Fraunhofer IGB

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

Sustainable Technologies for Human Health and the Health of Our Planet

Annual Report 2025/26

#biofabrication #alternativeproteins

We Combine Biology and Engineering

Fraunhofer IGB develops and optimizes processes, technologies, and products for health, nutrition, sustainable chemistry, the environment, and climate protection. Combining expertise in biotechnology, materials science, and process engineering the institute develops solutions for patient-tailored healthcare, a sustainable bioeconomy, and a climate-neutral and resource-efficient circular economy. Customers and partners benefit from research and development services encompassing the entire material value chain, accompanied by a wide range of analysis and testing services. The ability to deliver end-to-end solutions, from laboratory to pilot-scale applications, is one of the institute's unique selling points.

▸ *www.igb.fraunhofer.de/advisory-board*

▸ *www.igb.fraunhofer.de/profile*

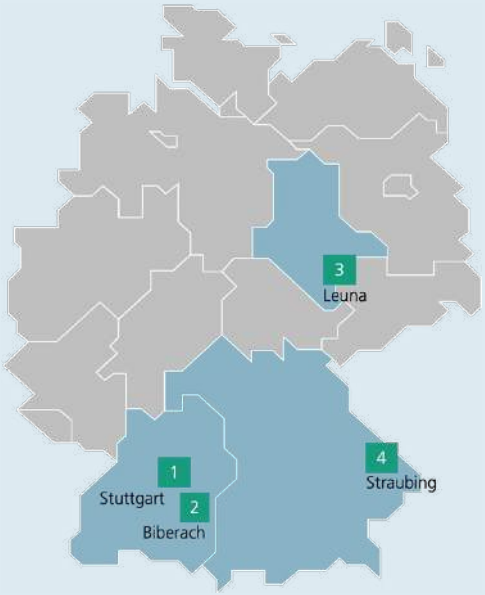
Locations

1. Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Stuttgart

2. Branch office Virus-Based Therapies
Biberach

3. Fraunhofer Center for Chemical-Biotechnological Processes CBP
Leuna branch of the institute

4. Bio-, Electro-, and Chemocatalysis BioCat
Straubing branch of the institute



Transfer for Our Future

Dear Reader,

Our goal and commitment is to conduct cutting-edge research for business partners that benefits us all: humans and animals, our planet's resources, the environment, and the climate. We achieve this by combining biotechnology and process engineering at the interfaces with chemistry and materials science. At the same time, our biotechnological production approach and circular thinking strengthen supply security and economic resilience.

Last year, we were able to recruit Professor Petra Kluger, an experienced and internationally renowned scientist, to expand the institute's management team. New areas of expertise in medical biotechnology and biofabrication ideally complement and deepen the existing competencies at Fraunhofer IGB. In addition, this allows us to tap into additional markets in the fields of health and nutrition, which you can read about in this report. As Professor of Interfacial Process Engineering at the University of Stuttgart, combined with her role as Director of the Institute of Interfacial Process Engineering and Plasma Technology (IGVP), Petra Kluger now once again forms the bridge to basic university research.

We completed our strategy process this past year and reorganized the institute: Our expertise is now bundled into six topic-oriented research divisions, which we introduce to you starting on page 12.

Our annual report has been further digitized, and we present the printed version for the first time as a compact excerpt taking you on a brief journey through the multifaceted research conducted in our six divisions. We invite you to follow the links and QR codes to obtain more detailed information about the scope of our R&D services on our website.

We wish you an inspiring read and interesting insights into our research. Please feel free to get in touch with us – we look forward to working with you!

Prof. Dr. Petra Kluger
Institute Director (executive)

Dr. Markus Wolperdinger
Institute Director (on sabbatical)

Content

From the Institute

Organization chart

The organizational design of Fraunhofer IGB, as defined in the Strategy Process 2025, bundles technological expertise into six topic-oriented research divisions.

Management of the Institute
Prof. Dr. Petra Kluger (Institute Director, executive)
Dr. Markus Wolperdinger (Institute Director, on sabbatical)

Deputy Directors
Prof. Dr. Steffen Rupp, Dr.-Ing. Ursula Schließmann

Head of Administration
Dr. Michael Hofer
Dipl.-Ing. Wolfgang Oesterling (Deputy)

Management of Locations
Leuna – Dr. Holger Wondraczek
Straubing – Dr. Michael Hofer
Biberach – Dr. Ralf Amann

DIVISIONS

Medical Biotechnology
Prof. Dr. Steffen Rupp

Biofabrication and Materials Development
Dr. Achim Weber

Greentech Solutions
Dr.-Ing. Ursula Schließmann

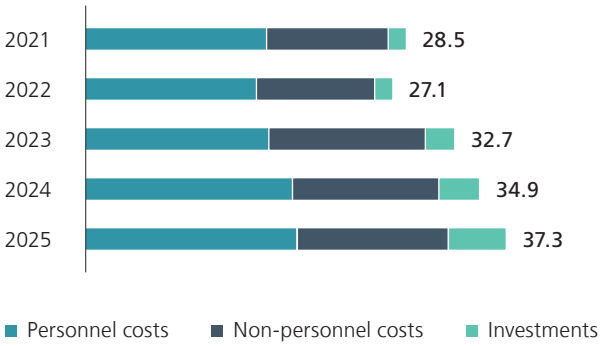
Smart Engineering and Scale-up
Dr.-Ing. Ursula Schließmann

Innovative Synthesis Processes
Dr. Arne Roth

Chemical and Biotechnological Processes
Dr. Christine Rasche

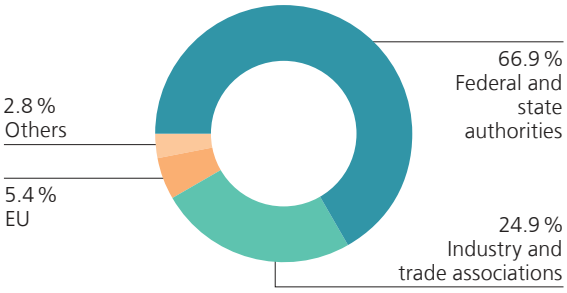
Key Figures

Development of total budget in million euros



The total budget for 2025 amounted to 37.3 million euros, of which 32.4 million euros was allocated to the operational budget (personnel costs: 18.8 million euros; non-personnel costs: 13.6 million euros). A total of 4.9 million euros was spent on investments.

Revenue from contract research 2025



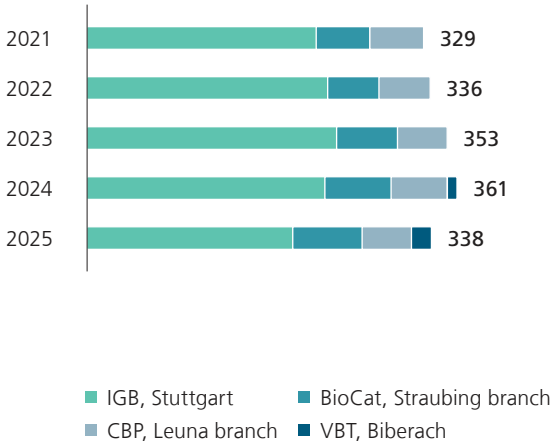
79.4 percent of the operational budget was financed from Fraunhofer IGB's own revenues generated from contract research projects. 24.9 percent of the institute's revenues came directly from industry.

+++ **KEY FIGURES** +++++ 239 projects ++++++++++++ 7 newly granted patents ++++++++++++++++++++++

++++++++++++++++++++++++++++++++++ 51 scientific publications ++++++ 10,212 followers on LinkedIn +++++++

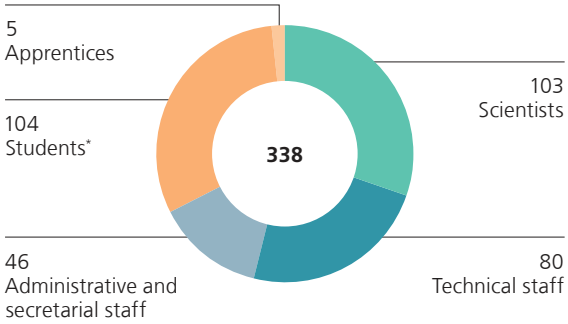
Development of staff members

number at year end



Numbers of staff members

as of December 31, 2025



* Doctoral students; scholarship recipients; students working on their theses / interns; student / research assistants

++++++++++++++++++ ACADEMIC THESES +++ 6 dissertations ++ 28 master theses +++++ 97 teaching activities +++++

++++++++++ 23 press releases and news +++++++ 191 mentions in the press, media, TV, and radio ++++++++++++

++++++++++++++++++ Our publications: *www.igb.fraunhofer.de/publications* +++

Talking With

Institute Director Prof. Dr. Petra Kluger

You joined Fraunhofer IGB as a new director in June 2025. How would you sum up your "early days" at the institute?

