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Fraunhofer Institute for Applied Polymer Research IAP

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Fraunhofer IAP

Annual Report 2022

thirty years
Fraunhofer IAP

Contents

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Newsletter registration We are happy to send you information about current topics at Fraunhofer IAP.

Preface

"I am proud of the range of products and services we offer today at Fraunhofer IAP. We develop individual solutions along the entire value chain – from the idea to the customized prototype."

Prof. Dr. Alexander Böker
Director Fraunhofer IAP

Dear readers,

Founded in 1992, Fraunhofer IAP has been a part of Brandenburg's scientific landscape for 30 years. During this time, we have rapidly developed and steadily grown into what we are today: your partner for innovative materials, processes and technologies.

Our customized solutions accompany entrepreneurs and customers around the world on their journey into the future. Together, we develop concepts to make products more sustainable, improve manufacturing processes and enhance technologies – for the advancement and success of our industrial partners and to create an environment and society worth living in. We use a holistic approach that combines extensive know-how in polymer research with expertise in engineering, materials technology, nanotechnology and biotechnology. This makes us unique.

Thirty years of successful, cutting-edge research and development speak for themselves and are a testament to what unites our employees at the institute: curiosity, ambition, creativity, knowledge and experience. I am proud of the joint efforts of our team at Fraunhofer IAP – past and present – of their willingness to try new techniques, processes and methods, make tiny improvements, achieve ambitious goals, and develop custom-made solutions to meet the high demands of our customers and partners – from both an economic and an ecological perspective.

We bundle together our unique competencies in order to meet the latest market needs in an optimal way. From the very beginning, our focus has been on polymer research, especially biobased polymers, and fiber research. We are building upon the know-how of our predecessor, the Institute of Polymer Chemistry (IPOC) of the Academy of Sciences of the GDR. Other areas of expertise have been added over the years. We develop and optimize the scale-up of polymer synthesis to ton scale at the Pilot Plant Center PAZ in Schkopau. We test and optimize the processing of biobased and biodegradable polymers at the Biopolymers Processing Center in Schwarzheide. In Wildau, we are driving forward the development of lightweight construction technologies. Sustainable materials and energy-efficient systems will continue to be relevant in the future. Therefore, it gave me great joy in May 2022 to inaugurate our new office and laboratory building at the Wildau site. Made possible through support from the European Regional Development Fund, the federal government and the state of Brandenburg, these additional capacities allow us to reinforce our commitment to Lusatia and strengthen the innovative power of our industrial partners in aerospace technology, energy technology and vehicle construction. The integration of the CAN research division into Fraunhofer IAP began five years ago. The research division bundles core competencies for the development of displays, LEDs, fuel cells, the life sciences as well as home and personal care. Today, it is a key player in Hamburg, a center of science, and a strong cooperation partner within the Fraunhofer-Gesellschaft. As the institute's director, I highly value this know-how and the expansion of our expertise it brings with it.

We celebrated our institute's thirtieth anniversary last year with a festive colloquium. I would like to take this opportunity to thank all those who have contributed to the success of the Fraunhofer IAP: Our partners from industry and society for their trust, policymakers for their valuable support, former colleagues for the foresight with which they developed the institute, and our employees for their passion and motivation day after day to expand our technological know-how and permanently improve the products of our customers. This joint collaboration is the key that enables us to develop creative solutions now and into the future. With this in mind, I hope you have an exciting and inspiring time reading our annual report.

Sincerely,

Prof. Dr. Alexander Böker
Director

From innovative materials to solutions for the future

Creative solutions are the key to overcoming the challenges of the present and the future – whether they be climate change, pandemics, the energy transition, structural change or new mobility concepts.

We focus on the following topics:

Bioeconomy and sustainability
We tap sustainable raw materials and enable a circular economy to reduce dependency on fossil energy sources.

Health and quality of life
From arteries to wrist: For new active ingredients, products and processes for medicine, medical technology and cosmetics, we offer individual solutions from a single source.

Energy transition and mobility
The integration of innovative materials into components and products is a key to the energy transition and the evolution of new mobility concepts.

Industry and technology
We are your competent partner along the value chain: from innovative materials to market-relevant prototypes.

Research divisions

Biopolymers
In the research division Biopolymers, we develop sustainable materials based on renewable raw materials such as cellulose, lignin, starch or thermoplastics like polylactic acid (PLA). Using our decades of experience, we develop more effective processes as well as new and enhanced materials for new and existing applications. This is done in collaboration with our partners in the pulp and paper industry and the polymer processing industry and with end-product manufacturers.
Division director:
Prof. Dr. Johannes Ganster

Functional Polymer Systems
In the research division Functional Polymer Systems, we develop materials with special optical and electrical properties as well as processes, technologies and conceptual designs for customer-specific applications. These materials have semiconducting, chromogenic or phototropic properties or are able to emit light, convert sunlight, or react to mechanical pressure or temperature. We use new digital printing processes, for example, for the low-cost production of OLEDs or solar cells.
Division director:
Dr. Armin Wedel

Synthesis and Polymer Technology
The activities of the research division Synthesis and Polymer Technology span the entire value chain – from polymer synthesis to process development, analysis and characterization. We rely on a balanced mix of competencies in our departments Polymer Synthesis, Shape Memory Polymers, Microencapsulation and Polysaccharide Chemistry, as well as Membranes and Functional Films. One focus of our activities is material-oriented and technology-driven research from a laboratory to a pilot plant scale.
Division director:
Dr. Thorsten Pretsch

Life Science and Bioprocesses
In the research division Life Science and Bioprocesses, we use proven mechanisms from nature to expand the functional spectrum of polymers. Our focus is on integrating new biological functions into polymer materials. We develop processes, materials and key substances for biotechnology, chemical industry, textiles, medical devices, pharmaceuticals and cosmetics, as well as for environmental technologies and nanotechnologies.
Division director:
Prof. Dr. Ruben R. Rosencrantz

Pilot Plant Center PAZ
The Fraunhofer Pilot Plant Center for Polymer Synthesis and Processing PAZ in Schkopau is a joint initiative of the Fraunhofer Institutes IAP and IMWS. Its main activities in polymer synthesis include developing and optimizing polymer synthesis processes, upscaling and providing sample quantities.
Division director:
Prof. Dr.-Ing. Michael Bartke

Polymeric Materials and Composites PYCO
The research division Polymeric Materials and Composites PYCO provides key expertise in lightweight construction along the entire value chain – from monomers to high-performance components. Prototypes, including special polymers and semi-finished fiber composites developed in-house, can be designed and scaled to meet the demands of large-scale production. These synergies represent a unique selling point in the German research landscape.
Division director:
Prof. Dr.-Ing. Holger Seidlitz

Center for Applied Nanotechnology CAN
Research at the Center for Applied Nanotechnology CAN focuses on the development of innovative, industrial-scale manufacturing processes for customized composites made of nanoparticles which can be used in displays, in lighting, in infrared sensors, as safety markings and in medical diagnostics.We also develop fuel cells with highly efficient nanocatalysts, polymers for cosmetic applications, and nanocapsules for the targeted release of active ingredients in medical applications.
Division director (acting):
Dr. Christoph Gimmler

thirty years
Fraunhofer IAP

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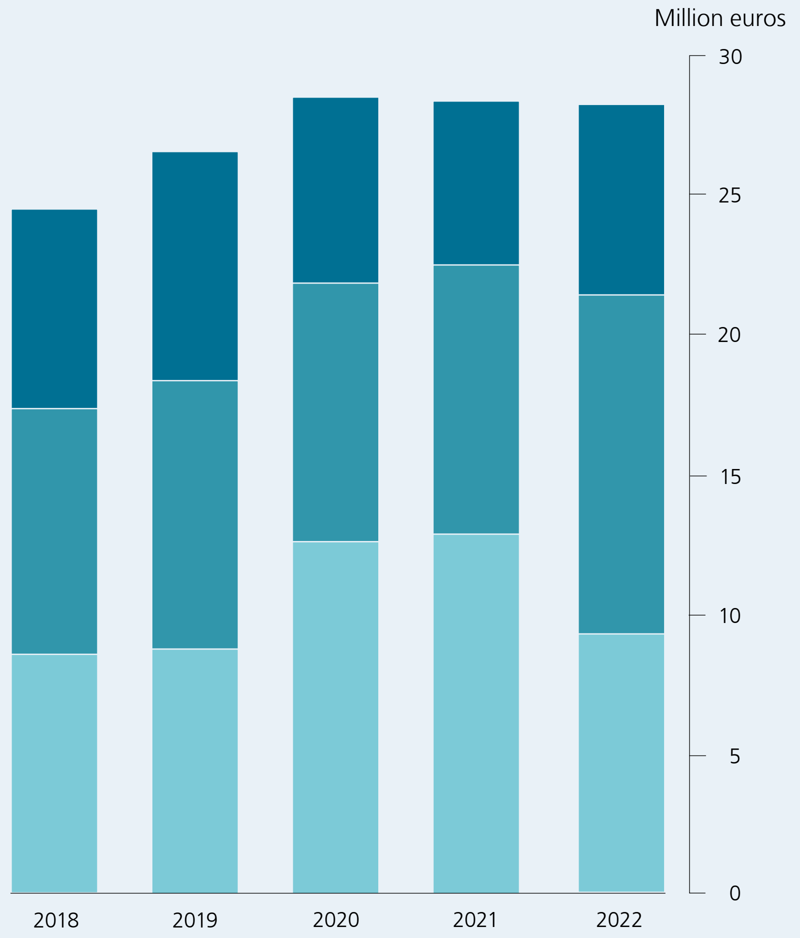
Status May 2023

The institute in figures

The total budget in 2022 amounted to 28.2 million euros and decreased slightly compared to the previous year. The institute generated a surplus of around 150 thousand euros.

Total revenue consisted of base funding (9.4 million euros), revenue from publicly funded projects (state, federal, EU) of 12.1 million euros, and industrial revenue (6.8 million euros). Compared to the previous year, industrial revenue (+15.3 percent) and especially the revenue from the public sector (+27.4 percent) increased significantly.

A total of 3,5 million euros were invested in 2022.



- Industrial revenue
- Revenue from publicly-funded projects
- Base funding

254 **People**
were employed at Fraunhofer IAP at the end of 2022.

114 Scientific staff

94 Technical Staff

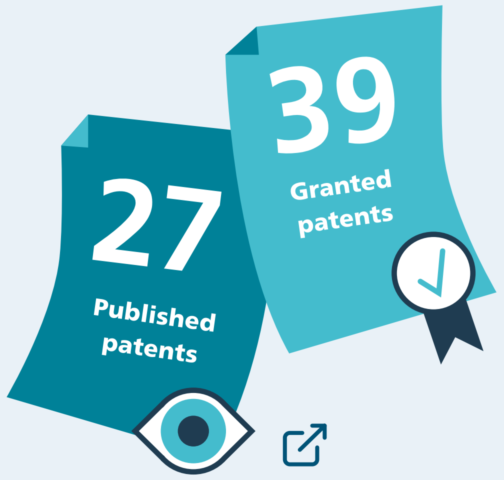
10 Ph.D. students

2 Apprentices

21 Administration / Scientific and Technical Services

13 Strategy and Marketing / High-Perfomance Center

97 Bachelor's and master's students, research assistants and student research assistants, interns and guest researchers from Germany and abroad were also employed at Fraunhofer IAP in 2022.



30 years of innovative materials, processes and technologies

In 2022 we celebrated thirty years of successful material and process developments: bio-based carbon fibers, flexible OLED displays, rubber for tires with a reduced abrasion, artificial corneas and much more.

Today, the Fraunhofer Institute for Applied Polymer Research IAP and its approximately 250 employees are significantly shaping the future in areas such as the bioeconomy, the energy transition, mobility and personalized medicine. On September 1, 2022, the institute celebrated its 30th anniversary by hosting a colloquium at the Fraunhofer Conference Center in the Potsdam Science Park with distinguished guests from politics, industry and science.

"30 years of IAP – That's 30 years of applied polymer research, of a successful transformation of the East, and of cutting-edge research in the state of Brandenburg."

Dr. Manja Schüle
Minister of Science, Research and Culture of the State of Brandenburg

"I have always been personally impressed by the technical and scientific expertise as well as the very great commitment of the employees at Fraunhofer IAP."

Dr. Bernd Wohlmann
Chairman of the Management Board at Teijin Carbon Europe GmbH, Chairman of Board of Trustees at Fraunhofer IAP

"Thanks to the excellent cooperation with IAP, we have succeeded in developing lightweight construction into an important pillar of structural change in Lusatia."

