnology, Forschungszentrum Jülich / BioSC
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13:50	**Farewell Lunch**

Presentation Abstracts

Keynote I

Accelerating the implementation of the SDGs in a (geo)politicized world: What role for Germany and Europe?


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Dr. Axel Berger
German Institute of Development and Sustainability (IDOS), Bonn

With only 17 percent of SDG targets on track and more than one third of targets stalling or even regressing, there is great urgency to accelerate the implementation of the 2030 Agenda. At the same time, negotiations on the UN "Pact for the Future" have reflected a tense geopolitical situation, autocratisation is a concerning trend across regions, and voting behaviour across the world in the "super election year 2024" has shown an increasingly difficult context of social tensions and political polarisation. Germany has made good progress concerning implementation of the SDGs within Germany, but lacks behind in critical areas like climate action and occupies one of the final places regarding negative spill-over effects that prevent other countries from advancing the 2030 Agenda. Looking at Europe, commitment towards the Agenda appears uncertain, with Ursula von der Leyen's Political Guidelines for the Next European Commission 2024–2029 having lacked any mention of the 2030 Agenda, while the Mission Letters to the Commissioners have indeed included references to the SDGs. The keynote will explore what is required to move the Pact for the Future into practice against this backdrop. It will explore key levers for accelerating implementation of the 2030 Agenda in, with, and by Germany and Europe and highlight the need for advancing key transformation areas such as the restructuring of our economies and the protection of ecosystems.

Session I: What nature provides and humans create - Natural and man-made ecosystems

Feeding on diversity - useful plants and plant uses


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Prof. Dr. Maximilian Weigend
Bonn Institute of Organismic Biology (BIOB) and Botanical Gardens, University of Bonn

Historically, plants have been responsible to most human needs, with obvious uses for food and feed, construction, clothing and less obvious uses such as environmental management. A total of 40.000 plant species have been documented across use categories. Most of these uses have been replaced with non-sustainable alternatives based on fossil energies. Historically, an estimated 11.000 plant species have been used and well in excess of 100.000 varieties have been selected and bred for food and feed alone - in order to satisfy the needs of humans and their domestic animals under different climate regimes. The last decades have brought about dramatic shifts in production systems, eating away at diversity at all levels – a large scale loss of entire ecosystems, plant species and a dramatic loss of crop varieties – and compromising ecological stability and human health. Modern society depends on a handful of plant species and varieties for their sustenance.

Instead of using crops adapted to local environments, the local environments are adapted with brute force to the requirements of a handful of crops. The enormous range of tens of thousands of varieties of food and feed plants would enable human to satisfy their needs much more sustainably and on the basis of much healthier foods, addressing a whole range of challenges with regards to energy consumption, global supply chains, malnutrition, and limited resources such as water and fertilizer. The presentation tries to give some insights into the (threatened diversity) focusing on fruits of the temperate zone.

Plant nutrition for sustainable plant production

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Prof. Dr. Stanislav Kopriva
Institute for Plant Sciences, University of Cologne

Plants are our source of food and increase in plant production is essential for the global food security. However, intensive agriculture is also a major contributor of greenhouse gas emissions and other environmental pollutants. There is, thus, a need of a transition to a more sustainable agricultural practices. One important aspect of increasing sustainability and diminishing negative impacts is reducing the dependence on fertilisers and pesticides. This can be achieved by increasing nutrient use efficiency of the crop plants as well as by employment of beneficial microorganisms to improve plant nutrient acquisition. Understanding the molecular principles of nutrient homeostasis and the mechanisms by which plants attract specific beneficial microbes are the prerequisites for generation of crop varieties capable of high production at low inputs without penalty in the nutritional quality. In the presentation, examples of such principles will be discussed.

Bio-based approaches for plant health

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Dr. A. Sylvia S. Schleker
INRES – Molecular Phytomedicine, University of Bonn / BioSC

Maintaining plant health in crop production is often challenging but essential. In particular, plant pathogens and pests are a devastating problem causing significant yield and quality losses worldwide. Research and development to identify, characterize and implement novel and environmentally friendly means for effective management strategies is urgently needed. One promising approach is to explore microbes and naturally occurring compounds that can be used as such or as a chemical scaffold for the development of active substances with superior properties. Examples of potential new compounds discovered from nature's toolbox and insights into their properties and modes of action are presented.

The role of bioeconomy for climate change mitigation and adaptation

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Prof. Dr. Daniela Jacob
Climate Service Center Germany (GERICS), Helmholtz-Zentrum Hereon, Hamburg

Integrated life cycle sustainability assessment as support for the development of sustainable bio-based products


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Nils Rettenmaier
ifeu-Institut für Energie- und Umweltforschung, Heidelberg

In order to reach net zero climate targets, manufacturing processes need to use renewable carbon feedstock as far as possible, i.e. atmospheric CO_2 or biogenic carbon sources. Researchers and engineers all over the world are therefore striving to develop CO_2-based (synthetic) and bio-based products. But how can they know whether their ideas will actually lead to more sustainable products and that those are still compatible with the world in the year 2030 or 2045, i.e. after transformation towards a green, digital and resilient economy?

We have developed the integrated life cycle sustainability assessment (ILCSA) methodology, which has been successfully applied for more than 10 years. ILCSA provides procedures for creating a common basis for environmental life cycle assessment (LCA), techno-economic assessment (TEA), and social life cycle assessment (S-LCA), and joining their results to yield practicable recommendations to various stakeholder groups depending on their individual needs. ILCSA also allows for the integration of further assessments relevant to sustainability, such as environmental/social aspects not covered by LCA/S-LCA, barriers including socio-economic and political barriers to acceptability and awareness, as well as feedstock availability, circularity, and resource use aspects.

My presentation will show that i) bio-based products are not automatically more sustainable compared to conventional (fossil) products, ii) it is essential to evaluate the environmental aspects throughout the entire life cycle and not just at the level of individual processes and iii) it is beneficial to intertwine life cycle thinking / ILCSA and process development, not only to quantify the sustainability impacts of products, but also to identify hotspots and optimisation potentials from early on.

Session II: Sustainability perspectives of the generations

The PRACC project: Practical Challenges of Climate Change - Intergenerational Justice and Freedom

Prof. Dr. Dirk Lanzerath
German Reference Centre for Ethics in the Life Sciences (DRZE), Bonn

A broad discourse in society about how to deal with climate change and the loss of biodiversity requires a scientific foundation that discusses both ethical challenges and legal instruments for action, as well as the way we conduct our economic activities and our relationship with nature. How can ecology and economy be better aligned to meet the challenges of the global socio-ecological crisis?

The aim of PRACC is to develop an ethical and legal framework for society to deal appropriately with the consequences of climate change, based on the fundamental principles of intergenerational justice and freedom. This framework will then serve as a basis for designing adaptations for production processes and consumer behaviour, informed by bioeconomic analyses, and for providing analyses for nature conservation measures in the face of biodiversity loss caused by climate change.

From the perspective of ethics, the normative challenge is to develop an ethics of metabolic and aesthetic engagement with nature that takes into account the position of humans as cultural and natural beings in the context of a society that is undergoing an intergenerationally challenging transformation process.

The PRACC consortium project is funded by the German Federal Ministry of Education and Research (BMBF) as part of the funding priority ‘Ethical, Legal and Social Aspects in the Life Sciences’ (ELSA). The aim of this funding guideline is to support interdisciplinary research projects that analyse and evaluate societal challenges arising in the context of the life sciences.

Evening debate: Controversial sustainability perspectives of the generations
Additional participants


© Martin Braun

Prof. Dr. Sandra Venghaus
Decision Analysis and Socio-economic Assessment, RWTH Aachen University / BioSC


© Hanne Horn

Prof. Dr. Anna von Mikecz
Member Bioeconomy Council NRW, Vice Chair Nabu NRW, Düsseldorf


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Linda Lütkes
Office Bioeconomy Council NRW, Düsseldorf

Keynote II

Sustainable Development: international cooperation and contributions of bioeconomy


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Dr. Adrian Leip
European Commission
DG R&I - Bioeconomy and Food Systems, Brussels

The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles [1]. The 2018 Bioeconomy Strategy complements sectoral policies and enables countries and regions to design transition pathways according to their specific challenges and opportunities, benefitting from a non-prescriptive, integrated and systemic framework [2]. The current EU Bioeconomy Strategy defines five objectives: (i) ensure food and nutrition security, (ii) manage natural resources sustainably, (iii) reduce dependence on non-renewable, unsustainable resources, (iv) mitigate and adapt to climate change and (v) strengthen European competitiveness and create jobs. Globally, the concept of the bioeconomy is gaining importance for the policy process: currently, almost 60 countries have dedicated bioeconomy policies or bioeconomy-related policies [3]. The relevance of Bioeconomy as a driver for sustainable development is increasingly recognised [4, 5]. The EU Bioeconomy Monitoring System (BMS) [6,7] maps BMS indicators to the UN Sustainable Development Goals. Using selected examples, this presentation will discuss the role of international cooperation and bioeconomy for sustainable development.

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[2] EC 2022, EU Bioeconomy Strategy Progress Report. European Bioeconomy policy: stocktaking and future developments. COM(2022)283. https://op.europa.eu/en/publication-detail/-/publication/ae0a36d3-eac3-11ec-a534-01aa75ed71a1
[3] IACGB 2024. Global Bioeconomy Policy Report (IV). A decade of bioeconomy policy development around the world. https://gbs2020.net/wp-content/uploads/2021/04/GBS-2020_Global-Bioeconomy-Policy-Report_IV_web-2.pdf
[4] IACGB 2024. Global Bioeconomy Summit 2024. One Planet – Sustainable Bioeconomy Solutions for Global Challenges.. Communique. https://gbs2024.org/wp-content/uploads/2024/10/IACGB-Communique-24October2024.pdf
[5] G20 Bioeconomy High-Level Principles https://www.gov.br/secom/pt-br/assuntos/noticias/2024/09/g20-chega-a-consenso-e-estabelece-principios-de-alto-nivel-sobre-bioeconomia/11092024-g20-principios-bioeconomia-pdf-em-ingles.pdf
[6] EU Bioeconomy Monitoring System | Knowledge for policy https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en
[7] EC-JRC 2024. Trends in the EU bioeconomy - update 2024. https://publications.jrc.ec.europa.eu/repository/handle/JRC140285

SESSION III: Natural human needs - Food supply and health

Tasty futures – Accelerating system change through food

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Lee Greene
Food Horizons & Food Hub NRW e. V., Düsseldorf

Fermenting a Sustainable Future: The Role of Micro- and Precision Fermentation in Achieving Global Sustainability Goals


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Dr. Maria Scharfe
Formo, Berlin

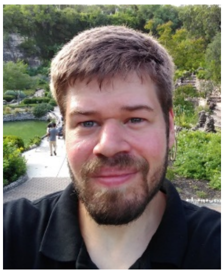
The global food system is a significant contributor to climate change, responsible for approximately one-third of global greenhouse gas (GHG) emissions. Transitioning to more sustainable methods of food production is critical to achieving international sustainability goals, including the reduction of carbon dioxide emissions. Micro- and precision fermentation have emerged as transformative technologies, enabling the production of high-quality, animal-free proteins, fats, and functional ingredients with substantially lower environmental footprints.

This presentation explores the potential of these fermentation technologies to revolutionise food production and mitigate the environmental impact of traditional agricultural systems. By leveraging microorganisms as efficient biological factories, micro- and precision fermentation can drastically reduce carbon dioxide emissions, land use, and water consumption compared to animal farming. Real-world examples, including the production of globular and dairy proteins and their application in food products, will be analyzed to demonstrate the scalability and sustainability of these innovations.

However, challenges remain. The presentation will also address key gaps in these technologies, including currently high production costs, the use of energy-intensive processes during protein production, and the need for optimised fermentation feedstocks. Additionally, we will discuss the scalability of fermentation-based systems to meet global demand and the infrastructure investments required to bridge the gap between lab-scale success and industrial-scale implementation.

By critically assessing both the opportunities and limitations, this talk aims to provide a comprehensive perspective on how micro- and precision fermentation can contribute to achieving global sustainability goals and outline actionable strategies for overcoming current barriers to their widespread adoption.

From Innovation to Acceptance: Shelf Life-Extending Technologies to Combat Food Waste



Dr. Jeanette Klink-Lehmann
Institute for Food and Resource Economics, Chair of Agricultural and Food Market Research University of Bonn / BioSC

Dr. Florian Bourdeaux
Institute of Biotechnology, RWTH Aachen University / BioSC

Alexander Minges[1], Jeanette Klink-Lehmann[2], Jana Kilimann[2], Robert Koller[4], Florian Bourdeaux[3], Tetiana Kurkina[3], Mark Müller-Linow[4], Denise Moser[1], Marlene Otto[1], Georg Groth[1], Monika Hartmann[2], Ulrich Schurr[4], Ulrich Schwaneberg[3]
[1]Institut für Biochemische Pflanzenphysiologie, HHU Düsseldorf; [2]Institut für Lebensmittel- und Ressourcenökonomik, Universität Bonn; [3]Lehrstuhl für Biotechnologie, RWTH Aachen; [4]IBG-2: Pflanzenwissenschaften, FZ Jülich

Fruits and vegetables are fundamental to human nutrition, yet significant quantities are prematurely discarded annually, resulting in a waste of valuable production resources and an exacerbation of food insecurity and climate change. Addressing these issues aligns with the Sustainable Development Goals (SDGs), particularly goals 12.3 and 12.5, which aim to substantially reduce food waste and promote sustainable consumption by 2030. Innovative technologies like shelf life-extending coatings, e.g., in the form of peptide-based ethylene inhibitors, present promising solutions to mitigate post-harvest losses. Within the RIPE project, the natural ripening-delaying peptide NOP-1 was introduced, and the follow-up project PepTechFruit aims to advance its market readiness. As a first step in the project, we aim to develop a sustainable method to produce NOP-1. For this a new inclusion body tag and cheap cleavage method was developed and will now be further improved. In addition to the production of NOP-1, a biobased coating will be developed, which allows the application of NOP-1 while also protecting the fruit. However, the implementation of such technologies relies on of stakeholder acceptance across the food system. To address this, within the PepTechFruit project, we conducted a qualitative study to explore consumer acceptance of shelf life-extending technologies. Preliminary findings indicate that while consumers value natural, edible, and invisible coatings, they harbor concerns about chemical additives, health risks, and industry transparency. These insights highlight the importance of clear communication to support sustainable innovations. Our research underscores how combining technological innovation with stakeholder-focused perspectives can bridge the gap to market implementation.

Session IV: Beyond natural needs - Biomanufacturing and circular economy

Driving Bioeconomy Forward: From Biorefineries to Biomanufacturing

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Dr. Michel Mangion
Bioeconomy for Change Network, France

Biorefineries are central to the transition toward a sustainable, climate-conscious economy. By replacing fossil carbon with renewable carbon from photosynthesis, they create high-value products while addressing environmental challenges. They also foster local economic development by mobilizing biomass, creating non-relocatable jobs, and strengthening the resilience of supply chains. As a leading network for the bioeconomy in France, Europe, and internationally, Bioeconomy For Change (B4C) supports its 500 members in advancing innovative projects. Notable examples include AFTER-BIOCHEM, which is building a flagship biorefinery to transform agricultural co-products into high-value molecules, and SCALE, which develops bioactive compounds from microalgae for various industries using sustainable processes.

The biorefinery at Pomacle-Bazancourt near Reims, France, showcases the evolution from traditional biorefining to advanced biomanufacturing, demonstrating the potential of local agricultural resources to drive regional development and global bioeconomic innovation.

The Jülich Biofoundry – Accelerated development of tailor-made biocatalysts and bioprocesses

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Dr. Stephan Noack
IBG-1 Biotechnology, Forschungszentrum Jülich / BioSC

Laboratory automation in biotechnology has made significant progress in recent years, revolutionizing the way experiments and research are conducted. The automation of entire workflows from strain engineering to bioprocess optimization is currently in the focus of attention in industry and academia, and various biofoundries are emerging around the world. I will introduce the Jülich Biofoundry and discuss some challenges and solutions in the field of automated microbial bioprocess development. In particular, the miniaturization and modularization of methods for strain engineering and phenotyping is crucial for exploring and exploiting the broad genetic and metabolic parameter space for the production of biobased compounds. In addition to current technological developments, I will showcase selected application examples to further improve the substrate and product spectrum of industrially used microorganisms.

Integrated Bio-Process Development at the Center for Next Generation Processes and Products - Itaconic Acid Production as a Case Study

© Jörg Eberz

Katharina Maria Saur,
AVT - Process Engineering, RWTH Aachen University / BioSC

Katharina Maria Saur, Robert Kiefel, Paul-Joachim Niehoff, Luca Grebe, Jochen Büchs, Jørgen Magnus, Andreas Jupke, RWTH Aachen University, Aachen

Bio-based bulk chemicals, including carboxylic acids, play a vital role in the shift towards a circular bioeconomy. While they show a broad application range, their entry into the market is often obstructed by the lower price of their fossil based counterparts[1]. To improve the economic feasibility of bio-based bulk chemicals, integrated process design is essential.