The institute is working on the right topics for the future – also with a view to challenges such as the climate crisis. Furthermore, we have a highly motivated team. I believe this provides us with a solid foundation for addressing current economic and political developments.

Fraunhofer IGB is not new territory for you. You were already head of department at the institute before you accepted the position at Reutlingen University in 2017. How has the institute changed since your time there?

I notice changes primarily at the personnel level – there are many new faces at the institute. In addition, we now have the Biberach branch office "Virus-Based Therapies." And the coronavirus pandemic has clearly left its mark on our everyday work.

During your time in Reutlingen, you built up an extensive network. How would you like to expand this in Stuttgart – for example, within the framework of the new biofabrication center – in line with the IGB's objectives?

I see that bioengineering topics have become much more prominent in Stuttgart, both at the Fraunhofer Institute Center and at the university. With our strengths, we at IGB have a good chance of helping to shape the future of the location. Biofabrication, a topic close to my heart, fits in perfectly with this. My goal is to establish a strategic regional research hotspot here, also involving the local economy.

With your appointment as director of both Fraunhofer IGB and IGVP, both institutes are now once again under the same leadership. How do you intend to bring the institutes closer together again?

As a first step, we want to strengthen personal exchanges between the employees of both institutes again. In addition, I am planning joint events such as a colloquium on interfacial process engineering with contributions from both sides. In everyday research, I would like to promote more joint research proposals.

A number of scientists from your team in Reutlingen have followed you to Stuttgart. What special or new skills can the team contribute?

My team from Reutlingen can build on a lot of things here. I was able to lay the groundwork for biofabrication at IGB in the past. We can now build on that and provide new impetus. In addition to their expert knowledge, my team has the important ability to think outside the box. Above all, we are focusing on the food industry, such as the biotechnological production of meat and fish products.

What are your plans for the coming years? Which goals have you set for your institute?

The primary goal is, of course, to position the institute for a sustainable future within the Fraunhofer model. This means taking an even stronger focus on identifying topics that we can exploit from an economic standpoint. We also need solid early-stage research – that driving curiosity to find new topics that are relevant to our customers. To this end, I would also like to contribute more scientifically in the divisions of greentech solutions, chemical and biotechnological processes, innovative synthesis processes, as well as smart engineering and scale-up.

Which new markets would you like to open up for the institute?

I am convinced that we can operate across an even broader range of markets than we do now. In addition to our traditional markets, I see growth potential in the food industry, and the issue of supply security and resilience is also becoming increasingly important. The aim is to strengthen our local and national markets while opening up international markets more effectively.

Short notes

Awards, People, Events 2025

You too can benefit from our innovations!

Here you will find topics and dates for 2026 (German): *www.igb.fraunhofer.de/b2i*

break2innovate: online series successfully launched

Last year, we established our new online series "break2innovate". Once a month – in a focused, concise, and compact format – IGB researchers take just 30 minutes to present how they are solving current challenges for a wide range of industries.

Award-winning publication on glycolipid biosurfactants

A review article on glycolipid biosurfactants published in the Journal of Surfactants and Detergents by researchers around Dr. Susanne Zibek received the American Cleaning Institute's Distinguished Paper Award 2025.

▸ *www.igb.fraunhofer.de/publication-biosurfactants*

This is what the new Fraunhofer IGB building in the port of Straubing-Sand will look like after completion.

Press briefing with local politicians at the port of Straubing-Sand

During a press event on May 23, 2025, Institute Director Dr. Markus Wolperdinger and Site Manager Dr. Michael Hofer met with local politicians in Straubing-Sand. A modern new building is to be constructed on the BioCampus at the port of Straubing from 2026 as an extension for IGB's Straubing branch "Bio-, Chemo- and Electrocatalysis BioCat."

▸ *www.igb.fraunhofer.de/pressegespraech-straubing-sand* (German)

Baden-Württemberg promotes new centers on the Stuttgart campus

Last year, the state of Baden-Württemberg approved three new S-TEC centers in which Fraunhofer IGB is also involved: the S-TEC Zentrum für Industrialisiertes Bauen und Sanieren ZIBS (S-TEC Center for Industrialized Construction and Renovation), the S-TEC Center for Bio-Intelligent Value Creation ZBW – The Biointelligence Engine, and the S-TEC Transfermotor: Innovation für KMU in Baden-Württemberg (Innovation for SMEs in Baden-Württemberg). The institute supports companies with quick checks on the feasibility of new ideas in the respective subject areas and implements these in a prototypical application as part of exploring projects. In addition, the "Stuttgart Climate Tech Hub (S-CTH)" is being established at the Fraunhofer Institute Center in Stuttgart to create an open research and transfer platform where companies can test and demonstrate climate-friendly technologies with pilot plants under real-world conditions.

▸ *www.igb.fraunhofer.de/en/s-tec*

Petra Kluger takes over as chair of the German Society for Biomaterials

IGB Institute Director Professor Petra Kluger was elected as the new chair at last year's congress of the German Society for Biomaterials (DGBM) from October 8 to 11, 2025, in Dresden.

- *www.igb.fraunhofer.de/dgbm-vorsitz* (German)

EARTO Innovation Award for NGS-based pathogen diagnostics

On October 14, 2025, in Brussels, the European Association of Research and Technology (EARTO) presented Dr. Kai Sohn, head of the In-Vitro Diagnostics research group, with the Innovation Award in the "Impact Delivered" category for developing a method for the rapid and precise identification of sepsis pathogens. The corresponding diagnostic kit has already been approved for the indication of sepsis and is marketed by Noscendo GmbH, a spin-off from Fraunhofer IGB, as an IVD-certified product for routine care (see also p. 12).

- *www.igb.fraunhofer.de/en/earto-innovation-award*

Three million euros for biofabrication center

In November 2025, Fraunhofer IGB received a grant from the state of Baden-Württemberg to establish a center for biofabrication in Stuttgart. Funded by the EU, the federal government, and the state, the center will research and optimize manufacturing processes for biological tissues and products and translate them into scalable, marketable solutions for customers in a pilot plant.

- *www.igb.fraunhofer.de/bescheid-biofabrikationszentrum* (German)

Seminar "Virus-based therapies – from engineering to process development"

In May 2025, we launched the new seminar series at our Biberach branch with the aim of connecting stakeholders in the field of virus-based therapies. Once a month, researchers present their findings on the development and production of virotherapeutics and shed light on issues of specificity, efficacy, and safety. The event takes place in a hybrid format and participation is free of charge.

The seminar series will continue in 2026. We look forward to seeing you there!

- *www.igb.fraunhofer.de/vbt-seminar-2026*

Ceremony for the EARTO Innovation Award 2025 in Brussels: Fraunhofer IGB award winner Dr. Kai Sohn (left) with Michiel Scheffer, President of the Board of the European Innovation Council.

Presentation of the symbolic funding check for the biofabrication center

Fraunhofer IGB mourns the loss of Christian Oehr

It is with great sadness that we bid farewell to Professor Christian Oehr, who passed away suddenly and unexpectedly on June 29, 2025. Christian Oehr played a decisive role in shaping the fortunes of our institute for more than three decades.

- *www.igb.fraunhofer.de/nachruf-oehr* (German)

Medical Biotechnology

Contact

Prof. Dr. Steffen Rupp
Phone +49 711 970-4045
steffen.rupp@
igb.fraunhofer.de

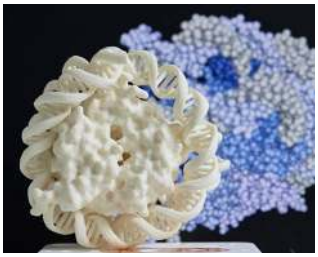
We develop technologies for **preventive and precision medicine** in close cooperation with clinics and industry. Our focus is on virus-based therapeutics and diagnostics.