Prof. Dr. Gesine Grande
President of Brandenburg University of Technology Cottbus - Senftenberg (BTU)

Impressions of the anniversary celebration at the Fraunhofer Conference Center.

Prof. Dr. Alexander Böker (3rd from left), Director of Fraunhofer IAP with greeters at the ceremony: Agnes von Matuschka, Managing Director Standortmanagement Golm GmbH (left); Dr. Bernd Wohlmann, Teijin Carbon Europe GmbH (2nd from left); Dr. Manja Schüle, Minister of Science, Research and Culture of the State of Brandenburg (3rd from right); Prof. Oliver Günther, President of the University of Potsdam (2nd from right); Prof. Hans-Peter Fink, former Director of Fraunhofer IAP (right).

30 years at a glance

1992

Fraunhofer IAP emerges in 1992 from the Institute for Polymer Chemistry of the Academy of Sciences of the GDR in Teltow-Seehof. Applied polymer research continues in what was initially a temporary Fraunhofer Research Institution led by Professor Heinz Zimmermann.

1994

After two years as a temporary Fraunhofer Research Institution, Fraunhofer IAP becomes an independent institute in 1994. The Fraunhofer-Gesellschaft and the University of Potsdam agree on a contract for joint cooperation. Potsdam-Golm becomes the future headquarters of the institute.

1997

Professor Ulrich Buller is appointed director of the institute. A fortunate move for the institute, which is able to develop successfully under his leadership. The founding of the now very successful Pilot Plant Center PAZ is one of the achievements of the new director.

2000

We move to Potsdam. The new building has 5,000 square meters of floor space near the University of Potsdam's Golm campus. It provides new cooperation opportunities and firmly establishes Fraunhofer in the Brandenburg research landscape.

2005

Opening of the Fraunhofer Pilot Plant Center PAZ in Schkopau. At the time, the institute's director, Professor Buller, and division director, Dr. Hahn, are key figures in the success of this project, which has had a positive impact on Fraunhofer IAP to this day.

2006

Prof. Dr. Fink takes the helm as head of the institute. From car doors to sausage casings – he focuses on industrial applications based on renewable materials such as cellulose. Today, bioeconomy and sustainability are still top priorities at Fraunhofer IAP.

2012

In 2012, Fraunhofer IAP celebrates its 20th anniversary and grows: The "Application Center for Innovative Polymer Technologies" opens with 2,800 square meters of office and laboratory space. Here we develop printed OLEDs, solar cells and polymers for biomedicine.

2013

We expand our expertise in bioplastics processing with the opening of the "Processing Pilot Plant for Biopolymers Schwarzheide". From injection molding and extrusion, to films and 3D-printing filaments – we continue to offer applied biopolymer expertise up to the present day.

2015

Professor Böker, an internationally recognized polymer expert, takes over as head of the institute. Building on the institute's range of expertise, he sets a new goal for the future: sustainable innovations at the interface between biology and polymer science.

2016

The research division "Polymeric Materials and Composites PYCO" becomes part of Fraunhofer IAP and further expands the institute's expertise: fiber composites for sustainable lightweight construction, printed electronics, and large-scale 3D printing.

Inauguration of the Fraunhofer-Conference Center: the center's 275 square meters provide space for 150 people to meet for conferences, workshops and network meetings. A forum for dialog between science, politics, business and the public.

2017

Opening of the Fraunhofer High-Performance Center "Integration of Biological and Physical-Chemical Material Functions", a joint venture between Fraunhofer IAP and Fraunhofer IZI-BB. Functional materials are the key technology for sustainability, the energy transition, mobility and health.

2018

The Center for Applied Nanotechnology CAN GmbH is integrated into Fraunhofer IAP. Led by Professor Weller, the production of high-quality nanoparticles opens up new possibilities for displays, LEDs, fuel cells, medicine, diagnostics and cosmetics.

2021

We move into our new building in Wildau! Our PYCO research division now combines all of our lightweight expertise under one roof – from monomers to components. 2,700 square meters of modern laboratory and office space provide room for sustainability and the energy transition.

2022

Interview: plastic recycling

Recycling is an essential part of achieving a plastics-based circular economy. In an interview, Dr.-Ing. Marcus Vater explains current developments and fields of action at the institute.

"Chemical recycling is a growing field of research and development. One of the major challenges is to recover monomers that have a high degree of purity."

Up to now, mechanical methods have mainly been used to process waste plastics into recycling granulate, so-called recyclate, which can be reused as a raw material for new products. Scientists at Fraunhofer IAP are also developing approaches to recover the chemical building blocks of plastic products. Monomers constitute the focus of our attention. These can be used to produce new, high-quality polymers. Their repeated use reduces our dependency on fossil raw materials. Marcus Vater heads the working group for chemical and biological recycling.

A 50 percent recycling quota for packaging and a 25 percent recycled content in bottles by 2025 – these are the requirements of the European Union's Circular Economy Package and Germany's Packaging Act. This means that industry needs to take quick action and improve recycling concepts. How is Fraunhofer IAP supporting its customers in achieving these goals?

We collaborate with partners from industry on recycling projects for plastics based on polyamide and polyester, for example. One project that has occupied us for several years is the validation of recycled monomers, for example for polyethylene terephthalate, or PET for short. PET is a polyester-based material used to make bottles, fibers and films. We are the port of call for industrial customers who are developing recycling processes and recovering the monomer terephthalic acid contained in PET. We also cater to manufacturers of PET who are offered the monomer on the recycling market. We use the recovered terephthalic acid to produce polymers in various quantities. Small quantities starting at 25 grams can be used to test suitability. Quantities up to six kilograms are used to characterize mechanical properties and colors. We also synthesize research samples of up to 1,000 kilograms. Our customers test whether the PET can be reprocessed with the recycled monomers into a suitable bottle or fiber. We are currently developing our own recycling process for another polyester, polybutylene succinate, which goes by the abbreviation PBS.

What obstacles need to be overcome in the development of chemical recycling processes?

Chemical recycling is a growing field of research and development. One of the major challenges is to recover monomers that have a high degree of purity. This is imperative if new, high-quality polymers are to be produced from them. Removing ink residues, stabilizers and detergents, for example, is part of the recycling process. This requires the development of new purification processes. Our many years of experience in the synthesis and process development of polymers forms the foundation for this. Our goal is to design a monomer cycle with as little loss of mass and quality as possible.

Industries such as the automotive and aviation industries are also looking for recycling solutions. Which activities does Fraunhofer IAP pursue in this regard? What services do you offer?

We work closely with industry in the field of thermosets and thermoplastics. For example, we provide the expertise for those who are interested in knowing the exact properties of their recyclate and which applications it can be used for. We specialize in the evaluation of plastic materials. When it comes to recycling a component made of a composite material – for example the rotor blades of a wind turbine – we are able to chemically recycle the plastic matrix and retain the fibers so that this high-quality material can be reused.

You are greatly committed to further developing the recycling competencies of Fraunhofer IAP. What is your personal vision of the plastic cycle in 2050?

In 2050, the plastic cycle will be close looped. Unavoidable losses will no longer be a problem, as plastics will be fully biodegradable and losses will be compensated for by renewable resources. Once we have achieved this vision in 2050, I can look forward to retiring with a smile. //

> **"**
> Our Partners from industry and research benefit greatly from integrated system solutions for their lightweight construction applications."
>
> **Prof. Dr.-Ing. Holger Seidlitz**
> **Head of Research Division PYCO**

New building for sustainable lightweight technologies

A unique contact point for sustainable and holistic lightweight construction technologies has been created at the Wildau site. The newly erected, 2,700 square meter office and laboratory building provides space for the development of energy-efficient and sustainable lightweight construction systems and materials that meet the high demands of aerospace engineering, energy technology and vehicle construction. To this end, the Polymeric Materials and Composites PYCO research division combines materials and engineering sciences along the entire value chain in a unique way – from polymer development and processing, to novel manufacturing technologies for high-performance components and forward-looking optimization strategies and recycling concepts.

Until 2020, the PYCO working groups were spread over two different locations: the traditional site in Teltow, formerly the Institute for Fiber Research of the Academy of Sciences of the GDR, and the Wildau site. Now they are united under one roof in Wildau. The modern building is not only equipped with the latest technology, but also provides excellent conditions for interdisciplinary collaboration between researchers.

Construction costs amounted to 20.5 million euros. The European Regional Development Fund (ERDF) provided 80 percent of the 19.4 million euros funding budget. The federal government and the state of Brandenburg contributed ten percent each towards the funding. The new building was officially inaugurated on May 25, 2022. //

Top: Inauguration of the new office and laboratory building of Fraunhofer IAP at the Wildau site. F.l.t.r.: Prof Dr.-Ing. Holger Seidlitz, Fraunhofer IAP and Head of Research Division PYCO; Prof. Dr. Ulrike Tippe, President TH Wildau; Prof. Dr.-Ing. Reimund Neugebauer, President Fraunhofer-Gesellschaft; Steffen Weber, State Secretary MWFK Brandenburg; Prof. Dr. Alexander Böker, Director Fraunhofer IAP.

Production plant for novel bioplastics starts operation

The Polymer Synthesis department, headed by Dr. Antje Lieske, has partnered with SoBiCo GmbH, a subsidiary of the Polymer Group, to develop a novel class of bioplastics based on polylactide (PLA). The flexible PLA copolymers open up completely new fields of application.

Both the development of the material and the manufacturing process have incorporated the extensive knowledge of the polymer specialists at Fraunhofer IAP. The novel production process for PLA combines two previously separate process steps. This saves time, energy and costs.

PLA has strong market potential in the field of bioplastics. However, conventional PLA materials are often stiff and brittle. The mechanical properties of these newly developed PLA copolymers can be widely adjusted. Thus, these bioplastics are suitable for applications such as flexible packaging films, injection molded parts for the automotive industry, and thermoplastic elastomers for construction applications. PLA copolymers are currently between 75 and 95 percent biobased. The proportion of biobased PLA in the plastic can be used to very precisely control the material's flexibility. Elongation at break is a characteristic value indicating how deformable a material is. Currently, elongations at break of 3 to 300 percent have been achieved.

The commissioning of the first production line was celebrated in July. Covering an area of 2,000 square meters, the plant in Pferdsfeld will produce 2,000 metric tons of the novel bioplastics per year in the future.

Funding: Federal Ministry for Food and Agriculture | Agency for Renewable Resources (FNR). //

> **"**
> Our PLA copolymers are currently between 75 and 95 percent biobased."
>
> **Dr. Antje Lieske**
> **Head of Department Polymer Synthesis**

Dr. Gerald Hauf, Managing Director of the Polymer Group and Dr. Antje Lieske, Head of Department "Polymer Synthesis" at Fraunhofer IAP open up new fields of application for bioplastics with innovative PLA copolymers.

Farewell to a pioneer of nanotechnology

Over the past 40 years, Professor Horst Weller has made a significant contribution to the international development of nanochemistry. Today it is a branch of chemistry in its own right. As Head of the Research Division Center for Applied Nanotechnology CAN at Fraunhofer IAP, he has been an invaluable member of the Fraunhofer-Gesellschaft since 2018.

Professor Horst Weller (center) was bid farewell by Senator for Science Katharina Fegebank (left) and Professor Alexander Böker (right), Director of Fraunhofer IAP.

Horst Weller founded the Hamburg Center for Applied Nanotechnology CAN GmbH back in 2005. This enabled him to strongly advance the commercialization of nanotechnology. His research on semiconductor nanocrystals, the synthesis of new materials and their application in areas such as optoelectronics, solar energy conversion and biomedicine has been pioneering on an international level. He is one of the most influential scientists in the world in the fields of photochemistry, nanoscience and physical chemistry. Weller has received numerous awards, including the Nernst-Haber-Bodenstein Prize of the German Bunsen Society (1991), the Elhuyar-Goldschmidt Prize (2010), the Cellagon-Research Prize (2010), the Julius Springer Prize for Applied Physics (2012), and the Solvay Prize of the European Colloid Society (2018). Horst Weller had also been a professor of physical chemistry at the University of Hamburg since 1998. He retired in December.

Prof. Dr. Alexander Böker, Director of Fraunhofer IAP: "Professor Weller is a pioneer in nanotechnology. I congratulate Horst Weller, an extraordinary person and researcher, on his life's work and thank him for his contribution to pioneering research and innovation at Fraunhofer IAP. I wish him all the very best for his retirement."