Taking the production of itaconic acid as a case study[2], we present a holistic strategy for developing processes tailored to bio-based bulk chemicals. To establish a safe process that adheres to EU regulations, we changed the production process from *Aspergillus terreus*, a filamentous fungus categorized as biosafety level S2, to *Ustilago cynodontis*, an S1 organism known for its robust yeast-like growth properties. Based on an initial conceptual process design derived from literature and equilibrium experiments with pure systems, we concurrently developed both upstream and downstream unit operations up to a 100 L scale[3]. However, product inhibition still restricts the maximum fermentation yield and space-time yield[3,4]. To tackle this, we implemented *in situ* product removal via reactive extraction[5]. We investigated how solvents affected microbial performance and how optimal production conditions shifted when moving from fed-batch to continuous fermentation. Thereby we illustrate how operating conditions in downstream processing influence fermentation performance and identify opportunities for enhancing process efficiency.

This study enhances our understanding of the advantages of integrated process development for downstream processing and fermentation. Additionally, it seeks to establish a foundation for synchronizing research efforts in both domains to improve the economic feasibility in production of bio-based bulk chemicals.

1. Nova Institute. Roadmap for the Chemical Industry in Europe towards a Bioeconomy. Strategy Document.
2. Steiger, M. G., Wierckx, N., Blank, L. M., Mattanovich, D. & Sauer, M. Itaconic Acid – An Emerging Building Block. In *Industrial Biotechnology* (2017), pp. 453–472.
3. Saur, K. M. et al. Holistic Approach to Process Design and Scale-Up for Itaconic Acid Production from Crude Substrates. *Bioengineering* 10; 10.3390/bioengineering10060723 (2023).
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Poster Abstracts

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P4	Marco Löhrer	P³roLucas - Optimization of plant performance and products for lupin cascade use
P5	Philipp Sowa	Harnessing lupin defense mechanisms for the production of valuable compounds
P6	Bodo Rehm	From Precontemplation to Action: Understanding the Biostimulant Adoption Process
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P9	Anika Wiese-Klinkenberg	Salt-priming effects on salinity tolerance of young tomato plants – a method to induce abiotic stress tolerance in tomato production?
P10	Luzie Kruse	ProPlantMicro - Production, vesicle encapsulation and plant growth promoting effects of microbial siderophores
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P26	Larissa Laurini	LignoPharm: From the valorisation of lignin to new pharmaceuticals
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P1 - Regionalisation of bioeconomy: Innovation-based biological transformation of regions

Denise Gider, Christian Klar, Ulrich Schurr

Forschungszentrum Jülich, BioökonomieREVIER, IBG-2 Plant Sciences

Achieving the United Nations Sustainable Development Goals (SDGs) requires transformative approaches that address regional challenges while utilising local strengths. The regionalisation of bioeconomy offers a practical framework to empower regions to transition into circular bioeconomy model regions. These model regions enable stakeholders to drive innovation, sustainable growth, job creation, and community well-being. Key sectors such as agriculture, forestry, fisheries, and industries are integrated through circular approaches, fostering collaboration to maximize resource efficiency, enhance competitiveness, and contribute to climate protection adapted to regional conditions.

Rooted in systemic thinking, the concept integrates biological, economic, and social innovation with regional characteristics. It provides a blueprint for tailoring bioeconomy strategies to local contexts and tangible fields of activity, linking natural resources, stakeholders, and markets. Originating from the activities of the Bioeconomy Science Center (BioSC) and further developed by BioökonomieREVIER at Forschungszentrum Jülich, the framework supports the systemic transformation of GHG-intensive regions into bioeconomy model regions. In the Rhenish Mining Region, for instance, the transition from lignite dependency to a bio-based economy creates opportunities for sustainable jobs, enhanced regional quality of life, and catalysed innovation. Notable examples include the set-up of a value chains for the cascade utilization of safflower and an industry-driven initiative for developing sustainable, plant-based fibers.

As part of the European BIO2REG project, the concept was refined and tailored to meet the needs of European regions through workshops with bioeconomy experts and stakeholders. Its adaptability ensures relevance across varying maturity levels, from emerging bioeconomy model regions to fully integrated innovation hubs. By translating macro-level strategies into actionable local solutions, bioeconomy model regions foster knowledge exchange, inclusive development, and systemic transitions. This replicable framework reinforces the role of regions as catalysts for the global bioeconomy while addressing pressing challenges in sustainability and climate protection.

Contact:
Dr. Denise Gider
email: d.gider@fz-juelich.de

P2 - A Decision Analysis Approach for Optimizing School Garden Interventions - Addressing Child Health, Biodiversity, and Economic Outcomes

Cory Whitney, Johannes Kopton, Eike Luedeling, Thi Thu Giang Luu

Institute of Crop Science and Resource Conservation, Horticultural Sciences (INRES), University of Bonn

This study evaluates the impacts of school gardens in Vietnam, focusing on child health, biodiversity, and economic outcomes across public and private schools. We assessed five investment scenarios using decision analysis, including school gardens with and without integration of STEM (Science, Technology, Engineering, and Math) education into the garden. It includes specialized teaching equipment and teacher training to enhance learning experiences. curriculum and schools without gardens. We mapped impact pathways to identify trade-offs, risks, and uncertainties, employing Monte Carlo simulations, sensitivity analysis, Pareto optimization, and Expected Value of Perfect Information (EVPI) to guide decision-making.

Our Pareto optimization model revealed trade-offs among economic, biodiversity, and health outcomes. Gardens without STEM integration consistently provided greater health benefits. STEM gardens, particularly in public schools, faced financial and operational challenges. Key success drivers included garden-related events, teacher training, and community support, highlighting the critical role of targeted investments in addressing uncertainties in economic returns. We used Non-dominated Sorting Genetic Algorithm II (NSGA-II) to explore 2500 Monte Carlo simulation runs to approximate Pareto fronts for each scenario. Optimal configurations were reached when garden size and frequency of public school events were maximized. Integrating animals in the garden increased child health benefits while reducing overall economic return. Public schools showed strong potential for biodiversity improvements with minimal economic trade-offs, while private schools demonstrated higher economic feasibility, especially when leveraging gardens to enhance reputation and enrollment. Our integrated analytical approach provides actionable insights for policymakers and educators to optimize school garden interventions. These approaches can foster sustainable food environments and improve child health.

Contact:
Dr. Cory Whitney
email: cory.whitney@uni-bonn.de

P3 – Farmers' Associations in a Bioeconomy-related Innovation System (FABIOS)

Jochen Dürr[1], Marcelo Sili[2], Jan Börner[1,3], Ulrich Schurr[4]

[1] *Center for Development Research (ZEF), Bonn*
[2] *Universidad del Sur, Argentina*
[3] *Institute for Food and Resource Economics, University of Bonn*
[4] *Institute of Bio- and Geosciences 2: Plant Sciences, Forschungszentrum Jülich*

Farmers' associations (FA) play an important role in agricultural knowledge and innovation systems (AKIS). However, this has hardly been explored in the context of the bioeconomy. Here, the AKIS approach is combined with the concept of a sustainable bioeconomy ("BAKIS"). We analyze to what extent the concept of bioeconomy has been incorporated and how it is understood by FA in NRW and Argentina, what knowledge and practices are promoted by FA to consolidate a sustainable bioeconomy and identify potential innovations for a sustainable bioeconomy and the necessary BAKIS. The methods used are qualitative and participatory, including interviews with key actors of the FA, online questionnaires with the members of the FA, and workshops with important stakeholders. Preliminary results show that the bioeconomy is seen by the Argentinean Farmer Association AAPRESID members as an activity of generating biologically-based products and services that combines: sustainability, business, added value, circularity, natural resources and efficiency. The main innovations pursued by members focus on making zero-tillage systems more sustainable, which is also the main objective of AAPRESID. The main support that members received from AAPRESID to advance with innovations are focused on technical information, training and capacity building, and on contacts that allowed to improve production systems. These are also the main factors that positively influenced their innovations. We conclude that the concept of bioeconomy seems relatively well understood by the majority of members of AAPRESID. However, the innovative practices followed by the members and promoted by the FA are still limited to certain areas that have been pursued for a longer time, i.e., they are path-dependent. More advanced sustainable bioeconomic innovations are only pursued by few farmers. Finally, AAPRESID plays an important role within a national BAKIS that still needs a lot of improvement.

Contact:
Dr. Jochen Dürr
email: jduerr@uni-bonn.de

P4 – P³roLucas - Optimization of plant performance and products for lupin cascade use

M. Löhrer, U. Schaffrath[1]
Björn Usadel, Anika Wiese-Klinkenberg, Sebastian Beier, Mansi Singh[2]
J. Pietruszka, T. Classen, Philipp Sowa[3,4]
M. Hartmann, J. Klink-Lehmann, Bodo Rehm[5]

[1] *Department of Molecular Plant Physiology (Biology III), RWTH Aachen University*
[2] *IBG-4, Forschungszentrum Jülich*
[3] *IBG-1, Forschungstrentrum Jülich*
[4] *IBOC - Bioorganic Chemistry, HHU Düsseldorf*
[5] *Chair of Agricultural and Food Market Research, Institute for Food- and Resource Economics, University of Bonn*

The BOOST FUND 2.0 project P³roLucas explores benefits and challenges of cultivation of lupin as a crop plant. Lupin is a valuable alternative protein source suitable for human food and animal feed and presents an attractive alternative to (GMO-)soybean from international markets. Lupin fixes N² from the air via symbiosis with Rhizobia and in contrast to e.g., soybean can cover its nitrogen demand up to 100% by this mechanism. Species of the genus Lupinus are known for their alkaloid content, which is reduced in the “sweet” varieties, but high in the naturally more disease resistant “bitter” varieties. Up to now the alkaloids are treated as waste but contain highly valuable and rare (pro)chiral compounds such as sparteine. Breeders try to increase overall lupin stress-resistance in both species and L. mutabilis (“Andean” lupin) could be a valuable resource for novel/improved agronomic traits. On a short-term basis, biostimulants could help to overcome challenges in lupin production and we explore their potenial use in agricultural practice. We present an overview of the latest results of this project.

Contact:
Dr. Marco Löhrer
email: loehrer@bio3.rwth-aachen.de

P5 - Harnessing lupin defense mechanisms for the production of valuable compounds

Philipp Sowa[1], Sebastian Myllek[1], Mirai Alosh[1], Ashley Nicole Beers[1], Jan Lukas Heise [1], Dr. Thomas Classen[2], Dr. Marco Löhrer[3], Prof. Ulrich Schaffrath[3], Prof. Jörg Pietruszka[1,2]

[1] *HHU Düsseldorf, IBOC - Bioorganic Chemistry*
[2] *FZ Jülich, IBOC - Bioorganic Chemistry*
[3] *Department of Plant Physiology (Biology III), RWTH Aachen University*

Lupins are commended for their nitrogen- and phosphate fixating capabilities and attractive blooms[1]. Besides being valued as regeneration tools for agricultural purposes, they also produce quinolizidine alkaloids, a class of secondary metabolites with significant pharmaceutical and agricultural value that has long been seen as toxic waste in lupin harvest[2]. These toxic putative high value chemicals derive from the amino acid L-lysine and undergo a number of biosynthetical steps forming a bisquinolizidine ringsystem. From this diiminium cation late stage functionalization takes place and the final quinolizidine alkaloids are produced[3]. Although a rudimentary understanding of this mechanism is available, most of the synthesis steps as well as the interconnection of the alkaloids is largely unknown. This project focusses on the identification of the major components of the alkaloid profile in different lupins and comparing the alkaloid profiles under stress so that the correlation between the alkaloids will become apparent. This targeted approach will also result in further knowledge about preferable environments for targeted production of certain alkaloids in lupins.

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Contact:
Philipp Sowa
emails: p.sowa@fz-juelich.de

P6 - From Precontemplation to Action: Understanding the Biostimulant Adoption Process

Bodo Rehm, Jeanette Klink-Lehmann, Dominic Lemken, Monika Hartmann

University of Bonn, Institute for Food and Resource Economics (ILR), Chair of Agricultural and Food Market Research

Biostimulants aim to reduce reliance on fertilizers and plant protection measures by enhancing plant vigor, resilience, and nutrient availability, aligning with the EU's Farm-to-Fork Strategy to reduce chemical pesticide and fertilizer use by 50% and 20% by 2030. Despite this, adoption of biostimulants among German farmers remains low. Furthermore, research on biostimulant adoption is scarce and often oversimplifies adoption as a binary decision, neglecting behavioral processes.

This study addresses this gap by adopting the Transtheoretical Model (TTM) to explore biostimulant adoption as a multi-stage process: precontemplation, contemplation, preparation, and action. Biostimulants are defined as additives from plants, microbes, minerals, or humic acids that enhance plant development, excluding rhizobia inoculation.

The ongoing pre-registered online survey (January 2025) targets a sample of 550 arable farmers in Germany. We apply ordinal logistic regression to analyze the effects of subjective knowledge, information channel usage (specialized, mass media, and network-based), trust in efficacy, and farm characteristics (size, soil quality, and age) on adoption stages.

Preliminary findings from a subsample (N=106) indicate that trust in biostimulants' efficacy is critical in advancing through adoption stages. Farmers with low trust are more likely to remain in precontemplation. As trust increases, the probability of entering the contemplation stage initially rises but declines at higher trust levels, suggesting a transition to the preparation and action stages. Subjective knowledge is positively associated with progression. Intensive use of specialized sources and mass media favors progression to higher adoption stages, the opposite holds for reliance on network-based information. Farm size and soil quality are positively while age is negatively associated with advancement.

Except for trust in efficacy, findings are not significant, however, broad confidence intervals indicate the need for a larger sample. Nonetheless, the preliminary findings highlight the critical role of building trust in the efficiency of biostimulants to promote their adoption.

Contact:
Bodo Rehm
email: bodo.rehm@ilr.uni-bonn.de

P7 - De novo chromosome-level genome assembly of Lupinus mutabilis highlights genomic characteristics and agronomically important genes

Mansi Singh[1,2], Anika Wiese-Klinkenberg[1,2], Sebastian Beier[1,2], Marco Löhrer[4], Ulrich Schaffrath[4], Björn Usadel[1,2,3]

[1] Institute of Bio- and Geosciences (IBG-4: Bioinformatics), CEPLAS, Forschungszenturm Jülich GmbH, Wilhelm Johnen Straße, 52428 Jülich, Germany
[2] Bioeconomy Science Center (BioSC), Forschungszentrum Jülich GmbH, 52428 Jülich, Germany
[3] Institute for Biological Data Science, Faculty of Mathematics and Natural Sciences, Cluster of Excellence on Plant Sciences (CEPLAS), Heinrich-Heine-University Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf, Germany
[4] Department of Molecular Plant Physiology, RWTH Aachen University, Worringer Weg 1, 52056 Aachen, Germany

Lupin species like Lupinus angustifolius and Lupinus mutabilis offer a sustainable and high-quality protein content alternative to soybeans. Their capacity converting atmospheric nitrogen into ammonia through rhizobium-root nodule symbiosis makes them ideally suited for growth in low-nitrogen soils. To advance lupin cultivation, the project P^{3}roLucas, explores the optimization of plant performance and an establishment of cascaded use of lupins including their quinolizidine alkaloids. Lupinus mutabilis is particularly intriguing for agricultural applications in Europe as the crop is adapted to temperate climate conditions and low input farming.

We assembled a draft genome assembly for Lupinus mutabilis cultivar Cruckshankii, utilizing a combination of Oxford Nanopore sequencing and PacBio sequencing. We additionally used chromosome conformation capture sequencing (Hi-C) to arrange and align the sequence contigs into pseudo-chromosomes. The de novo assembly has a N50 and N90 length of 24.06 Mb and 19.09 Mb.
In a cold stress RNA-Seq experiment we investigated the cold stress response of L. mutabilis. We identified 4,728 differentially expressed genes in cold-stressed leaf samples and these included PAMP-INDUCED SECRETED PEPTIDE (PIP) and PIP-LIKE (PIPL) peptides, known to be induced by abiotic stress and the CASPARIAN STRIP INTEGRITY FACTOR (CIF), a regulator of stress-responsive gene expression.
We utilised RNA-Seq data for gene annotation and to be able to call splice variants and isoforms. We employed the deep learning tool Helixer for ab initio gene prediction combined with RNA-Seq based stringTie predicted transcripts. To refine and select the most reliable transcript sets, we applied Mikado. We conducted a functional classification of proteins using Mercator4 and integrated a portion of the alkaloid pathway into the MapMan software.

These novel resources are intended to propel advancements in lupin breeding and cultivation, ultimately contributing to the development of sustainable regional agriculture in the future.