In the field of **In-vitro Diagnostics**, we are working on new liquid biopsy methods for indications with high medical need, such as early cancer detection, with a focus on prevention and precision. Our expertise covers the entire chain from sample collection to medical reporting. Core technologies include sample preparation, next-generation sequencing (NGS), and bioinformatic analysis using machine learning and artificial intelligence. This enables us to identify characteristic biomarker patterns that, for example, enable improved early detection of tumors or rapid identification of microbial pathogens in sepsis and complex infectious diseases.

In the field of **Virus-Based Technologies and Therapies**, we focus on the development of process technologies (CMC – chemistry, manufacturing, and controls) for the efficient production of therapeutic viruses (oncolytic viruses, vaccine vectors). These are based on three pillars: cellular production technologies (upstream), purification processes for active viruses (downstream) and their formulations, and analytical methods for qualifying virus products. This includes the integration of omics technologies for precision process development. Our approach enables us to form a competence hub for CMC screening of virus-based technologies – neutral, manufacturer-independent, industry-oriented, and scientifically sound. For all relevant CMC modules, we develop a clear assessment of GMP compatibility, scale-up capability, delivery reliability, and cost structure.

Latest research news

Award-winning NGS-based pathogen diagnostics

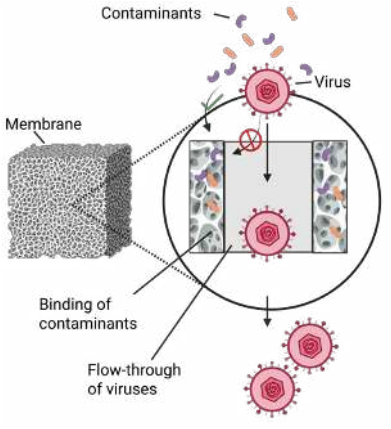


Using their method, the researchers can detect fragments of DNA in the blood.

A method developed at Fraunhofer IGB enables bacterial, viral, fungal, or parasitic pathogens in sepsis patients to be identified much faster than before and with the highest precision. The approach is based on high-throughput sequencing of cell-free DNA circulating in the blood. Clinical studies conducted under the direction of Essen University Hospital confirm that the NGS method has excellent performance characteristics: Compared to blood culture, NGS diagnostics led to a positive diagnosis four times more often at the onset of sepsis and ten times more often three days after the onset of sepsis. For this development, Dr. Kai Sohn, head of the In-Vitro Diagnostics research group, received the EARTO Innovation Award in the "Impact Delivered" category in Brussels on October 14, 2025 (see p. 11).

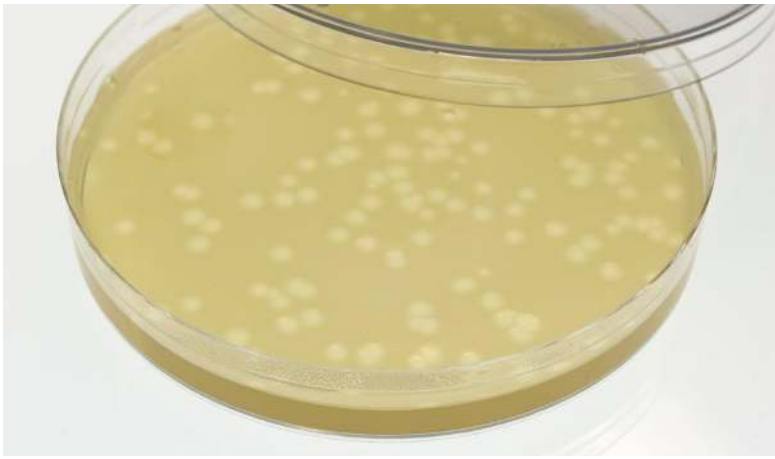
▸ *www.igb.fraunhofer.de/sepsis-diagnostics*

Membranes for gentle purification of therapeutic viruses



Viral therapeutics are promising new medicinal products; however, biopharmaceutical production faces challenges due to a lack of suitable purification methods. In an interdisciplinary in-house collaboration, Fraunhofer IGB is developing an innovative membrane-based chromatography approach for separating viruses and contaminants since 2025. Porous membrane adsorbers are being developed for this purpose to bind the contaminants (instead of the viruses). Designed for single-use applications, IncuMem membranes not only protect the virus products, but also enable high flow rates and economical use in biopharmaceutical production.

▸ *www.igb.fraunhofer.de/en/incumem*



Plant-based production of endolysins as antibiotic substitutes

A research consortium consisting of the Fraunhofer Institutes IGB and IME together with the Max Planck Institute of Molecular Plant Physiology successfully secured internal funding last year through the Fraunhofer-Max Planck Cooperation Program. The idea: to produce endolysins, enzymes formed by phages to lyse their host bacteria, in plants. For this purpose, the team aims to establish an integrated pipeline in the ambitious ELYDIA project, ranging from AI-supported identification of host-specific endolysins and rational protein engineering to plant-based production and preclinical testing.

▸ *www.igb.fraunhofer.de/en/elydia*

Virus-based technologies and therapies under new leadership

At the turn of the year, Professor Susanne Bailer, head of the "Virus-based Technologies" research group at Fraunhofer IGB, retired. With the establishment of a patented virus technology platform based on reprogrammed herpes viruses, she succeeded in establishing a new field of Fraunhofer-wide health research. Since October 2023, she has also headed the "Virus-based Therapies" branch in Biberach, funded by the state of Baden-Württemberg, to develop new technologies for the production and testing of viral therapeutics.

The institute was able to recruit Dr. Ralf Amann as her successor. Amann is an immunologist specialized in viral vector platforms, vaccines, and translational research. His career took him from the Friedrich Loeffler Institute to the University of Tübingen and to the University Hospital of Tübingen, where he worked on innovative vaccine and vector approaches in immunology and tumor immunology. The goal of his work at Fraunhofer IGB is to integrate virus engineering, process development, and optimization in order to accelerate the implementation of virus-based therapeutics in real-world applications.

▸ *www.igb.fraunhofer.de/en/ralf-amann*

Biofabrication and Materials Development

Contact

Dr. Achim Weber
Phone +49 711 970-4022
achim.weber@
igb.fraunhofer.de

Biofabrication is an interdisciplinary field of research that combines biotechnology with engineering and materials science. Accordingly, this area brings together expertise in the fields of biofabrication, cell and tissue technologies, and functional surfaces and materials. To translate these developments into practice, a biofabrication center is being established at Fraunhofer IGB and IGVP at the University of Stuttgart.

The new field of **Biofabrication** deals with process development and optimization for the production of tissue models and functional tissue substitutes, for example through bioprinting, co-culture models, defined and sustainable media, and bio-based carrier materials and bio-inks. The development of printable bioink formulations based on natural and bio-based polymer materials for 2D and 3D printing has already been incorporated into the Functional Surfaces and Materials research area.

In the field of **Cell and Tissue Technologies**, the institute provides 2D and 3D tissue models of varying complexity, as well as organoids and spheroids as in-vitro test systems for the safety assessment of pharmaceutical and cosmetic active ingredients and chemicals. The aim is to replace animal testing. A patented reporter skin model is already undergoing validation for OECD guidelines.

The **Functional Surfaces and Materials** research area develops coatings with a wide range of functions – e.g., hydrophilic, hydrophobic, scratch-resistant, antimicrobial, or with defined functional groups – for a variety of industries. The customized modification of implants enables personalized solutions for medical technology.

Latest research news

New field of research: biofabrication

Following the appointment of Professor Petra Kluger as Institute Director, Biofabrication was established as a field of research at Fraunhofer IGB in 2025. The new group is developing innovative processes for the production of bioartificial functional tissues – for example, as in-vitro test systems (e.g., adipose tissue models), for biomedical applications (tissue replacement), or for cell-based foods (cultured meat). In addition, we present current developments in the field of engineered living materials, including fungus mycelium-based materials for lightweight construction or as bioactive filter systems.

▸ *www.igb.fraunhofer.de/biofabrication*

Successful completion of the EU project TriAnkle

Over a period of five years, nine European partners conducted research into developing 3D-printed biomaterials for the personalized regeneration of ankle injuries. Their efforts were successful: carrier systems made from 3D-printed collagen and gelatin biomaterials were functionalized with cells or growth factors, and the implants were precisely adapted to the respective defect. Preclinical studies in animal models show significantly improved regeneration of tendon and cartilage tissue, reduced inflammatory reactions, and accelerated functional healing.