Dr. Christoph Gimmler has been acting Head of the Research Division since January 2023. //

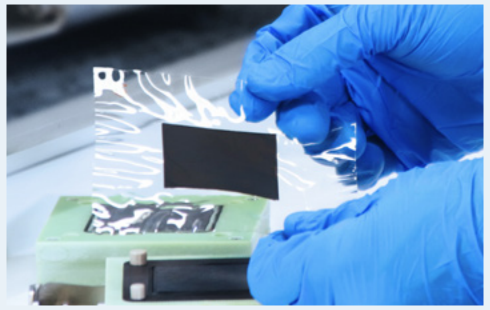
Partner for innovative nanotechnology

At the **Center for Applied Nanotechnology CAN,** inorganic nanoparticle systems are developed for applications in the fields of functional materials, the life sciences, home and personal care.

Core competencies include the fabrication and characterization of materials in the form of inorganic nanoparticles, the hybrid structures of nanoparticles and polymers, and the adaptation of these to the aforementioned applications. Established particle systems include fluorescent, magnetic, electrically and thermally conductive, X-ray opaque, electrocatalytically active, metallic and ceramic nanoparticles.

The Center for Applied Nanotechnology CAN provides support to its customers through innovative developments:

- displays, LED and lighting, water electrolysis and fuel cells
- diagnostic tools, biomarkers
- additives for cosmetic products, detergents and special polymers as formulation aids



High-Performance Center Functional Integration

Since 2017, the High-Performance Center "Integration of Biological and Physical-Chemical Material Functions" in the Potsdam Science Park has been fostering the shoulder-to-shoulder cooperation between industry and university and non-university research.

Fraunhofer high-performance centers are central contact points for transfer-oriented, site- and topic-specific collaborations within a network of universities, colleges, universities of applied sciences, non-university research institutions, and companies. The activities are coordinated from the joint office of the Functional Integration Performance Center of the participating Fraunhofer Institutes, the Fraunhofer Institute for Applied Polymer Research IAP, and the Department of Bioanalytics and Bioprocesses at the Fraunhofer Institute for Cell Therapy and Immunology IZI-BB.

The high-performance center in the Potsdam Science Park focuses on integrating functionalities into materials. Functional materials are a key technology because they offer solutions to challenges in the fields of healthcare, transportation, energy, communication, the environment and society. The group of functional materials includes materials that are characterized by their electrical, magnetic, acoustic, optical and biological properties. The development is complex and based on a range of knowledge in chemistry, physics, biology, medicine and engineering. The performance center bundles the competencies of its partners. The aim is to develop new materials, processes and technologies to manufacture complex products more efficiently and to integrate novel functions into polymer materials. This requires a mutual exchange between partners from science and industry. This takes place within the framework of joint R&D projects at the Fraunhofer institutes and/or with the anchor university in Potsdam, the partner universities BTU-Cottbus and TH Wildau, as well as regional companies. Furthermore, topic-specific partner events with business associations are held and successively expanded upon, and exploitation workshops and transfer support are organized.

In order to sustain the networking, cooperation and assistance-related tasks between the partners in the performance center, the focus in 2022 was on building up a pool of student employees who could provide support in the areas of market research, trade fairs, communication and events. The performance center cooperated with the University of Potsdam as part of the pilot module "Transfer and Innovation Management" to ensure an ongoing staffing of students with, ideally, an understanding of the natural sciences and economics. Prototype projects from the high-performance center were brought in as case studies and students from different disciplines jointly developed product-related transfer concepts.

Starting in 2023, this personnel structure will be able to provide more targeted support to the stakeholders in the performance center. New R&D projects will address current needs in the areas of recycling, 3D printing, sensor technology and the cross-cutting topic of AI. //

Fraunhofer

Leistungszentrum FUNKTIONSINTEGRATION bio · phys · chem

Innovative University

Innovative University Potsdam – INNO-UP

Innovative University Potsdam (Inno-UP) is a project that is part of the joint federal-state initiative "Innovative University". Fraunhofer IAP has been a direct partner in the project of the funding initiative of the Federal Ministry of Education and Research and the Joint Science Conference since January 2018. Fraunhofer IAP is active in the "Technology Campus" sub-project, which involves the establishment and testing of so-called joint labs (JLs).

The aim of the JLs is to provide networking possibilities to scientific stakeholders in order to stimulate transfer activities and create innovation potential. Until the end of 2022, they were used as innovation spaces that crossed the boundaries of organization and discipline. The Joint Labs were accompanied by workshops on open collaboration, open innovation in science, co-creation and citizen science. Two JLs were established in close cooperation with the Fraunhofer Institutes at the Potsdam site: the JL OPAT (Optical Process Analysis Technologies) with Fraunhofer IAP and the JL BioF (Biofunctional Surfaces) with Fraunhofer IZI-BB. Here, activities focused on the acquisition of joint projects and the joint processing of cooperation requests. The JL OPAT was consolidated by the University of Potsdam and will continue run in the future. //

Innovative University – new approaches to transfer technology

The "Innovation Hub 13 – fast track to transfer" at the Technical University of Applied Sciences Wildau and the Brandenburg University of Technology Cottbus-Senftenberg is an instrument of the joint federal-state initiative "Innovative University".

As part of Innovation Hub 13, transfer scouts from Fraunhofer IAP are developing a regional innovation system to sustainably strengthen knowledge and technology transfer in the southern Brandenburg region. They work on an interdisciplinary team with the universities, Fraunhofer IMW and the Leibniz Institute for Spatial Social Research. Networking activities focus on the topics of life sciences, digital integration and lightweight construction.

In 2022, projects were launched on the biologization of technology and the development of sustainable lightweight structures using parts of climate-resilient fruit varieties. Cooperation partners were farmers from Brandenburg and companies from Saxony. In addition, the scout team actively supported the market launch of rotor blades for small wind turbines and expanded activities relating to renewable energies. Digital networking formats, such as idea scouting, InnoMix, InnoTalk and InnoRadar, also strengthened collaboration among the participants. Innovation Hub 13 thus effectively supports regional companies in analyzing technology trends and future markets, in research projects, in preparing project proposals and in networking with research institutions. //

Innovative Hochschule

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Gemeinsame Wissenschaftskonferenz GWK

Fraunhofer Cluster of Excellence

The Fraunhofer Clusters of Excellence benefit from an inter-institute research structure. The aim of the research clusters is not just to temporarily implement single projects but rather to follow a roadmap for the long-term development of a complex technological trend.

Using a synthesis process developed at Fraunhofer IAP, first sample quantities of a novel thermoplastic polyester elastomer based on biogenic 2,5-furandicarboxylic acid were produced.

Programmable Materials CPM

The research cluster "Programmable Materials CPM" develops the scientific and technological basis for materials that can replace entire highly functional systems as a result of their molecular structure and macroscopic design.

In the field of programmable friction, it was possible to release electrically switchable fluids on demand. Tribologically stressed coatings showed even lower friction values than commercially available bonded coatings.

In the field of 4D printing, researchers produced objects from a shape memory polymer that autonomously change shape and are thermoreversible, in other words, they can switch back and forth between two shapes. The material showed stable actuation of 5.7 percent after the 20th heating/cooling cycle. The material behavior was studied throughout one hundred cycles. This is an important step in exploiting the material's two-way shape memory effect for repeated and reliable switching. The team also 4D-printed a ring-shaped gripper that can grasp a vial when the ambient temperature changes, hold it in place, and put it down "on command". The developed technology saves both time and energy over conventional systems. As a result, researchers are now no longer dependent on the use of universal testing systems that are complex to handle and equipped with temperature chambers in certain programming scenarios.

The material formulation was adapted in order to further develop polyurethane foams for thermally switchable rear ventilation or for façade insulation. The aim is to develop self-sufficient insulation systems for the building industry that can switch back and forth within the temperature range of 0 °C and 50 °C. For the first time, a strong actuation of around 23 percent under constant mechanical stress was demonstrated in three consecutive cycles.

In the future, the aim is to strengthen the application relevance of programmable materials by further expanding collaboration with industry. This will be done in addition to running the cluster independently as a cooperative project of several Fraunhofer institutes according to the Fraunhofer research and funding model.

Core institutes: Fraunhofer IAP, Fraunhofer IBP, Fraunhofer ICT, Fraunhofer ITWM, Fraunhofer IWM, Fraunhofer IWU. //

Circular Plastics Economy CCPE

The concept of circular value creation is gaining in importance as a way to achieve the sustainability goals of the United Nations' Agenda 2030. It is particularly important for the plastics industry. Production is growing and is a significant economic factor in many countries. Plastics for industrial and consumer goods have optimized and wide-ranging properties; in many cases they are almost impossible to substitute. Their low weight makes them indispensable for resource-efficient products. However, a lot of plastic waste ends up in the environment.

The change from a largely linear system to an efficient circular economy requires systemic, technical and social innovations. The CCPE research cluster is contributing to this. It bundles competencies, methods and products for the circular plastics economy. The Fraunhofer IAP is responsible for the Circular Polymers research department within the cluster and works closely with the Fraunhofer Institutes LBF, ICT and UMSICHT.

At Fraunhofer IAP, the focus is on bio-based plastics. These enable a reduction in the use of fossil resources, thereby lowering the carbon footprint of plastic products. Specifically, the researchers are developing modified polybutylene succinates as substitutes for plastic products that contain polyolefins. Another focus is on thermoplastic polyester elastomers (TPEE) made from bio-based furandicarboxylic acid. The synthesis process was developed at Fraunhofer IAP and can be implemented on an industrial scale. Initial sample quantities are being produced to investigate the fundamental properties. The aim is to adapt the crystallization behavior to commercial, petroleum-based TPEE grades. This is essential if bioTPEEs are to be used in established applications as well.

In the area of polymer processing, fibers are produced from polylactide (PLA) that have an improved thermomechanical performance. Researchers at Fraunhofer IAP are using fibers based on stereocomplex crystal structures (scPLA). They are working together with Fraunhofer ICT to investigate whether they can be used as reinforcing fibers in recyclable monomaterial composite applications. The recycling process is simplified significantly since the matrix and fibers of these composites are chemically identical.

Core institutes: Fraunhofer IAP, Fraunhofer ICT, Fraunhofer IML, Fraunhofer IVV, Fraunhofer LBF, Fraunhofer UMSICHT. //

Lighthouse Projects

The lighthouse projects of the Fraunhofer-Gesellschaft put the focus on strategic objectives with a view to developing practical solutions from which economies such as Germany's can benefit. We aim to turn original scientific ideas into marketable products as quickly as possible.

The goals of the lighthouse project SUBI^{2}MA are to develop new biobased and biohybrid materials and to accelerate future material substitutions with digitalization as well as model- and data-based simulation methods.

"Replacing fossil materials with biobased materials is not enough for the biotransformation of plastics technology. Bioplastics additionally require exclusive properties to become real alternatives for conventional materials."

Prof. Dr. Ruben R. Rosencrantz
Project coordinator "SUBI^{2}MA" and head of research division Life Science and Bioprocesses

Biobased and biohybrid materials

The lighthouse project "Sustainable Biobased and Biohybrid Materials" (SUBI^{2}MA), coordinated by Fraunhofer IAP, has a unique approach to the biotransformation of plastics technology. The focus of the six participating Fraunhofer institutes is on the use of biobased material components. By integrating biological components, entirely new biobased and biohybrid materials are being developed and manufactured. The researchers are also developing model- and data-based simulation methods to accelerate material development.

"SUBI^{2}MA" materials provide the plastics and chemical industries, as well as downstream markets such as construction chemicals, automotive, textile chemicals and healthcare, with a way to respond to the challenges of national and global sustainability strategies. Fraunhofer IAP contributes its expertise to the project in the fields of polymer synthesis, fiber spinning, nanoparticles, and biofunction integration. In the area of polymer synthesis, the focus is on developing materials from sustainable raw materials and manufacturing processes on a pilot plant scale. In the area of fiber development, the focus is on manufacturing processes for staple fibers and nonwovens based on native polymers from renewable raw materials. Plasma-assisted processes for the surface treatment of polymers, as well as stabilized enzymes integrated into polymers, are used for the biofunctionalization of materials.

