

Impact Objectives

- Improve by-product output through sustainable and integrated closed-loop biorefineries
- Support second-generation biorefineries to deliver innovative and commercially viable new solutions

Closed-loop integrated biorefineries

Dr Klaus Rischka forms part of a project that seeks to use valorisation to address many of the challenges associated with developing a sustainable economy for the future. Below, he discusses his research background and his latest research efforts



Could you begin by describing your career trajectory thus far?

I studied chemistry at the University of Bremen in

Germany and received my doctoral degree in 2001. My topic was the synthesis of artificial photosynthesis systems and, after a postdoctoral stay at the University of Bremen, I started as a scientific staff member at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials (Fraunhofer IFAM) in the Department of Adhesives and Polymer Chemistry in 2002. In 2008, I participated in the Industry-Academia Partnerships and Pathways (IAPP) Marie Curie Action titled Blue4Glue: Reinforcing Capacity towards Industrially Relevant Research on Bio-inspired Materials and Delivery Mechanisms. One of the goals was the synthesis of new bio-adhesive polymers and co-polymers that have been studied for adsorption onto surfaces, thereby allowing fundamental understanding of the interactions with various surfaces for different product applications such as cleaning, anti-sticking and anti-fouling.

Can you elaborate on the Valor Plus project and what it is expected to achieve?

The project targets the generation of bulk and high value product streams from the by-

products lignin, hemicellulose and glycerol by developing new science and technologies, and utilising a platform of integrated technologies. The platform technologies will enable the optimum value to be achieved for each by-product stream whilst ensuring cost-effective and complete utilisation of available resources. The project will therefore enable the realisation of sustainable, economically viable closed-loop integrated biorefineries.

Valor Plus will lead to the design, development and integration of new processes to form closed-loop systems to make the best use of biorefinery by-products and deliver new high value products with improved economic and environmental performance. To this end, it will provide new knowledge, new biotechnologies and new products that support the release, refinement and transformation of lignocellulosic biomass lipids and low volume functional chemicals to produce multiple bulk and high value product streams, allowing for the full use of the biomass with zero waste and thereby generating the highest value return.

What challenges have you faced while undertaking this research?

Unlike petrochemical refining – which is an established sector of optimised processes and understood products – biorefining is an emerging sector of relatively new and non-optimised processes and poorly understood

product streams. Because of this, there are several barriers that must be overcome, such as demonstrating the potential scale-up and integration of new and emerging technologies within existing and future biorefineries.

Despite the great relevance of bio-based products for many industries, there are still numerous technical, strategic and commercial challenges that need to be overcome before any large-scale commercialisation. Biorefineries must employ and integrate the best possible technologies to ensure that bio-based products break even. This requires the concerted action of many non-traditional partners to cover all aspects of the complex biorefinery value chain, bringing results from lab scale to bigger volumes and quantities which cannot be covered by the scope of this project.

Where do you see your work heading in the future?

We estimate that within three years after the project completion, we could have a large-scale commercial process, so this is the direction that we hope to take. We believe that the project will have an important impact on the assimilation of the newly developed technologies and lead to a significant decrease in our dependency on oil and fossil-based products.



Maximising the energy potential of biomass

The Valor Plus project is seeking to address the serious challenges Europe is facing around establishing a sustainable economy for fuel, energy, materials and chemicals. The findings from the project could herald a new era by making the best use of biorefinery by-products to deliver new products with high value

In response to the overwhelming evidence for climate change, scientists from around the world are working on developing new products and methods to enable the world's population to move away from unsustainable practices. One potential source of energy that has attracted increasing interest in recent times is biomass – a renewable energy source that can be transformed into a broad range of products. However, despite the attractive potential for biomass resources, they remain an underused option for a variety of reasons.

As with any new technology and approach, cost is the main deterrent. Indeed, the determining factor behind the lack of development of biorefineries to achieve commercial implementation is the difficulty in reducing production costs and increasing the efficiency of the conversion to bioenergy and bioproducts. However, with more interdisciplinary developments between biologists, chemists and engineers a huge step

forward to reduce the limiting factors could be achieved.