▸ *www.igb.fraunhofer.de/en/triankle*

Validation of reporter skin for the assessment of skin sensitization by lipophilic compounds

There is currently a lack of reliable animal-free methods (new approach methodologies, NAMs) for the risk assessment of lipophilic active ingredients and substance mixtures in cosmetics and pharmaceuticals. A promising new test system is the Nrf2 reporter epidermis model, which was established and patented at Fraunhofer IGB, further developed in collaboration with Beiersdorf AG, and awarded the 2024 4th Research Prize for Alternatives to Animal Testing by the City of Hamburg. On behalf of the International Collaboration on Cosmetics Safety (ICCS), Fraunhofer IGB is currently investigating the use of this epidermis model to evaluate lipophilic substances for their skin sensitizing effects.

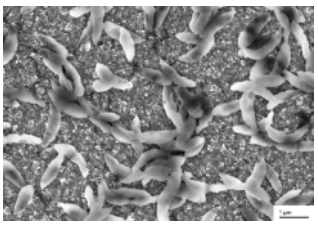
▸ *www.igb.fraunhofer.de/reporter-skin-validation*

3D intestinal organoids for the development of new active ingredients and prebiotics / probiotics

Inflammatory diseases of the intestine have increased in many countries; at the same time, consumers are paying more attention to supporting the gut microbiome and thus their intestinal health. To test the effects of new prebiotic or probiotic substances and screen for new active ingredients to treat intestinal diseases, Fraunhofer IGB has developed three-dimensional multicellular intestinal organoids. Due to their tissue- and organ-like properties, these self-organized 3D microtissues realistically replicate the in-vivo situation. They are suitable for investigating the properties of substances that are toxic to the intestine, as well as the immune response and host-microbiota interactions. Special inside-out models, in which the intestinal epithelium faces outward, facilitate testing.

▸ *www.igb.fraunhofer.de/intestinal-organoids*

Surface-modified biosensor for rapid detection of antibiotic resistance



The rapid increase in antibiotic resistance has become an acute problem for global health. Fraunhofer IGB is a partner in a Fraunhofer research project launched in 2025 that is addressing this threat with an innovative diagnostic approach: A microfluidic rapid test system based on single-walled carbon nanotubes (SWCNT) uses special surface modifications to ensure that bacteria adhere to the measuring cell, making cellular metabolic reactions to antibiotics and thus bacterial resistance visible within just a few minutes – significantly faster than conventional methods.

▸ *www.igb.fraunhofer.de/cnt-biosensors*

AI-supported material analysis for high-performance PFAS adsorber

Since 2025, the company instrAction and Fraunhofer IGB have been developing a combustible absorber with high loading capacity for long- and short-chain per- and polyfluoroalkyl substances (PFAS). The increased loading capacity is to be achieved by modifying the polymer coating of the adsorbent material, enabling effective and low-emission combustion of the pollutants. To achieve this, Fraunhofer IGB analyzes the decomposition and combustion processes using chemical methods and evaluates the measurement data with new AI approaches.

▸ *www.igb.fraunhofer.de/en/pfas-adsorber*

Greentech Solutions

Contact

Dr.-Ing. Ursula Schließmann
Phone +49 711 970-4222
ursula.schliessmann@
igb.fraunhofer.de

The Greentech Solutions division focuses on process engineering developments in the areas of energy and resource efficiency, water, and the environment. We develop environmentally friendly production methods and optimize processes, integrate renewable energies, and improve water quality and environmental compatibility. Our R&D services are aimed at companies that want to work with us to develop, test, and implement sustainable technologies in a practical and cost-effective manner. We support you from feasibility studies and pilot plants to the implementation of processes on a technical scale – always with a focus on the environment, cost-effectiveness, and regulation.

Energy efficiency and bioenergy: We develop and optimize energy-efficient processes and utilize and integrate bioenergy. Energy balances and efficiency measures enable us to reduce costs and emissions. The goal is to achieve robust, maximum process stability.

Circular economy and resource efficiency: We develop solutions for waste and wastewater treatment as well as the recovery of nutrients, water, and materials. By transforming waste into valuable materials, we optimize resource flows and make disposal routes obsolete.

Water management and process hygiene: We improve water quality, reduce environmental impact, and promote water reuse. Microbiological process hygiene measures contribute to process stability. Monitoring and control concepts ensure robust operation and transparency.

Membrane technology: We develop, characterize, and integrate membrane-based separation processes. This includes material development, module and system technology, and surface modifications. We test and evaluate membranes in laboratory and pilot plants and support scale-up to industrial application. Another focus is on integration into complete process chains – an integral part of all other topics.

Testing of various microorganisms for the mobilization of metals in a shaking flask

Analytics: We offer an expanded range of analyses by developing analytical methods – from sampling and sample pretreatment to quantitative analysis. One focus is on non-target analytics. Thanks to our accreditation according to DIN EN ISO 17025, our methods meet the highest standards.

Digital twins, sensor technology, and AI analytics support developments and enable real-time monitoring, forecasting, and data-driven optimization. Demonstrators and pilot plants accompany the market launch, and LCA, TEA, and scenario analyses provide reliable environmental and economic indicators so that informed investment and transformation decisions can be made (see p. 18).

Latest research news

HypoWave+ – implementation of a hydroponic system for agricultural water reuse

Regional competition for water resources is no longer a rarity, and new concepts and processes for water reuse are in demand. Following the piloting of hydroponic plant production using water reuse in the HypoWave project, the research consortium accompanied the large-scale implementation in the Gifhorn region in the follow-up project HypoWave+ from 2021 to 2025. Fraunhofer IGB implemented the digital networking of water management and crop production system elements, developed a detection method for viruses, and, as part of an integrated quality management system, was responsible for drawing up a risk management plan (RMP) for the responsible water authority, which made implementation possible in the first place.

▸ *www.igb.fraunhofer.de/en/hypowave-plus*

Study on securing irrigation on the island of Reichenau

The water supply on the island of Reichenau, known for its vegetable cultivation, faces challenges: The distribution network is complex and partly outdated; extreme weather events such as low water levels affect access to water, and invasive mussel species have also settled as a result of climate change. In a recent study, Fraunhofer IGB investigated technical, climatic, and biological factors influencing the water supply and presented concrete recommendations for action to ensure a reliable, efficient, and sustainable irrigation infrastructure.

▸ *www.igb.fraunhofer.de/reichenau-irrigation*

Feasibility study on the economic recovery of nutrients from fermentation residues

The production of biogas from agricultural raw materials and farm fertilizers produces a digestate with a very high water content. If it is directly applied on the field overfertilization can easily occur. This may lead to nitrate pollution of groundwater and surface water. A valuable and resource-saving solution would be to recover the nutrients from the digestate. The approach already developed with European partners in the BioEcoSIM project for utilizing liquid manure has now been further developed with the company PreZero in the PIGM feasibility study: Based on laboratory tests, simulations using a mathematical model showed under which conditions the recovery of nutrients from the digestate is economically and ecologically sensible.

▸ *www.igb.fraunhofer.de/en/pigm*

Potential of metal recovery through biomining

Electronic waste contains valuable metals, including rare earths such as neodymium and palladium, which are indispensable for the manufacture of electronics, electric motors, and wind turbines. However, only a fraction of these metals are currently recycled, while demand continues to rise and supply is becoming more uncertain in the current geopolitical situation. In a feasibility study, Fraunhofer IGB investigated the potential of biological biomining processes for recycling rare earth metals from electronic waste. The focus was on the biotechnological release of metals by bacteria and fungi and the adsorption and desorption of the dissolved metals using microalgae.

▸ *www.igb.fraunhofer.de/en/ruebiom*

Strategies and material flow analyses for a circular economy of biogenic residues in urban regions

To achieve a sustainable and resource-efficient economy, residual and waste materials are recycled and fossil raw materials are replaced by renewable and secondary resources – this lies at the heart of the circular bioeconomy. Waste, wastewater, and emissions are mainly generated in urban environments, with responsibility at the municipal or regional level. Fraunhofer IGB supports cities and regions in this transformation: Using the "urban BioEconomyLab" methodology, the institute analyzes the potential for creating value from previously unused residues, closing material cycles, and designing regional and resilient supply chains. The goal is to achieve a resource-efficient and sustainable economy based on biomass and the circular economy.