Partner institutes: Fraunhofer IAP, Fraunhofer IGB, Fraunhofer LBF, Fraunhofer ICT, Fraunhofer ITWM, Fraunhofer IWM. //

Shaping the Future of Green Chemistry

The chemical industry is pursuing the ambitious goal of converting production processes into ones that use renewable raw materials and sustainable energies. Through the lighthouse project "Shaping the Future of Green Chemistry by Process Intensification and Digitalization" (ShaPID), the Fraunhofer-Gesellschaft supports the transformation of the industry towards sustainable and environmentally friendly production – so-called green chemistry. Based on the internationally recognized "12 Principles of Green Chemistry", new methodologies and technologies are being developed and demonstrated on a practical and technical scale. In the Green Plastics subproject, a research team from several institutes, led by Fraunhofer IAP, is developing the entire process chain for the production of sustainable polymers. The focus is on new biobased polymer building blocks that are produced using fermentation, i.e. microbial or enzymatic processes. The food for the microorganisms is called formate, which is obtained from climate-damaging carbon dioxide. The researchers are obtaining data on the interaction of green catalysis and smart process technology – from the cultivation of the microorganisms to the adaptation of the fermentation in bioreactors, the purification of the target substances and the reactor design. This data will be used to evaluate green chemistry technologies and to develop sustainable standards.

Partner institutes: Fraunhofer IAP, Fraunhofer ICT, Fraunhofer IFF, Fraunhofer IGB, Fraunhofer IMM, Fraunhofer IME, Fraunhofer ISC, Fraunhofer ITWM, Fraunhofer UMSICHT. //

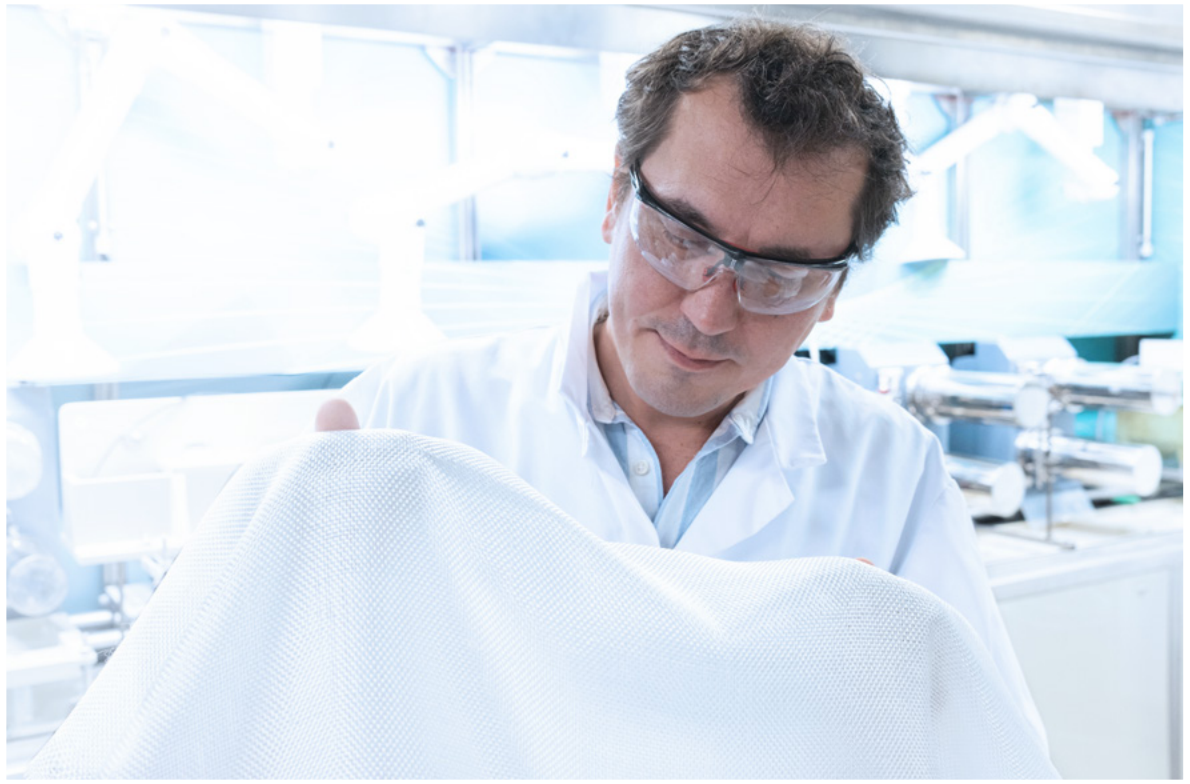
Electrocaloric heat pumps

Heat pumps are a key component for the energy transition. Operated with renewably generated electricity, they form the missing link between electricity and heat generation. As part of the lighthouse project "Electrocaloric Heat Pumps" (ElKaWe), six Fraunhofer institutes are working on developing electrocaloric heat pumps for heating and cooling. Possible fields of application include buildings, cooling devices in households or industry, and air conditioning systems in cars. Until now, heat pumps have worked almost exclusively on the basis of compressor technology. Electrocaloric heat pumps promise a significantly higher efficiency and do not require harmful refrigerants.

Fraunhofer IAP's role in the project is to develop electrocaloric materials and components. These respond to changes in the material's electric field strength caused by cooling or heating. The research team is working on optimizing the material properties with regard to the high electrocaloric effects. The improved polymer materials are the basis for the development of active electrocaloric components. These are produced through layer or stack processes and subsequently integrated into the overall system.

Partner institutes: Fraunhofer IAP, Fraunhofer IPM, Fraunhofer FEP, Fraunhofer IAF, Fraunhofer IKTS, Fraunhofer LBF. //

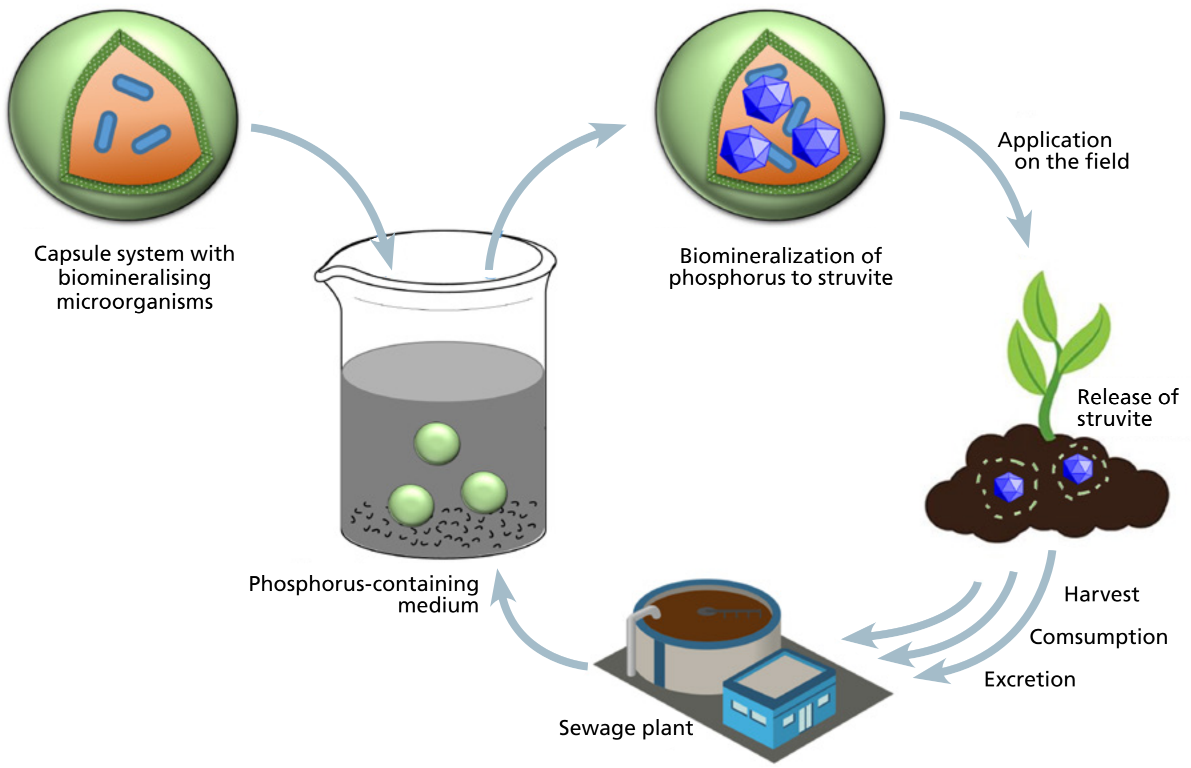
Bioeconomy and sustainability



"Our goal is to develop recyclable fiber composites made from 100 percent bio-based PLA with advantageous mechanical properties to further advance the transition to a sustainable circular economy."

Dr. Evgueni Tarkhanov
Department Fiber Technology

thi rty years Fraunhofer IAP



Dr. Juta Rottke
Microencapsulation and Polysaccharide Chemistry

Project: _From the wastewater treatment to the field: Phosphorus recycling with the help of encapsulated bacteria (PhosMOs)_
Funding ID: _13XP5156_
Partner: _InterEnviroCon GmbH_
Additional contact:
Dr. Sophia Rosencrantz (Biofunctionalized Materials and (Glyco) Biotechnology)

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Phosphorus recycling with encapsulated bacteria

Phosphorus plays an important role in agriculture. Up until now there has been no uniform guideline for a sustainable phosphorus cycle. Researchers at Fraunhofer IAP have now designed a recycling process as part of the "PhosMOs" project. They have succeeded in producing struvite through biomineralization. The research team has also developed a biobased and biodegradable system with living encapsulated bacteria that even reproduce inside the capsule. The initial foundations have thus been laid for using encapsulation technologies to create closed reservoirs for biomineralizing microorganisms. Such a system makes it possible, for example, to recover phosphorus from sewage sludge directly in a sewage treatment plant. The struvite-enriched capsules could be applied directly to fields as fertilizer. Struvite is an effective, low-energy and low-pollutant fertilizer option and is even suitable for organic farming. //

Bio-based reactive resins

Aromatic building blocks are indispensable for a large number of polyester-based materials. This is also true for unsaturated polyester resins, which are widely used as thermosets. The aromatic dicarboxylic acids phthalic and isophthalic acid used in these resins will not be produced from renewable carbon sources in the foreseeable future. In contrast, 2,5-furandicarboxylic acid (FDCS) offers clear prospects for the future, replacing the dicarboxylic acids currently being used with biobased starting materials. Researchers at Fraunhofer IAP are collaborating with industrial partners to develop biobased reactive resins based on FDCS. These have properties that are, at the very least, equivalent to their petroleum-based counterparts. Areas of application include boat building. As a biobased aromatic monomer, FDCS is considered a promising building block for the future production of plastics, which is to be based exclusively on renewable carbon sources (including recycling, biomass). The knowledge gained will be transferred in a follow-up project to the development of bio-based reactive resins for semi-automated processing methods such as vacuum infusion and sheet molding compound (SMC). //

Dr. Daniel Zehm
Polymer Synthesis

Project: _Production and evaluation of bio-based reactive resins for use in sewer rehabilitation and boat manufacturing (FDCA-containing reactive resins) // Bio-based reactiv resins for semi-automated processing methods_
Funding ID: _IGF 19804 BR // 22368 BG_

Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

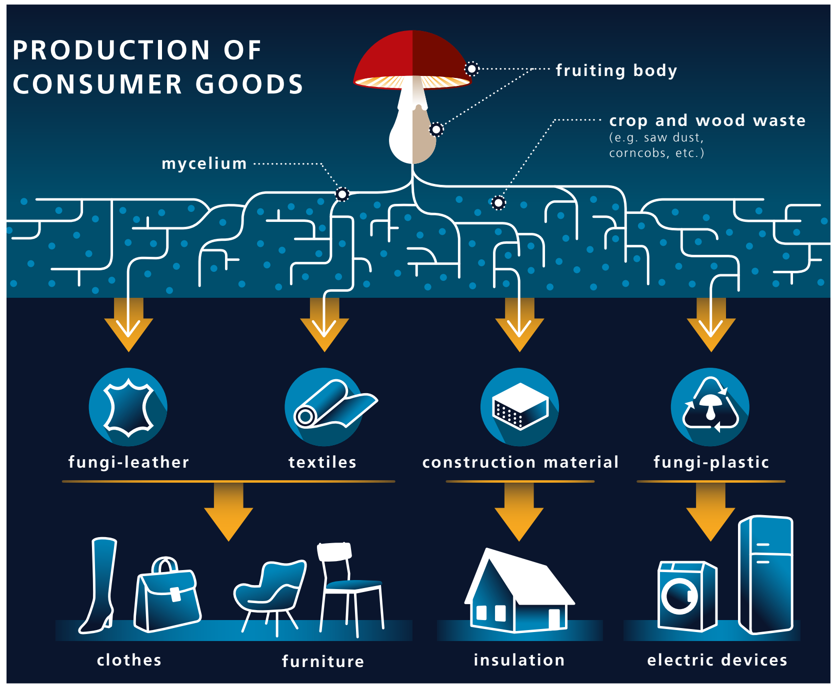
Dr. Jens Balko
Processing Pilot Plant for Biopolymers Schwarzheide

Project: _Development of new applications for bioplastics and composites in electronics and logistics using halogen-free flame retardant systems_
Funding ID: _22022717_
Partner: _Fraunhofer WKI_

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages
FNR Fachagentur Nachwachsende Rohstoffe e.V.