Contact:
Mansi Singh
email: m.singh@fz-juelich.de

P8 - Exploring buckwheat as a crop for marginal soils - root development under nitrogen deficiency

Beverley Wolters[1], Anika Wiese-Klinkenberg[2,3], Kerstin Nagel[1], Uwe Rascher[1], Laura Junker-Frohn[1,2]

[1] *Forschungszentrum Jülich GmbH, IBG-2: Institute of Plant Sciences, 52425 Jülich, Germany*
[2] *Bioeconomy Science Center, c/o Forschungszentrum Jülich, 52425 Jülich, Germany*
[3] *Forschungszentrum Jülich GmbH, IBG-4: Institute of Bioinformatics, 52425 Jülich, Germany*

Common buckwheat (Fagopyrum esculentum MOENCH), a globally grown pseudocereal, is currently hardly cultivated in Germany and merely used as a cover crop. However, buckwheat's market share is increasing, because of its health-promoting properties. Additionally, buckwheat is of interest to diversify crop rotation in response to global warming. Due to a high content of secondary metabolites, buckwheat leaf biomass might serve as a valuable source of pharmaceutically interesting phytochemicals. The project BIMOTEC aims to establish buckwheat as a dual-use crop in Germany, exploiting both buckwheat grains for food production and residual biomass for the extraction of valuable phytochemicals, like rutin. This utilization of residual biomass is intended to enhance resource use efficiency and sustainability of buckwheat cultivation, contributing to meet the German government's bioeconomy strategy. Additionally, given buckwheat's capacity to thrive in marginal soils, it holds potential for soil recultivation. Plant performance under inadequate environmental conditions, like low nutrient availability, largely relies on their root architectural traits, which have hardly been studied in buckwheat. As part of the BIMOTEC project, favorable root traits and suitable buckwheat genotypes will be identified by automated high-throughput plant phenotyping with the novel GrowScreen-Rhizo III phenotyping facility. By growing plants in flat soil-filled rhizotron pots with a translucent side plate, the root system can be regularly imaged to quantify root growth. In an initial pilot experiment, buckwheat was grown in rhizotrons under control and nitrogen-deficient conditions to detect root architectural dynamics in response to low nitrogen availability. The results of this study will be used to determine suitable conditions for further phenotyping trials with 60 buckwheat genotypes. By unraveling the normally inaccessible root system of buckwheat, BIMOTEC intends to unlock its potential to contribute to bioeconomy.

Contact:
Dr. Laura Junker Frohn
email: l.junker-frohn@fz-juelich.de

P9 - Salt-priming effects on salinity tolerance of young tomato plants – a method to induce abiotic stress tolerance in tomato production?

Sara Beier, Sebastian Beier, Franziska Genzel, Anika Wiese-Klinkenberg

Institute of Bio- and Geosciences (IBG-4: Bioinformatics), Bioeconomy Science Center (BioSC), CEPLAS, Forschungszentrum Jülich GmbH, Jülich, Germany

In order to secure food production in terms of the impending climate change involving extreme temperatures and drought, novel stress tolerant crops must be bred. Priming is a mechanism that allows organisms to react more efficiently to external influences such as abiotic or biotic stress factors. It involves exposing the organism to a priming-stress to put the defenses on alert and thus strengthen the response to further stress. Priming can therefore be considered an attractive additional way to increase the stress tolerance of crops.
Tomato greenhouse cultivation involves a young plants pre-culture, enabling a priming treatment during or after young plants production. We established priming in young tomato plants by exposure to salt stress. Plants' defense responses to salt stress were analyzed by image-based phenotyping, quantification of secondary metabolites, and gene expression analysis. Primed plants showed increased growth as a result of salt tolerance, when exposed to a repeated salt stress after recovery from the priming treatment, which indicates a stress memory effect. Quantification of total phenolics in leaves implies an elevated antioxidant defense response. To unravel the molecular mechanisms of the salt tolerance mediated by the salt priming, a gene expression analysis (RNA Seq) was performed. Comparison of the gene expression in primed and unprimed plants under salt stress resulted in a group of differentially expressed genes (DEGs), which will be further analyzed for their function and associated biological processes, including improved salt stress tolerance.
The improved tolerance to salt stress indicates that priming could serve as a plant protection method in tomato production in the future.

Contact:
Dr. Anika Wiese-Klinkenberg
email: a.wiese@fz-juelich.de

P10 – ProPlantMicro - Production, vesicle encapsulation and plant growth promoting effects of microbial siderophores

Luzie Kruse[1], Jiaxin Cui[2], Peter Dörmann[2] & Thomas Drepper[1]

[1] *Institute of Molecular Enzyme Technology, Faculty of Mathematics and Natural Sciences, Heinrich Heine University Düsseldorf, Düsseldorf*
[2] *Institute of Molecular Physiology and Biotechnology of Plants, Rhenish Friedrich Wilhelms University of Bonn, Bonn (UB)*

Iron deficiency poses a significant challenge in agriculture, affecting plant growth and crop yields. In this context, certain microbes have shown to improve the bioavailability of this essential micronutrient by synthesizing and secreting siderophores – a class of secondary metabolites capable of efficiently chelating insoluble Fe3+. Recent studies have already demonstrated plant growth promoting effects of microbial siderophores in iron-depleted soils. Therefore, siderophores have tremendous application potential in agriculture as ingredients in alternative fertilizers. However, their native biosynthesis in bacteria is controlled by complex regulatory networks, which hampers functional analysis and biotechnological production.
To address this challenge, the BioSC project ProPlantMicro aims to efficiently produce the siderophore pyoverdine (PVD) in the engineered microbial host Pseudomonas putida to gain access to this class of valuable compounds. To this end, we successfully developed novel P. putida strains that facilitate the controlled production of PVD. The PVD-enriched supernatants from these cultures, were subsequently tested for their ability to promote plant growth under conditions of iron depletion. We tested pyoverdine produced by wild type and genetically modified strains, as chelators during plants growth in a modified MS medium enriched with Fe2O3 to mimic natural soil conditions. It could be demonstrated that PVD-containing supernatants from these strains enhance plant growth parameters (leaf chlorophyll and root iron content) when applied to roots of Arabidopsis thaliana. These results emphasize pyoverdine's potential in sustainable agriculture as an iron chelator to improve plant growth by facilitating the utilization of Fe2O3 from soil.
In addition, we have started to generate engineered P. putida strains that exhibit increased formation of outer membrane vesicles (OMVs). We are currently investigating whether these OMVs can serve as microcompartments for the encapsulation of siderophores, potentially enhancing their bioavailability to plants.

Contact:
Dr. Thomas Drepper
email: t.drepper@fz-juelich.de

P11 - Interfering Peptides as C4-specific Herbicides (InterPepHerb)

Florian Bourdeaux, Ulrich Schwaneberg [1]
Sören Nagel[2,3]
Laura Hartmann[2]
Meike Sauerland, Georg Groth, Alexander Minges [4]

[1] *Lehrstuhl für Biotechnologie, RWTH Aachen*
[2] *Institut für Makromolekulare Chemie, Universität Freiburg*
[3] *Institut für Biochemische Pflanzenphysiologie, HHU Düsseldorf*
[4] *Institut für Biochemische Pflanzenphysiologie, HHU Düsseldorf*

The use of interfering peptides (iPs) in agriculture represents a novel approach to combat pests and weeds. Although the application of iPs has been extensively explored in medical research, their role in regulating biochemical and physiological processes in plants remains largely unexplored. This project aims to develop herbicides based on iPs to monomerize and thereby specifically inhibit Pyruvate-Phosphate-Dikinase (PPDK), an essential multimeric enzyme of the C4 photosynthetic pathway, which is used by many troublesome weeds, whereas most crops rely on C3 photosynthesis.
The project combines bioinformatics and biochemical assays to identify and characterize iPs that can effectively inhibit PPDK. Through screening of peptide variants, we identified multiple sequences that show significant potential as inhibitors. Protein-peptide interaction and binding studies of synthesized iPs by MST demonstrated high affinity binding to the target protein in vitro. The chemical synthesis of desired iPs was successful. We are currently developing a fluorescence polarization assay to confirm and further characterize the iP-PPDK interaction with fluorescently labelled peptides. While the chemical synthesis of short peptides (20 aa). In this approach, peptides are initially produced as precursors in microorganisms and are subsequently chemically cleaved into the desired peptides. Once we have verified the inhibition of PPDK by iPs, the next steps will be to scale up production and to see if cell-penetrating peptides should be fused to the selected iPs to improve their effect.
The InterPepHerb project is paving the way for this novel weed management strategy by identifying new iPs and developing a scalable production method. Using iPs to inhibit the PPDK allows the development of sustainable, environmentally friendly herbicides, thereby improving agricultural practices and contributing to global food security.

Contact:
Meike Sauerland
email: meike.sauerland@hhu.de

P12 – NewBIAS: New Biochars für the Improvement of Agricultural Soils

Dr. Thorsten Kraska, Prof. Dr. Ralf Pude, Prof. Dr. Eike Lüdeling [1]
Alexandra Brautlacht, Kevin Carl, Prof. Dr. Peter Quicker [2]
Dr. Sabine Willbold [3]
Dr. Otavio dos Anjos Leal, Dr. Nina Siebers, Prof. Dr. Nicolas Brüggemann, Prof. Dr. Harry Vereecken [4]
Dr. Silvia Schrey, Dr. Arnd Kuhn, Prof. Dr. Ulrich Schurr [5]
Johanna Rütt, Ali Abdelshafy, Johannes Kern, Prof. Dr. G. Walther [6]

[1] *INRES, University of Bonn*
[2] *TEER, RWTH Aachen University*
[3] *IBI-7, Forschungszentrum Jülich GmbH*
[4] *IBG-3, Forschungszentrum Jülich GmbH*
[5] *IBG-2, Forschungszentrum Jülich GmbH*
[6] *OM, RWTH Aachen University*

Biochar is increasingly recognized as a sustainable soil amendment to improve soil quality and plant growth. The NewBIAS project focuses on optimizing biochar production and application using Miscanthus giganteus as a renewable feedstock. Miscanthus-based substrates were tested for soilless cultivation of tomatoes, bell peppers, and cucumbers. Results showed that crop yields on these substrates were comparable to standard substrates, with biochar additions (1%-2%) slightly improving tomato yields. After one reuse cycle, however, Miscanthus substrates exhibited declining yields and structural degradation, indicating their limited suitability for further horticultural applications. At this stage, these substrates transition effectively into a new value chain as feedstock for biochar production.
Miscanthus biochar production was optimized through pyrolysis at 600 °C for 10 minutes, achieving biochar yields of 25% and 37% from fresh and used substrates, respectively. Substrates used for one growing cycle contained higher levels of nutrients and smaller particle sizes compared to fresh substrates, enhancing water-holding capacity (WHC) by 42%. Elemental analyses revealed significantly increased concentrations of key nutrients (e.g., P, Ca, Mg) in used substrate biochar due to root residues and residual fertilizers. Structural analysis via 13C-NMR showed higher aromaticity in fresh substrate biochar, favoring long-term carbon sequestration, while used substrate biochar exhibited increased hydrophilicity and nutrient availability, making it more suitable for soil fertility improvement. Life cycle assessments confirmed that Miscanthus-based biochar substrates are cost-effective and environmentally sustainable alternatives to peat, reducing CO2 emissions associated with horticultural substrates. Biochar application improved soil water retention, soil structure, and reduced greenhouse gas emissions without altering available phosphorus. This project demonstrated that recycling and value-added utilization of horticultural residues through technologies such as pyrolysis can increase recoverable energy, close the nutrient recycle loop, and ensure cleaner agricultural production.

Contact:
Dr. Nina Siebers
email: n.siebers@fz-juelich.de

P13 - Characterization of biochars produced from fresh and used miscanthus horticultural substrate for their optimal use in agriculture

Otávio dos Anjos Leal[1], Alexandra Brautlacht[2], Sabine Willbold[3], Nina Siebers[1], Thorsten Kraska[4], Holger Wissel[1], Silvia Schrey[5], Nicolas Brüggemann[1]

[1] *Institute of Bio- and Geosciences—Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, Wil-helm-Johnen-Straße, 52428 Jülich, Germany*
[2] *Unit of Thermal Processes and Emission Control in Waste Management and Recycling, Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen, Wüllnerstraße 2, 52062 Aachen, Germany*
[3] *Institute of Biological Information Processing—Structural Biochemistry (IBI-7), Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich, Germany*
[4] *Institute for Crop Science and Resource Conservation (INRES), Horticultural Sciences, University of Bonn, Auf dem Hügel 6, 53121 Bonn, Germany*
[5] *Institute of Bio- and Geosciences—Plant Sciences (IBG-2), Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich, Germany*

In Germany, 8.5 million m^3 of peat are used annually as horticultural substrate, emitting 1.0 million tons of CO_2 equivalent. Miscanthus giganteus grows well in diverse soils and climates and can successfully substitute peat, mitigating this problem. Miscanthus is also a valuable feedstock for biochar production. Cascading miscanthus biomass strengthens local value chains meeting environmental and socioeconomic goals. We analyzed the elemental composition, particle-size distribution, water-holding capacity (WHC), and 13C-NMR-assessed structure of biochar from fresh miscanthus (Bfm) and from used miscanthus substrate (Bum) after one tomato growing season in greenhouse to identify promising applications of each biochar. In Bum, the content (mg kg–1) of Na (1.24), Mg (5.77), Ca (65.5), S (6.90), P (26.6), Al (1.30), Si (28.2), Fe (9.07), Mn (0.70) and Zn (0.65) was 589%, 215%, 1642%, 808%, 1037%, 767%, 24%, 43%, 126% and 242% higher, respectively, than in Bfm, reflecting the presence of root residues and residual fertilizer in Bum feedstock. For Bum, 25.4%, 35.5%, and 38.6% of particles were in the size range of 4–2 mm, 2–1 mm, and 8 mm. The C/N ratio was higher in Bfm (324) than in Bum (72). Aryl-C dominated the 13C-NMR spectra of Bfm (81.1%) and Bum (61.5%). The carboxyl-C contribution in Bum spectrum (8.1%) was 3.7-fold greater than that in Bfm. The aromaticity index (aryl-C/(O-alkyl-C+alkyl-C)) of Bfm (12.9) was 3.3-fold higher than that of Bum. The WHC of Bum (456 g 100 g–1) was 42% greater compared to Bfm, probably because of fragmentation and partial decomposition of miscanthus substrate increasing particles' surface area and reducing Bum hydrophobicity. Comparatively, Bum may be better for improving soil/substrate fertility and water retention, while Bfm may be better for soil C sequestration.

Contact:
Dr. Otávio dos Anjos Leal
email: o.dos.anjos.leal@fz-juelich.de

P14 - Polysaccharide root exudates affect aggregation of of coarse-and fine-textured arable soils

O.A. Leal[1], M. Sader[2], G. Salahee[1], D. Drobietz[2], N. Siebers[1], N. Brüggemann[1], A. Kuhn[2], H. Klose[2], M. Wrona[2], S.D. Schrey[2]

[1] *Institute of Bio- and Geosciences / Agrosphere (IBG-3), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany*
[2] *Institute of Bio- and Geosciences / Plant Sciences (IBG-2), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany*

Plant roots exude photosynthetically fixed carbon via roots to the soil. Here, the root exudates help to shape the rhizosphere and modify soil structure. Polysaccharides are well-known as components of plant cell walls but understudied as part of the root exudate profile. Biochar is a soil amendment that provides multiple services, including improving the structure of soils with low agricultural productivity. In this study, we aimed to analyze the spectrum of polysaccharides released by plant roots and determine their role in soil aggregate formation, particularly when using biochar as a soil amendment. We tested maize root exudates as well as a range of commercially available polysaccharides on soil adhesion to a positively charged nitrocellulose membrane using four arable soil types with contrasting texture (sand, sandy loam, silt loam), pH (4.6–7.4), and organic carbon content (3.0–21.0 g kg–1), with and without biochar amendment (5–15 Mg ha–1). We further studied the effects of a 12-week incubation of a soil-biochar blend on soil adhesion, compared to freshly mixed soil-biochar soil samples. Microaggregate stability and CO2 release from polysaccharide-soil mixtures were measured. Our findings show distinct pattern in polysaccharide – soil interaction. While some polysaccharides are not soil specific, others are less effective in sandy soils compared to those of finer texture. Overall, biochar increased soil adhesion. Using xyloglucan as a model polysaccharide we further show that microaggregate stability is increased, and CO2 release is reduced compared to glucose as an easily available sugar. Thus, more complex exudates may persist longer in soil, thereby favoring soil aggregate formation.
Our results show the potential and relevance of plant root-exuded polysaccharides interacting with soil particles and biochar. Promoting soil aggregation, particularly in marginal soils, by elucidating interactions between root exudates, soil types and biochar may provide a nature-based solution for sustainable agriculture.