▸ *www.igb.fraunhofer.de/urban-bioeconomy*

Smart Engineering and Scale-up

Contact

Dr.-Ing. Ursula Schließmann
Phone +49 711 970-4222
ursula.schliessmann@
igb.fraunhofer.de

In the area of "Smart Engineering and Scale-up", we combine our expertise in the use of digital technologies and process engineering to support companies in the chemical and process industries from the initial idea to market readiness and beyond. Our approach combines intelligent engineering, prototype construction, automation, and customized scaling concepts with the aim of reducing costs and minimizing technological risks through holistic planning and validation. This makes it easier to justify investments and make operations more resource-efficient. As a result, operations become more economical while consuming fewer resources.

Modeling and simulation: We create digital models and digital twins of your processes and plants (including CAD) to understand and control behavior and performance as well as planning, operation, and optimization in a comprehensible manner. Through parameter studies, optimization, and robustness analyses, we identify the best operating ranges and design options so that design reliability, efficiency, and scalability can be reliably planned before construction. Variants can be tested virtually and risks and costs can be better controlled, which increases planning reliability and speeds up decisions. We enable the connection of digital twins with process control for real-time operational optimization of your plants.

Digitalization and automation: We integrate digital infrastructure, sensor technology, and automation solutions (MES/SCADA, IoT, data analysis) for real-time monitoring and control. Through automated workflows, control strategies, and predictive maintenance, we reduce manual intervention and downtime. This results in stable, transparent processes with better reproducibility.

Design and prototyping: We support you in CAD/CAE design, prototype manufacturing, and the integration of hardware, sensor technology, and controllers. Through iterative testing, functional testing, and rapid completion, we validate concepts in a practical manner.

Scaling and piloting: We accompany the transition from the laboratory to the pilot or demonstration plant and provide support in terms of technical and economic feasibility. With scalable process concepts, techno-economic analyses, and risk minimization, we pave the way to production. Practical field tests and validation ensure transferability in industry.

Systemic evaluation: We carry out holistic evaluations, e.g., life cycle and techno-eco analyses, to bundle environmental, cost, and performance indicators. This reveals impacts along the value chain, including supply chains, resource and energy mobilization. The results support your decision-making processes with reliable sustainability and economic data.

Latest research news

Cométha: pilot plant for the treatment of organic waste and sewage sludge in the greater Paris area successfully completed

In the greater Paris area, several million people generate enormous amounts of waste and wastewater. In order to recycle this waste in the best possible way, the Cométha research partnership was established, a German-French consortium that set itself the goal of piloting a new process for treating waste materials.

The Cométha pilot plant at Triel-sur-Seine near Paris

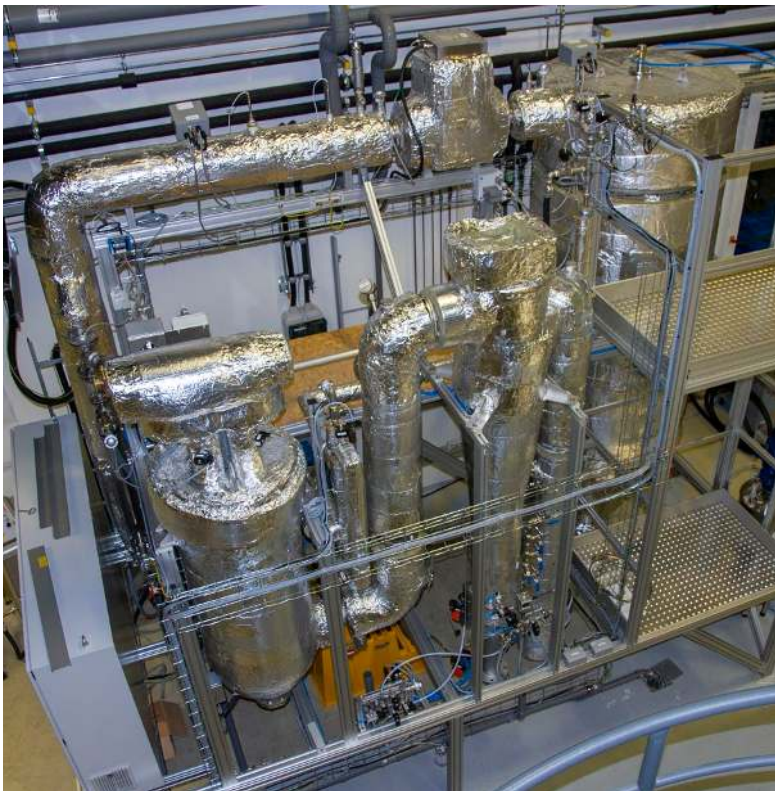
Fraunhofer IGB was involved as a partner from the very beginning: After initial investigations on a laboratory scale, the process was piloted on site and the pilot plant was operated in Paris from December 2024 to December 2025. It uses an innovative combination of processes which, compared to conventional methods, achieves a significantly higher biomethane yield in particular. In addition to biomethane production, the plant contributes to the recovery of important nutrients such as nitrogen and phosphorus. Fraunhofer IGB played a key role in the implementation and operation of the plant. This enabled various IGB technologies (AmmoRe, ePhos, SHS drying) to be tested and validated on a pilot scale under real conditions and for mixed substrates (sludge, biowaste, manure).

▸ *www.igb.fraunhofer.de/en/cometha*

Industrial drying: electricity-based, energy-efficient, intelligent

Nearly a quarter of industrial energy consumption in Germany is attributed to drying processes, which are largely carried out using fossil fuel-fired convective exhaust air dryers. Fraunhofer IGB is therefore further developing its energy-efficient superheated steam (SHS) drying process so that it can be combined with a heat pump and powered by electricity. Model predictive control enables the integration of real-time electricity forecasts so that operation takes place when low-cost renewable electricity is available. A pilot plant for spray drying silica is being built for demonstration purposes.

▸ *www.igb.fraunhofer.de/en/lowcarbdry*



Spray drying prototype for demonstrating electricity-based drying with superheated steam

Innovative Synthesis Processes

Contact

Dr. Arne Roth
Phone +49 9421 9380-1030
arne.roth@igb.fraunhofer.de

Using bioinspired and sustainable catalytic approaches, the division "Innovative Synthesis Processes" opens up new reaction and product spaces for the resource-efficient synthesis of chemical substances, synthetic fuels, bio-based polymers, and functional materials.

One focus is the development of catalytic power-to-X-to-Y process cascades. These technologies can be used to sustainably synthesize industrially important platform chemicals, fuels, and higher-value products from simple and almost unlimited resources – renewable energy, CO_2, and water. To this end, we conduct research on thermo-, electro-, and biocatalytic processes and combine them in such a way that novel process routes for the drop-in synthesis of "green" chemical products are created.

Another approach is the use of structural and functional motifs of biogenic raw materials, which we use to produce new, functionally optimized materials. In this context, we develop solutions along the entire value chain of sustainable materials and substances – from the systematic consideration of the renewable raw material base, through conversion and optimization of product properties, to end-of-life options.

Against this backdrop, we are working on various specific research areas:

Power-to-X and "green" platform chemicals: We produce CO_2-neutral platform chemicals as drop-in products using fully renewable raw materials and process routes. Central elements are power-to-X-to-Y process cascades to generate energy-rich products such as methanol and ammonia from regeneratively produced hydrogen and CO_2 or nitrogen.

Synthetic fuels from CO_2: Our spectrum ranges from the development of individual process steps to their integration into an industrially applicable process. We chemically convert alcohols (such as methanol or ethanol from CO_2 or other raw materials) via light olefins (alkenes) as intermediate products into middle distillate fuels such as kerosene and diesel.

Electrochemical processes: We use renewable electrical energy as the driving force for chemical reactions and store it in the form of chemical bonds. From renewable raw materials such as carbon dioxide, water, and biomass, we synthesize hydrogen peroxide, formic acid, ethylene, and organic diols – as a pillar of a sustainable circular economy.

Biotechnology: We integrate biotechnology and power-to-X by using CO_2-based compounds such as alcohols and formic acid instead of sugars as substrates for the microbial synthesis of sustainable chemicals. Metabolic engineering is used to modify yeasts and bacteria so that they efficiently convert CO_2-based substrates. We also develop chemo-enzymatic syntheses and specifically improve enzymes for new applications to replace conventional processes with sustainable ones.

Bio-based polymers and additives: We identify suitable biogenic raw materials and modify them into monomers, additives, and polymers. By integrating biogenic molecular structures and understanding structure-activity relationships, we create new properties and open up new areas of application. In this way, we support the transformation of the chemical and plastics industries.

