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Globally, industrial biotechnology is advancing the production of new products from sustainable raw materials through efficient processes while reducing energy and disposal costs. This is creating potential in the value chain and opening new commercialization options. Industrial biotechnology employs microorganisms and enzymes as biocatalysts for industrial production and is benefiting a variety of industries, including chemicals, food and beverage, and paper. Worldwide, industrial biotechnology is currently commercially established in the chemicals industry, particularly in specialty chemicals (e.g., amino acids), consumer goods (e.g., detergents and food additives), and biopolymers (e.g., for packaging materials).

Germany has been active for decades in a range of biotechnology areas and has long been investing in the research and development of biotechnology processes. These industries are now starting to see the benefits of industrial biotechnology at commercial scale. Possibly to an even greater degree, lesser known small and medium-sized enterprises (SMEs) are conducting research in biotechnology fields that offer potential for innovation and growth.

In Europe, more than 40 percent of SMEs active in industrial biotechnology are located in Germany, according to a 2008 Ernst & Young study.1 Approximately 70 SMEs,2 as well as several large companies, primarily in the chemical industry, are currently conducting industrial biotechnology research and development in one of Europe’s strongest economies. With a high level of R&D activities, German companies are forming the greatest number of strategic partnerships in Europe: Of the 24 new partnerships announced in the past five years, 15 involved German companies. Of these, five involved Zwingenberg-based BRAIN (including collaborations with Clariant and with MerLion Pharmaceuticals), and three involved Direvo, based in Cologne (including a deal with Danisco/Genencor).3

Current global revenues for goods produced using industrial biotechnology are estimated between €50 and 60 billion annually, according to data released by the industry trade publication Analytik News in 2009.4

By 2030 the global market for industrial biotechnology could grow to roughly €300 billion, according to the so-called Cologne Paper, published in May 30, 2007, in Cologne at the conference “En Route to the Knowledge-Based Bio-Economy,” hosted by the German Presidency of the Council of the European Union.5

Biorefineries represent the cutting-edge concept of large-scale use of renewable resources, including cellulosic materials and industrial and municipal wastes. In addition, the generation of renewable energies from sustainable raw materials and waste products through biotechnology processes is expected to accelerate. It is generally acknowledged by industry that production of energy and chemicals from renewable resources should not interfere with the food supply or damage the environment.

Industrial implementation of these innovative technologies then occurs when the production costs of biotechnology processes are competitive with their conventional counterparts. BASF currently plays a leading role in the industrial production of Vitamin B2. Converting production to a biotechnology-based process resulted in a 40 percent reduction in production costs, a 30 percent lowering of carbon dioxide emissions, and a 95 percent reduction of waste, according to company figures.

German companies from a variety of industries are applying industrial biotechnology, such as for cosmetic agents (e.g., Bitop), detergents (e.g., Henkel), and pharmaceutical applications (e.g., Evonik). Other companies are in the process of developing new lubricants and surfactants from renewable feedstocks (companies such as Addinol Lube Oil and Taminco, both located in Leuna) or epoxide-based products (e.g., Dracosa) with significantly reduced toxicity levels compared to conventional epoxides, for various industries, such as automotive. Tangible industrial products are also being developed. Fischer has developed a universal screw anchor out of biopolyamide (Nylon 5.10) that has the same performance as the standard product made of synthesized nylon, according to the company.

According to the European Bioplastics association, roughly 5–10 percent of current market demand for plastics can be met by existing biobased plastics production. Global production capacity, however, currently assessed at 350,000 tonnes, accounts for but a fraction of total production (250 million tonnes). According to a survey by Patel et al, the bioplastics industry expects production to grow by an average of 19 percent per year between 2007 and 2020, ultimately resulting in the production of 3.45 million tonnes annually by 2020.6
BASF, for example, is building a new facility that will increase the production capacity from 14000 to 60000 tonnes annually for its biodegradable Ecoflex® plastic, at its Ludwigshafen site; this production capacity is expected to be reached by early 2011. In addition to Ecoflex, BASF also produces Ecovio® at the Ludwigshafen site; that product was launched in 2006, based on Ecoflex compounded with approximately 45 percent polylactide.

The majority of projects intended for commercialization are still in pilot phases, although the German industry is well on its way to mass commercial production of numerous products.

One example here is the Linde Group, which is involved in a number of activities in the industrial biotechnology field, including the development of processes for the production of second-generation biofuels and biologically sourced ethylene, as well as the development of new CO₂ supply technologies for large microalgae cultivation plants.

Munich-based Süd-Chemie announced in late July 2010 that it is building Germany’s largest plant to date for production of second-generation, cellulosic ethanol. The total project has a volume of altogether € 28 million and is based on its Sunliquid® enzymatic production process, which Süd-Chemie has been testing in a pilot plant in Munich since the beginning of 2009. By the end of 2011, the new demonstration plant is anticipated to produce annually up to 2000 tonnes of bioethanol from lignocellulosic residues, such as cereal straw.