Contact:
Dr. Silvia D. Schrey
email: s.schrey@fz-juelich.de

P15 - Biodegradation of Chitosan Microgels by the Soil Microbiome

Fabian Kolodzy[1,2], Anna Wendel[3], Claudia Knief[3], Andrij Pich[1,2,4]

[1] *DWI - Leibniz-Institute for Interactive Materials, RWTH Aachen University, 52056 Aachen, Germany*
[2] *Institute of Technical and Macromolecular Chemistry, RWTH Aachen University, 52074 Aachen, Germany*
[3] *Institute of Crop Science and Resource Conservation, University of Bonn, 53115 Bonn, Germany*
[4] *Aachen Maastricht Institute for Biobased Materials, Maastricht University, Geleen, 6167 RD, The Netherlands*

Controlled delivery systems in agriculture aim to reduce agrochemical usage while maintaining plant health and crop yield. Microgels, which are crosslinked polymer networks, have emerged as promising candidates for the controlled release of various fertilizers and pesticides. However, further investigation on their biodegradation is required due to concerns regarding their environmental persistence and potential impact on the soil microbiome.
This study investigates the biodegradation behavior of physical and chemical crosslinked microgels made from chitosan which is a polysaccharide derived from crustacean shells as a waste product of the food industry. The primary objectives were to evaluate the biodegradability of these microgels under controlled soil conditions and assess the ecological impact on soil microbiota.
The microgels were produced via scalable gelation of vibration-induced droplets. Light microscopy confirmed the responsiveness of these microgels to pH and salt concentrations which could potentially be applied for controlled delivery of agrochemicals. The microbial degradation in soil was monitored for 80 days by respiratory activity and the impact on microorganisms was assessed by qPCR. Interestingly, both types of microgels exhibited enhanced degradability compared to pure chitosan which can potentially be traced back to the low water solubility of chitosan.
These findings confirm the biocompatibility of chitosan microgels regarding the soil microbiome, thereby supporting their practical use in agricultural formulations. Additionally, their biodegradation aligns with the principles of a circular bioeconomy and underscores the potential of polysaccharide-based microgels to mitigate environmental challenges posed by persistent polymers. Consequently, the investigated chitosan microgels emerge as viable candidates for controlled delivery systems for anionic fertilizer and pesticides, including RNA-based drugs.

Contact:
Fabian Kolodzy
email: kolodzy@dwi.rwth-aachen.de

P16 – Rhamnolipid field application for sugar beet protection and feasibility of microbial production using overpressure (RhamBO)

Sandra Bredenbruch[2], Florian M. W. Grundler[2], Lars M. Blank[1], Jörn Viell[3], A. Sylvia S. Schleker[2], Till Tiso[1]

[1] *iAMB – Institute of Applied Microbiology, RWTH Aachen University*
[2] *INRES – Molecular Phytomedicine, University of Bonn*
[6] *AVT.Biorefinery – RWTH Aachen University*

Crop health is crucial for a sustainable bioeconomy, yet pathogens pose a significant threat to productivity. Rhamnolipids (RLs), biosurfactants with antifungal and immune-modulating properties, offer a sustainable alternative for crop protection. This study evaluates RL application for safeguarding sugar beet crops against fungal pathogens, particularly Cercospora beticola, and explores scalable microbial RL production.
Field trials revealed that a single foliar RL application effectively inhibited Cercospora beticola infection, achieving complete protection without the need for commercial fungicides. Molecular analyses using dual RNA-Seq identified RL-induced modulation of plant immune-response genes. Gene expression analyses of field samples further highlighted RL-mediated protective mechanisms, providing insights into plant-pathogen interactions.
To address scalability, we optimized microbial RL production processes, overcoming challenges like foaming and achieving efficient synthesis of RL variants not commercially available. This scalable production method supports the broader adoption of RLs for agricultural use.
Our findings demonstrate the dual benefits of RLs as effective crop protectants and their potential for sustainable production, highlighting their role in advancing agricultural resilience and bioeconomic strategies. Future work will expand field trials and refine production technologies to improve RL availability and affordability.

Contact:
PD Till Tiso
email: till.tiso@rwth-aachen.de

P17 – PepTechFruit - Peptide-based Technologies Prolonging Fruit Durability: Fighting Food Waste with Advanced Biotechnology

Alexander Minges[1], Jeanette Klink-Lehmann[2], Jana Kilimann[2], Robert Koller[4], Florian Bourdeaux[3], Tetiana Kurkina[3], Mark Müller-Linow[4], Denise Moser[1], Marlene Otto[1], Georg Groth[1], Monika Hartmann[2], Ulrich Schurr[4], Ulrich Schwaneberg[3]

[1] *Institut für Biochemische Pflanzenphysiologie, HHU Düsseldorf*
[2] *Institut für Lebensmittel- und Ressourcenökonomik, Universität Bonn*
[3] *Lehrstuhl für Biotechnologie, RWTH Aachen*
[4] *IBG-2: Pflanzenwissenschaften, FZ Jülich*

Fruits and vegetables are essential to human health, primarily due to their nutrient richness. However, large quantities are discarded annually before consumption along the supply chain, wasting valuable resources. Ethylene, a gaseous plant hormone, accelerates ripening, senescence and spoilage in climacteric fruits, contributing to food waste. Current solutions - manipulation of storage conditions, enzyme inhibition, genetic engineering and chemical ethylene antagonists - have limitations in usability and legal compliance. The PepTechFruit project builds on BioSC BOOST FUND's RIPE project and aims to further develop the antagonistic ripening-delaying peptide NOP-1. Derived from the ethylene signal transduction network (EIN2), NOP-1 interacts with ethylene receptors (ETRs) and delays ripening. It is easily applicable in aqueous solutions and offers strong commercial prospects within the fruit market.

To address the complex issue of food waste, the project incorporates a multi- and interdisciplinary approach across five work packages (WPs). WP 1 aims to characterize and optimize the peptide-based inhibitor to better understand its mode of action. WP 2 works on the establishment of techniques to monitor and identify different fruit ripening stages based on a range of model fruit. WP 3 develops a sustainable production method for NOP-1 and its variants by applying state-of-the-art biotechnological methods, while WP 4 explores application strategies, including pectin-based gel coatings and direct application. Lastly, WP 5 investigates consumer and stakeholder acceptance using qualitative and quantitative (experimental) methods. This interdisciplinary collaboration not only promotes the further development of the peptide, but also drives its market maturity and realization in order to fully develop the potential of the technology.

Contact:
Dr. Jeanette Klink-Lehmann
email: jeanette.klink@ilr.uni-bonn.de

P18 - Tackling Fruit and Vegetable Waste in German Households: Consumers' Strategies and Perceptions of Shelf Life-Extending Technologies

Jana Kilimann, Jeanette Klink-Lehmann, Johannes Simons, Monika Hartmann

University of Bonn, Institute for Food and Resource Economics (ILR), Chair of Agricultural and Food Market Research

Fruits and vegetables are essential to human diets, yet substantial quantities are discarded in German households, resulting in a waste of valuable production resources. Innovative technologies, such as shelf life-extending coatings aim to preserve the quality of fresh produce and reduce their premature disposal. To realize the potential of such technologies in reducing fruit and vegetable waste, it is essential to understand (1) the underlying causes of waste, (2) consumers' current waste reduction strategies, and (3) their perceptions of shelf life-extending coatings. This study investigates these aspects within the context of German households. To address our research questions, we conducted nine focus group discussions in Cologne over five days in November 2024, involving a total of 72 participants. The discussions were transcribed, and will be coded using the software NVivo, with data analyzed applying Thematic Content Analysis (TCA).

Preliminary results reveal a complex interplay between consumers' appreciation for the diverse range of available produce and the challenges they face in managing their purchases effectively. Consumers already employ various strategies to 1) avoid or 2) compensate for overbuying and reduce waste, yet shelf life-extending coatings could benefit when these strategies fail. Such failure often arises due to product-related factors, personal preferences, difficulties in planning and handling, or external conditions. Participants expressed a preference for coatings that are "natural", edible, washable, invisible, without affecting the taste. Concerns were raised about the presence of "chemicals", potential "manipulation", and health risks uncovered over time. These perceptions highlight a tension between trust in regulatory frameworks ensuring product safety and skepticism toward the food industry, which some participants perceive as prioritizing profit over consumer health.

Our findings suggest that shelf life-extending technologies should be regarded as one element within a broader set of strategies aimed at supporting consumers in implementing effective waste reduction measures.

Contact:
Jana Kilimann
email: jana.kilimann@ilr.uni-bonn.de

P19 – IN-FIBRE: Integrated multistep approaches for efficient fibre extraction from alternative sources

Halim Choo[1], Moritz Doeker[1], Axel Wizemann[2], Holger Klose[1], Andreas Jupke[1,3]

[1] *Forschungszentrum Jülich GmbH, Institute for Bio- and Geosciences (IBG-2), Jülich*
[2] *wizemann:beratung GmbH, Köln*
[3] *RWTH Aachen University, Fluid Process Engineering (AVT.FVT), Aachen*

Two-stage fractionation and electrical purification processes are promising approaches for extracting high-purity cellulose from non-wood biomass while enabling the recovery of valuable side streams. IN-FIBRE aims to develop these integrated biorefinery concepts through a systematic approach. This poster highlights both the process concepts and the findings of a recent study on the two-stage fractionation process.

Contact:
Halim Choo
email: h.choo@fz-juelich.de

P20 – OptiCellu: A multidisciplinary approach towards the sustainable production of cellulose fibres

Raguin, De, Bonnabaud La Bruyere[1]
Klose, Grande, Uellendahl, Wrona Pezo[2]
Koschorreck, Urlacher, Mohammadi[3]
Gohlke, Lapsein[4]
Kühn, Schriever, Hien, Mohr[5]
Hartmann, Klink-Lehmann, Meyer, Simons, Macht[6]

[1] *Computational Cell Biology, Heinrich Heine University Düsseldorf*
[2] *Institute of Bio- and Geosciences: Plant Sciences (IGB-2), Forschungszentrum Jülich GmbH, Jülich*
[3] *Biochemistry II, Heinrich Heine University Düsseldorf*
[4] *Computational Pharmaceutical Chemistry and Molecular Bioinformatics, Heinrich Heine University Düsseldorf*
[5] *Institut für Textiltechnik (ITA) of RWTH Aachen University*
[6] *Institute for Food and Resource Economics (IRL) of University Bonn*

In the project Opticellu, we aim to establish an alternative approach based on enzyme biotechnology for the sustainable production of cellulose fibres from plant biomass, accounting for the complexity of the substrate while also achieving a fine control of the properties of the final product. This calls for a combination of expertise in three scientific units: experimental, computational, and manufacturing and innovations.

In the first step, the chemical composition of plant cell walls of several biomasses is characterised; and based on their properties, hemp and miscanthus are selected as the reference biomass for further analysis. Extracted fibres are examined to correlate the pectin and lignin contents to fibre spinnability. In parallel, suitable enzymes are selected for cleaving hemicellulose and pectin linkages in Miscanthus. This preliminary selection of enzymes includes endo-1,4-beta-xylanase (GH10 and GH11) and endo-polygalacturonase (GH28). In order to enhance the recombinant expression of proteins in selected host organisms a free and open-source web application (https://expressinhost.cs.hhu.de/) is under development. With its library of more than 4000 organisms, the web application provides a user-friendly platform for experimentalists to optimise gene expression in the host organisms. For a deeper understanding of the enzymatic degumming process, computational modelling of lignin and hemicellulose and their interactions with enzymes are being implemented at two scales. At the atomistic level, MD simulations elucidate the detailed chemical structure of lignin and hemicellulose. The PyPE_RESP python tool has been developed to enable and standardize the restrained electrostatic potential for the molecular mechanics force field for lignin molecules. At the mesoscale, coarse-grained stochastic simulations model the enzymatic degumming process through time while accounting for the detailed three-dimensional structure of the microfibril. Finally, focus group discussions gain insights into consumer acceptance of cellulose-based products for different use case scenarios.

Contact:
Dr Adélaïde Raguin
email: Adelaide.Raguin@hhu.de

P21 - Innovative value chains for a sustainable fibre industry

Mira Goßen[1], Sven Laygraf[1], Holger Klose[1,2]

[1] *FaserInnovationsZentrum Zerkall, Gustav-Renker-Straße 5, 52393 Hürtgenwald*
[2] *Forschungszentrum Jülich GmbH, Wilhelm-Johnen-Straße, 52428 Jülich*

The ever-increasing demand for fibre-based materials in multiple industrial sectors such as paper, packaging, construction and textiles, requires the development of resource-saving and environmentally friendly solutions. In view of the finite nature of fossil raw materials and the fact that ecological limits have been exceeded, the Fibre Innovation Centre Zerkall (FIZZ) aims to promote a sustainable fibre industry in the Rhenish region and neighbouring areas.
The FIZZ has set itself the goal of supporting and intensifying cooperation between the stakeholders in research, industry, agriculture and society in order to stir innovative value chains for fibre-based materials. One focus is on identifying suitable fibre plants depending on the application and developing or adapting appropriate processing technologies. At the same time, the aim is to minimise the ecological fingerprint of the entire production network.
Research is being conducted into alternative fibre sources and improvements to fibre processing to enable the multiple use of existing raw materials. FIZZ focuses on the interface between research and industry, supporting the scaling of research results from the laboratory to industrial application by networking relevant stakeholders. Another approach is to optimise the recycling of fibre-based materials. To this end, the current situation in the paper, packaging, textile and construction sectors is being analysed to identify the need for action and develop suitable solutions.
The centre thus serves as a platform for interdisciplinary dialogue and promotes the targeted transfer of knowledge and technology.

Contact:
PD Dr. rer. nat. Holger Klose
email: mira.gossen@fizz-ev.de

P22 - German Consumers' Perspectives on Sustainable Cellulose Packaging and Clothing

Lisa-Marie-Meyer, Johannes Simons, Monika Hartmann, Jeanette Klink-Lehmann

University of Bonn, Institute for Food and Resource Economics (ILR), Chair of Agricultural and Food Market Research

The transition to a sustainable bioeconomy requires renewable resources, innovative technologies, efficient supply chains, and consumer acceptance. Cellulose-based clothing and packaging offer promising sustainable alternatives to fossil-based products. However, current production methods often involve extreme water usage and processes, undermining environmental benefits. Enzyme-based technologies provide a solution by reducing the ecological footprint of those products. Despite growing interest in sustainable products, German consumers' perceptions and preferences regarding sustainably produced cellulose-based clothing and packaging remain unexplored. This study aims to fill this gap by examining: (1) consumers' habits and behaviors concerning clothing and packaging, (2) their perceptions of cellulose-based products, (3) factors shaping acceptance across different use cases, (4) the influence of local sourcing and sustainable processing in consumers' product evaluation. Eight focus group discussions involving 64 participants were conducted in Cologne in November 2024 with transcripts being analyzed in NVivo using Thematic Analysis (TA) with a mixed inductive-deductive framework approach. Preliminary findings reveal consumers prioritize tangible product attributes such as texture, smell, and price over social and ecological sustainability, which often require prompting. While sustainability is acknowledged as important, incorporating it into purchases is fre-quently perceived as burdensome. Factors influencing the acceptance of cellulose-based products vary: adults prioritize functionality and affordability for clothing and children brand recognition. Non-food packaging hinges on waste reduction and practicality and food packaging on durability, protection and hygiene. Consumers are skeptical of higher costs for sustainable options unless benefits like sustainable production and comparable quality to conventional alternatives justify them. Local production, though seen positively and linked to quality and ethics, remains secondary to price and functionality. By identifying barriers and drivers of consumer acceptance, this research supports the development of targeted strategies to promote sustainably produced cellulose-based innovations and foster behavioral changes essential for advancing the bioeconomy in Germany.

Contact:
Dr. Jeanette Klink-Lehmann
email: jeanette.klink@ilr.uni-bonn.de

P23 – LignoTex - Integrated Biorefinery for Sustainable Production and Processing of Lignin for Textile Application

Daniel Wolters[1], Philipp M. Grande[2], Tim Langletz[3], Aishe Grotjohann[4], Jörn Viell[5], Jeanette Klink[6], Milan Tatic[6]; Holger Klose[2], Sascha G. Schriever[1], Alexander Hoffmann[3], Thomas Gries[1], Sonja Herres-Pawlis[3], Jupke & A. Holtz[4], Monika Hartmann[6]

[1] *Institut für Textiltechnik (ITA) of RWTH Aachen University, Aachen, Germany*
[2] *Institute of Bio- and Geosciences: Plant Sciences (IGB-2), Forschungszentrum Jülich GmbH, Jülich, Germany*
[3] *Institute of Inorganic Chemistry (IAC) of RWTH Aachen University, Aachen, Germany*
[4] *Fluid Process Engineering (AVT.FVT) of RWTH Aachen, University, Aachen, Germany*
[5] *NGP2 Biorefinery, RWTH Aachen University, Aachen 52074, Germany*
[6] *Institute for Food and Resource Economics (IRL) of University Bonn, Bonn, Germany*

Lignin is a promising and abundant coupling product in biorefineries (e.g. paper and textile industry), which in most biorefinery concepts is burned for its energy value. To make biorefineries economically more viable and to reduce the CO2 footprint, however, a valorization strategy exploiting the high potential of lignin is crucial. In this project we are focussing on the lignin valorization for different applications in the textile industry.