THE POTENTIAL FOR BIOMASS ENERGY

In recognition of the potential biomass holds for future generation's energy production, the Valor Plus project has been established. The project forms part of the EU's Seventh Framework Programme (FP7) and seeks to maximise the use of the by-products associated with the production of biochemicals, biocompounds and bioenergy. In producing these, vast quantities of by-products such as hemicellulose, lignin and glycerol are generated but, because of the difficulty in extracting and transforming them into usable products, they do not currently represent an attractive field of enquiry for commercial exploitation. The team that form Valor Plus are investigating several ways to make use of these by-products and, in doing so, hope to make biomass a much more commercially attractive proposition.

The Valor Plus project consists of a consortium made up of 14 partners, including SMEs, research centres, universities and one large enterprise. Ultimately, those involved are keen to deliver improved sustainability and commercial and environmental benefits. To achieve those aims, the project is focused on several areas of interest. Technical Project Coordinator Dr Klaus Rischka is a senior scientist at the Fraunhofer Institute for Manufacturing Technology and Applied Materials Research (Fraunhofer IFAM) in Bremen, Germany. Since 2002, Rischka has been responsible for the acquisition and execution of public-funded and industrial research projects. With a research focus on bio-based and bio-inspired materials, he is acutely aware of the promise biomass offers: 'Biorefineries based on simple raw materials are already in operation – but the end goal is to develop plants which, by using

a wider range of raw materials, can develop multiple products, including biomass-based energy and chemical products. The step up from biorefineries to integrated biorefineries appears inevitable.'

Given the underuse of by-products such as hemicellulose, lignin and glycerol, the project will develop quality control procedures for the reliable and consistent recovery of minimally degraded hemicellulose fibres and lignin macromolecules, and the use of crude glycerol to obtain higher value product streams. To achieve this, the Valor Plus project team is undertaking a complete life cycle assessment, and evaluation and demonstration of the potential for scale-up and integration of the project results within existing and future biorefineries. In addition, the team will develop potential biorefinery technology and product streams to increase the awareness and engagement of stakeholders – an essential consideration when seeking commercial investment.

CRUCIAL CONSIDERATIONS AND KEY FOCUS AREAS

The research has been broken down into 12 different Work Packages that consider separate (though related) topics of enquiry. Through these, the ambitions of the project will be in a better position to be realised. Perhaps most importantly, however, is the fact that the project has been divided into key areas of focus.

One key area involves the development of a process for the controlled and selected hydrolysis of hemicellulose to high value oligosaccharides and building block sugars using newly engineered hemicellulase enzymes; another is focused on developing a novel process for the selective depolymerisation of lignin into oligomers and monomer product streams with controlled structure and chemistry. A variety of strategies to depolymerise lignin and fragment it into chemicals that can be used are being investigated. The researchers are also developing novel bacterial strains for the fermentation of crude glycerol into value product streams, including lipids and alcohols suitable for biodiesel production and value organic acids.

A crucial consideration that forms part of the key areas of focus concerns the demonstration

of the technological and economic potential of using these by-products as a sustainable energy, products and compounds source. 'We will ensure the protection and management of the knowledge garnered during the project, as well as the exploitation and dissemination of the project results and technology transfer for target and wider markets,' explains Rischka. 'Accordingly, the external communication and outreach strategy includes dissemination and communication activities to reach potential direct beneficiaries and indirect target groups.'

The team has also ensured that the scope of the project includes a review of the potential for scale-up and integration of the results within existing future and biodiesel and lignocellulose biorefineries. In doing so, the consortium will be able to create a series of biorefinery technology and product stream roadmaps to promote awareness and engagement of stakeholders and to strengthen partnerships across the biorefinery value chain. Getting buy-in from those closest to current technologies is essential to move the results from the lab to the bench and make the best use of them.

PLANTING THE SEEDS FOR A SUSTAINABLE FUTURE

Ultimately, the results from the project (and the developments they will signify) will help contribute to Europe's target of 20 per cent overall energy consumption from renewable sources by 2020. In addition, Valor Plus will support the reduction in European greenhouse gas emissions in line with the Kyoto Protocol. Importantly, by increasing the diversity of Europe's energy mix, the security of the EU's energy supply is strengthened.

The approach taken by those involved with the Valor Plus project will potentially enable the total usage of the whole crop, thereby maximising the process of using biomass for energy, preventing unnecessary waste, and recycling unavoidable by-products in a valuable and effective way. The potential is there – it only remains for it to be realised. Once it is, a new era will be ushered in, one that promotes sustainability and, perhaps more importantly, responsibility.

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Project Insights

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