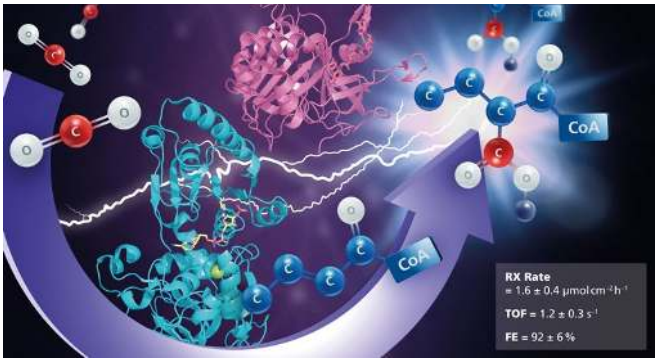
Materials of the future: We develop next-generation bio-based materials, for example by using technical proteins (protein-to-X) or bio-based thermoplastics such as polyethylene furanoate (PEF) – for biodegradable single-use packaging as well as for special applications. Our exclusive laboratory for technical biopolymers enables the development and testing of new materials on a kilogram scale.

Latest research news

ZENK platform: research infrastructure for synthetic fuels

In the ZENK (Bavarian Center for Sustainable Fuels) project, the Fraunhofer institutes IGB and UMSICHT in Straubing and Sulzbach-Rosenberg are working on new production routes for synthetic fuels based on renewable raw materials and energy. The IGB's focus is on establishing a research infrastructure for the production of synthetic fuels specifically made from CO_2 and renewable H_2. Following initial investigations and scaling of the successive heterogeneously catalyzed process steps in the laboratory, these are to be transferred to a pilot plant at the new BioCat site in Straubing-Sand. Last year, a large part of the laboratory infrastructure for the ZENK platform was procured and the basic engineering of the free-standing pilot plant, including a HAZOP study, was successfully completed. From 2027 on, we can conduct the entire process development at our site, from small-scale lab testing to demonstration at pilot-scale and under industrially relevant operational conditions.

▸ *www.igb.fraunhofer.de/en/zenk*



Decarbonization of biocatalysis through the use of hydrogen as an electron donor

In biocatalytic processes, carbon-rich compounds typically serve as electron donors. The SynHydro³ project has now succeeded in making special hydrogenases usable for syntheses in which technical hydrogen acts as an electron donor. The trick: The hydrogenases are embedded in a redox-active hydrogel that protects against oxidative damage and preserves the functionality of the enzymes – together with all other enzymes required for the cofactor regeneration of oxygen-dependent enzyme cascades. This is the first time that the idea of hydrogen-driven biocatalysis has become a reality in the form of a modular and scalable platform technology.

▸ *www.igb.fraunhofer.de/en/synhydro*

Project Manager Vanessa Wegat sampling the fermenter

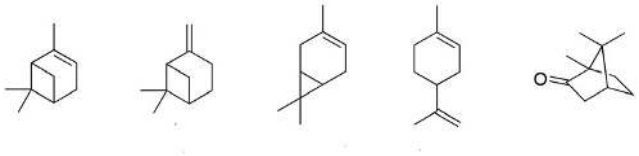
Oil yeasts as producers of tailor-made lipids from CO_2-based substrates

Fats and oils are needed in cosmetics, cleaning agents, and the food industry. Lipids produced using biotechnology are a sustainable alternative to plant-based lipids such as palm oil. Fraunhofer IGB in Straubing develops various oil yeasts as a flexible platform for the production of customized lipids. Fermentation can be scaled up using both CO_2-based substrates, such as methanol or ethanol, and waste streams. Last year, the scale-up of a fermentation process developed in Straubing for the Mibelle Group was launched in order to produce a palm oil-like fat mixture on a kilogram scale in the pilot plants at Fraunhofer CBP.

▸ *www.igb.fraunhofer.de/oil-yeast-platform*

Monoterpenes: a versatile class of substances from nature's chemical building blocks

One highlight at last year's K trade fair was caramides, bio-based polyamides made from terpene-containing waste streams. In the Fraunhofer SUBI²MA flagship project, monoterpene-based lactam monomers (caranlactam) were produced for the first time in a safe and scalable process on a kilogram scale, polymerized to caramide, and then further processed into filaments, foams, or sheets. Lactams are just one of many possible applications for natural terpenes. The BioCat branch of the institute converts monoterpenes into fine and bulk chemicals for a wide range of applications in the chemical industry – whether as fragrances or flavorings, plasticizers, or (meth)acrylates.



▸ *www.igb.fraunhofer.de/monoterpenes*

Bioplastisols as a substitute for PVC

Artificial fishing baits made of PVC plastisols (soft PVC) are popular with anglers. However, many do not end up in the mouths of predatory fish, but are lost in the water and cannot be biodegraded there. The aim of a project that has been running since the end of 2025 is to develop fishing baits made from biodegradable plastisols based on bio-based polymers, plasticizers, and additives. The matrix approach pursued in the development allows the material to be adapted for other fields of application, such as coatings in the automotive and textile industries, resulting in considerable market potential.

▸ *www.igb.fraunhofer.de/bioplastisols*

Chemical and Biotechnological Processes

This division addresses issues relating to the development of chemical and biotechnological processes and their combination to create fully scalable procedures. The division primarily uses biomass and CO_2 as raw materials to enable the transformation to sustainable and resilient value chains for producing chemicals and materials. Examples of such process developments range from the fermentative production of biosurfactants and the chemical modification of fat residues for the production of sustainable solvents to the CO_2-based synthesis of fuels and basic chemicals.

A particular focus is always placed on the fundamental scalability of the processes, which can be offered consistently on a laboratory, benchtop, and pilot scale thanks to the collaboration between the Stuttgart and Leuna sites. In addition, there is expertise in the construction, integration, and research operation of customer-owned plants. This concept is particularly attractive for demonstration projects, e.g., by start-ups, to reduce investment costs and ramp-up risk.

Thanks to the division's special research and technology infrastructure, with fermentation capacities of up to 10 m^3, integrated biorefineries for processing lignocellulose, oilseeds, and insects, and a range of different chemical reactors and processing technology in an industry-oriented environment, the division is particularly active in **research into faster and lower-risk scalability of chemical and biotechnological processes**. This includes, in particular, the continuous alignment of relevant infrastructures with industrial needs and political framework conditions (e.g., Germany's High-Tech Agenda). One such instrument, which is being promoted with significant involvement from the division, is IBISBA. This is a pan-European initiative for the strategic networking of research infrastructures in the field of industrial biotechnology, which aims to take the form of a European Research Infrastructure Consortium (ERIC). Issues such as interoperability and improved access to pilot plants are to be addressed more intensively by the division within this framework.

In addition to scaling external processes, the division is also developing its own processes in strategic areas. These include, for example

- **Bioprocess development** for the fermentative production of biosurfactants and biopolymers
- **Biorefinery concepts** for the full utilization of all material flows from (reclaimed) wood, rapeseed, and also insects
- **Sustainable chemical processes** to support the transformation of the chemical industry's raw material base toward sustainable alternatives such as biomass (especially lignin and hemicellulose) and CO_2. The integration of processing technologies through to the final product plays a particularly important role here.

To pursue the activities described, the division cooperates closely with the Innovative Synthesis Processes and Smart Engineering and Scale-up divisions.

Contact

Dr. Christine Rasche
Phone +49 152 06384199
christine.rasche@
igb.fraunhofer.de

Bioreactor cascade for scaling fermentation processes at Fraunhofer CBP

Latest research news

Biosurfactants from renewable raw materials

Microbial biosurfactants are an alternative to chemically synthesized surfactants in detergents, household cleaners, and cosmetics. After many years of intensive research and development, Fraunhofer IGB has developed and optimized fermentation and downstream processes to provide high-purity glycolipid biosurfactants – produced from local renewable raw and residual materials. The optimization of biosurfactants was also investigated as part of the "Alliance Biosurfactants" project. The alliance partners presented the fruits of their labor at a final conference at Fraunhofer IGB in February 2026.

▸ *www.igb.fraunhofer.de/biosurfactants*

BioTraIn4Eco – expansion of the biotechnological transfer infrastructure in Saxony-Anhalt

Fraunhofer CBP currently has biotechnological facilities on a medium to large pilot scale. An expansion of capacity on a smaller scale is intended to improve the scalability of new processes and make Fraunhofer CBP the central location for biotechnological innovations in the state of Saxony-Anhalt. The Leuna Chemical Park offers ideal conditions for this, but there is still a need to expand the range of services on offer in order to promote the establishment of a sustainable biotechnological economy.