Contact:
Dr. Sascha Schriever
email: sascha.schriever@ita.rwth-aachen.de

P24 - A novel bio-based flame retardant finish based on polyphenolic polyphosphazenes for cellulose

Laura Hetjens[1,2], Kevin Sabel[2], Uma Beate Alekse[1,2], Melvin Mrose[1,2], Regina Palkovits[2], Andrij Pich[1,2]

[1] *DWI - Leibniz Institute for Interactive Materials, Aachen (Germany)*
[2] *ITMC - RWTH Aachen Institut for Technical and Macromoleculare Chemistry, Aachen (Germany)*

The trend towards sustainable flame retardants (FR) is growing, with a focus on environmentally friendly, halogen-free and bio-based materials such as polymeric phosphorus-based colloids could be a new approach towards sustainable flame retardants. Consequently, novel halogen-free FRs derived from polyphenol-polyphosphazene colloids, particularly phosphornitrilic chloride trimer (HCCP) in combination with polyphenols such as isocraugsodine, hold considerable promise as FR finishes. This is attributable to their elevated phosphorus and nitrogen content, substantial crosslinking density, and adaptability to diverse surfaces. These bio-based polyphosphazene colloids are biocompatible and biodegradable due to the P-N rich cyclomatrix structure and the combination of functional aromatic polyphenols. The successful synthesis of tannic acid/HCCP colloids has already been confirmed by the Pich working group and such halogen-free cyclomatrix polyphosphazene materials have shown suitable properties in thermal analyses, allowing FR applications on diverse cellulose surfaces.
A new synthesis method has been developed, using isocraugsodine, a bifunctional polyphenolic building block synthesized from biomass, as a reagent to crosslink with HCCP via precipitation polycondensation to form new bio-based colloids. These FR colloids were pad on or in-situ-coated on for example cotton fibres and analysed for their thermal stability and FR properties. The mild reaction conditions, ease of purification, and scalability are favourable for further improvements in sustainability. This new FR material is characterised by high thermal stability, attributable to intumescence, low degradation up to 300 °C, and a high carbonisation effect, particularly on cotton. The present study systematically investigates the influence of the chemical composition and coating amount of the bio-based polyphenol-polyphosphazene colloids on the thermal stability and performance of FR, in bulk and on coated cardboards on textiles. A range of analytical techniques were employed, including thermogravimetric analysis, vertical flame tests, and limiting oxidation index (LOI) and proved the high thermal stability of this innovative FR finish.

This work is part of the IGF-Project “BioFlammSchutz” (22206 N).

Contact:
Prof. Andrij Pich
email: pich@dwi.rwth-aachen.de

P25 - Bio-based Innovations: Consumer Preferences for Plastic Products containing Lignin

Milan Tatic, Monika Hartmann, Leonie Krüsken, Jeanette Klink-Lehmann

University of Bonn, Institute for Food and Resource Economics (ILR), Chair of Agricultural and Food Market Research

In the context of a sustainable bioeconomy, lignin holds great potential for use in biocomposites and value-added products, yet it is still largely incinerated for energy. Since many people are unfamiliar with lignin, providing clear and targeted consumer information is essential to bridge knowledge gaps, enhance acceptance, and harness its market potential. This study investigates the effect of product attributes and communication framing on consumer preferences for plastic products containing lignin. Specifically, the objectives are to (1) evaluate how consumers value different product attributes, focusing on lignin content, and (2) determine whether additional information about the benefits of lignin - framed in terms of environmental sustainability or regionality - influences consumer preferences. In a discrete choice experiment administered via an online consumer survey (N=4,070), each participant evaluated one of three products - cutlery, pots, and sand toys - under one of three informational treatments: a control group, a sustainability framing, or regionality framing. Participants repeatedly chose between two product alternatives with varying lignin content levels (5%, 25%, and 50%), end-of-life attributes (recyclable or biodegradable), plastic type (bioplastics or no label), and prices, or opted to buy none of the alternatives. The results indicate that consumers are willing to pay (WTP) a premium for 50% lignin across products and informational treatments. Compared to the control group, sustainability and regionality information significantly enhance WTP for 50% lignin. Additionally, a WTP premium for 25% lignin was consistently observed across all products for both informational treatments. Low lignin level (5%) was generally not positively valued, except for pots under the informational treatments. This study underscores the importance of lignin content in shaping consumer preferences. It highlights the potential of communication strategies to enhance consumer acceptance of lignin-containing products, particularly at intermediate and high lignin levels.

Contact:
Milan Tatic
email: milan.tatic@ilr.uni-bonn.de

P26 – Ligno Pharm: From the valorization of lignin to new pharmaceuticals

L. Laurini, S. Herres-Pawlis [1]
P. Grande, U. Schurr [2]
D. Calabrese, L. Lauterbach [3]

[1] *Institute of Inorganic Chemistry, RWTH Aachen University*
[2] *Institute of Bio- and Geosciences, FZ Jülich*
[3] *Institute of Applied Microbiology, RWTH Aachen University*

To generate new, bio-based antimicrobial agents, lignin monomers are extracted from lignocellulose followed by hydroxylation and oxidation using a Cu2O2 catalyst species. Subsequent condensation with diamines results in phenazine products displaying antibacterial behavior. Finally, imine reductases are used to reduce the aromatic phenazines into aliphatic hydrophenazines creating new building blocks suitable for antimicrobial agents.

The project focusses on plant species with G- and H-unit rich monomer compositions as an unsubstituted C-atom in ortho-position to an hydroxy group is necessary for phenazine formation. Lignin monomers are extracted from lignocellulose using the OrganoCat process. A following anti-solvent fractionation with 2-methyltetrahydrofuran separates low molecular weight fraction with the desired high G- and H-unit content from the reaction mixture.

For the hydroxylation and oxidation process tailored copper complexes based on guanidine or bispyrazolylmethane ligands are designed. As impurities resulting from the OrganoCat process may decrease the catalytic activity of the Cu2O2 catalyst, robust complexes tolerating water as well as organic contamination are in the center of this approach. By the systematical choice of ligand building blocks, catalyst properties like speed of formation, temperature stability and tolerance of impurities can be tuned. By variation of the amine species used as condensation reagent new phenazine products will be generated.

To reduce the new phenazine product into the final hydrophenazines products, novel imine reductases with suitable active sites will be synthesized. Then, the redox activity of the novel will be studied. Resulting hydrophenazines products as well as new phenazines are evaluated for their antibacterial behavior using different types of sensitive tests with gram-positive and gram-negative bacteria.

Contact:
Prof. Sonja Herres-Pawlis
email: sonja.herres-pawlis@ac.rwth-aachen.de

P27 – MetaProcess: Towards a sustainable production of chiral amino alcohols by biocatalyst engineering and process optimization

Stephan Schott-Verdugo[1], Berit Rothkranz[2,3], William Graf von Westarp[4], Jesko Kaiser[5], Rocco Gentile[5], Andreas Jupke[4,6], Dörte Rother[2,3], Holger Gohlke[1,5]

[1] *Institute of Bio- and Geosciences 4 - Bioinformatics, Forschungszentrum Jülich*
[2] *Institute of Bio- and Geosciences 1 - Biotechnology, Forschungszentrum Jülich*
[3] *Institute of Applied Microbiology, RWTH Aachen University*
[4] *Fluid Process Engineering - AVT.FVT, RWTH Aachen University*
[5] *Institute for Pharmaceutical and Medicinal Chemistry, Heinrich Heine Universität Düsseldorf*
[6] *Institute of Bio- and Geosciences 2 - Plant Sciences, Forschungszentrum Jülich*

MetaProcess aims at establishing synthetic pathways for chiral amino alcohols using the biosynthesis of metaraminol with biocatalysts and second-generation feedstocks as a showcase. To ensure an economically competitive and sustainable process, it is essential to achieve greater stability at the level of the biocatalysts, specifically the pyruvate decarboxylase of Acetobacter pasteurianus, ApPDC, and the amine transaminase of Chromobacterium violaceum, Cv2025. Further, it is necessary to implement effective downstream processing with an in-situ product removal (ISPR) step, and a comprehensive life cycle assessment.
We have recently implemented state-of-the-art AI based methods to predict the stability of variants of ApPDC, leading to the modification at selected positions of the enzyme and generating new variants. Further testing of ApPDC at reaction conditions has shown irreversible inactivation when incubated with the substrate due to a covalent modification, currently under assessment by MS. In the Cv2025 reaction on the other hand, the product inactivates the reaction due to a modification when interacting with the enzyme cofactor, PLP. Absorbance spectra of PLP with metaraminol and QM calculations suggests the formation of a Pictet-Spengler product. Testing of an ISPR continuous production process with a membrane reactor have been performed using acetophenone to phenylethylamine transamination as a blueprint. An LCA analysis and comparison with a representative chemical reaction has indicated that a main optimization point of a continuous process is the usage/recycling of solvents. Our results show the potential of MetaProcess at establishing a sustainable process by using biocatalyst engineering and process optimization.

Contact:
Dr. Stephan Schott-Verdugo
email: s.schott-verdugo@fz-juelich.de

P28 - The enzymatic synthesis of metaraminol – an (un)solved mystery

Berit Rothkranz[1,2], Doris Hahn[2], Lilia Arnold[2], Daniel Becker[1,3], Jesko Kaiser[1,3], William Graf von Westarp[4], Andreas Jupke[4], Darja Deobald[5], Lorenz Adrian[5], Stephan Schott-Verdugo[1,6], Holger Gohlke[1,3,6], Dörte Rother[1,2]

[1] *Bioeconomy Science Center (BioSC)*
[2] *Institute for Bio- and Geoscience (IBG-1): Biotechnology, Research Center Jülich*
[3] *Institute for Pharmaceutical and Medicinal Chemistry, Heinrich Heine University Düsseldorf*
[4] *Fluid Process Engineering (AVT.FVT), RWTH Aachen University*
[5] *Environmental Research Center (UFZ) Leipzig, Department Molecular Environmental Biotechnology*
[6] *Institute of Bio- and Geosciences 4 (IBG-4): Bioinformatics, Research Center Jülich*

A multi-step enzymatic process was established for the production of metaraminol, an active pharmaceutical ingredient for the treatment of hypotension. The enzymatic approach was designed as a green alternative to the conventional chemical production route, potentially including renewable resources as starting materials [1, 2].
The enzymatic process consists of two steps: (1) carboligation of benzaldehyde and pyruvate to (R)-3-hydroxyphenylacetylcarbinol and (2) reductive amination of the intermediate to metaraminol. Although the principle of enzymatic metaraminol synthesis works well, the enzymes required for this process lack high operational stability and suffer from low metaraminol yields.
To overcome this major hurdle, we aim to improve the operational stability of the carboligase and optimize the reaction conditions to increase the overall product yield.
For the carboligation step, LC-MS/MS analyses have shown the formation of a covalent adduct between the lysine residues and benzaldehyde. In particular, the lysine at position 300 seems to play a crucial role in the carboligase's inactivation mechanism. Based on these investigations, we are engineering new ApPDC variants to find a suitable candidate for the process. In addition to enzyme engineering strategies, the process will be optimized by testing different reaction modes and systems, e.g. the microaqueous reaction system (MARS), which increases the solubility of substrates and products. First MARS experiments yielded 49% (R)-3-OH-PAC and showed that the concept for (R)-3-OH-PAC synthesis works in general. Further optimization of the process is planned.
With respect to the amine transaminase, it was observed that the yellowish color of the cofactor pyridoxal-5'-phosphate (PLP) disappeared in the presence of low concentrations of metaraminol. The individual compounds were analyzed by LC-MS, suggesting that PLP forms a Pictet-Spengler product with the target product metaraminol, leading to product inhibition. Here, process optimization is targeted as a suitable option to overcome the unexpected hurdle of low product yield.

Contact:
Berit Rothkranz
email: b.rothkranz@fz-juelich.de

P29 - Identifying a potential binding site of the inhibitor oleic acid in Cv2025 using MD simulations

J. Kaiser, R. Gentile, D. Becker, Stephan Schott-Verdugo, Holger Gohlke

Institute for Pharmaceutical and Medicinal Chemistry & Bioeconomy Science Center (BioSC), Heinrich Heine University Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf

Synthetic routes for the drug metaraminol and related amino alcohols traditionally rely on petrochemical resources and metal-based catalysis reactions, and are thus not environmentally sustainable. Recently, it was shown that the biosynthesis of metaraminol can be achieved by combining an enzymatic carboligation step and a subsequent transamination step catalyzed by an aminotransaminase (Cv2025) [1,2]. Notably, the process can be carried out with readily available raw materials such as xylose and glucose, making it environmentally friendly and sustainable. To increase the yield of the aminotransaminase, a two-phase system consisting of an aqueous phase in which the reaction takes place, and an organic phase in which the product accumulates, is used [3]. For the product to pass into the organic phase, oleic acid is added as a reactant. However, it has been shown that the addition of oleic acid also leads to inhibition of the enzyme and its addition is thus limited [3]. To further understand the binding mode of oleic acid within Cv2025, we performed free ligand diffusion MD simulations. Those simulations gave first insights into potential binding regions but failed to characterize a specific binding site. Thus, we combined this approach with utilizing state-of-the-art AI approaches for predicting the binding site and binding mode of oleic acid. Thereby, we could see that oleic acid may bind in the catalytic core of the protein, overlapping with the binding site of the cofactor pyridoxal phosphate, potentially explaining the inhibitory effect. This binding region is in line with results we could observe during free ligand MD simulations. By using unbiased MD simulations based on the newly proposed binding mode, we also investigated the effect of receptor plasticity on oleic acid binding. Based on these insights, new fatty acids may be suggested that are sterically unable to bind within this binding site and thereby show no inhibition of the protein.

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Contact:
Prof. Dr. Holger Gohlke
email: gohlke@uni-duesseldorf.de

P30 – Insights into the conformational dynamics of NoCAR, an attractive enzyme for the sustainable synthesis of valuable aldehyde building blocks (CasCAR)

Benoit David[1], Sabahuddin Ahmad[2], Svyatoslav Kondrat[3], Dörte Rother[2,4], Eric von Lieres[2], Holger Gohlke[5]

[1] Institute of Bio- and Geosciences 4 - Bioinformatics, Forschungszentrum Jülich
[2] Institute of Bio- and Geosciences 1 - Biotechnology, Forschungszentrum Jülich
[3] Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw
[4] Institute of Applied Microbiology, RWTH Aachen
[5] Institute for Pharmaceutical and Medicinal Chemistry, Heinrich Heine Universität Düsseldorf

Carboxylic acid reductases (CARs) are attractive catalysts for the green synthesis of valuable aldehyde building blocks. The CAR enzyme from Nocardia otitidiscavium (NoCAR) has been characterized as one of the most potent enzyme to efficiently convert benzoic acid into benzaldehyde, an important building block in pharmaceutical ingredients. However, little is known about how this enzyme function is carried out at the structural level. Previous works have shown that NoCAR follows a two-step catalytic mechanism, involving an adenylation and a reduction step, each of which is carried out in two distinct catalytic domains, an N-terminal adenylation domain and a C-terminal reductase domain. Crystallization studies conducted on both catalytic domains suggested that such a mechanism requires that NoCAR undergoes a conformational transition from a closed to an open conformation to facilitate the channeling of the reaction intermediate from the adenylation domain to the reductase catalytic site. In this study, we characterized the structural aspects and energetics of this conformational transition at the atomistic level for the first time using targeted Monte-Carlo and unbiased MD simulations. These simulations allowed the characterization of a conformational free-energy landscape to identify NoCAR major conformational ensembles and determine the kinetics of the transitions between these different conformations. In addition, umbrella sampling simulations were conducted to quantify the impact of cofactors binding on the conformational free-energy barriers. To explore large simulation timescales and effectively simulate the previously characterized conformational transitions, three coarse-grained (CG) models of NoCAR were developed using the configurational equilibrium probability distribution derived from unbiased MD simulations data. The subsequent determination of the best CG model will be based on its ability to reproduce the thermodynamic data obtained from umbrella sampling simulations. We expect this project to provide transferable rational knowledge to better understand the impact of conformational dynamics on CARs catalytic activity.

