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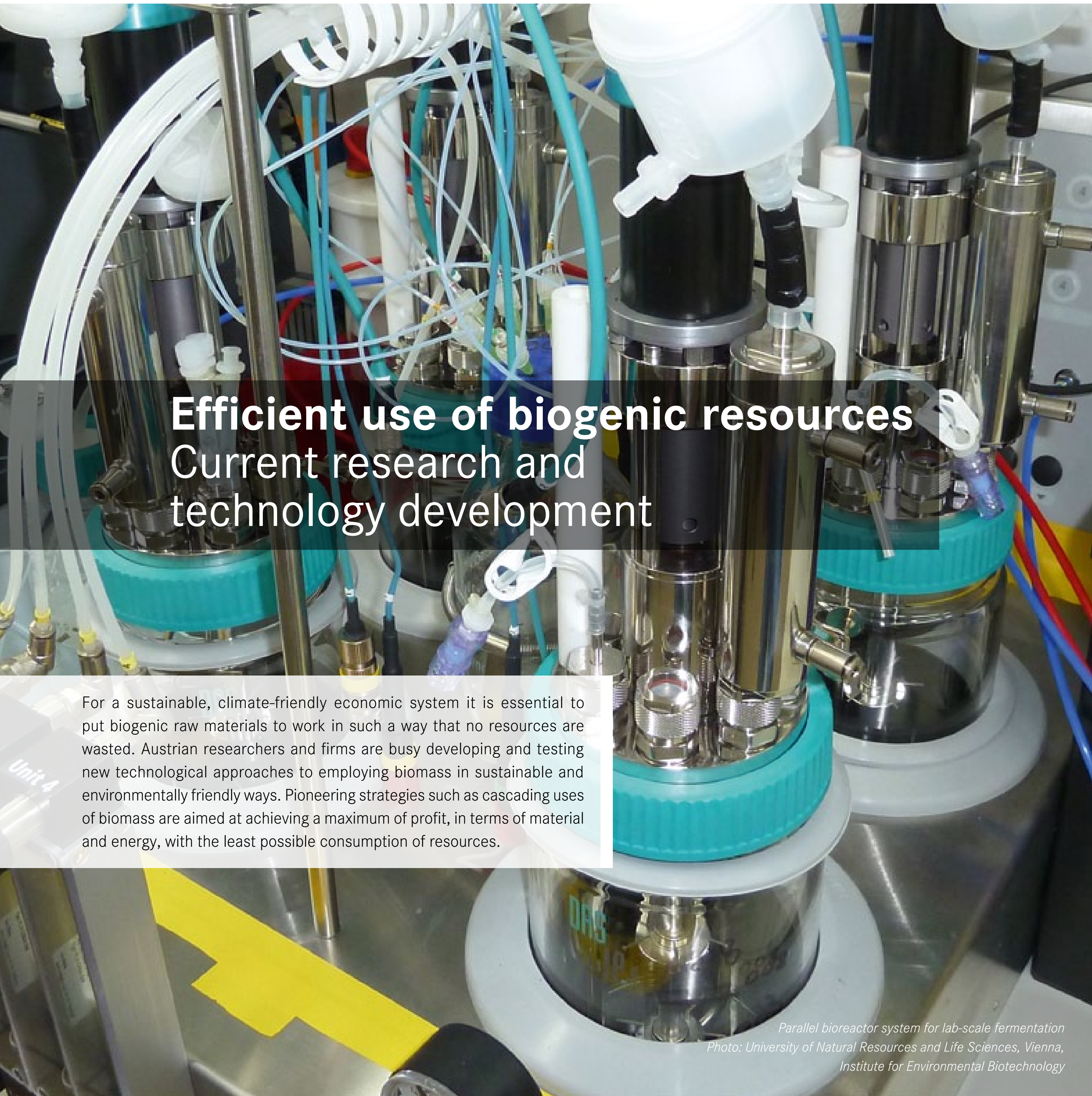
energy innovation austria

Current Developments and Examples of Sustainable Energy Technologies



Efficient use of biogenic resources
Current research and technology development

For a sustainable, climate-friendly economic system it is essential to put biogenic raw materials to work in such a way that no resources are wasted. Austrian researchers and firms are busy developing and testing new technological approaches to employing biomass in sustainable and environmentally friendly ways. Pioneering strategies such as cascading uses of biomass are aimed at achieving a maximum of profit, in terms of material and energy, with the least possible consumption of resources.

