Federal Ministry
of Education
and Research

# Innovation made easy

**Ideas contest: “New products for the bioeconomy”**

The mycelium of a fungus provides enzymes for biologically cleaning wastewater.

# Preface

Islands of plastic as vast as continents floating in the sea, poisonous waste that can be disposed of only at great expense – we need to permanently change the way we live and do business. The bioeconomy offers us custom solutions for the most pressing challenges facing our society such as food security, climate change, and the conservation of natural resources. Instead of fossil resources, the bioeconomy opts for renewable raw materials and biological principles such as the material cycle. Many biological systems are efficient, robust and don't produce waste, only material cycles – thereby making them sustainable.

The Federal Government recognised such potential early on and paved the way for the switch to a bio-based, sustainable society and economy. In 2010, led by the Federal Ministry of Education and Research, the government developed and put forward its "National Research Strategy BioEconomy 2030". One of the aims of this strategy is to use scientific findings to bring products to market more quickly. We are looking for ideas for "New products for the bioeconomy" – a competition that we set up in 2013. We hope to encourage not only scientists, but also businesses to test the marketability of their original ideas for new bio-based products or processes. After all, the obstacles to getting a new product off the ground are particularly high at the beginning. More than 100 ideas have been funded with almost 6 million euros to date.

This brochure looks back at four successful years of innovative product ideas and visions. It highlights the extraordinary diversity and originality of the approaches to a bio-based, sustainable economy.

It is well worth taking a look inside.

Your Federal Ministry of Education and Research

# Ideas contest: “New products for the bioeconomy”

**Developing new ideas for bio-based products or processes, testing their feasibility and making them a reality: The ideas contest held by the Federal Ministry of Education and Research (BMBF) offers researchers with original business ideas for the bioeconomy enticing funding to help out during the early stages of development.**

## Sustainable, bio-based economy – call for new ideas

Demand for sustainable and environmentally-friendly products is on the rise. Environmentally-conscious consumers are driving the change toward sustainable consumption. At the same time, governments all over the world have committed to support this development by implementing the UN’s Sustainable Development Goals – tackling challenges such as a growing world population, climate change, and the finite nature of resources. The bioeconomy can contribute to the development of new solutions. It is based on the efficient and sustainable use of biological knowledge. The bioeconomy also follows the principle of a bio-based economy that is oriented around material cycles

found in nature which can be relevant for all sectors of industry. The bioeconomy brings about enormous potential for scientific and economic innovation. Novel ideas for bio-based products, processes and services that find their way onto the market are a key requirement for making a global bioeconomy a reality, but also for Germany as a top business location and for making our country competitive in future.

**The National Research Strategy BioEconomy 2030**

At the end of 2010, under the chairmanship of the Federal Ministry of Education and Research (BMBF), the Federal Government took the first steps towards the development of a German bio-based economy thanks to its "National Research Strategy BioEconomy 2030", becoming a global leader in the field. Research funding programmes provided huge support to the German bioeconomy, resulting in the development of considerable expertise and key infrastructure. Today, there are 745 scientific and humanities institutes across Germany dedicated to the bioeconomy.

Between 2010 and 2016 alone, the BMBF awarded 876 million euros in grants to around 1,800 individual and collaborative projects. More than 30 funding measures have advanced a wealth of research

**Where the bioeconomy is involved**

Whether it's enzymes in washing powder, skin cream or dough, car tyres made from dandelion rubber, bioplastic crockery, t-shirts made from waste material such as coffee grounds or shoes with fibres from spider silk proteins – there is already a diverse range of innovative products that have found their way from the lab to our daily lives thanks to bioeconomy research. Thanks to scientific advances, biological resources can be tapped into more effectively, while new technologies allow for new avenues to be explored in how to use them. The BMBF information portal, biooekonomie.de, offers an overview of the various developments in science and technology.

*For further information see:* biooekonomie.de

activities in the natural sciences, but also social science, economics and humanities, as well as promoting innovative business ideas within a diverse range of industries.

**Over 1,800 bioeconomy projects funded by the Federal Ministry of Education and Research**

We've seen that a bio-based economy calls for extraordinary ideas and new kinds of funding instruments. Many minds harbour creative potential just waiting to be unleashed. It's not unusual for creative ideas and innovative approaches to be cast aside or go unpursued because they appear absurd or complicated at first. A lack of funding can also be the cause.

**Funding creative solutions from the get go**

It was against that backdrop that the Federal Ministry of Education and Research first organised the "New products for the bioeconomy" ideas contest in 2013. The objective of the contest is to offer people with original product ideas for a bio-based economy a clear port of call and straightforward start-up funding. A concept that works.