▸ *www.cbp.fraunhofer.de/en/biotrain4eco*

300-liter bioreactor at Fraunhofer IGB

CIRCULAR-C – novel bio-based compounds for circular building materials

The EU project CIRCULAR-C aims to develop innovative bio-based adhesives, coatings, and functionalized fibers for circular building materials. The use of sustainable raw materials and the integration of digital product passports are intended to make wood-based materials more recyclable and environmentally friendly. In addition, new recycling opportunities and secondary market applications are being created to promote circularity and sustainability in the building materials industry.

▸ *www.cbp.fraunhofer.de/en/circular-c*

RESycling – reduced emissions in the steel and cement industries through the use of pig iron desulfurization slag

The RESycling project processes previously unused pig iron desulfurization slag from steel production so that it can replace primary raw materials in the steel, cement, and fertilizer industries. Jaw crushers, magnetic separators, and wet-chemical methods are used to recover valuable materials, reducing emissions and resource consumption. An assessment ensures ecological and economic sustainability; Fraunhofer CBP is scaling up the process and further developing the pilot plant.

▸ *www.cbp.fraunhofer.de/en/resycling*

DiPisum – digitalization-driven development of Saxony-Anhalt into an innovation center for pea breeding, cultivation, and utilization

The DiP project DiPisum aims to make Saxony-Anhalt an innovation center for pea breeding and utilization. The goal is a digitally networked value chain – from variety evaluation to industrial processing. The project relies on digital methods to improve the quality and scalability of pea proteins for a wide range of food applications. This will strengthen regional value creation, agricultural innovation, and independence from imports.

- *www.cbp.fraunhofer.de/en/dipisum*

Pea flour made from peas

NA-WIR – new medicinal plants and active ingredients from Saxony-Anhalt

The NA-WIR project of the DiP alliance promotes the establishment of climate-resilient medicinal plants such as rosemary, sage, and Chinese bush nettle in Saxony-Anhalt in order to tap into their economic potential for cosmetics and medicine. The aim is to develop innovative, digitally supported value chains from cultivation to the isolation of bioactive substances such as carnosic acid and oridonin. The active ingredients are obtained using supercritical carbon dioxide extraction at Fraunhofer CBP.

- *www.cbp.fraunhofer.de/en/na-wir*

AlkaEx – technical and legal feasibility study for the safe extraction of alkaloids from ergot

The AlkaEx project is investigating the feasibility of safely extracting alkaloids from ergot. The goal is to establish new value chains between the food and pharmaceutical industries in central Germany through innovative, sustainable, and scalable extraction processes. The study analyzes safety and regulatory aspects as well as market potential, thus providing a basis for decision-making for further projects and the sustainable use of previously untapped raw material flows.

- *www.cbp.fraunhofer.de/en/alkaex*

NachDruck – sustainable and regional solvents for web offset printing inks

The BioZ project NachDruck is developing a sustainable and regional printing ink system for web offset printing by replacing mineral oil-based components with bio-based solvents from residues from the food industry and biodiesel production. The aim is to create a stable, regional value chain that offers ecological and economic advantages. The innovative use of waste fats and oils creates a resource-saving alternative to conventional vegetable oils.

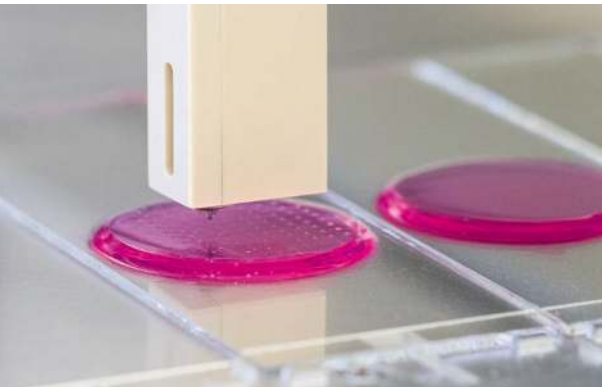
- *www.cbp.fraunhofer.de/en/nachdruck*

SysWeB – systematic identification of new regional value chains in the bioeconomy

The SysWeB project analyzes waste and residues from the agricultural and food industries in central Germany in order to develop them as new raw materials for the chemical industry and replace fossil raw materials. The aim is to collect scientific data on quantities, qualities, and possible uses and to develop new recycling lines. The networking of stakeholders from the agricultural, food, and chemical industries is intended to contribute to the initiation of regional, bio-based value chains.

- *www.cbp.fraunhofer.de/en/sysweb*

Biofabrication – Building Blocks for the Medicine of the Future



Challenge: Regeneration of joint cartilage

The future of medicine is biological. Fraunhofer IGB combines cell biology, materials science, and biotechnology to produce in-vitro tissues for use as test systems, tissue models, or biological implants.

At Fraunhofer IGB, the research field of biofabrication encompasses the systematic production of complex biological structures, such as tissues and organs, through the targeted interaction of cells, biomaterials, and process-based manufacturing technologies. Additive processes in particular enable the creation of hierarchically structured tissues, which can be crucial for the functionality of cell structures. Biofabrication thus forms the technological basis for the targeted development, functional design, and scalable production of biological systems.

Fraunhofer IGB as a partner along the entire biofabrication value chain

Thanks to its diverse expertise, research and development at Fraunhofer IGB covers the entire biofabrication value chain – from cell isolation and cell cultivation in optimized and sustainable media, to material development, process development and scaling in application-oriented dimensions, and the implementation of prototypes. The institute sees itself as a partner for companies and funding agencies that want to further develop and use biofabrication as a platform technology for future products, processes, and markets.

Biomaterials as a bio-intelligent, functional basis

In biofabrication, we use biomaterials as scaffolds or carrier structures for cells in order to create biologically active cell models, tissue constructs, or implants. As in their natural counterparts, biomaterials must also provide cells with an environment that is as physiological as possible, i.e., conditions that promote adhesion, growth, and differentiation. The institute has been researching and developing bio-based and functional biomaterials for many years. These include natural and polymer-based carrier materials and hydrogel systems, for example made from gelatin, collagen, or hyaluronic acid, which are specifically designed for the respective application in terms of their properties, structure, and biological functionality. Areas of application include coatings for medical devices, inks and formulations for bioprinting, and biotechnological production platforms.

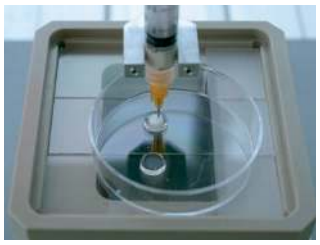
> **In our printed tissues, biomaterials derived from the molecular components of the natural tissue matrix provide the structural and functional framework."**
>
> **Dr. Achim Weber,**
> Head of Biofabrication and Material Development

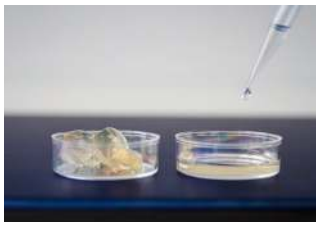
Cell cultivation: from laboratory solution to scale-up

The controlled cultivation of cells is a key challenge in biofabrication – particularly with regard to reproducibility, scale-up, and process stability. Fraunhofer IGB establishes suitable cell lines and production strains for this purpose, develops defined and sustainable cell culture media, co-culture models, and process-based cultivation concepts that realistically replicate physiologically relevant conditions. In this way, we enable the transfer of bio-intelligent research solutions into industrial development environments.

Bioink development and bioprinting

Before biomaterials can be shaped using printing processes, their flow properties must be adapted to the printing technology used. A key focus is therefore on the development of printable bioink formulations for 2D and 3D bioprinting applications. At Fraunhofer IGB, natural polymer materials (e.g., alginates, gelatin, collagen, or hyaluronic acid) and bio-based polymer materials (e.g., chemically modified biopolymers such as GelMA, modified hyaluronic acid) are combined into application-specific bioinks that combine high cell viability, defined rheological properties, and reliable processability. The close integration of material design, printing process, and application enables the construction of complex cell-material constructs for research, technology development, and industry-oriented demonstrators.





Top:
3D printing of different bioinks

Bottom:
Gelatin-based bioink with adjusted viscosity

Collaboration and transfer

Fraunhofer IGB develops technologies and products in the field of biofabrication in publicly funded projects and on behalf of customers in the medical engineering, research, and clinical sectors. Partners benefit from our state-of-the-art laboratories, specialized infrastructures, and technology platforms for cell culture, material development, process development and scaling, and prototype manufacturing. Our services range from initial feasibility studies to technology and product development along the entire innovation chain. We are also happy to support you with our expertise in preparing regulatory-relevant applications.

