Valorization of biological materials

ValBio-Urban brings bioeconomy research to users

Reducing carbon dioxide emissions and the capture and utilization of CO_2 are important steps towards achieving a climate-neutral and sustainable economy. Accordingly, as part of the ValBio-Urban research project, an interdisciplinary team from the University of Stuttgart is developing bioeconomic approaches to solutions that will be implemented with companies from Baden-Württemberg.

Limiting global warming to well below 2 °C above pre-industrial levels (the stated aim of the 2015 Paris Climate Agreement[1)]) requires the combined efforts of industry, society and government. This notion is supported by the Baden-Württemberg government, which has been promoting the development of innovative concepts for the use of renewable and recyclable raw materials since 2019. All of which is underpinned by the state 'Sustainable Bioeconomy for Baden-Württemberg' strategy. The aim is to significantly reduce both the use of fossil resources and the emission of greenhouse gases, while maintaining or strengthening Baden-Württemberg's competitiveness as a business location.

ValBio-Urban wants to valorize anthropogenic material flows

Prof. Dr. Ralf Takors and Dr. Dinah Henritzi lead and coordinate the ValBio-Urban project at the University of Stuttgart.
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Against this background, several researchers from the University of Stuttgart founded the interdisciplinary Stuttgart Research Initiative - Valorization of Bioresources (SRI ValBio), which aims to produce raw materials from biowaste. "The 13 participating institutes from six faculties have joined forces to reflect on the topic of bioeconomy, with all its different facets, through activities at the University of Stuttgart," explains Prof. Dr. Ralf Takors from the Institute of Biochemical Engineering (IBVT). This includes using biotechnological principles for producing chemicals, developing sustainable cycles or even taking new approaches in architecture. Thanks to the different competencies, current issues are discussed and explored from all angles during the regular meetings.

The first joint project to emerge was ValBio-Urban, which has been funded by the Baden-Württemberg Ministry for the Environment, Climate Protection and the Energy Sector since April 2022. "The focus here is on the use of anthropogenic material flows to ultimately recycle or upgrade them in a meaningful way," explains Takors, who heads the project. "All the activities within the project are also run from the perspective of translation, i.e., implementation in concrete applications, preferably in the state of Baden-Württemberg." The participating institutes are supported by scientific coordination manager Dr. Dinah Henritzi, who occupies a post created specifically for SRI ValBio. Her task is to establish contact with local users and make the protagonists of ValBio-Urban visible as problem solvers within the bioeconomy. This is leading to broad cooperation with other networks across Baden-Württemberg.

Versatile starting points

The five ValBio-Urban projects reflect the range of competencies at the University of Stuttgart:

In the 'Bioconcrete' project, large-format structural components will be produced with the help of an environmentally friendly alternative to cement, a common binding agent. Cement is produced by burning limestone and clay, a process that is

responsible for six to eight percent of global CO_2 emissions every year. Conventional cement-bound concrete is produced by mixing cement with water and aggregate. Bioconcrete, on the other hand, is produced using natural biological processes that bind and consolidate aggregate. Special bacteria are used for this biomineralization process; they break down urea into ammonia and carbonic acid with the help of the enzyme urease. In the presence of calcium, this process leads to calcium carbonate crystals ($CaCO_3$), which bind the aggregate.

Bioconcrete is already being applied in some areas of construction, e.g. to seal cracks in concrete, stabilise sandy soils and make bricks. As part of ValBio-Urban, the researchers now want to further develop the process of microbiologically induced calcite production (MICP) in order to produce load-bearing components that would offer a CO_2-neutral alternative for the construction industry. Collaboration between the Institute of Lightweight Structures, Design and Construction (ILEK), the Institute of Microbiology (IMB) and the Materials Testing Institute of the University of Stuttgart has already made it possible to produce the first bioconcrete test specimens with a compressive strength of up to 50 megapascals.

The bioconcrete test specimens produced by microbiologically induced calcite precipitation already have a high compressive strength.
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The 'Extraction of organic compounds from waste' project aims to obtain valuable substances such as organic acids, amino acids or sugars from biological waste. "Here, we are focusing on waste products from the food industry," Henritzi says. "The first part of the project is primarily concerned with identifying useful source companies and looking at which substances can be extracted from the respective wastes. "The Institute of Energy Economics and Rational Energy Use (IER) and the Institute of Combustion and Power Plant Technology (IFK) subsequently want to use specific examples to demonstrate the technical and economic potential of biowaste and develop utilisation concepts. To this end, they are already in close contact with various disposal companies.

In the ValBio-Urban project, technologies for the valorization of biological materials will be developed and implemented with local users.
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In the 'Social perception' project, the Center for Interdisciplinary Risk and Innovation Research (ZIRIUS) is investigating how producers and end consumers evaluate bioeconomic products: are substances based on the use of waste accepted in the same way as conventionally produced substances? Is there a preference for certain feedstocks or technologies? The analysis of these questions forms the basis for successful translation of bioeconomic research into urban areas.

In the 'Microbial valorization of point emissions' project, waste gases containing CO_2, such as those generated through cement production, will be used to produce valuable organic substances such as short-chain alcohols or organic acids with the help of microorganisms. Acetogenic bacteria are used to convert the CO_2 into the basic chemical acetic acid, which is then further processed. However, since the bacteria react very sensitively to the presence of O_2, any residual oxygen must be completely removed from the exhaust air. In collaboration with a cement company that provides concrete data, researchers from IBVT and IFK are seeking to jointly develop a practicable process that will enable the company to make bioeconomic use of the exhaust gases and thus contribute to more climate-friendly cement production.

In the fifth project, which is called ‘Thermal-biological waste recycling’, the IBVT and IFK institutes are working on the production of a high-quality synthesis gas from CO_2 contained in the exhaust air streams generated during sorption-assisted gasification (SEG) of household waste. At temperatures of 1,000 - 1,600 °C and pressures of up to 60 bar, as well as limited oxygen supply, the basic molecules CO_2, hydrogen (H_2), carbon monoxide (CO) and water vapour (H_2O) are formed. The synthesis gas composition can be tailored with regard to its CO, CO_2 and H_2 content by changing the gasification temperature. The project aims to improve the technology so that the synthesis gas can be used for microbial valorization.

All ValBio-Urban projects aim to achieve a carbon-neutral, sustainable economy that also strengthens local supply. After all, as Takors notes, "own sources and independence from international networks are also an important component of the bioeconomy". With this in mind, the researchers are very interested in finding further cooperation partners based in Baden-Württemberg.

References:

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