Bio-based flame retardants

Researchers at Fraunhofer IAP and Fraunhofer WKI, together with industrial partners, have achieved initial success in the development of bio-based flame retardants in bioplastics. This means that, in the future, plastics made entirely from biobased materials could be used in electronics and electrical engineering. Processing was tested using compounding, injection molding and additive manufacturing. One focus was to develop a halogen-free flame retardant that could be used in small quantities and therefore at low cost. The research team succeeded in developing flame-retardant PLA compounds based on the bioplastic polylactide (PLA). Flammability tests in accordance with UL94 resulted in a very good classification (V-0). The researchers also tested existing halogen-free flame retardants in compounding with unreinforced biopolymers and biopolymers reinforced with wood particles. They concluded that these are suitable for PLA and biobased polybutylene succinate (PBS) in terms of process technology. The industrial partners are very optimistic about the processing results for the injection molding process. Technical, flame-retardant components and parts such as tunnel sliders for switch boxes or storage boxes in the logistics sector could be manufactured under conditions close to production conditions. For the PBS-based materials, processing times are comparable to those of petroleum-based plastics. //



Fungal mycelium consists of an underground, interwoven network of fibers. From these emerge fruiting bodies known as mushrooms.

Dr. Hannes Hinneburg
Biofunctionalized Materials and (Glyco) Biotechnology

Project: *MySolation*
Partners: *Fraunhofer institutes IGCV, UMSICHT and WKI*

Funded within the internal programs of the Fraunhofer-Gesellschaft (Sprintprogramm).

Sustainable construction with fungal mycelium

Fungal materials offer great potential for making our lives more ecologically sustainable. As a new class of materials, possible applications include insulating materials, leather alternatives, construction elements and packaging. In the project "MySolation", a Fraunhofer research team has developed and characterized mushroom-based materials whose properties are comparable to commercial products (e.g., sheep's wool, glass wool) in terms of insulation, flame retardancy and mechanical stability. Fungi can be cultivated on low-energy residues from agriculture and forestry. Sawdust, bark, tree cuttings, husks, straw or pomace are transformed by the fungus into materials with new properties. In the process, the fungal meshwork – known as mycelium – acts as a kind of glue. This results in pure materials or composites of mycelium and various fillers. With the help of the materials produced at Fraunhofer IAP, a valuable contribution can be made to the sustainable circular economy in Germany and dependence on petroleum can be reduced. //

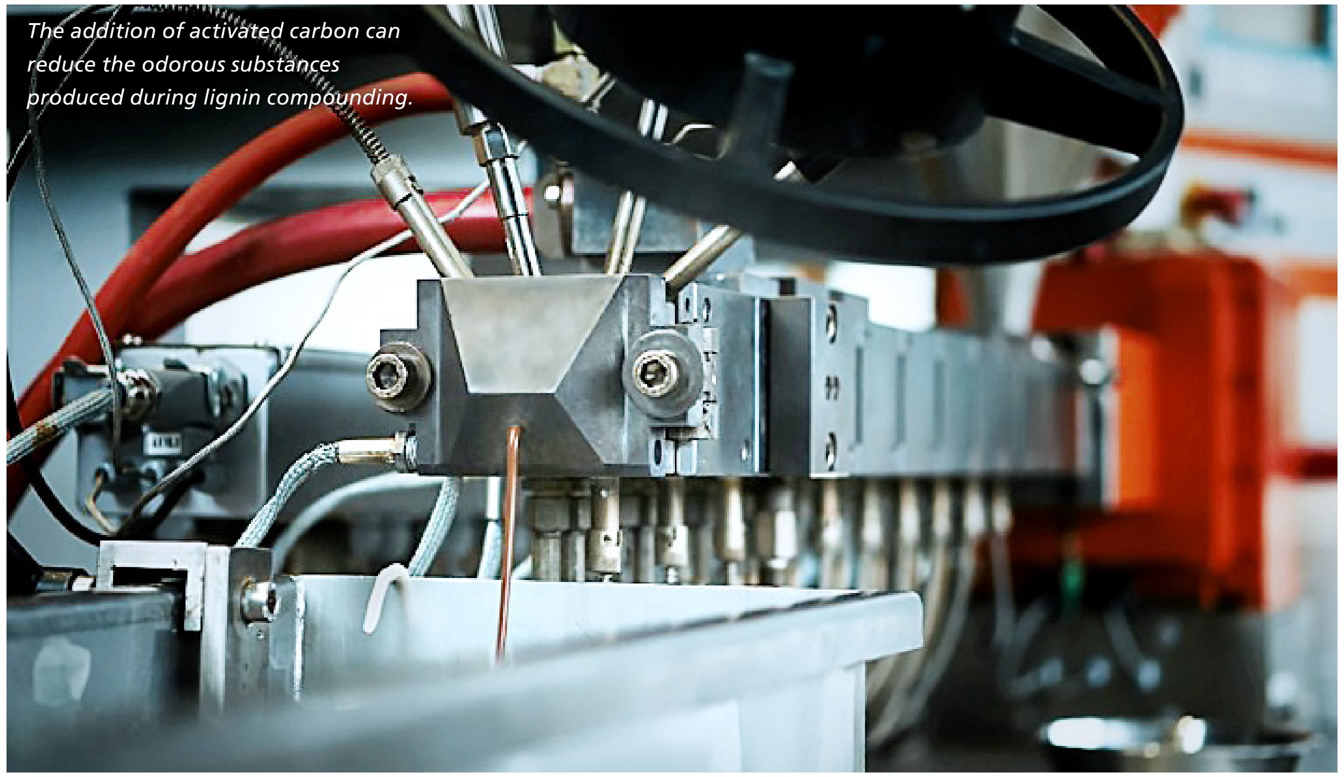
Low-odor lignin blends

The odor of lignin hampers its use in thermoplastic blends and impedes its establishment in mass markets. High temperatures in the manufacturing process further intensify this odor. In the project "LigOdor", researchers investigated the influence that lignin type and matrix polymer have on odor and developed solutions to reduce the odor of thermoplastic lignin blends. The aim was to expand the range of applications for the material. A comparison of different lignin types initially showed that lignin from annual plants produced the weakest and most pleasant odor. The researchers then developed a formulation and process for the production of low-odor thermoplastic lignin blends. Using poly(butylene succinate-co-butylene adipate) (PBSA) as a bio-based polymer matrix enables the production of a completely bio-based material and reduces the odor-generating degradation of lignin due to its low processing temperature. Specifically modifying lignin by adding activated carbon further reduced the perceptible emissions of the blends. A cellulose-based coating was applied to the surface of the molded part as a final sealing to prevent the emission of further odorants. The result was that test persons no longer detected any odor on optimized lignin blends. //

Dr. Melanie Bartel
Material Development and Structure Characterization

Project: *Odor reduction of thermoplastic lignin blends (LigOdor)*
Funding ID: *2219NR172*
Partners: *Zellstoff Stendal GmbH, ESE GmbH, Adesiv GmbH, SWK Innovations GmbH & Co. KG, Linotech GmbH & Co. KG*
Additional contact:
Dr. Gunnar Engelmann (Microencapsulation and Polysaccharide Chemistry)

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages
FNR Fachagentur Nachwachsende Rohstoffe e.V.

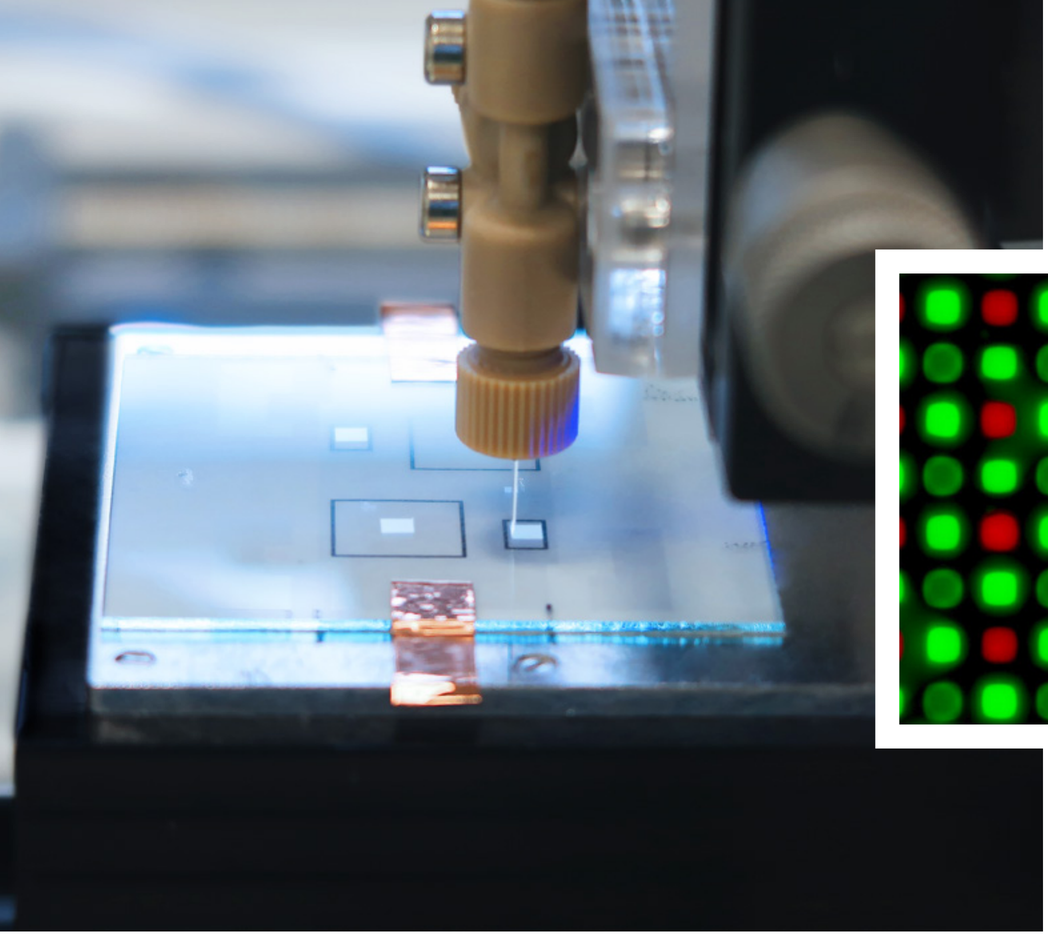


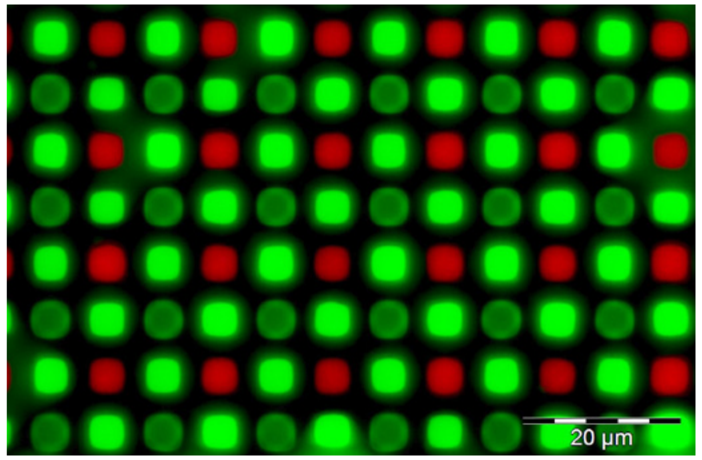
The addition of activated carbon can reduce the odorous substances produced during lignin compounding.

Energy transition and mobility

"With the development of new functional polymers, we are making a significant contribution to the technologies of the energy transition and thus to achieve the climate targets. Today and in 30 years."

Dr. Taybet Bilkay-Troni
Head of Department Polymers und Electronics





Red and green QDs printed at high resolution. Image taken under UV light.

EHDJET printing with high resolution on conductive glass.