**Facts and figures for the ideas contest**

To date, the four rounds of the "New products for the bioeconomy" ideas contest have seen almost **6 million euros** in funding provided for **108 new ideas** as part of the test phase, of which **51 collaborative projects** have been selected from those for the feasibility phase. The Federal Ministry of Education and Research has made a total of **43 million euros** available. The product ideas originate from sectors such as agriculture, food and health. Many projects are concerned with the bio-based manufacture of materials which are important for industrial production. Materials research also plays a key role in that regard, in addition to device and IT-specific developments. Other funded projects include bioenergy or the development of new kinds of packaging.

Over a hundred ideas have received start-up financing with more than 50 making it through to the second phase of funding. Approximately 43 million euros have already been made available (see infobox above).

The ideas contest is primarily geared towards young scientists at technical universities and independent research institutes. Private individuals also have the opportunity to enter their ideas, however. Funding is granted within a two-tier system: The start-up financing totalling a maximum of 65,000 euros is used to explore early phase high-risk product ideas, to plan their technical implementation and to build a network of partners. The second stage involves a jury which decides if the product idea is to receive further funding for its realisation.

## Straightforward application procedure is well received

The "New products for the bioeconomy" ideas contest is unique in that the application procedure is very straightforward compared to other funding instruments. Notable features of the ideas contest include minimum bureaucracy and a streamlined selection procedure. The application process is outlined on six standard A4 sheets. The annual cut-off date for submission to "Project Management Jülich" is always in February.

Taking part is definitely worthwhile! Just consider the impressive record of the ideas seen in the contest. This brochure gives you a glimpse into the wide-ranging ideas that have received funding up to now. You'll be introduced to a cutting-edge aquaculture system where popular gourmet fish such as Lake Constance whitefish are raised together with noble crayfish. If this system can be implemented on a larger scale, it will be a key step in the fight against the diminishing stocks of these fish.

Other researchers are developing a bio-based "pill" that can rectify issues with biogas plants quickly and effectively. A biotechnology start-up has created a new, cost-effective method for manufacturing peptides used as bioactive additives or active ingredients within the pharmaceutical and cosmetics industries.

A different project has seen the development of mobile mini sensor spheres which float in small and large bioreactors, transmitting important measurement values to a base station. The adhesive protein in mussels has inspired another team of scientists to develop a process to produce a bio-based superglue.

**Minimum bureaucracy and a streamlined selection procedure**

**An overview of the "New products for the bioeconomy" ideas contest**

**Introduce your idea:** Outline your original idea for a bio-based product on up to six A4 pages and apply for funding using this draft.

**Plan how to implement the idea:** The "test phase" gives you twelve months and up to 65,000 euros to explore your idea, create a project plan and find suitable partners. A jury decides if funding is to continue.

**Implement the idea as a project:** In the "feasibility phase", the Federal Ministry for Research supports you and your project partners for around two years so that a product or a company can be formed from the idea. The budget depends on actual needs.

**The brochure provides examples from the ideas contest**

Beyond these five examples, the ideas contest has been able to provide the necessary seed capital to make promising projects a reality: one such project involves the development of a biofilter that uses enzymes to target the breakdown of xenobiotics in wastewater. Xenobiotics are chemical compounds, such as crop protection agents, that are rarely biodegradable. Another team is building robust and lightweight disposable camp beds made from cardboard for use on humanitarian missions. Yet another organisation funded by the ideas contest has been manufacturing a high-quality bio-based composite from coffee grounds.

A successful project from the Federal government's schools' competition for young people, "Jugend forscht", has even received funding from the ideas contest. A Bavarian team made up of school pupils developed a procedure to generate industrial base chemicals such as olefine from rapeseed oil.

The ideas contest has already unleashed a wealth of creative potential over the past number of years. Let this brochure inspire you to contribute to the bioeconomy with your own product ideas.

# Breeding whitefish with noble crayfish

**A Tübingen-based research team is testing a cutting-edge approach to aquaculture where popular gourmet fish such as Lake Constance whitefish and lavaret are raised together with noble crayfish.**

The Lake Constance whitefish, a relative of the salmon, is a popular gourmet fish. Yet fishermen rarely capture the *Coregonus wartmanni* in their nets. This can be attributed to lower phosphate values and increased fishing in Germany's largest inland lake. There is high demand for these delicacies amongst local restaurateurs and they are often imported from countries such as Canada, Finland or Italy. The European noble crayfish (*Astacus astacus*) is on the red list of species at risk of extinction. This relative of the lobster is an increasingly popular gourmet food in star cuisine. Thanks to nature conservation projects, the species is likely to be recolonised.