Read the full article online:
▸ *www.igb.fraunhofer.de/biofabrication-for-medicine*

Alternatives to fish and meat with sustainable agricultural systems

Alternative Proteins – New Raw Materials and Processes for the Protein Supply of the Future

Alternative protein sources to meat and animal products have become an important part of the food industry and offer choices for a more sustainable food supply. Fraunhofer IGB is researching new processes and biotechnological agricultural production systems for proteins from rapeseed, microalgae, fungi, bacteria, and cell cultures in order to provide resource-efficient solutions and contribute to food security.

Proteins are essential components of human and animal nutrition. Fish and meat, eggs and dairy products are traditionally considered good sources of protein. However, the market for vegetarian and vegan alternatives in Germany is growing – for health, ethical, or environmental reasons on the part of consumers.

Moreover, current animal production systems are reaching their limits when it comes to ensuring a sustainable protein supply for a steadily growing world population. In addition to economic factors, the high consumption of land and resources as well as greenhouse gas emissions are particularly significant. Further impacts include soil and water pollution from pesticides and fertilizers.

Alternative proteins for sustainability, resilience, and food security

Alternative proteins from plants, algae, insects, or fungi require less arable land and water than meat, and their carbon footprint may also be lower, depending on the production method. In addition, they can be produced locally – from domestic sources or industrial side streams and with the help of biotechnological processes. This makes food production independent of climatic and seasonal fluctuations, strengthens the resilience of the regional economy, and increases food security.

Fraunhofer IGB – your partner for biomass processing, biotechnological production processes, and closed material cycles

As a process developer and optimizer with expertise in industrial biotechnology and biofabrication, Fraunhofer IGB is researching a wide range of new solutions for providing alternative proteins from plants, microalgae, microorganisms, fungi, and cell cultures for use in food and feed. The focus is on developing new processes for fractionating plant biomass, new biotechnological

(including cell technology) production processes, and scaling up fermentation processes at Fraunhofer CBP in Leuna.

Plant protein from rapeseed

Using the EthaNa process employed at the oilseed biorefinery at Fraunhofer CBP in Leuna, rapeseed can be used to produce not only high-quality oil but also a protein-rich rapeseed kernel concentrate with a protein content of over 50 percent.

In current projects, researchers have been able to show that rapeseed concentrate has a balanced amino acid composition that is beneficial to the human organism and can be processed into protein-rich food products: it formed stable emulsions in combination with other ingredients, and burger patties impressed with their good consistency, pleasant bite, and good mouthfeel. Feeding trials have shown that rapeseed kernel concentrate is also ideal for use as animal feed due to its high content of essential amino acids.

Rapeseed concentrate forms stable emulsions with other ingredients and is ideal for use in burger patties, minced meat and fish stick substitutes, and pasta.

Protein-rich microalgae biomass

The cultivation of microalgae has been researched at Fraunhofer IGB in Stuttgart for decades. These photosynthetically growing single-cell organisms produce polysaccharides, important omega-3 fatty acids, carotenoids, vitamins – and also proteins. This makes algae interesting for use as food or animal feed.

With its flat-panel airlift photobioreactors (FPA-PBR), Fraunhofer IGB provides companies with a modular, scalable technology for producing algae biomass with outstanding productivity, product quality, and cost efficiency. Remote maintenance enables automated operation at any location. Due to its omega-3 fatty acid content, protein-rich algae biomass can be used directly in food production, for example as an alternative to fish.

Photobioreactor for cultivating microalgae

Fermentation and precision fermentation with microorganisms

The biotechnological production of proteins using microorganisms (bacteria or yeasts) is another way of providing protein-rich biomass (single-cell protein) or high-quality solitary proteins such as milk proteins. The selection of microorganisms that already possess the desired properties and can be used for the production of specific proteins, as well as their optimization, is carried out by the biotechnology team at the Fraunhofer IGB site in Straubing, as is the design of high-performance strains using model-based methods and metabolic engineering.

The fermentation processes developed are then scaled up in the pilot plants at Fraunhofer CBP. The biotechnology team in Leuna also provides startups, SMEs, and large companies with equipment and expertise, including the associated downstream processes (e.g., spray drying), for the scale-up of their own precision fermentation processes. With the help of automated, sterile bioreactors up to 10 m^3, sample quantities can be produced on a kilogram to ton scale and process parameters can be obtained for transfer to industrial scale.

In the **Fraunhofer FutureProteins flagship project**, six Fraunhofer institutes have pooled their expertise to develop new sustainable protein sources using specially developed indoor cultivation systems that can be used all year round, regardless of space, climate, or location, and to produce food from them. The project was completed in 2025.

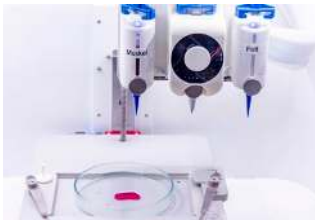
Fungal proteins with submerged culture of basidiomycetes

Thanks to its many years of experience in submerged culture of basidiomycetes, the industrial biotechnology team at IGB in Stuttgart has now developed a fermentation process for the production of fungal proteins using basidiomycetes as part of the Fraunhofer FutureProteins flagship project. The edible mushroom Flammulina velutipes was selected for the utilization of starchy side streams from industrial potato starch production.

In the course of the project, the fermentation process was successfully optimized. This included pre-culture management, agitator geometry, gas supply rate, and investigation of the optimal C/N ratio in the substrate. By introducing a new speed regime during mixing, the proportion of firmly attached mycelium was reduced, the amount of mycelium formed was doubled, and the space-time yield was thus increased. Fermentation was gradually scaled up to a scale of 300 liters (working volume of 200 liters).

Cell culture-based foods

Meat grown in cell cultures in the laboratory (cultivated meat) is considered a genuine alternative to meat from traditional agriculture in terms of taste and texture. With the appointment of Professor Petra Kluger as Professor of Interfacial Process Engineering at the University of Stuttgart and, in a dual role, as Institute Director of Fraunhofer IGB, the institute is now also researching the production of functional tissues for cell-based foods in its new Biofabrication division, in close cooperation with the Institute of Interfacial Process Engineering and Plasma Technology IGVP.



Cultivated meat is produced using a 3D printing process.

The focus is on muscle and fat tissue, whose controlled cultivation is crucial for the structure, nutritional value, and sensory properties of the end products. Suitable cell lines are being established for this purpose, based on muscle and fat precursor cells from cattle, pigs, chickens, and fish. Support structures and edible bio-inks are used to shape the animal cells using various methods, e.g., 3D bioprinting.

Agricultural systems with closed material and energy flows

In the FutureProteins flagship project, waste materials or by-products were to be used as far as possible for the production of further protein raw materials in order to close material and energy flows – in line with the principles of the circular economy.

Fraunhofer IGB has established a methodology for this purpose that records and analyzes material and energy flows. The model developed is now ready for use in the planning and design of new agricultural systems to balance material and energy flows and evaluate process efficiency and resource utilization. This balancing can thus help to optimize new production systems in terms of resource and energy efficiency.

Read the full article online:
▸ *www.igb.fraunhofer.de/alternative-proteins*

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Editorial team
Dipl.-Wirt.-Ing. (FH) Antje Hetebrüg,
Dipl.-Betriebswirt (DHBW) Jan Müller M. A.,
Dipl.-Des. Thaya Schroeder M. Sc. (pictures),
Dr. Claudia Vorbeck
and the scientists referred to as authors or contact persons.

Layout and production
Dipl.-Des. Thaya Schroeder M. Sc.

Editorial address
Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Dr. Claudia Vorbeck
Nobelstrasse 12, 70569 Stuttgart, Germany

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Submerged culture of the edible mushroom Flammulina velutipes for producing protein-rich fungal mycelium from food industry residues. In contrast to solid-state cultivation with fruiting bodies, mycelia can be produced more quickly and under controlled conditions in the bioreactor, even on a technical scale.

Fraunhofer IGB has many years of experience in the submerged cultivation of basidiomycetes.

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Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB

Nobelstrasse 12
70569 Stuttgart
Germany

Phone +49 711 970-4401
info@igb.fraunhofer.de

www.igb.fraunhofer.de/en

Stay in contact: