HUMAN & BIOTECHNOLOGY

Fields of Expertise TU Graz

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Gernot Müller-Putz,
Human & Biotechnology
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The current issue of TU Graz research focuses on biotechnology. Represented by five core institutes at our university, research in this field explores important molecular-cellular biosystems and applications of them in the context of modern bioproduction. Biotechnology research at TU Graz is strongly interconnected with chemistry, process engineering and informatics.

50 years ago, in 1971, a new field of research was established at TU Graz: biomedical engineering. Starting as a major of electrical engineering, today it is a standalone study with Bachelor's and Master's degree programmes and even its own doctoral school for PhD students. The research started in a single, large institute (Elektro- und Biomedizinische Technik), which was split into separate institutes. After several developments, today, there are five institutes located in the Faculty of Computer Science and Biomedical Engineering: Medical Engineering, Biomechanics, Health Care Engineering with European Testing Center for Medical Devices, Neural Engineering and Biomedical Informatics. All Institutes have found their home in the Biomedical Engineering Building in Stremayrgasse 16.

Later this year (from 30 September to 1 October 2021) we are hosting the Annual Conference of the Austrian Society of Biomedical Engineering and are celebrating this anniversary (https://oegbmt2021.tugraz.at). We have invited keynoters and there will be talks about current scientific findings in the field.

Calls for appointments: Professorship in Biomedical Imaging, §98, successor to Rudolf Stollberger is currently in its negotiation phase. The Professorship in Computational Medicine, §98, could not be filled and a new call has been postponed. We will continue to report here.

Regina Kratzer

CO_2 and Lignocellulosic Biomass as Feedstocks for Upcoming Biotechnology

Nature provides an eco-friendly alternative for almost any chemical reaction but examples of industrial bioprocesses are rare. The main reasons for slow implementation of bioprocesses are the generally more labor-intensive development and more expensive feedstocks and process steps compared to chemical processes. For bulk products (e.g. biofuels, biopolymers) the feedstock contributes to >70% of the total production cost. The exploration of waste streams as feedstocks is the required boost to further exploit modern biotechnology. Use of carbon dioxide (CO_2) as feedstock opens the door to a vast number of bioproducts.

CO_2 is the only carbon source that can quantitatively replace fossil fuels. However, CO_2 is a stable molecule and high energy input in the form of temperature, electricity, light or reactive reagents is required to transform CO_2. In biotechnology, there are three main routes of using CO_2 as feedstock (i) directly as carbon source for specialized microorganisms, (ii) as biomass subsequently to CO_2 fixation by plants, (iii) after chemical transformation to e.g. formic acid or methanol (Figure 1). We, at the Institute of Biotechnology and Biochemical Engineering, have been taking a closer look at the efficient conversion of CO_2 used directly as feedstock and, subsequently to assimilation by plants, as lignocellulose. The utilization of CO_2 or lignocellulosic waste circumvents the food vs. fuel debate as it is the case with e.g. corn, sugar cane or vegetable oil feedstocks. >