Dr. Manuel Gensler
Functional Materials and Devices

__Project:__ High-ACCuracy printed electronics down to µm size, for Organic Large Area Electronics (OLAE) Thin Film Transistor (TFT) and Display Applications (Hi-Accuracy)
__Grant agreement ID:__ 862410
__Partners:__ Joanneum Research Forschungsgesellschaft MbH, Precision Varionic International Ltd., Teknologian Tutkimuskeskus VTT Oy, SmartKem Ltd., Dycotec Materials Ltd., Humboldt-Universität zu Berlin, University College London UCL, Interuniversitair Micro-Electronica Centrum imec, Centro Ricerche Fiat SCPA, Bionanonet Forschungsgesellschaft MbH

Funded by the European Union

Printed displays with quantum dots

Electroluminescent QD-LED displays are exceptionally thin, glow in extremely brilliant colors and can even be printed on flexible films. Quantum dot (QD) materials used in display applications are not evaporated like OLED materials. Instead, they are printed with inkjet. However, the printable droplet volume is physically limited, which is why such displays could not be produced at a resolution higher than 200 pixels per inch (ppi) until now. In the EU-project "Hi-Accuracy", researchers at Fraunhofer IAP are developing special barriers against water vapor, QD materials, inks and processes to achieve a resolution of 300 ppi and more. Such a resolution is needed for smartphones, virtual reality, and other applications. This is achieved by enhancing the electrohydrodynamic jetting process (EHDJET), a method that allows QD-LED inks to be printed to within one micrometer. EHDJET printing is currently receiving a lot of attention because it could solve technological challenges in a variety of other applications as well. The challenge is to print the ink in a highly accurate way so that it can dry in uniform layers without running into adjacent pixels. For some QD materials, it has even been possible to print structures measuring four microns. This will enable resolutions of more than 1000 ppi in the future. //

Revolution in e-mobility

The project "REVOLUTION" involves developing and implementing an innovative technology for the use and processing of recycled plastics in the area of e-mobility. One of the main objectives of the project was to reduce the weight of components, which will extend range and pave the way for future electric vehicles. It will also incorporate the principles of a circular economy and sustainability into the automotive industry by increasing the recovery of materials for recycling and reuse to up to 80 percent.

Fraunhofer IAP is focusing on developing an AI-supported platform which uses recycled plastics to optimize the injection molding process and provides suitable manufacturing parameters. The AI platform draws data from various areas throughout the course of production and processing with the aim of predicting component quality and structural properties when recycled materials are used. This enables the creation of innovative, lightweight components for future electric vehicles which have sustainable end-of-life properties. //

Marcello Ambrosio, M.Sc.
Simulation and Design

__Project:__ Supporting the Electric Vehicle REVOLUTION through maximising Electric Vehicle Range and End-of-Life Vehicle Recovery through optimisation of recycled plastics and advanced light materials (REVOLUTION)
__Grant agreement ID:__ 101006631
__Partners:__ Farplas, Tofas, Maier, LyondellBasell, Clariant, Trinseo, Heathland, VTT, Norner, Idener, Iconiq, Imec, Centro Ricerche Fiat

Funded by the European Union

Dr. Michael Höltig
Nanoscale Energy and Structure Materials

__Project:__ Project initiation between Fraunhofer CAN and SFU Canada in the field of hydrogen research (CANCAN)
__Funding ID:__ 01DM21011
__Partner:__ Simon-Fraser-University (SFU), Vancouver Kanada

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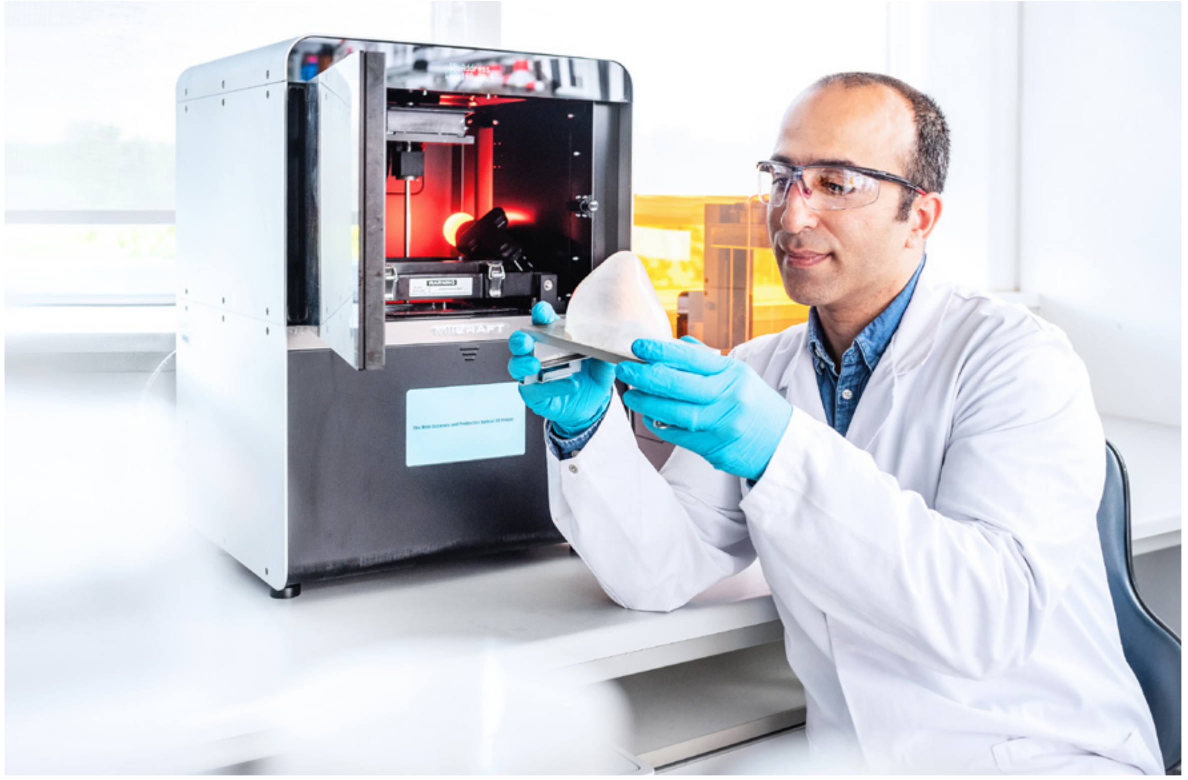
Hydrogen research

Joint research projects that investigated applications in the field of nanoparticle-based hydrogen technology were carried out as part of the "CANCAN" project. The aim was to establish a network between the Nanoscale Energy and Structural Materials working group at the Fraunhofer Center for Applied Nanotechnology CAN (a research division of Fraunhofer IAP) and Simon Fraser University (SFU, Vancouver/Canada). Young scientists at both partner institutions were to be involved in the R&D activities, trained and recruited for future dissertations.

In addition to regular online meetings, grant funding enabled two in-person project meetings lasting several days. In June 2022, participants met in Vancouver to exchange information on the processing and characterization of the catalyst material produced at CAN from associated fuel cell tests. The first meeting on the topic of catalyst synthesis had already taken place in the CAN research division in Hamburg in November 2021. In addition to providing scientific insights into the work of the project partners, the two meetings enabled everyone involved to personally get to know each other. The project revealed many points for further collaboration. //

Health and quality of life



"With novel polymers for artificial pericardial tissues, for example, we print precisely fitting implants that meet the mechanical requirements."

Dr. Hadi Bakhshi
Department Biofunctionalized Materials and (Glyco)Biotechnology

Strengthening antibodies against viruses with polymers

Dr. Anne Krüger-Genge
Healthcare, Biomaterials and Cosmeceuticals

__Project:__ Development of an antibody fragment-polymer conjugate as a multivalent therapeutic agent against viruses (COVITRAP) __Funding ID:__ 01DP21012 __Partners:__ Universität Potsdam, Ghent University (UGENT, Belgium) Universitas Padjadjaran (UNPAD, Indonesia)
__Additional contact:__ Dr. Ulrich Glebe

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As part of the joint project "COVITRAP", Fraunhofer IAP is collaborating with the University of Padjadjaran in Indonesia and Ghent University in Belgium to develop biocompatible antibody-polymer conjugates. These are designed to effectively bind the spike proteins of the SARS-CoV-2 virus. The conjugation of polymers to antibodies has been known for decades to increase protein stability. As a result, the antibodies have a longer residence time in the body. However, the antibody-polymer conjugates in the "COVITRAP" project are designed to go one step further: one polymer will bind together multiple antibodies. This scientific approach is based on the fact that the spike proteins of SARS-CoV-2 have a trimeric structure and thus three binding sites with which they attach to the ACE2 receptors of human cells. The multivalent conjugates were able to bind to multiple binding sites of the spike proteins, thus cutting off the viruses even more effectively and inhibiting or significantly reducing the infection of cells. Such conjugates could be used both therapeutically and prophylactically in the future. This approach can later be applied to the diagnosis, prophylaxis and treatment of novel viruses. //

Cellulose nanoparticles as a sustainable defoamer

In the project "BIO-DEFOAM", researchers have developed a high-performance, biodegradable and biobased defoamer. This prevents the formation of foam in processing operations or destroys foam that has already formed, for example, in paper production, fermentation in bioreactors, wastewater treatment, cleaning, or food processing. Commonly used defoamers are currently based on a mixture of silicone or mineral oils and silica particles. These mixtures are neither biodegradable nor are they sustainable as they are largely produced from fossil raw materials. Biodegradable defoamers with vegetable oil as the main active ingredient do exist, however they have so far exhibited a comparatively poor defoaming performance. Fraunhofer IAP has developed a new sustainable concept alongside industrial partners. Here, vegetable oils serve as carriers of modified biogenic cellulose nanoparticles, which bring about effective foam destruction. //

Dr. Vesna Aleksandrovic-Bondzic
Sustainable Polymers / Home and Personal Care

__Project:__ BIO-DEFOAM - Biodegradable and sustainable defoamers
__Partner:__ Schill + Seilacher Struktol GmbH

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Innovative formulation through biofunctionalization

Research into RNA-based active ingredients has not just been happening since the Corona pandemic, however the pandemic has accelerated the development of RNA technology. RNA active ingredients need the right formulation to increase stability and bioavailability and to enable delivery. A cleverly devised formulation can bring many advantages for other active ingredients as well.

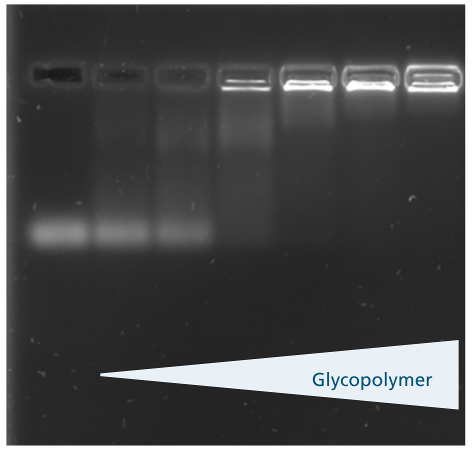
Researchers at Fraunhofer IAP are developing polymer- and lipid-based formulations and specially modifying them for this purpose. This gives the formulations additional properties and enables directed drug transport. Particular attention is being paid to the attachment of sugar molecules, which possess certain charges or are hydrophilic and can enter into selective interactions with cell receptors or lectins. This adapts the formulation to the application site, allowing it to reach the site in a targeted manner and deliver the active ingredient.