Contact:
Dr. Benoit David
email: be.david@fz-juelich.de

P31 – OpTooGlu - Optogenetic toolbox for two-color light-controlled gene expression in the acetic acid bacterium Gluconobacter oxydans

Matthias Pesch[1], Arne Kayserling[1], Sophie Helgers[2], Lena Müller[2,3], Eva Federer[1], Mohammad Yoonus Khan[1], Sophia Dorenkamp[1], Wolfgang Wiechert[1], Dietrich Kohlheyer[1], Jörg Pietruszka[2], Thomas Drepper[3], Tino Polen[1]

[1] *Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich, Germany*
[2] *Institute of Bioorganic Chemistry, Heinrich Heine University Düsseldorf, Forschungszentrum Jülich, Germany*
[3] *Institute of Molecular Enzyme Technology, Heinrich Heine University Düsseldorf, Forschungszentrum Jülich, Germany*

This project aims to develop and establish new optogenetic tools for temporal gene expression in Gram-negative bacteria and the first ones for the versatile industrial workhorse Gluconobacter oxydans to improve its huge biotechnological potential. The ultimate goal is to establish the simultaneous use of UV-A and long wavelength light-sensitive caged effector molecules for dynamic control of gene expression and thus cellular functions and its application in two-color bioprocess engineering strategies. First, we synthesized the two UV-A-activatable photocaged inducers NP-L-arabinose and NP-L-rhamnose for initial experiments in G. oxydans. In parallel, the corresponding regulator/promoter systems AraC-ParaBAD and RhaS-PrhaBAD were characterized in G. oxydans using fluorescence reporter genes to determine the (i) basal and (ii) maximal expression levels as well as (iii) the gradual inducibility. For comparative evaluation, Escherichia coli and Pseudomonas putida were used as reference organisms. For single cell analysis, the microfluidic setup was successfully established for G. oxydans. Induction experiments with the conventional inducers L-arabinose and L-rhamnose and subsequent fluorescence reporter protein analysis clearly demonstrated that the inducers and the AraC-ParaBAD and RhaS-PrhaBAD expression systems can also be applied in microfluidic cultivation systems having cultivation volumes in the nanoliter range. In BioLector experiments, initial tests with G. oxydans and the NP-caged inducers under UV-A exposure showed that potentially toxic effects of relevant factors on the growth of G. oxydans are neglectable. Also, a second type of caging group has been synthesized and we currently are investigating the coupling to the sugars to obtain caged inducer molecules that can be deprotected by light at long wavelengths (>600 nm).

In conclusion, synthesis, evaluation, and supply of caged compounds for two-color bioprocess engineering strategies to control cellular functions in bacteria is on the way. For Gluconobacter, the prerequisites to test the usage of caged compounds are met.

Contact:
Dr. Tino Polen
email: t.polen@fz-juelich.de

P32 - Automated flow cytometry for high-throughput screening of rationally engineered strain libraries

Luisa Wachtendonk, Julia Tenhaef, Stephan Noack

Institute of Bio- and Geosciences, IBG-1: Biotechnology, Forschungszentrum Jülich, D-52425 Jülich, Germany

In the "AutoBioTech" innovation lab[1] as part of the Jülich Biofoundry[2], a versatile automation platform has been established that enables the rational engineering of microbial production strains in high-throughput. Using standardized workflows, automated transformations of prokaryotic model organisms with plasmids assembled via modular cloning can be routinely performed[3]. However, the screening and first assessment of generated strain libraries remain a bottleneck, in particular in the production of active and stable enzyme variants.

Flow cytometry is a powerful analytical tool that has been used for decades to gain information about cells in solution. It allows monitoring of physical cell properties associated with scattered light, as well as the detection of fluorescence signals created by staining of cells, labeling with antibodies, or expression of fluorescent reporter proteins such as GFP. This combination of parameters allows insight into characteristics like cell size and granularity, total cell count, viability, and gene expression. To further enhance the analytical capabilities of the AutoBioTech platform, we have integrated a MACSQuant® X flow cytometer (Miltenyi Biotec) via custom software solutions.

As a first demonstrator, flow cytometry is being applied to automatically engineered strains prepared for whole-cell bio-catalysis. While Escherichia coli remains the preferred host for recombinant enzyme production, a common challenge is aggregation of misfolded enzymes. These insoluble particles often show diminished activity. By employing automated flow cytometry, this effect can be detected at-line and at high-throughput for whole enzyme libraries. Furthermore, we will investigate the influence of expression levels (modulated by different promoter variants upstream of the enzyme-encoding target genes) on aggregate formation and the associated change in specific enzyme activity.

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Contact:
Dr.-Ing. Stephan Noack
email: s.noack@fz-juelich.de

P33 - MK-ScaLoop – Towards an industrial-scale process for a biotechnological production of methyl ketones in a multiphase loop reactor

Diana Wall[1], Tobias Schwanemann[2], Andreas Schonhoff[3], Andreas Jupke[1], Lars M. Blank[2], Till Tiso[2], Petra Zapp[3]

[1] *RWTH Aachen University, Fluid Process Engineering (AVT.FVT)*
[2] *RWTH Aachen University, Institute of Applied Microbiology (iAMB)*
[3] *Forschungszentrum Jülich GmbH, Institute of Climate and Energy Systems | ICE 2 - Jülich Systems Analysis*

Methyl ketones (MKs) show a wide range of applications from fragrances and flavors to precursors in pharmacological production. Furthermore, they are promising solvents, which can be used in biotechnological processes. It is possible to produce MKs biotechnologically with microorganisms like Pseudomonas taiwanensis VLB120 by altering the fatty acid metabolism.

Nevertheless, successful implementation in conventional reactors is hindered by product inhibition despite the theoretically high production rate. Combining strain development and process engineering with integrated reaction and separation techniques can overcome this limitation. An example is in situ liquid-liquid extraction, whereby a second liquid organic phase is added, allowing the removal of inhibiting components while reducing their concentration in the aqueous phase. In agitated multiphase reactor concepts, bubbles and droplets are finely dispersed. This causes emulsions that are difficult to separate, resulting in valuable biomass and products accumulation in the emulsion and leading to a reduction in efficiency of these reactor concepts.

In the multiphase loop reactor (MPLR), where extraction and gassing occur in distinct zones, the riser and the downcomer, this issue can be effectively mitigated. The lower turbulence in the downcomer compartment leads to droplet sizes that can more easily coalesce and thus be withdrawn as a coherent phase. Within the framework of MK-ScaLoop, the concept of the MPLR was tested, further developed and transferred to a biotechnological process for the production of biotechnological MKs in terms of ecological and economic aspects.

The poster illustrates the steps to be considered to implement industrial production of methyl ketones in the future. This takes the organism, the reactor concept, along with the downstream processing and a process evaluation into account.

Contact:
Diana Wall
email: diana.wall@avt.rwth-aachen.de

P34 - Fluid Dynamics and Process Parameters: Insights from a Scaled Loop Reactor

Diana Wall, Andreas Jupke

RWTH Aachen University, Fluid Process Engineering (AVT.FVT)

The implementation of many biotechnological processes in conventional reactors is often limited by the toxicity of substrates or products, despite their potential for high production rates. To address these challenges, the integration of strain engineering and process engineering has been explored, focusing on advanced reaction and separation strategies. One promising approach is in situ liquid-liquid extraction, where a second organic liquid phase is introduced to selectively accumulate toxic components, thereby reducing their concentration in the aqueous phase. Multiphase reactor designs for this purpose typically include a stirred compartment to disperse bubbles and droplets. However, the resulting finely dispersed droplets can form stable emulsions, complicating phase separation and leading to efficiency losses through the unintended removal of valuable biomass and products entrapped in the emulsions.

To overcome the challenges of emulsion formation and separation efficiency, a multiphase loop reactor was developed. This reactor design has already been tested as a bioreactor prototype for the production of methyl ketones and rhamnolipids at a 5 L scale. Building on these results, the fluid dynamics of the reactor were further investigated to mitigate scale-up risks. For this purpose, a 100 L prototype was constructed, and measurement methods were developed to determine key parameters such as gas hold-up, volumetric mass transfer coefficient (kLa), mixing time, and phase velocities.

The poster will discuss the influence of process parameters on these target variables and their implications for optimizing reactor performance.

Contact:
Diana Wall
email: diana.wall@avt.rwth-aachen.de

P35 - Surface Active Biomolecules for the Chemical Industry (SurfIn)

Philipp Kohl[1], Sonja Kubicki[2], Max Dicke[3], Rafael Reifsteck[4], Ana Vanacker[5], Lars M. Blank[1], Karl-Erich Jaeger[2], Jørgen Magnus[3], Andreas Jupke[4], Stefanie Bröring[5], Mario Beckers[6], Joern Viell[6], Michael Wustmans[5], Marcel Mann[3], Stephan Thies[2], Till Tiso[1]

[1] *iAMB – Institute of Applied Microbiology, RWTH Aachen University*
[2] *IMET – Institute of Molecular Enzyme Technology, HHU Düsseldorf*
[3] *AVT.BioVT – Biochemical Engineering, RWTH Aachen University*
[4] *AVT.FVT – Fluid Process Engineering, RWTH Aachen University*
[5] *CEIT – Centre for Entrepreneurship Innovation and Transformation, Ruhr University Bochum*
[6] *AVT.Biorefinery – RWTH Aachen University*

The increasing demand for sustainable alternatives in the chemical industry drives the exploration of microbial production of biosurfactants. This work presents advancements toward the commercialization of two novel biosurfactants: Serrawettin W1 and polyol lipids. Key objectives include optimizing microbial strains, developing scalable production processes, and addressing economic feasibility.
Significant achievements include the successful scale-up of polyol lipid production using Aureobasidium pullulans, reaching a yield of 60 g/L with a productivity of 0.28 g/L/h in a 150 L bioreactor. Additionally, heterologous production of Serrawettin W1 in Pseudomonas putida was optimized through genome-integrated strain engineering and inducer screening. Strain SK69 demonstrated superior performance with mannitol induction, achieving a yield of 7.15 mg/g.
To enhance scalability and sustainability, alternative substrates like acetate were utilized for polyol lipid production, demonstrating compatibility with fed-batch processes and increased space-time yields. These advances highlight the feasibility of integrating biosurfactants into industrial applications, with initial focus areas including lubricants and personal care products.
A comprehensive roadmap developed through expert workshops emphasizes the need for continuous strain engineering, feedstock optimization, and downstream processing to achieve market adoption within the next decade. Regulatory shifts and partnerships are identified as key drivers for success, paving the way for biosurfactants as sustainable replacements in the chemical industry.
This work establishes a foundation for efficient bioprocess development, addressing critical challenges in sustainability and scalability, and underlines the potential of biosurfactants in contributing to a circular bioeconomy.

Contact:
PD Till Tiso
email: till.tiso@rwth-aachen.de

P36 – Economically Guided Process Development for Biobased Production of Monomers for Polymerization using Terpenoid based Extraction for Purification (Eco-T-REX)

Sascha Stark[1], Hendrik Ballerstedt[2], Lutz Burow[3], Riccardo Clerici[2], Peter Förster[4], Johannes Többen[1], William von Westarp[4], Lars M. Blank[2], Sonja Herres-Pawlis[3], Andreas Jupke[4], Sandra Venghaus[1]

[1] *Forschungszentrum Jülich, Jülich Systems Analysis*
[2] *RWTH Aachen University, Institute of Applied Microbiology*
[3] *RWTH Aachen University, Chair of Bioinorganic Chemistry, Institute of Inorganic Chemistry*
[4] *RWTH Aachen University, Fluid Process Engineering*

Guided by economic and techno-economic analysis, Eco-T-REX features a holistic process development for the production of bio-based mono- and polymers. Economic implementation of biomass-based processes for the production of value-added products requires three main issues to be addressed: the possible product range has to be extended, the separation processes for obtaining the products have to be improved, and catalytic steps have to be designed robustly and efficiently. To achieve this goal, all process steps need to be considered in an integrated way to exploit synergies. In a first step, C4 components such as 2,3-butanediol (2,3-BDO) are produced from sugar by fermentation. The focus is on the most selective possible production of the target components as well as strain development in order to make further C4 derivatives such as butanal accessible by fermentation to intensify and broaden biobased synthesis for bioeconomy. In order to efficiently separate the biotechnologically produced products such as 2,3-BDO from the diluted aqueous media, novel green solvents are used for extraction, namely terpenoids. These offer particularly good extraction efficiencies in combination with advantages in downstream distillative processing, so that the target products can be obtained with low-energy input in the cell-free ("clean") head fraction of the distillation. The further processing of the monomers obtained for polymerization is mainly dependent on the catalyst and the reaction conditions. In the case of biobased production of the monomers, these must now be specifically adapted to the new conditions (e.g. sidecomponents) in order to be able to produce polymers with suitable physiochemical properties. In Eco-T-REX, all process steps will be considered to exploit synergies and will be demonstrated in scaled-up form as a proof-of-concept.

Contact:
Dr. Sascha Stark
email: sa.stark@fz-juelich.de

P37 – BioPlastiCycle – Transitioning bioplastics to the circular economy

Benedikt Wynands[1], Lars Halle[1], Tabea Becker[2], Sandra Mücke[3], Thomas Konjetzko[1], Sara Adeleh[4], Niclas Conen[5], Nil Güreli[6], Marcel Gausmann[5], Jörn Meyer[6], Ali Abdelshafy[6], Stephan Noack[1], Sonja Herres-Pawlis[2], Laura Hartmann[3,7], Nick Wierckx[1], Roland Bol[4], Thomas Pütz[4], Andreas Jupke[5], Grit Walther[6]

[1] *Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich*
[2] *Institute of Inorganic Chemistry, RWTH Aachen University*
[3] *Institute of Organic Chemistry and Macromolecular Chemistry, Heinrich Heine University Düsseldorf*
[4] *Institute of Bio- and Geosciences IBG-3: Agrosphere, Forschungszentrum Jülich*
[5] *Fluid Process Engineering (AVT.FVT), RWTH Aachen University*
[6] *Chair of Operations Management, School of Business and Economics, RWTH Aachen University*
[7] *Institute of Macromolecular Chemistry, University Freiburg*

Plastics fulfill many vital functions in modern society, but in the past not enough consideration has been given to the end-of-life fate of these extremely stable materials. There is now a strong societal and technological push for the development of more sustainable biodegradable bioplastics. However, viable recycling options are still lacking for many of these emerging materials, and there is thus an urgent need for new technology development towards a more circular bioplastics economy.

BioPlastiCycle aims to tackle this challenge by developing and evaluating a complete value cycle for well-established bioplastics and newly developed materials based on α-ketoglutarate.

Contact:
Dr. Benedikt Wynands
email: b.wynands@fz-juelich.de

P38 - Environmental Behavior and Fate of 14C-Polylactic Acid in Soils

Sara Adeleh[1,2], Tabea Becker[2], Roland Bol[1], Sonja.Herres Pawlis[2], Thomas Pütz[1]

[1]*Institute of Bio and Geosciences (IBG-3: Agrosphere), Forschungszentrum Jülich*
[2] *Institute of Inorganic Chemistry, RWTH Aachen University*

Transitioning to a circular model for plastics has become vital amid growing global production. Bioplastics, derived from renewable sources, offer a sustainable alternative to traditional plastics by reducing CO_2 emissions and reliance on fossil fuels. Despite their promise, challenges such as recyclability and environmental degradation persist. Plastic degradation in complex environments like soil is influenced by polymer properties and environmental factors, requiring advanced evaluation techniques.
Carbon-14 (^{14}C) tracing provides a significant breakthrough in studying plastic degradation. Unlike traditional methods that primarily monitor CO_2 emissions, ^{14}C labeling tracks polymer decomposition comprehensively, offering insights into residual polymers and their environmental interactions. Polylactic acid (PLA), a widely used biodegradable polymer, is notable for its composability and reduced fossil fuel dependency. However, polymer degradation varies with environmental conditions; conventional plastics like polyethylene degrade at less than 1% per year, while bioplastics, including PLA, can degrade completely within months under favorable conditions.
To enhance understanding, a laboratory-scale synthesis process for ^{14}C-labeled PLA was developed, addressing challenges such as stereoisomer instability and impurities. This labeled PLA will be used in soil degradation and leaching studies across sandy and silty soils over 180 days to 12 months. The experiments will evaluate the influence of temperature, soil humidity, and organic manure on PLA degradation. Evolved CO_2 will be quantified using Liquid Scintillation Counting (LSC), providing critical data on the environmental fate of PLA. This research aims to advance the sustainable development of bioplastics and their integration into a circular economy.

Contact:
Sara Adeleh
email: S.Adeleh@fz-juelich.de

P39 - Microbially produced monomers for biopolymers: Bioprocess development for 2-oxoglutarate production with Corynebacterium glutamicum

Lars Halle[1,2], Jochem Gätgens [1], Wiechert W[1,2], Marienhagen J[1,2], Stephan Noack[1,2]

[1] *Institute of Bio- and Geosciences, IBG-1: Biotechnology, Forschungszentrum Jülich, 52425 Jülich, Germany*
[2] *Bioeconomy Science Center (BioSC), Forschungszentrum Jülich, 52425 Jülich, Germany*

Efficient bioprocesses open the door for the transition from a fossil-based economy to a sustainable circular economy. However, the development of new bioprocesses is very time-consuming and labor-intensive due to manual execution. To save time, costs and resources, miniaturization, parallelization and automation are state of the art to modern bioprocess development [1].
In our study within the BioSC project BioPlastiCycle, molasses, a sucrose-containing 2nd generation feedstock from the sugar industry, is used as raw material to synthesize 2-oxoglutarate (AKG) as a higher-value product for biopolymers. Corynebacterium glutamicum is used as a suitable platform organism for the production of biobased AKG, the precursor of the eponymous amino acid L-glutamate. Most importantly, C. glutamicum is naturally able to metabolize a broad range of carbon sources, including monomers such as acetate, ethanol and fructose contained in widely available industrial side streams [2, 3, 4]. To our knowledge, there is no data available for the efficient production of AKG from molasses. Therefore, a suitable bioprocess was developed from scratch and rapid metabolic engineering was supported by automated high-throughput experiments in combination with data-driven modeling and analysis.
In silico strain design followed by targeted metabolic engineering of C. glutamicum and automated phenotyping in microliter scale resulted in a first strain for AKG production from defined sucrose-media with a batch-titer of 22 mM and a yield of 0.16 g g-1. Further screening on molasses-media revealed another strain variant, which was able to produce 80 mM AKG at a yield of 0.64 g g-1. Interestingly, this strain showed no grow and production from sucrose-based media. A first scale up to a 1 L fed-batch process on molasses resulted in a AKG titer of 350 mM. For product purification an organic extraction approach was carried out and a concentrated AKG solution with a purity of > 91% was obtained [5].