Parallel bioreactor system for lab-scale fermentation
Photo: University of Natural Resources and Life Sciences, Vienna, Institute for Environmental Biotechnology

Reactors in bio-based fermentation pilot plant, extracted product (PHA), Photos top and middle: Egon Fischer, Fischermedia, Photo below: University of Natural Resources and Life Sciences, Vienna, Institute for Environmental Biotechnology

Make better use of biomass
New approaches for bio-based industries

In the context of the energy policy turnaround we need to face the issue of how to make the best, most resource-efficient use of agricultural and forestry biomass, organic residues and new raw materials such as algae. With the aid of modern technologies solid, liquid or gaseous biomass is now being used to generate heat and electricity and to produce synthetic biofuels or hydrogen.

In addition, there are many ways of utilizing it as material. Given that biomass is chemically related to the fossil sources of energy, it should be possible to make the same products from biomass as from petroleum, natural gas and coal. **Bio-based industries** turn biomass into material goods (products). A distinction is made between conventional bio-based products, such as paper or foodstuffs, and new bio-based products made from biogenic materials instead of the fossil raw materials previously used.

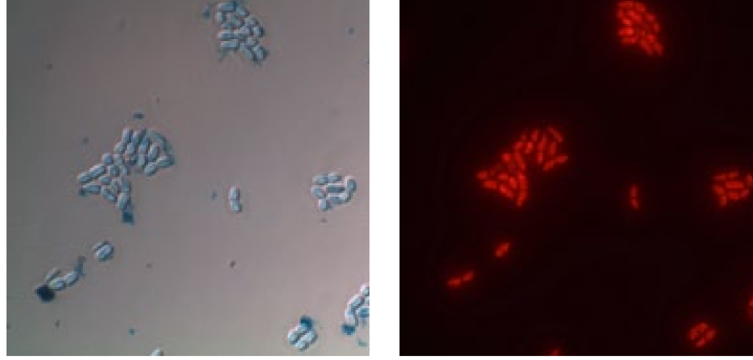
Biogenic raw materials can be used to make products and substances in many sectors of industry, including chemicals, pharmaceuticals, composite materials, biopolymers, construction and insulation materials, plus a wide range of specialized bio-based products. The long-term aim must be to develop region-specific strategies for managing biomass that achieve maximum utility, in terms of material and energy, with the least possible consumption of resources.

One cutting-edge approach to making efficient use of biogenic raw materials is **cascading uses for biomass**. Here biomass is first processed materially in a succession of stages and only later exploited as a source of energy. The word biorefinery refers to technologies for sustainably processing biomass to yield a wide range of marketable products. The use of local biomass has real advantages in both ecological and economic terms; it can help to reduce pollution, diminish dependence on imported non-renewable raw materials and create more value locally. In this issue we present various examples of national and international R&D activities in this field. ◘

Austria‘s strengths in bio-based industries

As part of a survey published by the ÖGUT (Austrian Society for Environment and Technology) and the AIT (Austrian Institute of Technology) in 2016, the current state of bio-based industries in Austria was analysed. Patent applications were identified in particular technological sectors of bio-based industry. They were assigned to the various provinces geographically and compared with other countries in Europe. All in all 2,028 IPC (International Patent Classification) codes were identified as relevant to bio-based industries (BBI). They fall into eight technological categories.