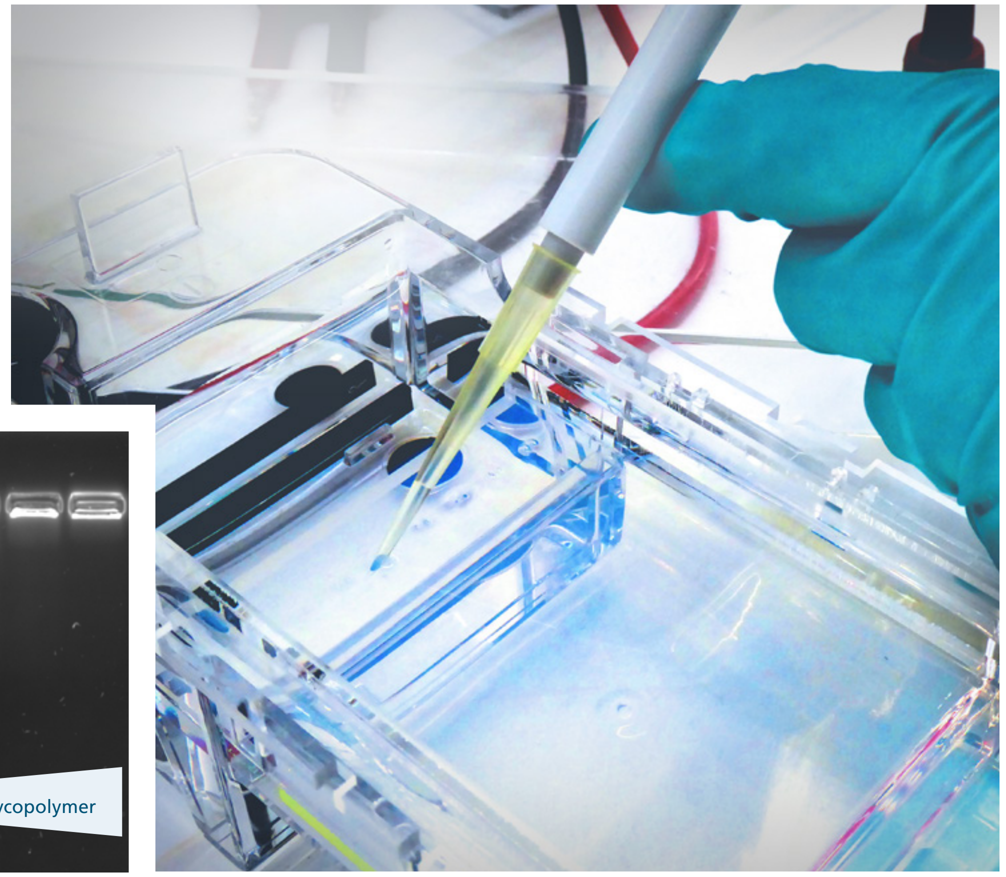
In addition to RNA molecules, other oligonucleotides and viruses are also formulated in this way and are tested in various cell, tissue and mouse models. //

Dr. Sophia Rosencrantz
Biofunctionalized Materials and (Glyco)Biotechnology

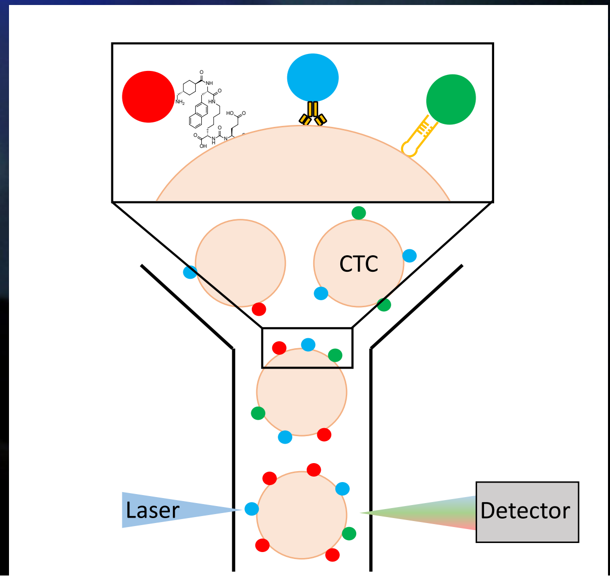
__Project:__ CIMD-Platform RNA-Therapeutics
__Partners:__ Joint project with Fraunhofer ITEM as lead institute

Funded within the Cluster of Excellence Immune-Mediated Diseases of the Fraunhofer-Gesellschaft.





Demonstration of successful formulation via gel electrophoresis. The results show that with higher amounts of glycopolymer, the formulation of RNA increasingly improves.



Multiplex characterization of circulating tumor cells (CTCs) using fluorescent and biofunctionalized nanoparticles.

Dr. Marina Mutas
Nanomedical Applications

__Project:__ Hamburg Translational Research in Cancer: Stimulating, Shaping and Sustaining Scientific Careers
__Partner:__ Institute for Tumor biology, University Medical Center Hamburg-Eppendorf

Funded by Mildred Scheel Cancer Career Center (MSNZ) Hamburg, German Cancer Aid (DKH).

Tracking tumor cells with nanotechnology

The proliferation of prostate cancer cells through circulating tumor cells (CTCs) in the blood has a significant impact on the formation of metastases and the further course of disease. In this context, the number and heterogeneity of the CTCs correlate with the malignancy of the proliferation and the patient's prognosis. Liquid biopsies (LB) can provide a real-time picture of the cancer by detecting CTCs in a non-invasive way with just one blood sample.

Fraunhofer IAP is collaborating with the University Medical Center Hamburg on a nanoparticle-based LB assay that combines CTC enrichment and characterization. After magnetic enrichment, the CTCs are analyzed using a library of tumor-specific fluorescent nanoparticles. The fluorescence signal enables the characterization of the circulating tumor cells. The newly developed multiplex nanosensor platform allows for the diagnosis, prognosis and treatment monitoring of patients with prostate cancer and potentially provides early diagnosis of metastases and recurrence. //

Fighting breast cancer with nanomedicine

Every year, around 10,000 people in Germany are diagnosed with triple-negative breast cancer (TNBC). The development of a new nanomedicine product to combat this particularly aggressive form of breast tumor is the focus of the project "PP-TNBC". The active ingredient paclitaxel is transported to the target site in the human body with the help of polymeric micelles. A team at the Pilot Plant Center PAZ is developing the synthesis process for the new drug and transferring it to an industrial scale. The scientists are also developing the protocols for all of the drug components – monomers and excipients – to meet the quality standards, i.e. good manufacturing practice, of the European Medicines Agency. This also applies to the polymerization process. Here they are comparing two polymerization processes in terms of their reproducibility. Furthermore, block copolymers modified with deferoxamine are also synthesized at the PAZ as a precursor for radioactive labeling. //

Dr. Hendrik Budde
Synthesis and Product Development

__Project:__ Drug delivery: Pacitaxel-loaded polymeric micelles (pellets) for the treatment of triple-negative breast cancer (PP-TNBC) – From synthesis to efficacy to the clinic

__Funding ID:__ 16GW0319K

__Partner:__ Uniklinik RWTH Aachen, EPO GmbH Berlin-Buch, Ardena BV

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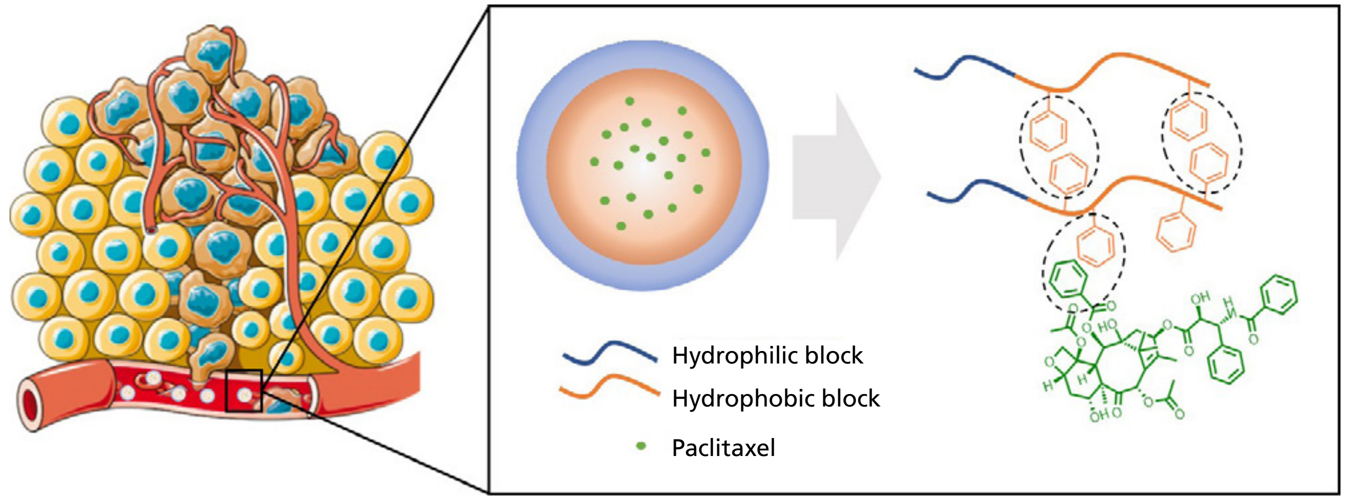
Bundesministerium für Bildung und Forschung

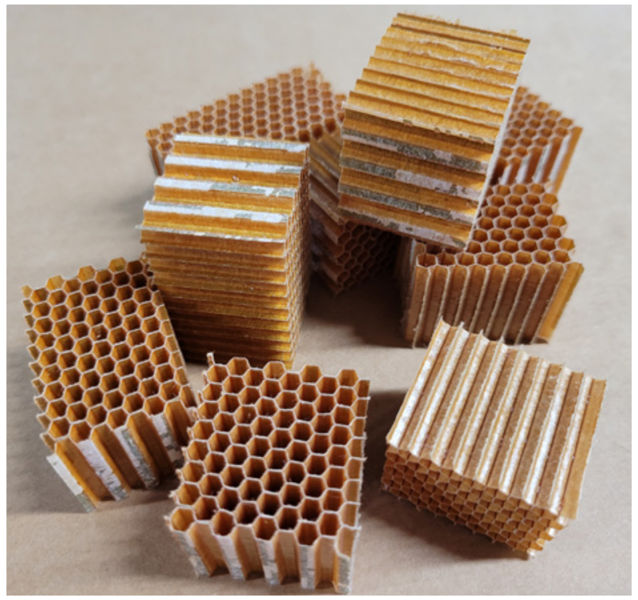


Schematic representation of drug-containing picelles within tumor tissue.

Industry and technology

"Our goal at Fraunhofer IAP: to get a car tire rolling with less abrasion and thus reduce the distribution of micro-plastics into the environment."

Dr. Marlen Malke
Department Synthesis and Product Development



Microwave-assisted solvolysis processes can be used to recover short fibers from aramid honeycombs.

Dr. Theresa Förster
Polymer Development

Project: *Selective recovery of aramid fibres for the production of sustainable paper-based materials (SEpARAte)*
Funding ID: *IGF-project 21150*
Partner: *Papiertechnische Stiftung (PTS), Technical University of Applied Sciences Wildau*

Bundesministerium für Wirtschaft und Klimaschutz

Forschungsnetzwerk Mittelstand

Industrielle Gemeinschaftsforschung

Recycling aramid honeycombs

The shortage of raw materials is a global problem and calls for responsible and sustainable use of the remaining resources. Establishing new material cycles is an important step towards minimizing the consumption of resources in the future. Innovative recycling technologies are therefore needed, especially in the field of lightweight materials. In recent years, researchers in the Polymer Materials and Composites PYCO research division have worked intensively on the chemical recycling of thermoset fiber composite materials and have developed a recycling concept for epoxy resin- and phenolic resin-based composites, among other things. This know-how has been successfully transferred to the recycling of aramid honeycombs in the project "SEpARAtE".

Aramid honeycombs are fiber composites containing phenolic resin that are used, for example, as flame-resistant core materials in aircraft cabins. A solvolysis-based process was developed as part of the AiF-IGF project "SEpARAtE" which enables the multi-material composite to be broken down in such a way that aramid fibers can be recovered with only moderate reduction in fiber length. The project team is collaborating with the Papiertechnische Stiftung and the Technical University of Applied Sciences Wildau to investigate the reuse of these recycled fibers in the production of nonwovens and in microwave-assisted solvolysis processes. //

Measuring temperature with polymer solutions

Fiber optic temperature sensors are suitable for use in environments with strong electromagnetic fields. For example, they are used for monitoring temperature during the charging of electric vehicle batteries. Currently, so-called fiber Bragg gratings fulfill this purpose. Converting the measurement signals into temperature values requires a spectral resolution of the light hitting the detector and a conversion of wavelength values into temperature values. Thermo-responsive polymer solutions exhibit temperature-dependent light transmission and therefore open up the possibility of assigning light intensity to a temperature value without complicated signal processing. This allows for the use of much simpler evaluation electronics and software. Polymer solutions developed at Fraunhofer IAP are tailor-made for use in fiber optic temperature sensors. They can be easily adapted for use in different temperature ranges and temperature spans. They also offer high measurement accuracy due to their low hysteresis in the temperature cycle. //

Dr. Erik Wischerhoff
Sensors and Actuators

Project: *Fiber optic temperature sensor for absolute temperature measurements based upon thermore-sponsive polymers (TurbTemp)*
Funding ID: *03VP07851*
Partner: *Bundesanstalt für Materialforschung und -prüfung (BAM)*

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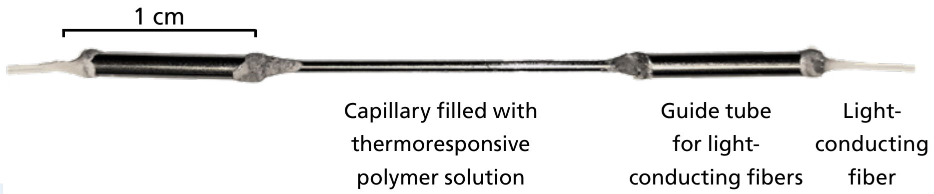
Prototype of fiber optic temperature sensor. © BAM, Division 8.6 Fibre Optic Sensors



Dr. Steffen Tröger-Müller
Membranes and Functional Films

Project: *Efficiency increase and emission minimization of biogas plants with simultaneous reduction of the plant complexity through innovative gas separation processes,subproject 1: Coordination and membrane development (Bio4Value)*
Funding ID: *2220NR156*
Partner: *KS-Kunststoffbau, Leibniz ATB*

Gefördert durch:

Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages

FNR Fachagentur Nachwachsende Rohstoffe e.V.