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Contact:
Lars Halle
email: l.halle@fz-juelich.de

P40 - Enzymatic and Microbial Approaches for Sustainable Poly(lactic acid) Degradation and Upcycling

Thomas Konjetzko, Benedikt Wynands, Nick Wierckx

Institute of Bio- and Geosciences, IBG-1: Biotechnology, Forschungszentrum Jülich GmbH, 52428 Jülich, Germany

The rapidly increasing industrial production of the biodegradable polymer poly(lactic acid) (PLA) requires efficient degradation and upcycling strategies to reduce waste and promote sustainability. This study aims to develop a biotechnological solution for PLA degradation and valorization, focusing on consolidating enzymatic depolymerization of the polymer, microbial metabolization of the resulting monomers, and funneling the carbon flux towards valorized compounds.
A comprehensive characterization of PLA-depolymerizing enzymes revealed optimal conditions regarding pH, temperature, buffer composition, calcium concentration, enzyme dosage, and culture medium complexity. These characterizations revealed key bottlenecks for the most efficient commercially available PLAse, Proteinase K, which are product inhibition and host cell protease limitations. Those bottlenecks must be addressed for real-world deployment. Thermophilic microorganisms were screened for efficient lactic acid utilization, identifying the industrial compost isolate Geobacillus subterraneus TDK1 as most efficient lactic acid metabolizer. This thermophile was combined with Proteinase K in a consolidated bioprocess (CBP), using PLA as the sole carbon source. Compared to PLA depolymerization utilizing the wild type strain without added enzyme, significant time-saving was achieved in the consolidated bioprocess. Furthermore, engineered Pseudomonas taiwanensis species successfully upcycled lactic acid into 4-coumarate, a high-value chemical used as precursor for aromatic bioplastics and pharmaceuticals.
The study demonstrates PLA waste treatment strategies from a biotechnological perspective with special emphasis towards degradation efficiency (using thermophiles in a CBP) and economic process viability (upcycling to 4-coumarate using engineered Pseudomonas taiwanensis species in a CBP).
This research exemplifies interdisciplinary bioeconomy innovation, combining scientific disciplines such as enzymology, microbial physiology, and bioprocess engineering to tackle global challenges of plastic pollution and climate change. By advancing sustainable solutions for PLA management, this work aligns with circular economy principles and highlights the potential of biotechnology to mitigate environmental impact of PLA waste.

Contact:
Prof. Dr. Nick Wierckx
email: n.wierckx@fz-juelich.de

P41 - Metabolic engineering of Pseudomonas taiwanensis VLB120 as chassis for the production of chorismate-derived bulk and fine chemicals

Franziska Kofler, Tobias Schwanemann, Nadine da Silva, Astrid Wirtz, Benedikt Wynands, Nick Wierckx

Institute of Bio- and Geosciences, IBG-1: Biotechnology, Forschungszentrum Jülich GmbH, 52428 Jülich, Germany

Increasing depletion of fossil resources requires a shift of industry towards a more sustainable production. This led to a focus on bio-based production of both bulk and fine chemicals.

Due to the robustness of Pseudomonas taiwanensis VBL120 as well as its highly versatile metabolism, this bacterium displays a suitable candidate for the production of a broad spectrum of compounds, especially aromatics. Chorismate is a key precursor for many aromatics, and we therefore modified P. taiwanensis to increase chorismate availability in the cell. This was achieved by targeting the bifunctional enzyme PheA, which catalyzes the first two steps from chorismate to the aromatic amino acids phenylalanine and tyrosine. Overall, metabolic engineering approaches could be applied to increase productivity up to 20.3±0.1% (Cmol/Cmol) from glucose and up to 25.4%±2.1 (Cmol/Cmol) from glycerol, depending on the respective aromatic compound.

To demonstrate its applicability, production of different chorismate-derived hydroxybenzoates was shown. These compounds can serve either as plastic building blocks, food additives, or as precursor for more complex secondary metabolites. In the latter context, we enabled the conversion of 2,3-dihydroxybenzoate (DHB) into myxochelin. In this metal-chelating siderophore, two DHB molecules are coupled via a lysine molecule. Like many other non-ribosomal peptides, native myxochelin biosynthesis results in low titers with hosts that are difficult to handle. Transfer of its synthesis to P. taiwanensis enables more efficient metabolic engineering, while also opening up process engineering options like supplementation of different carbon sources or addition of a second phase extractant.

Contact:
Prof. Dr. Nick Wierckx
email: n.wierckx@fz-juelich.de

P42 - P. taiwanensis cell surface engineering for the improved production tolerance to organic solvents

Till Redeker, Benedikt Wynands, Nick Wierckx

Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich, Jülich, Germany

To support the transition toward a sustainable bioeconomy, our research focuses on Pseudomonas taiwanensis VLB120, engineered for efficient biosynthesis of hydrophobic aromatic compounds within a second-phase system. Through the PROSPER project, we aim to develop a scalable, sustainable, bio-based production platform, providing a greener alternative to conventional chemical manufacturing. Due to toxic effects of hydrophobic compounds, we focus on enhancing solvent tolerance in the bacterium applying different strategies. One of the approaches is the reduction of the cell surface hydrophobicity (CSH), thereby mitigating negative cell-solvent interactions. Additionally, we analyze extracellular matrix components and their function as a diffusion barrier to optimize product transport. In our work, adaptive laboratory evolution (ALE) was used to harness the adaptive capacity of Pseudomonas taiwanensis under selective conditions, while genome editing enabled precise, targeted modifications to the bacterial genome. Phenotypic analyses included the Bacterial Adhesion to Hydrocarbons assay (BATH) to assess changes in cell surface hydrophobicity (CSH), biofilm formation, and emulsification assays. By integrating these approaches, we generated strains with significantly reduced CSH and identified the genetic basis for these adaptations. Reverse engineering further confirmed the mutations' role in decreasing CSH, with strains exhibiting reduced biofilm formation and emulsification to hydrophobic phases. Through targeted deletions of exopolysaccharide production clusters within the extracellular matrix, the cell's diffusion barrier was deliberately modified.

Our results validate ALE as a robust tool for adjusting cell surface properties, linking reduced hydrophobicity to lower emulsification and biofilm formation. These advancements, along with a potentially reduced diffusion barrier, will be integrated into host strains for efficient organic solvent production. As these are beneficial traits for industrial bioprocesses, these advancements mark progress toward a more efficient, biotechnology-driven production platform.

Contact:
Prof. Dr. Nick Wierckx
email: n.wierckx@fz-juelich.de

P43 - Studying cellular solvent transport dynamics using fluorescent biosensors in Pseudomonas taiwanensis VLB120

Tobias Probanowski, Jakob Rönitz, Benedikt Wynands and Nick Wierckx

Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich, Jülich, Germany

Today, our chemical industry continues to heavily rely on the extraction and refinement of fossil resources to produce its fundamental bulk building blocks. In contrast, we target the bio-based production of hydrophobic aromatics such as styrene or ethylbenzene, addressing major challenges such as climate change and environmental pollution. However, the toxicity of these products requires highly solvent tolerant biotechnological chassis to ensure the efficient production of hydrophobic aromatics. Pseudomonas taiwanensis VLB120 is a well-suited host for this approach, due to its native solvent tolerance mechanisms, genetic tractability, and the availability of streamlined production chassis.

In order to gain a deeper mechanistic insight into the tolerance mechanisms to intracellularly produced chemicals, we develop and apply fluorescent intracellular biosensors. These biosensors were developed based on transcriptional regulators of genes that encode solvent-efflux pumps, which are highly responsive to intracellular aromatic solvents. To normalize the biosensor readout to cell fitness, a second constitutively expressed fluorescent protein was integrated into the biosensor construct. Our goal with this ratiometric fluorescent biosensor is to investigate intracellular solvent concentrations and how they are affected by solvent-efflux pumps, focusing especially on externally added versus intracellularly produced hydrophobic aromatics.

Based on the data obtained, Pseudomonas taiwanensis chassis can be rationally developed to exhibit increased solvent production tolerance. The biosensors and improved chassis will serve as a foundation for enhancing the microbial production efficiency and achieving the de novo production of a second phase of hydrophobic aromatics.

Contact:
Prof. Dr. Nick Wierckx
email: n.wierckx@fz-juelich.de

P44 – Production of a sustainable and tailor-made microbial palm oil and milk fat substitute from agricultural residues (NextVegOil)

S. Robertz, V. Ramirez, M. Pauly[1]
K. Schipper, K. Müntjes, L. Plücker[2]
M. Mann, P. Richter, J. Magnus[3]
H. Hayen[4]
V. Lind, S. Ohlert[5]

[1] *Pflanzliche Zellbiologie & Biotechnologie, HHU Düsseldorf*
[2] *Mikrobiologie, HHU Düsseldorf*
[3] *Lehrstuhl für Bioverfahrenstechnik, RWTH Aachen University*
[4] *Institut für Anorganische und Analytische Chemie, Universität Münster*
[5] *Institut für Lebensmittel- und Ressourcenökonomik, Universität Bonn*

The global demand for plant oils continues to escalate, thereby driving significant environmental degradation and increasing carbon emissions due to its long-distance transportation. This reliance on unsustainable practices underscores the necessity for innovative solutions. The research project, NextVegOil, aims to develop sustainable alternatives to plant oils using microbial oil production. Specifically, we utilize the fungus Ustilago maydis to produce palm oil-like compounds from agricultural waste streams.
This project unites a multidisciplinary team of researchers, including experts in plant biotechnology, microbiology, bioprocess engineering, economics, and analytical chemistry. The project's primary focus is on the utilization of non-edible corn residues, such as leaves and stems, as substrates for microbial fermentation. The initial phase of the research involved a comprehensive analysis of the composition of these residues and the identification of corn varieties that exhibit enhanced properties for fermentation. Furthermore, pretreatment methods for enhancing the fermentability of these corn residues were investigated, thereby ensuring the viability and sustainability of the palm oil alternatives.
A significant milestone has been reached with the successful production of a variety of fatty acid profiles that closely resemble different plant oils like palm or avocado oil. To enhance the manufacturing scale, a stirred-tank reactor has been integrated in the developmental process, in addition to the establishment of a process model that facilitates a comprehensive cost analysis.
In parallel, we are engaged in the identification and exploitation of genetic targets to optimize microbial oil production, thereby laying the foundation for future advancements.
Additionally, we are investigating the current state of research and startup initiatives related to sustainable palm oil alternatives. This exploration highlights the key players and the interconnected dynamics within the field. Our ecosystem analysis indicates that the microbial oil sector is in the later stages of its developmental cycle, with no clear ecosystem leader yet established.

Contact:
Dr. Marcel Mann
email: marcel.mann@avt.rwth-aachen.de

P45 - Oil production in Ustilago maydis utilizing corn stover saccharides

Paul Richter[1,3]; Jathurshan Panchalingam[1,3], Katharina Miebach[1,3], Kerstin Schipper[2,3], Michael Feldbrügge[2,3], Marcel Mann[1,3]

[1] *Aachener Verfahrenstechnik – Chair of Biochemical Engineering, RWTH Aachen University, 52074 Aachen, Germany*
[2] *Institute for Microbiology, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany*
[3] *Bioeconomy Science Center (BioSC), 52425 Jülich, Germany*

The global demand for plant oils has hit an all-time high, impacting all industrial sectors and the increasing awareness of the environmental issues associated with traditional plant oils has led to a growing need for eco-friendly alternatives. Microbial oil production has emerged as a promising solution, leveraging the capabilities of oleaginous microorganisms to achieve sustainable oil production. Enhancing economic feasibility is vital, and this could be achieved by exploring renewable feedstocks such as agricultural waste streams for microbial bioprocesses. The fungal model organism Ustilago maydis is particularly noteworthy in this context due to its capacity to metabolize a diverse range of carbon sources and accumulate substantial amounts of intracellular triglycerides.
This study aims to investigate whether the diverse carbon sources metabolized by U. maydis can be utilized for triglyceride production, employing corn stover saccharides as a case study. The experimental results obtained demonstrated the capacity of U. maydis to metabolize the primary saccharides present in corn stover, including glucose, fructose, sucrose, xylose, arabinose and galactose for triglyceride synthesis. These findings underscore the remarkable versatility of U. maydis in utilizing a variety of carbon sources for microbial oil production. They also reveal the potential of U. maydis to metabolize galactose, which was previously thought to be toxic to U. maydis and other fungi. Further research into its metabolic capabilities with additional components of corn stover and other renewable feedstocks holds significant promise for advancing sustainable bioprocessing technologies.

Contact:
Dr. Marcel Mann
email: marcel.mann@avt.rwth-aachen.de

P46 - Optimizing squalene production in cyanobacteria via genetic engineering and media adjustment (LEDCyans)

Andreas Nakielski[2], Leon Poduschnick[1], Marcel Mann[1], Ilka Axmann[2], Jørgen Magnus[1]

[1] *AVT.BioVT – Chair of Biochemical Engineering, RWTH Aachen, Forckenbeckstraße 51, 52074 Aachen*
[2] *Institute for Synthetic Microbiology, HHU Düsseldorf, Universtitätsstraße 1, 40225 Düsseldorf*

Cyanobacteria are promising production hosts for the biotechnological industry due to their ability to fix CO2 directly through oxygenic photosynthesis, their genetic accessibility, and their vast portfolio of natural products. Nonetheless, cyanobacteria are currently underutilized in industry and science. In part, this results from suboptimal cultivation conditions being applied in terms of media formulations and lighting conditions which lead to lower product yields and productivity. In the LEDCyans project, the production of squalene, a commercially relevant chemical in the pharmaceutical and cosmetic industry, was realized by genetically engineering the model strain Synechocystis sp. PCC6803. This led to an initial product titer of 13.72 mg/L, at the time, the highest reported squalene titer for Synechcocystis. By further introducing overexpressions in the MEP pathway, the cellular squalene load could be increased 1.7-fold compared to the initial production strain. The resulting strain, termed Synechocystis Δshc sqs +3 MEP, was subjected to media optimization in high-throughput experiments. By increasing the concentration levels of the nitrogen and sulfur sources and limiting the trace element and iron source concentration, the squalene titer could potentially be further increased by roughly 2.6-fold to an expected value of (108.4±23.9) mg/L. The new predicted optimum still awaits experimental confirmation. The limitation of the iron source or of the trace element solution components could be potentially used to divert carbon flux from biomass synthesis to production in other cyanobacterial processes.

Contact:
Prof. Dr.-Ing. Jørgen Magnus
email: jorgen.magnus@avt.rwth-aachen.de

P47 - Converting phototrophic biomass into value-added products

Philipp Ernst[1,2], Max Denter[1], Michael Feldbrügge[2], Julia Frunzke[1]

[1]*Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich GmbH, Jülich, Germany*
[2]*Institute of Microbiology, Heinrich Heine University Düsseldorf, Düsseldorf, Germany*

Significance of the work: Nowadays, a large proportion of chemicals and fuels are derived from fossil resources such as oil, gas and coal. This heavy reliance results in substantial emissions of greenhouse gases, which are a primary contributor to global warming (Khoo et al., 2019). Consequently, the development of technologies for a more sustainable energy and chemical production is of global concern. A significant focus has been placed on the utilization of algal biomass, which has the capacity to convert sunlight, carbon dioxide and water into organic compounds, and possesses numerous advantages over traditional plant-based biomass (Singh & Olsen, 2011).
Objectives: The aim of this study is to cultivate the phototrophic microalgae Galdieria sulphuraria and Cyanidioschyzon merolae in shake flasks, multi-cultivator photobioreactors as well as in custom-made flat-panel photobioreactors and to utilize the resulting biomass as third-generation feedstock for the production of value-added compounds using heterotrophic platform organisms.
New results: Initial characterization of the microalgae strains with respect to temperature, illumination intensity and carbon dioxide concentration was performed in multi-cultivator photobioreactors. The highest growth rate of 0.05 h-1 was achieved at 42 °C, 400 µE and 5 % carbon dioxide. Subsequent scale-up to custom-designed flat-panel photobioreactors led to a reduction in the growth rate to 0.02 h-1, yet it enabled substantially higher optical density values of 35.7 ± 0.1. Heat-stable phycocyanin was identified as a valuable product extracted from the algal biomass. The residual algal biomass was successfully utilized by the biotechnological platform species Ustilago maydis for both growth and itaconic acid production.
Conclusions: This work provides a framework for the conversion of photosynthetic biomass into bioproducts essential for the pharmaceutical and polymer industries, supporting both carbon dioxide utilization and sequestration.