Overall Austria evinced an average degree of specialization in the various BBI sectors during the period under consideration, 2010 to 2014. In some technological fields, such as the textile and cellulose industries, there was a very great degree of specialization; in this sector Austria had twice as many patent applications as the other countries in Europe. The sectors construction and insulation materials from renewable raw materials, paper machines and accessories, polysaccharides, paper, starch and speciality bio-based products and manufacturing processes were also above average.



Microscope images of PHA-producing bacteria. In the photo on the right intracellular storage polymers (PHA) have been stained with a fluorescent dye. Photos: University of Natural Resources and Life Sciences, Vienna, Institute for Environmental Biotechnology

ValorPlast
Bioplastics from sugar-industry byproducts

In the ValorPlast project researchers at the University of Natural Resources and Life Sciences' Institute for Environmental Biotechnology are investigating how to transform sugar-industry byproducts into biopolymers. The project consortium includes Bioenergy 2020+ GmbH, Agrana Research & Innovation Center GmbH, IM Polymer GmbH and the Institute for Chemistry and Technology of Materials at Graz University of Technology.

By developing novel processing methods for sugar biorefineries, the researchers aim to make more efficient use of the raw material sugar beet and open up new applications, so as to make the industry more competitive. Up to now utilizing residues from the sugar industry was focussed almost entirely on molasses. For desugarized (residual) molasses and beet pulp the only options were the utilization as animal feed, as fertilizer or as a source of energy.

Making biopolymers

As part of ValorPlast residual molasses and beet pulp are to be fermented to yield PHAs (polyhydroxyalkanoates). These bio-based, biodegradable polymers have been identified as the most suitable product that can be obtained from transforming the residues by biotechnological means. PHAs can be used as packaging material, as compostable single-use products or in biomedical engineering, for instance. Up to now market opportunities have been limited by price, since the main feedstocks for making PHAs were refined sugars.

Two novel fermentation processes are being investigated in the project. One uses residual molasses as feedstock. Because this byproduct has a high salt content, there are currently no high-grade uses for it. However, its salt content can be an advantage in the fermentation process, because it is possible to employ halophilic (salt-loving) microorganisms that allow cultivation at non-sterile conditions. Some of these halophilic microorganisms can produce short-chain-length (scl) PHAs. The second process is meant to transform beet pulp into medium-chain-length (mcl) PHAs; these polymers are more elastic and have different processing characteristics which open up new areas of application for PHAs. In a two-stage process the beet pulp is pre-acidified to form volatile fatty acids, which are then transformed into PHAs.

Test specimens of PHA are made from the fermentation products and their processing and application characteristics are investigated. Finally the processes are evaluated overall; this involves assessing their potential and carrying out detailed economic analysis.

Initial findings

In the first year of the project the focus was on characterizing the feedstocks and on analysing and improving the acidification process for beet pulp at laboratory scale. The compositions of differing feedstocks (residual molasses and beet pulp) are already known and can be used for planning fermentation experiments. The acidification process for beet pulp has already been developed, with the most important process parameters defined. Preparations are currently in progress for moving on to a continuous process.

Various strains of microorganism that may be suitable for producing PHAs from the feedstocks selected have been investigated. One of the salt-tolerant strains identified is particularly promising, because residual molasses can be used at a relatively high concentration and PHA contents of up to 50 % of the dry matter in the biomass were obtained in the first experiments. Microorganisms suitable for producing mcl PHA have also been identified, with a view to improving the process further. ◘

Photo: University of Natural Resources and Life Sciences, Vienna

„The sugar industry has always found the most efficient ways of utilizing byproduct streams as they occur. Transformation into bio-based and biodegradable plastics also opens the way to high-value products with new properties. Developing the production process together with partners in industry is exciting for us; within the project consortium we are also able to evaluate the polymer properties and possible areas of application. For this it is vital that the byproducts be available in significant quantities – a prerequisite for cost-effective implementation."