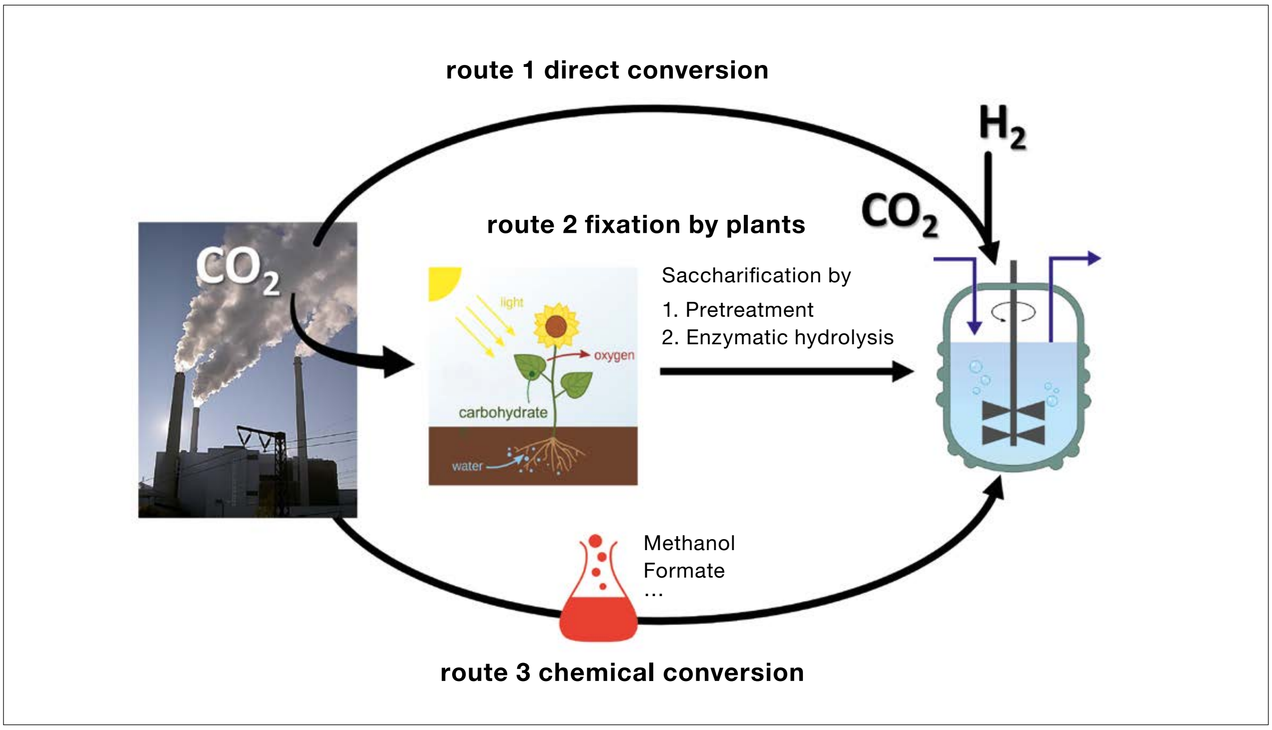


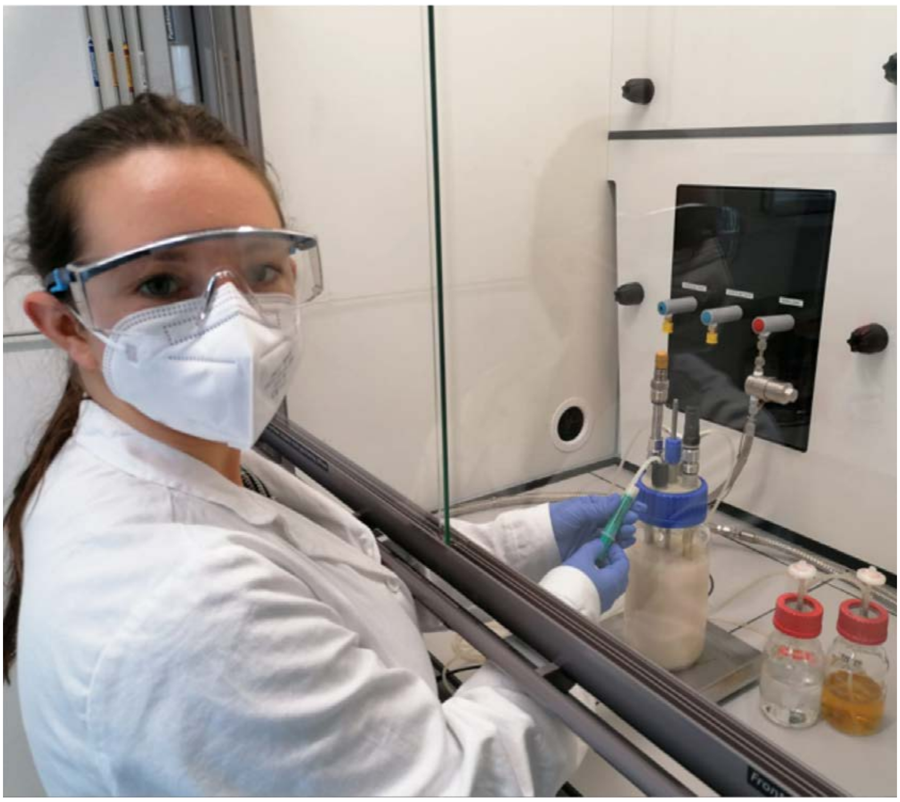
Figure 1: Main routes for CO_2 conversion in biotechnology.
Source: TU Graz / Institute of Biotechnology and Biochemical Engineering

Regina Kratzer is an associate professor at the Institute of Biotechnology and Biochemical Engineering focusing on the development of bioprocesses. The goal is to move away from trial-and-error based methods towards effective design strategies. Further reaching goals are industrial implementations in low-value, high-volume sectors.