Also in pilot-phase production are projects at Wacker Chemie AG. The company even renamed its fine chemicals division to Wacker Biosolutions in March 2010, to highlight the company’s focus on biotechnology. Wacker is employing acetic acid and ethylene as building blocks for vinyl acetate monomers. In October 2009, Wacker began operating a 500 tonne-per-year pilot plant in Burghausen, that produces acetic acid through the company’s Aceo® process technology. This involves yeast-based conversion of biomass feedstocks to ethanol before production of acetic acid via gas-phase oxidation.

Uhde Inventa-Fischer, which develops technology and equipment for production of polyester and polyamide polymers, is operating pilot plants in Berlin employing the company’s patented 2-Reactor Technology. This process is currently utilized in various polyester production plants worldwide as well as for a co-poly(butylene terephthalate) plant in Germany. The technology can also be used for production of polybutylene succinate, which may be sourced from renewable succinic acid. Uhde Inventa-Fischer is to start up a poly-lactic acid pilot plant in Guben (Germany) with a capacity of 500 tonnes per annum, by end of this year, and is offering partnership in research and development.

These investments are driven by private companies and initiatives, although government support in the form of research grants, incentives, and targeted commercialization initiatives are also making strong contributions. One such government program is the German Federal Ministry for Education and Research’s (BMBF) BioIndustry 2021, a competition-based initiative that has been supporting industrial biotechnology clusters since 2007. To encourage the advancement of ideas and research results to commercialized, marketable industrial biotechnology products, the BioIndustry 2021 initiative is supporting strategic partnerships between science and industry, to the amount of € 60 million.

To date, five industry clusters with varying focal points have been awarded funding through the program:

- **Biocatalysis 2021**
  - Hamburg, Hamburg
  - € 20 million
  - Focus: sustainable biocatalysis

- **Cluster Industrial Biotechnology 2021 (CLIB2021)**
  - Düsseldorf, North Rhine-Westphalia
  - € 20 million
  - Focus: chemical industry, monomers, fine and specialty chemistry, cosmetics, and detergents.

- **Cluster Biopolymers/Biomaterials**
  - Stuttgart, Baden-Württemberg
  - € 10 million
  - Focus: identification and development of plastics using microbial methods, bioprocess engineering, and biotechnological methods

- **BioM WB Network**
  - Munich, Bavaria
  - € 5 million
  - Focus: industrial processes employing biogenic building blocks, and performance proteins

- **Cluster Integrated Bioindustry (CIB)**
  - Frankfurt, Hesse
  - € 5 million
  - Focus: fine and specialty chemicals

Exemplifying the industry successes stemming from the BioIndustry 2021 competition, five companies (AMSilk in Munich, Autodisplay Biotech in Düsseldorf, Enzymicals in Greifswald, SeSaM-Biotech in Bremen, and Butalco in Hünenberg, Switzerland) have already been established as spin-offs.

To accelerate the move from the laboratory to market (a challenge even for established corporations, but especially difficult for SMEs), a € 50 million Fraunhofer Center for Chemical-Biotechnology Process Center (CBP) is being established at the Leuna chemical site, in Leuna, Germany. The CBP in Leuna is intended to bridge pilot-scale and industrial-scale production: Through access to industrial infrastructure, collaborators from research and industry will be able jointly to develop and scale up processes utilizing renewable resources on an industrial scale. Thus, the CBP represents a platform for advancing industrial biotechnology to a commercial relevance via a direct link to the chemical industry on the one hand, and to the research being conducted at the Fraunhofer-Gesellschaft, on the other.

The CBP will be built by the Fraunhofer-Gesellschaft (share of € 9.6 million of the € 50 million investment) at the Leuna chemical site, in an effort coordinated by the Fraunhofer Institute for Interfacial Engineering and Biotechnology and the Fraunhofer Institute for Chemical Technology, in close cooperation with the owner and operator of the infrastructure facilities, InfraLeuna GmbH. Fraunhofer-
Gesellschaft is the owner and operator of the overall center. With the CBP, Leuna intends to develop into an integrated biotechnological and petrochemical player and to play a key role in the industrial use of renewable raw materials.

The CBP is supported financially by the German Federal Government (€ 20.5 million) as well as the German federal state of Saxony-Anhalt (€ 20.1 million). Groundbreaking for the CBP is planned for later this year, with the completion of the project scheduled for 2012. The first collaborative development projects, with participation of major enterprises, small and medium-sized companies, universities, and non-university research establishments, commenced in 2009. To date, 23 industrial enterprises and 15 universities/research organizations are participating in projects.

REFERENCES
2. Gerecke U and Bengs H. In Going Public (Supplement White Biotechnology 03), 2010, 6-9.
7. Founded in 1949, the Fraunhofer-Gesellschaft carries out applied research that drives economic development and serves the wider benefit of society. At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 59 Fraunhofer Institutes. The majority of the 17 000 staff are qualified scientists and engineers who work with an annual research budget of € 1.6 billion.

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