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Contact:
Julia Frunzke
email: j.frunzke@fz-juelich.de

P48 - ValorCO2: Gas fermentation with autotrophic biorefineries for carbon-negative products

Paul R. F. Cordero[1], Hongyi Fan[1], Maximilian Hoffmann[2], Marcel Mann[2], Jørgen Magnus[2], Alexander Wassing[3], Marco Girhard[3], Vlada B. Urlacher[3], Ghazi Allagui[4], Sascha Stark[4], Sandra Venghaus[4], Marvin Doser[5], Tobias Alter[5], Lars M. Blank[5], Lars Lauterbach[1]

[1] *Synthetische Mikrobiologie, iAMB, RWTH Aachen University*
[2] *Aachener Verfahrenstechnik – Lehrstuhl für Bioverfahrenstechnik, RWTH Aachen University*
[3] *Institut für Biochemie, Lehrstuhl für Biochemie II, Heinrich-Heine-Universität Düsseldorf*
[4] *Institut für Energie- und Klimaforschung, Systemforschung und Technologische Entwicklung, Forschungszentrum Jülich*
[5] *Angewandte Mikrobiologie, iAMB, RWTH Aachen University*

Transitioning to a carbon-neutral society demands innovative solutions for sustainable chemical production. However, current industrial production processes rely on sugars, posing competition challenges with the food industry and land use. This is particularly relevant for creating fine chemicals, low-cost bulk chemicals, or biofuels. ValorCO2 aims to address these challenges by directly utilizing CO2 as a feedstock, bypassing the reliance on biomass. The project will utilize gas fermentation with the Knallgasbacterium Cupriavidus necator, an organism capable of coupling CO2 fixation with H2 oxidation. This process enables CO2-neutral production of valuable chemicals, including biopolymers (polylactide-hydroxybutyrate) and fine chemicals (oxyfunctionalized cyclic amines). Key project objectives include establishing robust platforms for enzyme and strain engineering, refining gas fermentation process conditions, optimizing metabolic fluxes for enhanced production efficiency, and assessing techno-economic feasibility and industrial competitiveness of gas fermentation with C. necator. By providing a workflow for strain design and fermentation engineering, ValorCO2 lays the groundwork for scalable, sustainable chemical manufacturing, paving the way for broader adoption of CO2-based production technologies and contributing to global efforts toward carbon neutrality.

Contact:
Dr. Paul R. F. Cordero
email: paul.cordero@rwth-aachen.de

List of Participants

Name	First name	Affiliation
Adeleh	Sara	Forschungszentrum Jülich
Ahmad	Sabahuddin	Forschungszentrum Jülich
Amelung	Wulf	Soil Science, University of Bonn
Asadi	Farimah	University of Bonn
Axmann	Ilka Maria	Heinrich Heine University Düsseldorf
Azizi	Abdul Haseeb	Center for Development Research (ZEF), University of Bonn
Ballvora	Agim	INRES-Plant Breeding, University of Bonn
Baron	Heike	BioSC Office c/o Forschungszentrum Jülich
Bauke	Sara	INRES - Soil Science, University of Bonn
Baum	Stephani	BioSC Office c/o Forschungszentrum Jülich
Beier	Sebastian	Forschungszentrum Jülich
Berger	Axel	German Institute of Development and Sustainability, IDOS
Blank	Lars M.	RWTH Aachen University
Bott	Michael	Forschungszentrum Jülich
Bourdeaux	Florian	RWTH Aachen University
Brandt	Sonja	Ministry for Culture and Science of the State of North Rhine-Westphalia
Braun	Melanie	Institute of Crop Science and Resource Conservation (INRES)-Soil Science and Soil Ecology, University of Bonn
Bredenbruch	Sandra	University of Bonn
Burow	Lutz	Institute of Inorganic Chemistry, RWTH Aachen University
Büschgens	Petra	BioSC Office c/o Forschungszentrum Jülich
Chen	Ruiqi	Institute of Nutrition and Food Sciences
Choo	Halim	Forschungszentrum Jülich
Classen	Thomas	Forschungszentrum Jülich
Conen	Niclas	AVT.FVT - Fluid Process Engineering, RWTH Aachen University
Cordero	Paul R. F.	Institute of Applied Microbiology, RWTH Aachen University
Cui	Jiaxin	IMBIO, University of Bonn
David	Benoit	IBG-4: Bioinformatics, Forschungzentrum Jülich
De	Partho Sakha	CCB, Heinrich Heine University Düsseldorf
Dicke	Max	AVT.BioVT, RWTH Aachen University
Diebig-Lorenz	Maja	INVITE GmbH
dos Anjos Leal	Otávio	IBG-3: Agrosphere, Forschungszentrum Jülich
Doser	Marvin	iAMB Institute of Applied Microbiology, RWTH Aachen University
Drepper	Thomas	Heinrich Heine University Düsseldorf
Eberle	Raphael	Biochemical Plant Physiology, Heinrich Heine University Düsseldorf
Edrisi Maryan	Khazar	Postdoctoral researcher
Ernst	Philipp	Forschungszentrum Jülich
Fan	Hongyi	RWTH Aachen University
Feldbrügge	Michael	Heinrich Heine University Düsseldorf
Feltes	Sophia	Forschungszentrum Jülich

Name	First name	Affiliation
Siekmann	Florian	ICE 2, Forschungszentrum Jülich
Förster	Peter	AVT.FVT - Fluid Process Engineering, RWTH Aachen University
Gauß	Judith	Forest / Forestry
Geiger	Marco	
Gentile	Rocco	Heinrich Heine University Düsseldorf
Ghaffari Nasab	Sajjad	Heinrich Heine University Düsseldorf
Ghazi	Allagui	ICE - 2, Forschungszentrum Jülich
Gider	Denise	BioökonomieREVIER, IBG-2: Plant Sciences, Forschungszentrum Jülich
Gohlke	Holger	Heinrich Heine University Düsseldorf
Goßen	Mira	FaserInnovationsZentrum Zerkall
Grande	Philipp	Institute of Bio- and Geosciences - Plant Sciences, Forschungszentrum Jülich
Grankin	Alina	Forschungszentrum Jülich
Greene	Lee	Food Horizons & Foodhub NRW
Groth	Georg	Biochemische Pflanzenphysiologie, Heinrich Heine University Düsseldorf
Grotjohann	Aishe	AVT.FVT, RWTH Aachen University
Gubelt	Angela	BioSC Office c/o Forschungszentrum Jülich
Güreli	Nil	RWTH Aachen University
Halle	Lars	IBG-1: Biotechnology, Forschungszentrum Jülich
Hartmann	Monika	University of Bonn
Herres-Pawlis	Sonja	Institut für Anorganische Chemie, RWTH Aachen University
Herrmann	Felix	Forschungszentrum Jülich
Hetjens	Laura	DWI-Leibniz-Institut für interaktive Materialien, RWTH Aachen University
Heumann	Roman	Invite GmbH
Hoffmann	Maximilian	Aachener Verfahrenstechnik Lehrstuhl der Bioverfahrenstechnik (AVT.BioVT), RWTH Aachen University
Huang	Mengmeng	Molecular Phytomedicine - INRES, University of Bonn
Jacob	Daniela	Helmholtz-Zentrum Hereon, Climate Service Center Germany (GERICS)
Jäger	Amelie	Forschungszentrum Jülich
Janzik	Ingar	BioSC Office c/o Forschungszentrum Jülich
Josten	Lukas	Trade and Invest British Columbia
Jupke	Andreas	AVT.Fluidverfahrenstechnik, RWTH Aachen University
Kasargodu Anebagilu	Prajna	INRES Horticultural Sciences, University of Bonn
Kesseler	Adolf	IBG-2: Plant Sciences, Forschungszentrum Jülich
Kilimann	Jana	University of Bonn
Klink-Lehmann	Jeanette	University of Bonn
Klose	Holger	IBG-2: Plant Sciences, Forschungszentrum Jülich
Kofler	Franziska	IBG-1: Biotechnology, Forschungszentrum Jülich
Kolbe	Carl-Christian	Bayer AG
Koller	Robert	IBG-2: Plant Sciences, Forschungszentrum Jülich
Kolodzy	Fabian	ITMC/DWI, RWTH Aachen University
Konjetzko	Thomas David	IBG-1: Biotechnology, Forschungszentrum Jülich

Name	First name	Affiliation
Kopriva	Stanislav	University of Cologne
Kopton	Johannes	INRES Horticulture, University of Bonn
Korbmacher	Melina	Biochemische Pflanzenphysiologie AG Groth, Heinrich Heine University Düsseldorf
Kraska	Thorsten	University of Bonn
Kruse	Luzie	Institute of Molecular Enzyme Technology, Heinrich Heine University Düsseldorf
Kubis	Armin	b.fab GmbH
Kühn	Justin	ITA - Institut für Textiltechnik of RWTH Aachen University
Küttner	Hannah	DWI - Leibniz Institut für Interaktive Materialien
Lahnaoui	Amin	Forschungszentrum Jülich
Langletz	Tim	Institute for Inorganic Chemistry, RWTH Aachen University
Lanzerath	Dirk	German Reference Centre for Ethics in the Life Sciences, University of Bonn
Lapsien	Marco	Heinrich-Heine-Universität (OptiCellu)
Laurini	Larissa	AK Herres-Pawlis IAC, RWTH Aachen University
Lauterbach	Lars	RWTH Aachen University
Lechtenberg	Thorsten	Institute of Bio- and Geosciences IBG-1: Biotechnology, Forschungszentrum Jülich
Leip	Adrian	European Commission
Op de Hipt	Leonie	Forschungszentrum Jülich
Lind	Vanessa	University of Bonn
Loehrer	Marco	RWTH Aachen University
Lohnecke	Martin	SDW e.V.
Lüdeling	Eike	University of Bonn
Lütkes	Linda	Office Bioeconomy Council NRW
Macht	Janine	University of Bonn
Mademann	Jane Anne	Forschungszentrum Jülich
Magnus	Jorgen Barsett	AVT.BioVT, RWTH Aachen University
Mangion	Michel	Bioeconomy for change
Mann	Marcel	AVT.BioVT, RWTH Aachen University
Martinez	Maria Mercedes	Project Manager- Pantaleon Sugarcane Group
Mason	Annaliese	Plant Breeding Department, INRES, University of Bonn
Maßjosthusmann	Marie	
Meyer	Lisa-Marie	University of Bonn
Mohammadi	Maryam	Heinrich Heine University Düsseldorf
Moon	Sanghyo	University of Bonn
Moser	Denise	Biochemical plant physiology, AG Groth, Heinrich Heine University Düsseldorf
Mücke	Sandra	Institute of organic and macromolecular chemistry, Heinrich Heine University Düsseldorf
Müller	Andreas	IBG-2: Plant Sciences, Forschungszentrum Jülich
Müller	Lena	Institute of Bioorganic Chemistry / Institute of Molecular Enzyme Technology
Müller-Linow	Mark	Forschungszentrum Jülich

Name	First name	Affiliation
Nagel	Sören	Institut für Biochemischen Pflanzenphysiologie, Heinrich Heine University Düsseldorf
Nakielski	Andreas	Heinrich Heine University Düsseldorf
Noack	Stephan	Forschungszentrum Jülich
Oleksakova	Silvia	Ruhr University Bochum
Otto	Marlene	Biochemical plant physiology, AG Groth, Heinrich Heine University Düsseldorf
Patermann	Christian	Direktor a.D. EU-Kommission
Pfennig	Andreas	University of Liège, Belgium
Pieruschka	Roland	Forschungszentrum Jülich
Pietruszka	Jörg	Heinrich Heine University Düsseldorf
Poduschnick	Leon	RWTH Aachen University
Polen	Tino	Forschungszentrum Jülich
Probanowski	Tobias	Forschungszentrum Jülich
Pude	Ralf	BÖR NRW
Rascher	Uwe	Forschungszentrum Jülich
Redeker	Till	Forschungszentrum Jülich
Rehm	Bodo	University of Bonn
Reifsteck	Rafael	Fluid Process Engineering (AVT.FVT), RWTH Aachen University
Rettenmaier	Nils	ifeu - Institut für Energie- und Umweltforschung Heidelberg gGmbH
Richter	Paul	AVT.BioVT - RWTH Aachen University
Rother	Dörte	Forschungszentrum Jülich
Rothkranz	Berit	Forschungszentrum Jülich
Rütt	Johanna	RWTH Aachen University
Saken-Braunstein	Elisabeth	Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg
Sauerland	Meike	Heinrich Heine University Düsseldorf
Saur	Katharina	AVT.FVT - Fluid Process Engineering, RWTH Aachen University
Schaffrath	Ulrich	Department Plant Physiology, RWTH Aachen University
Scharfe	Maria	Formo Bio GmbH
Scheersoi	Annette	University of Bonn
Schipper	Kerstin	Institute for Microbiology, Heinrich Heine University Düsseldorf
Schleker	Sylvia	INRES - Molecular Phytomedicine, University Bonn
Schmidt	Brigitte	ÖD
Schonhoff	Andreas	ICE 2, Forschungszentrum Jülich
Schott-Verdugo	Stephan	IBG-4: Bioinformatics, Forschungszentrum Jülich
Schrey	Silvia	IBG-2: Plant Sciences, Forschungszentrum Jülich
Schröder	Walter	Retired Senior Consultant for dESY
Schubert	Jasmin	BIO.NRW / Forschungszentrum Jülich
Schwaneberg	Ulrich	Chair of Biotechnology, RWTH Aachen University
Shinwari	Atifullah	University of Bonn
Siebers	Nina	IBG-3: Agrosphere, Forschungszentrum Jülich
Simon	Rüdiger	Heinrich Heine University Düsseldorf

Name	First name	Affiliation
Singh	Mansi	Forschungszentrum Jülich
Slusarczyk	Heike	BioSC Office c/o Forschungszentrum Jülich
Sowa	Philipp	Heinrich Heine University Düsseldorf
Stark	Sascha	Forschungszentrum Jülich
Stelter	Sina	Thermo Fisher Scientific
Stoffels	Peter	Cluster industrielle Biotechnologie e.V.
Sundermeyer	Lea	Forschungszentrum Jülich
Tatic	Milan	Institute for Food and Resource Economics (ILR), Chair of Agricultural and Food Market Research, University of Bonn
Thiel	Puja	University of Exeter
Thies	Stephan	Forschungszentrum Jülich
Tietjen	Anna	Institut für Textiltechnik (ITA), RWTH Aachen University
Tiso	Till	RWTH Aachen University
Trujillo	Marco	Institute of Molecular Plant Physiology, RWTH Aachen University
Uellendahl	Kora	Forschungszentrum Jülich
Ulrich	Schurr	Forschungszentrum Jülich
van Liempt	Henk	Scientists for Future
Vasquez Raffo	Fernanda	b.fab GmbH
Venghaus	Sandra	RWTH Aachen University
von Mikecz	Anna	IUF - Leibniz Research Institute for Environmental Medicine | Heinrich Heine University Düsseldorf
Wachtendonk	Luisa	Forschungszentrum Jülich GmbH
Wall	Diana	AVT.FVT, RWTH Aachen University
Walther	Grit	RWTH Aachen University
Wassing	Alexander	Heinrich Heine University Düsseldorf
Wegner	Carl-Eric	Bioinorganic Chemistry, Heinrich Heine University Düsseldorf
Weigend	Maximilian	University of Bonn
Westarp	William	Fluid Process Engineering (AVT.FVT), RWTH Aachen University
Weyers	Jan-Lorenz	Institute for microbiology and biotechnology, University of Bonn
Whitney	Cory	University of Bonn
Wiechert	Wolfgang	IBG-1: Biotechnology, Forschungszentrum Jülich
Wierckx	Nick	Forschungszentrum Jülich
Wiese-Klinkenberg	Anika	IBG-4: Bioinformatics, Forschungszentrum Jülich
Willbold	Sabine	Forschungszentrum Jülich
Wittmann	Christin	Geschäftsstelle Bioökonomie-Rat NRW
Wizemann	Axel	wizemann:beratung / Zirkuläre Bioökonomie und Innovationsmanagement
Wolters	Daniel	Institut für Textiltechnik of RWTH Aachen University
Wolters	Beverley	Forschungszentrum Jülich
Wormit	Alexandra	Chair of Molecular Botany, RWTH Aachen University
Wynands	Benedikt	IBG-1: Biotechnology, Forschungszentrum Jülich
Zlati	Felicia	Forschungszentrum Jülich