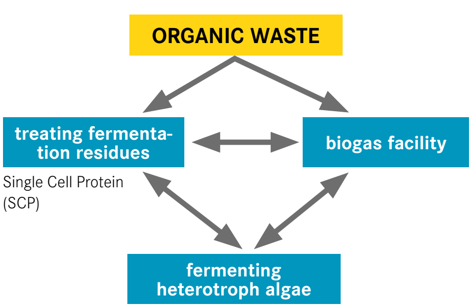
Markus Neureiter
University of Natural Resources and Life Sciences, Vienna
Department IFA-Tulln, Institute for Environmental Biotechnology

Treating fermentation residues, Laboratory, Photos: Botres Global GmbH

RERA-pro
Integrated biorefinery to process residues

RERA-pro, a project headed by the Styrian firm Botres Global GmbH, is concerned with research leading to an integrated biorefinery to process residues on an industrial scale. Also involved in the project: Stipits Entsorgung GmbH and the Process Engineering study group in the Institute of Food Technology at the University of Natural Resources and Life Sciences, Vienna. The aim is to make high-grade products from organic waste, entirely emission-free, by means of system integration and linking together various pioneering technologies.

The approach adopted here differs from cascading strategies, as full use is made of the biomass in an integrated process, with no competition between energy production and utilization of substances. The integrative approach combines biogas production, processing fermentation residues and fermenting algae, all in a single facility. Fermentation residues from producing biogas are used to make customized fertilizers and high-grade protein feed. Two-thirds of the remaining fermentation residues are converted into clean water, and the biogas process and the treatment of fermentation residues are used to obtain nitrogen with which to ferment heterotroph algae. In exchange for only 20 % less biogas produced, the process utilizes up to 70 % of the nitrogen accumulating.



Producing heterotroph algae

Utilizing algae for material has huge potential. Microalgae are used to produce polyunsaturated fatty acids on an industrial scale for the food and feed industries; they can also be used as a feedstock in the chemical and pharmaceutical industries. Usually, in phototrophic production, algae need sunlight, carbon dioxide and water to be able to grow. The energy to fix carbon dioxide in photosynthesis comes from the sun. In this process carbon dioxide is fixed in the form of chemical compounds which represent a source of carbon for the algae. Where heterotroph microalgae are fermented, the algae do not need light or carbon dioxide in order to grow; in heterotroph algae cultivation the algae cells are not supplied with carbon dioxide but with other sources of carbon, such as sugar or acetic acid.

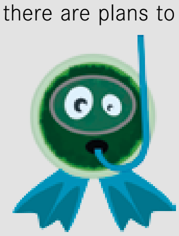
Organic waste as a source of protein for aquacultures

In the RERA-pro approach the heterotroph algae are intended to serve as a source of protein (algae SCP = Single Cell Protein) for aquacultures. The aim of the strategy is to cut costs dramatically – the cost of producing SCP is meant to go down by 50 up to 70 %. With a shortage of fishmeal expected all over the world, opening up new, tailor-made sources of feed protein presents a global challenge. This applies to the industrialized countries, too – the EU´s self-sufficiency in feed protein is only 32 %. Heterotroph algae are an ideal substitute for fishmeal; in comparison with vegetable proteins, they have a better spectrum of amino acids, and fish fed on them contain more omega-3 fatty acids.

Producing heterotroph algae from organic waste is a cutting-edge strategy that can help to mitigate the worldwide shortage of sources of feed protein. Implementing a first integrated biorefinery to process residues is planned for 2017, in the form of a research and test facility on the Stipits premises in Rechnitz (Burgenland). ◘

Netzwerk Algen

To encourage research, development and implementation of technologies and products connected with microalgae, bmvit manages Netzwerk Algen (“Algae Network”). Once a year a meeting is held at which the stakeholders in the field can link up together. Apart from activities in Austria, there are plans to exchange information with stakeholders in Germany and Switzerland.