## Great demand despite rapidly diminishing stocks

## Two fine products from one aquaculture

By raising both freshwater species together in an aquaculture, Norbert Wagemann not only intends on preventing the species from dying out, but also hopes to satisfy the high demand for premium, local products. The ideas contest “New products for the bio-economy” offered him the opportunity to develop and implement his idea.

During the test phase, the aquaculture expert from the Steinbeis Innovation gGmbh Institute for Sustainable Resource Management in Tübingen looked for suitable partners and locations. He found the partners he needed at the Koblenz-Landau University, Christian-Albrechts University in Kiel, Senect GmbH in Landau and Krebszucht Jeske in Oeversee. Together, these partners developed concepts to transform the polyculture into a business model.

## Whitefish in open water, noble crayfish on the waterbed

The combined cultivating of fish and crustaceans was an ideal choice as the two species don’t interfere with each other’s habitats. Crustaceans live on the water bed, whereas whitefish live in open water. The noble crayfish recycles the whitefish’s remaining food and even destroys some fish excrement, thereby reducing water pollution.

Circulation system where the polyculture is tested.

As a counterpart to the Lake Constance whitefish, which is found exclusively in the Alpine uplands, the researchers also tested their polyculture concept using a close relative from the north: The lavaret found in the lakes of Mecklenburg-Western Pomerania and Schleswig-Holstein, where it is a prized gourmet fish. “It allows us to give our polyculture the opportunity to prosper throughout Germany”, says Wagemann.

The Lake Constance whitefish is a much sought-after gourmet fish.

The polyculture has been tested not only in pond systems, but also in circular systems in the north and south of the country. Catches, measurements and weighing all became routine ways to determine to what extent the crustaceans and fish were thriving. In addition, food and water consumption, energy costs and labour costs were gathered to document the cost-effectiveness of the combined aquaculture. And it was a huge success: Whitefish and noble crayfish were raised together successfully and they even managed to multiply. In the case of the Lake Constance whitefish, two and a half years proved to be too short for the project to result in their numbers increasing.

A 3-star restaurant in the Black Forest is already growing the noble crayfish with the Lake Constance whitefish in its own pond and also plans on making the two species available for repopulating bodies of water. Aquaculture expert Wagemann now plans on getting more businesses on board with his polyculture procedure.

**An overview of project details**

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| **Project title:** | Polyculture of European noble crayfish with Lake Constance whitefish or lavaret |
| **Project manager:** | Norbert Wagemann, Steinbeis Innovation gGmbH |
| **Partners:** | University Koblenz-Landau, Kiel University, Senect GmbH in Landau, Krebszucht Jeske in Oeversee |
| **Funding:** | Test phase: 2014 (50,000 euros)<br>Feasibility phase: 10/2015 to 03/2018 (1.1 million euros) |

# “Polyculture improves water quality”

**Raising whitefish and noble crayfish together in an aquaculture – as part of the “New products for the bioeconomy” ideas contest, Norbert Wagemann tested whether this combination was economically viable and sustainable.**

**Norbert Wagemann** holds a qualification in forest science, is managing partner at the Institute for Sustainable Resource Management and works at Koblenz-Landau University.

What were the particular challenges in your poly-aquaculture project?

**Wagemann:** The fish should not only be reared in ponds or lakes with noble crayfish, but also multiply. As Lake Constance whitefish, lavaret and noble crayfish are a wild, non-domesticated species, their behaviour and optimum living conditions were unknown. To that end, we had to find the right mix and population density for the respective species.

What are the effects on the environment of these fish and crustaceans sharing a habitat?

**Wagemann:** The polyculture doesn’t negatively impact water quality, it actually results in vast improvements to quality. Water pollution and remains from fish excrement was much lower than that found in conventional aquaculture systems.

What was the outcome of the feasibility study?

**Wagemann:** We demonstrated that the polyculture works in a real-life setting and that it is cost effective. The optimum population density must be determined on a case-by-case basis. The project enabled us to develop a concept that we could successfully implement in time and multiply. The ideas contest helped the project get the best partners on board at an early stage.

# Neutralising excessive acidity in biogas plants

**If overacidification occurs in biogas plants, they can start to struggle or even come to a complete standstill. Researchers in Leipzig are developing a bio-based "pill" that can quickly and efficiently get biogas plants back on track.**

Germany has more than 9,000 biogas plants. At the heart of these plants are huge bioreactors known as fermenters. They contain microorganisms which transform biomass from plants, sewage or harvest residues into biogas and other fermented products. The resulting biogas is a mixture of methane and carbon dioxide that is then then used to produce electricity on site in a combined heat and power plant.