Source: TU Graz

Some versatile soil bacteria are capable of efficient, non-phototrophic CO_2 assimilation using hydrogen (H_2) as a reducing agent (route 1, Figure 1). The product scope of CO_2 reduction by chemical methods is limited whereas the use of bacteria with tractable metabolism enables the biosynthesis of a huge number of products. Biocatalytic CO_2 reduction by H_2 connects bioprocessing with topics around the future energy carrier H_2. Research at the biotechnology institutes of Graz University of Technology (TU Graz) aims at the bioproduction of value-added products by integrated process development. Metabolic pathway engineering of the bacteria for improved productivity and expanded product spectra is performed at the Institute of Molecular Biotechnology (Anita Emmerstorfer-Augustin, Robert Kourist). Instrumented bioreactor design, including gas sensors for precise monitoring of gaseous substrate utilization, and detailed evaluation of microbial physiology are developed at the Institute of Biotechnology and Biochemical Engineering (Regina Kratzer). The presence of explosive gas mixtures demands strict requirements regarding safety for reactor and process design i.e. construction measures in the lab and the building, specialized equipment and strict safety precautions (Figure 2). The interdisciplinary focus on hydrogen at Graz University of Technology offers interesting new cooperation opportunities with institutes of other faculties. Fortunately, we were able to join forces with Vanja Subotic from the Institute of Thermal Engineering. Vanja Subotic supports bioreactor and process design. The research is funded by acib GmbH competence center (Austrian Centre of Industrial Biotechnology) and the Marie Skłodowska-Curie Innovative Training Networks initiative (project ConCO_2rde, https: //www.conco2rde.eu).

An alternative route is followed in the Open Innovation Test Bed (OITB) Bionanopolys (https://twitter.com/bionanopolys, https://www.facebook.com/Bionanopolys).



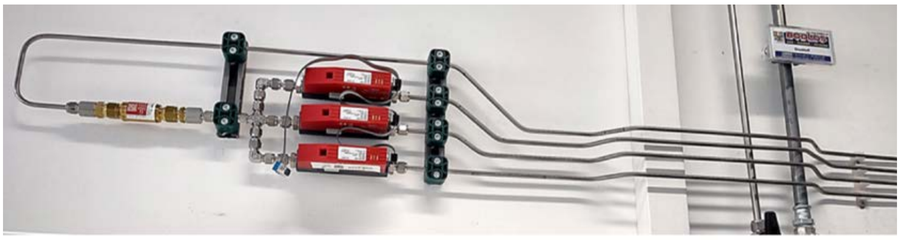


Figure 2:
Vera Lambauer working on gas fermentation, explosion-safe working space and gas lines .
Source: TU Graz / Institute of Biotechnology and Biochemical Engineering

Here, CO_2 is used indirectly after assimilation and transformation by plants into lignocellulose (route 2, Figure 1). Most microorganisms cannot use lignocellulose directly as a carbon source and polymeric structures need to be broken down by physical, chemical and enzymatic steps. The obtained nutrient solutions contain mainly monosaccharides and lignocellulosic residues. However, some by- and degradation products are toxic or inhibitory in subsequent fermentations. The biotechnology institutes of TU Graz are working on an integrated process design to use lignocellulosic waste as a carbon source for the efficient production of biopolymers in Bionanopolys. Engineering of metabolic pathways of selected microorganisms to efficiently metabolize lignocellulosic material is carried out at the Institute of Molecular Biotechnology (Harald Pichler). Biomass pretreatment and cultivability of microorganisms on nutrient solutions obtained from lignocellulose is investigated at the Institute of Biotechnology and Biochemical Engineering (Regina Kratzer). Trans-faculty, interdisciplinary research including genetics, bioprocessing and mechanical engineering facilitates an integrated engineering approach spanning from the molecular level to the multi-liter scale. Comparison of several routes (Figure 1) facilitates assessment of potentials and limitations of new feedstocks for upcoming biotechnology. Institutes of TU Graz work in close cooperation with acib GmbH competence centre (CSO Bernd Nidetzky) in all mentioned projects.

ConCO_2rde (https://www.conco2rde.eu) is a project within the Marie Skłodowska-Curie Innovative Training Networks (MSCA). MSCA supports cooperation between industry, academia and innovative training to enhance employability and career development. The aim of ConCO_2rde is to train 11 early stage researchers in new technologies for hydrogen use and CO_2 utilization in 5 European countries.

Bionanopolys is an Open Innovation Test Bed (OITB). The program aims at upgrading existing or developing pilot lines for the production of biobased nanomaterials starting from lignocellulosic feedstocks. 12 European countries are participating in this project.