Biomethane for the chemical industry

Methane is widely used as an energy source, but it is also a critical resource for the chemical industry in Germany. This dependence poses a major problem, especially given the current geopolitical situation. The focus of the "Bio4Value" project is to extract methane from biogas and develop it into a raw material for the chemical industry. Here at Fraunhofer IAP we are developing membranes for the targeted upgrading of biogas as well as a membrane module that can be cost-effectively retrofitted, especially to small biogas plants. Biogas is thus converted into biomethane for the chemical industry. At the same time, any carbon dioxide produced is separated and used as a by-product instead of escaping into the atmosphere. //

The Fraunhofer-Gesellschaft

The Fraunhofer-Gesellschaft, based in Germany, is the world's leading applied research organization. Prioritizing key future-relevant technologies and commercializing its findings in business and industry, it plays a major role in the innovation process. A trailblazer and trendsetter in innovative developments and research excellence, the Fraunhofer-Gesellschaft supports science and industry with inspiring ideas and sustainable scientific and technological solutions and is helping shape our society and our future.

At the Fraunhofer-Gesellschaft, interdisciplinary research teams work with partners from industry and government to turn pioneering ideas into innovative technologies, coordinate and implement system-relevant research projects and strengthen the German and European economies with a commitment to value creation that is based on ethical values. International collaboration with outstanding research partners and companies from around the world brings the Fraunhofer-Gesellschaft into direct contact with the most prominent scientific communities and most influential economic regions.

Joseph von Fraunhofer (1787–1826)

The Fraunhofer-Gesellschaft owes its name to the Munich scholar Joseph von Fraunhofer, who was equally successful as a scientist, inventor and entrepreneur.

Founded in 1949, the Fraunhofer-Gesellschaft now operates 76 institutes and research units throughout Germany. Currently around 30,800 employees, predominantly scientists and engineers, work with an annual research budget of about 3.0 billion euros, 2.6 billion euros of which is designated as contract research. Around two thirds of Fraunhofer contract research revenue is generated from industry contracts and publicly funded research projects. The German federal and state governments contribute around another third as base funding, enabling the Fraunhofer institutes to develop solutions now to problems that will drastically impact industry and society in the near future.

The impact of applied research goes far beyond the direct benefits to the client. Fraunhofer institutes strengthen companies' performance and efficiency and promote the acceptance of new technologies within society while also training the future generation of scientists and engineers that the economy so urgently requires.

As a scientific organization, the key to our success is highly motivated employees engaged in cutting-edge research. Fraunhofer therefore offers its researchers the opportunity to undertake independent, creative and, at the same time, targeted work. We help our employees develop professional and personal skills that will enable them to take up positions of responsibility within Fraunhofer itself or at universities, within industry and in society at large. Students involved in projects at Fraunhofer institutes have excellent career prospects on account of the practical vocational training they enjoy and the opportunity to interact with contract partners at an early stage in their career.

The Fraunhofer-Gesellschaft is a recognized non-profit organization named after Joseph von Fraunhofer (1787–1826), an illustrious researcher, inventor and entrepreneur hailing from Munich. //

Figures as of March 2023

thi rty years
Fraunhofer IAP

Board of trustees 2022

The board of trustees advises and supports the Fraunhofer-Gesellschaft as well as the institute´s directors. The following persons were members of the board of trustees of Fraunhofer IAP in 2022.

Networks and groups

Networking and knowledge exchange are important elements of successful research. Fraunhofer IAP cooperates with Fraunhofer Institutes from different fields as part of Fraunhofer groups and networks.

Our scientists also sit on many reputable committees and are involved in various associations and networks.

- Fraunhofer Strategic Research Field Bioeconomy
- Fraunhofer Group for Materials and Components – MATERIALS
- Fraunhofer Cluster of Excellence "Circular Plastics Economy" CCPE
- Fraunhofer Cluster of Excellence "Programmable Materials" CPM
- Fraunhofer Chemistry Alliance
- Fraunhofer Nanotechnology FNT
- Fraunhofer POLO®
- Research Area Technical Textiles TEXTIL
- Fraunhofer Sustainability Network
- Cultural Heritage Research Alliance

Fraunhofer Group for Materials and Components – MATERIALS

Fraunhofer IAP is a member of the Fraunhofer Group for Materials and Components – MATERIALS. The Fraunhofer MATERIALS group pools the expertise of the Fraunhofer Institutes working in the area of materials science and engineering. Materials science and engineering at Fraunhofer covers the entire value chain, from developing new and improving or application-specificly adapting of existing materials to manufacturing technology on a quasi-industrial scale, in addition to characterizing properties and assessing service behavior. This also applies to the components and products made from these materials and their system behavior in relevant applications.

Equal importance is attached to experimental studies in laboratories, technical centers and pilot plants and to methods of numerical simulation and modeling; they are used across scales, from molecule and component to complex system and process simulation.

Where materials are concerned, the Fraunhofer MATERIALS group covers the full spectrum of metals, inorganic non-metals, polymers, and materials made from renewable resources, as well as semiconductor materials. Over the last few years, hybrid materials have gained significantly in importance. //

Key figures:
- largest group within the Fraunhofer-Gesellschaft
- 14 member institutes
- 7 guest institutes
- more than 5000 staff members

Core topics:
- promoting the success of Industry 4.0 through suitable material concepts
- hybrid lightweight construction
- development of materials used to generate, store transport and convert renewable energy

Low-wind-speed rotors made of fiber composite material

© Thomas Kuhlenbeck

Fraunhofer Strategic Research Field Bioeconomy

Renewable raw materials and biobased processes decisively contribute to a sustainable way of life and economy. This was the conclusion of the roadmap "Circular Bioeconomy for Germany", which the Fraunhofer-Gesellschaft submitted to the Federal Ministry of Education and Research (BMBF) and the Federal Ministry of Economics and Climate Protection (BMWK) in December 2022. In their recommendations for action, the researchers outline how the performance of German industry can be maintained or increased in times of multiple global challenges and how the bioeconomy can simultaneously contribute to achieving climate targets and protecting biodiversity. The development of the roadmap was coordinated by the Fraunhofer Strategic Research Field (FSF) "Bioeconomy".

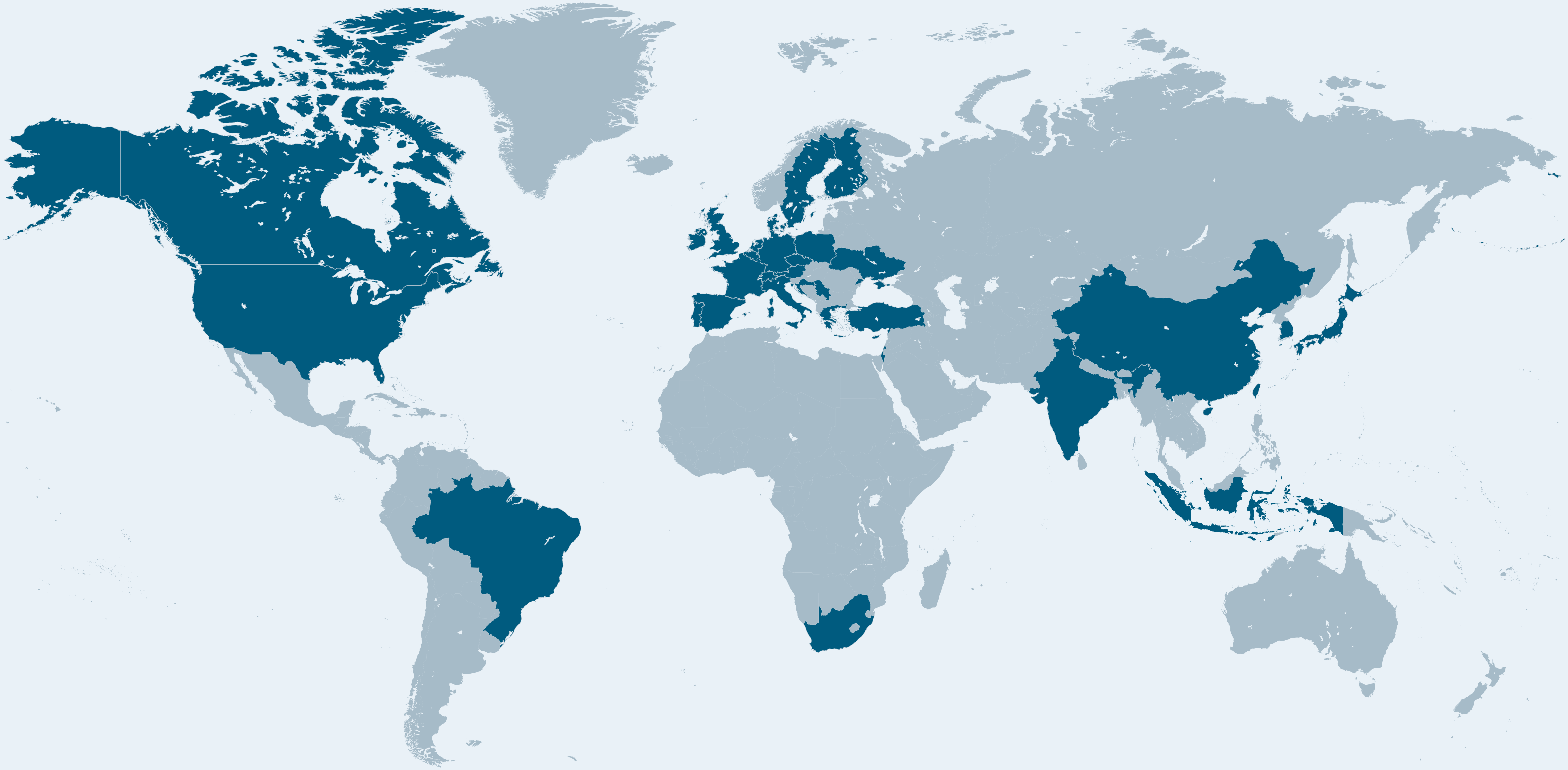
Bio-based plastics and recyclable materials are an important component of the circular bioeconomy and are a focus of materials research at Fraunhofer IAP. Many biogenic materials are also biodegradable. In short-lived applications, such as packaging, they have the potential to reduce the accumulation of plastic waste in the environment. In order to achieve value-added cascades focused on material and energy efficiency, the authors recommend that priority be placed on recycling such plastics rather than having them fully degrade.

Promoting the use of biobased plastics and facilitating the switch from conventional, petroleum-based materials to sustainable alternatives requires further research. Bioplastics still need to be optimized for use in various product sectors. At the same time, manufacturing and processing methods must be transferred to an industrial scale.

In addition to the technological possibilities and requirements, the roadmap also underlines the need to adapt the framework conditions. The development of the technology for bio-based plastics could be supported, for example, by carbon taxes on fossil raw materials. This would allow the favorable carbon footprint of biobased materials to become a competitive price advantage. //

"With our expertise in the modification, optimization and production of biopolymers, we create the basis for sustainable products."

Prof. Dr. Alexander Böker,
Director Fraunhofer IAP and Spokesman of the Fraunhofer Strategic Research Field Bioeconomy



Collaborations around the world

The scientists at Fraunhofer IAP are members of international networks and cooperate with research institutes, universities and companies in Germany, Europe and around the world. Many research topics are also tackled jointly within the Fraunhofer-Gesellschaft.

Collaboration with

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107 Universities
51 Research Institutions

35 countries
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Photo acknowledgements

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