More information is available at:
www.nachhaltigwirtschaften.at
https://infothek.bmvit.gv.at

Photos: University of Applied Sciences Salzburg

BioSubTro
Using biogenic substances when timber is dried

When woodland biomass, sawn timber and byproducts of sawing are dried, various constituents accumulate that have received little attention up to now. These substances have considerable potential as feedstocks in industrial production. In BioSubTro, a research project of the University of Applied Sciences Salzburg in collaboration with Weitzer Parkett GmbH & CO KG, Sanoll Biokosmetik GmbH and Sägewerk Johann Pöckl, new processes are being developed to capture these byproducts of timber drying and put them to work.

Substances obtained sustainably from lignified material are of special interest for the chemical, pharmaceutical and cosmetics industries. As a rule, extracting these is expensive; in most extraction processes the timber is shredded, after which it is no longer available for cascading uses.

Researchers at University of Applied Sciences Salzburg are now investigating new options for obtaining and utilizing usable substances from biomass. Here the materials (such as woodland biomass, bark or sawn timber) are dried on technically relevant scale, and the resulting volatile and extractive constituents are obtained in the form of condensates.

Various processes are then carried out to purify and separate the resulting mixtures; later the ingredients are characterized in terms of quantity and quality.

Preservatives for natural cosmetics

The wood and bark of living trees contain natural substances which protect them against attack by fungi and bacteria. These substances‘ antimicrobial properties are of great interest, and are meant to be harnessed in the new processes. Up to now manufacturers of natural cosmetics had to use conventional substances to protect their products. As part of the project various screening tests are carried out with condensate and its constituents, to demonstrate the antimicrobial efficacy of these substances and their preservative properties in cosmetic products.

Initial findings

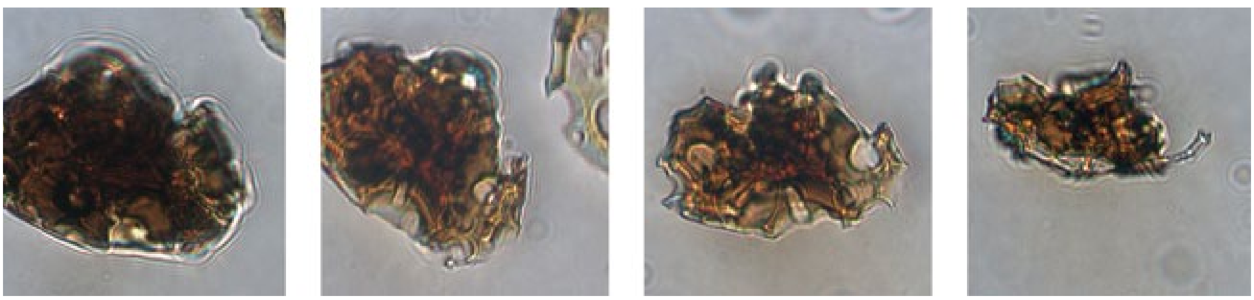
So far various categories of substance, such as carbohydrates or polyphenols, have been identified in the condensates in varying concentrations, and initial investigations have shown that the constituents have an antimicrobial effect on the test bacilli employed.

The next step will be to analyse how the active ingredients in cosmetic products can be processed, and to test their preservative effect there. Other possible fields of application and market potentials for these biogenic substances are to be identified within the project, too. ◘

Laboratory, Photos: University of Applied Sciences Salzburg

PROVIDES
Environmentally friendly solvents for the paper industry

Along with the steel and cement industries, the paper industry is a major energy consumer. For centuries the pulp and paper industry has been based on biomass. The processes to digest biomass and treat recovered paper have been repeatedly improved, but they still consume energy on a large scale. To move the European pulp and paper industry toward a low-carbon bioeconomy, new technologies will be needed, leading to savings in energy consumption and a reduction in carbon emissions. One starting-point here is researching new processes based on low-cost biodegradable solvents, so-called DES (Deep Eutectic Solvents), which can separate wood into lignin and cellulose with relatively low energy consumption.



