Industrial biotechnology – biological resources for industrial processes

Industrial or white biotechnology uses microorganisms and enzymes to produce goods for industry, including chemicals, plastics, food, agricultural and pharmaceutical products and energy carriers. Renewable raw materials and increasingly also waste from agriculture and forestry are used for the manufacture of industrial goods.

Microorganisms and their enzymes are the major drivers of industrial biotechnology.

Countless metabolic processes take place in a single cell. These processes break down and convert nutrients that have been taken up into new products. Enzymes are involved in controlling and coordinating reactions that happen simultaneously or consecutively. Humans have been making use of microbial and enzymatic processes for a long time. Everyday examples include the production of bread, yoghurt and vinegar using microorganisms and the use of enzymes in detergents.

Biotechnology is also used in many other industrial areas. Microorganisms and enzymes can be used for the production of food supplements such as vitamin B2, biobased plastics such as polylactic acid and energy carriers such as biogas and bioethanol.

And yet another example of how biotechnology can be used: Lamy, a well-known German company that produces writing instruments, has been polishing the nibs of fountain pens with walnut shells and polishing paste in place of organic solvents for around eight years now. However, the company had to find a solution to the problem that the tiny particles of walnut shell got jammed in the hollow spaces of the nibs. Initially, the particles were removed manually, which was rather a cumbersome process. Nowadays, Lamy uses an enzyme cocktail developed by researchers from Mannheim University of Applied Sciences. The enzyme cocktail makes the walnut granules smaller. Ultrasound is subsequently used to wash the remaining walnut shell pieces from the nib slits.

A common problem associated with the use of renewable resources on an industrial scale relates to the huge financial and technological cost. Many companies have developed attractive products in the laboratory, but fail to turn them into technical applications. Institutions like the Fraunhofer Centre for Chemical-Biotechnological Processes (CBP) in Leuna support partners from research and industry in their efforts to transfer new technologies to an industrial scale. The CBP provides infrastructure and pilot plants that enable its partners to develop biotechnological processes that utilise renewable resources on an industrial scale. The CBP is run by scientists from the Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) in Stuttgart and the Fraunhofer Institute for Chemical Technology (ICT) in Pfinztal.

The CBP is currently transferring a chemical-enzymatic process for the production of epoxides from plant oils to industrial scale. Epoxides are used for the production of grease and emulsifiers for washing agents and detergents.

Downstream processing and metabolic engineering

In comparison with conventional processes, white biotechnology processes run under relatively mild reaction conditions. Moderate temperatures and the use of aqueous media reduce the energy requirements and the number of problematic by-products. Since product concentration and formation rate are often very low, the resulting products need to be purified and recovered in marketable quantities in a process that is referred to as downstream processing. Product quantity can also be increased by optimising the manufacturing processes or biocatalysts used, for example by enhancing important metabolic activities, switching off less important ones (metabolic engineering) or optimising enzymes by directed evolution (enzymatic engineering).

White biotechnology uses renewable resources such as carbohydrates from cereals, corn and sugar beet or vegetable oils from sunflowers, rapeseed and oil palms. Increasing efforts are also being made to use waste products as raw materials. The energy supplier badenova operates a biomethane plant in the city of Eschbach and uses male corn plants as fermentation substrate.

The male corn plants are simply used to pollinate female corn plants and are then removed from the field once they have fulfilled their purpose.

The Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB) and partners from industry began operating the EtaMax pilot plant close to Stuttgart Central Market in October 2012. The plant produces methane from fruit and vegetable waste. The co-products of the fermentation process are used in algae breeding in photobioreactors where the microalgae produce fatty acids, pigments and proteins. Residual algae biomass is mixed with biowaste and converted into methane.

EtaMax: Production of biogas and valuable materials from fruit and vegetable waste.

Revenues of industrial biotechnology companies have grown

In 2012, Germany was home to 61 companies (10.8%) working in the field of industrial biotechnology (source: biotechnologie.de). These companies are focussed on the development of technical enzymes, new biomass utilisation strategies and biotechnological production processes. The majority of dedicated biotechnology companies in the white biotechnology sector are active in the fields of food/feed and pharmaceutical production, followed by chemistry, cosmetics and energy. The biotechnologie.de information portal identified an increase in sales to 193 million euros in 2012 (up 9.1% from 2011). The R&D budget of the companies was similar to that of the previous year, i.e. around 47 million euros.

In Baden-Württemberg, seven companies and seven universities, two universities of applied sciences and two non-university research institutions are working or carrying out research in the field of industrial biotechnology.

Funding programmes

With the "National Research Strategy BioEconomy 2030", the German government is laying the foundation for realising the vision of a biobased economy, "one which produces sufficient healthy food to feed the world and supplies quality products made from renewable resources." Industrial biotechnology plays a key role in the transition to a biobased economy. This is also reflected in the funds the German government has invested in industrial biotechnology projects. In fact, funding has increased from 31 million euros in 2010 to around 67 million euros in 2011.

In April 2011, the German Ministry of Education and Research (BMBF) launched the "Industrial Biotechnology Innovation Initiative" under the "National Research Strategy BioEconomy 2030" with the goal of encouraging research into biotechnological methods for the production of goods from renewable resources and replacing equivalent products made from fossil raw materials. The BMBF has plans to set aside up to 100 million euros for such projects over the next five to ten years. Proposals can be submitted until 1st June every year; the deadline for final submissions is 1st June 2015.

Sources:
The German Biotechnology Sector 2013. Facts and Figures. biotechnologie.de

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