Separating lignin out over 3 hours at only 60 °C, Photo: TU Eindhoven

As part of the EU‘s Joint Technology Initiative “Biobased Industries“ (JU BBI) European researchers and industry are investigating in the PROVIDES project (Grant Agreement NO 668970) the utilization of these eutectic solvents to selectively remove wood constituents without consuming much energy.

EU-wide collaboration Bio-based Industries (JU BBI)

The Joint Undertaking (JU) “Bio-based Industries“ (BBI) was set up in 2014 as a Joint Technology Initiative in the EU’s research and innovation programme Horizon 2020. The main focus of the initiative is on utilizing inedible parts of plants, such as wood, residues from agriculture and forestry and biodegradable waste, and transforming these into various bio-based products and biofuels. The investment volume planned for this JTI in the period 2014 to 2020 comes to 3.7 billion Euro.

BIO-BASED INDUSTRIES Public-Private Partnership · Horizon 2020 European Union Funding for Research & Innovation · Bio-based Industries Consortium

Hydrophobic DES (Deep Eutectic Solvent), Photo: TU Eindhoven

The international packaging and paper group MONDI is a partner in this research initiative. The project involves developing novel processes that operate at lower temperatures and pressures and use non-polluting solvents. Deep Eutectic Solvents (DES) are an alternative to conventional solvents, and can dissolve cell-wall constituents from various lignocelluloses at low temperatures (below 100 °C). To make DES, natural substances (amides, sugars, acids) are mixed with at least one proton donor (HBD) and at least one proton acceptor (HBA). The solvents are miscible with water, biodegradable, not very volatile, and inexpensive to make. DES can displace standard digestion processes; their potential for completely restructuring cellulose production, making a production process with reduced energy consumption and reduced emissions and residues possible, is considerable.

The main aims are:

- to reduce process energy intensity compared to conventional ways of making cellulose by at least 40 %
- to reduce investment costs compared to current cellulose plants by 50 %; this is feasible because the new equipment does not involve high pressures and recovering the chemicals is straightforward
- to improve the market position of products currently obtained from timber (e.g. paper, cardboard) and develop new applications with high added value, for instance in the textile and chemical industries

Metal ion extraction from water by hydrophobic DES (Deep Eutectic Solvents), Photo: TU Eindhoven

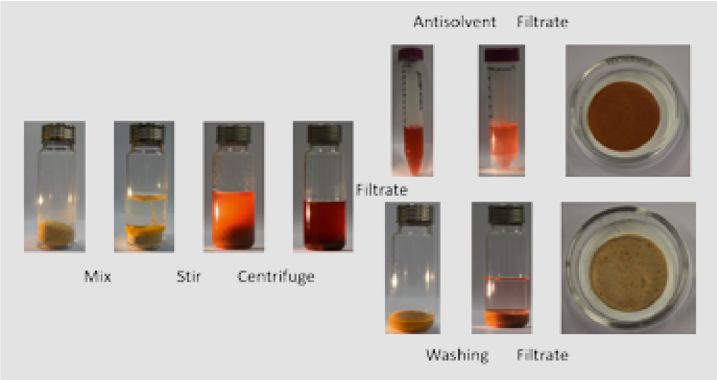
Various DES are currently tested in the PROVIDES project with regard to separating lignin out of lignocellulose and decontaminating recovered paper, i.e. removing printing inks and contaminants such as stickies. A number of new combinations of HBD (proton donors) and HBA (proton acceptors) have been developed, forming deep eutectic solvents. For the first time a hydrophobic DES has been investigated; hydrophobic DES are immiscible with water and make it much easier to separate individual components out of a mixture of water and cellulose. The researchers are also investigating techniques upstream and downstream to make the separation processes more effective. The aim is also to develop efficient methods of recovering both the solvents and the dissolved constituents.

Initial calculations have already been carried out as regards cost-effectiveness and environmental impact of the entire process for separating lignin out. A roadmap for activities up to 2030 has been drawn up on the basis of a list of critical aspects and outstanding research issues. ◘

Photo: Mondi Group

„For Mondi, taking part in PROVIDES means joining in developing a new technology for our industry at EU level. Here we pay special attention to closing process loops as completely as possible, minimizing energy consumption and cascading uses of the domestic raw material timber so as to maximize value creation. This makes PROVIDES an important research project that fits in with our strategy of developing sustainable value creation for our customers from high-quality packaging solutions and paper.“

Leo Arpa,
Head of Research & Development Paper, Mondi Group



Laboratory process, extracting lignin from lignocellulose, Photo: TU Eindhoven

IEA Bioenergy Task 42
Biorefining

Austrian researchers participate in the Technology Collaboration Programmes (TCP) of the International Energy Agency (IEA) via the Austrian Federal Ministry of Transport, Innovation and Technology`s IEA research cooperation. The Bioenergy Task 42 addresses the issue “Sustainable processing of biomass into a spectrum of marketable bio-based products and bioenergy“.

Within the framework of Task 42 strategically relevant information about biorefinery value creation chains is analysed and disseminated. The aim is to support the development towards a bioeconomy and generate inputs for a national R&D orientation. Linking the partner countries together and exchanging important findings from national R&D activities are intended to give more impetus to implementing biorefineries.

In Bioenergy Task 42 the following activities are carried out:

> Analysing, assessing and classifying biorefineries as regards technology, products, quality and marketability
> Assessing how sustainable biorefineries are by means of Life Cycle Analysis
> Developing strategies for implementing biorefineries and a “Circular BioEconomy“
> Disseminating the results widely, with all stakeholders interacting

The knowledge acquired will be published in reports on the issues Bio-based Chemicals, Biobased Materials/Fibres and Proteins, and will be discussed with the stakeholders at special national events. ◘

Interview with Heike Frühwirth, University of Applied Sciences, Biberach

Both photos: University of Applied Sciences, Biberach

You teach at Biberach University of Applied Sciences in the degree course "Industrial Biotechnology" and are concerned with pioneering processes serving to utilize raw materials sustainably. Which sectors of industry are particularly interested in these technologies?

Industrial biotechnology is concerned with making useful substances and supplying energy with the aid of microorganisms or enzymes. Because our fossil resources are finite, we need to develop various different arrangements to ensure a secure supply. Given the wide range of organisms and products involved, these processes can be applied in almost all sectors of industry. At the moment biotechnological products are implemented mainly in the cosmetics, food, chemical and pharmaceutical industries and in the field of energy supply.

Which technologies look particularly promising, specially in consideration of environmental friendliness?

Biotechnological processes that are flexible with respect to their material starting-points have a definite advantage. Seasonal variations in the amount of raw material available are also a logistical challenge. Utilizing residues plays an important part, too – but the quality of these feedstocks fluctuates. Thinking out future scenarios for the bioeconomy, we shall need novel solutions going beyond what is currently feasible.

Are cascading uses of biomass a vital approach for the future?

Integrative process designs have great value-creating potential, which biotechnological processes need if they are to compete with long-established conventional processes. Implementation in biorefineries can contribute significantly to providing pioneering, sustainable strategies.

You are also an expert in the field of algae research. What openings do you see for developing algae technology?

In contrast to other microorganisms, phototrophic organisms use carbon dioxide as a carbon source, so they fulfil one prerequisite for production without a biomass feedstock. Bio-based industries necessarily involve competition for arable land – here algae have the advantage that they can be cultivated on non-arable surfaces. So microalgae have considerable potential for making a worthwhile contribution to the bioeconomy. At the moment microalgae are used in production processes at the upper end of the price range.

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