The fermenting process doesn't always work smoothly: depending on the composition of the input raw materials, it can result in too little or a surplus of nutrients or temperature fluctuations. It is particularly

## Microorganisms ferment biomass in fermenters

worrying in the event of overacidification. “In the worst-case scenario, the plant will shut down, taking months to get it back on track,” explains Fabian Bonk of the Helmholtz Centre for Environmental Research (UFZ) in Leipzig.

## Chemicals not always helpful in the event of excess acid

Time-consuming analyses are required to determine whether or not organic acids are accumulating in the fermenters. Another warning signal for plant operators is if the level of methane production starts to sink. An immediate measure taken to counteract against excess acidity is to reduce the supply of biomass. Chemicals are also deployed to regulate the pH value and neutralise the excess organic acids. These strategies keep biogas production ticking over, but they often come at a price. It costs the plant operator around 40,000 euros to run a biogas plant for 60 days with 30% less revenue.

The Leipzig-based environmental researchers led by Bonk want to change this. Their idea: They plan on developing a kind of biogas pill, a bio-based antidote to quickly and effectively fight against overacidification in fermenters. The researchers aren’t opting for chemicals, but microbial assistants. “We are making available an additive that will act on the microbial population in the fermenter, thereby resolving the issue of overacidification,” explains the environmental engineer.

### An overview of project details

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| **Project title:** | Biogas pill – developing a product to combat over-acidification in biogas plants |
| **Project manager:** | Fabian Bonk, Helmholtz Centre for Environmental Research (UFZ) Leipzig |
| **Funding:** | Test phase: April to December 2017 (50,000 euros)<br>Feasibility phase: Approval still pending |

### Study on cases of over-acidification in Germany

The test phase for the "New products for the bio-economy" idea contest gave the team in Leipzig the opportunity to explore the technical and economic potential of their idea. The researchers from the knowledge and technology transfer department of the UFZ received support for a market study. The research revealed that over-acidification is in fact a major problem for biogas plant operators in Germany and that the use of a biogas pill could also be cost-effective.

### Biogas plant replicated in lab

As part of the next stage of the research process, the Leipzig-based team developed a prototype biogas pill in the lab, where it was tested in a miniature biogas plant. They created the process of over-acidification artificially in a 15-litre bioreactor. Their initial findings are promising. One thing is certain: The pill for the biogas plant is considerably larger than the typical tablets contained in your medicine cabinet at home.

Following the success of the nine-month test phase, the team from Leipzig plans on developing the biogas pill technology in the feasibility phase.

The next research step will involve testing the biogas pill in real-life conditions at a large plant. Another goal involves making the Leipzig product idea beneficial to the operators of smaller-scale equipment such as that used for cooking by households in developing countries. Bonk is striving to establish a start-up to implement the biogas pill and market it successfully.

# “Bio-based tablet to mitigate over-acidification”

**Leipzig environmental microbiologist Fabian Bonk wants to provide operators of biogas plants with a counteragent for over-acidification. A “pill” has been designed to neutralise excess acid by acting on the microbial population in fermenters.**

**Fabian Bonk** is an environmental engineer at Helmholtz Centre for Environmental Research (UFZ) Leipzig.

What has been the key finding of your market analysis on over-acidification in biogas plants, as carried out during the test phase of the ideas contest?

**Bonk:** Our analysis found that in the 9,000 biogas plants in Germany, on average 1,000 cases of over-acidification occur each year. In such cases, the plants either pare down or halt operations, leading to hefty financial losses. Our biogas pill is set to combat the problem.

How did the biogas pill perform in the first test phase?

**Bonk:** Our biogas pill prototype performed as expected in the lab experiment. Acid accumulation in the bioreactor reduces more rapidly. The pill is a sort of medication that neutralises excessive acidity in biogas plants.

How practical are your pills for use in a biogas plant?

**Bonk:** It goes without saying that the final product won’t be a tiny pill but rather a wheel-loader bucketful of substances that large plants will have to pour into fermenters. We are, however, working on streamlining the process for biogas plant operators as much as possible.

# Bacteria as biological peptide factories

**Peptides are protein molecules in demand in the cosmetic and pharmaceutical industries. To date, they have been synthesised by chemicals involving costly procedures. The Düsseldorf-based start-up Numaferm is using a biotech production process and aims to use peptides to develop better anti-corrosive agents.**

Peptides are small protein molecules comprised of up to 100 amino acids. They work in different ways: The pharmaceutical and cosmetic industries value such peptides for their use as active ingredients or bioactive additives in creams or ointments. Peptides are also suited to technical applications such as glues or surface coatings.

Industry has a long way to go before it has fully tapped into the vast economic potential of peptides. Why is this the case? Their manufacture is time-consuming and costly. The leading manufacturing process, chemical synthesis, requires several tonnes of raw

## Versatile molecules made from protein building blocks

materials to make one kilogram of peptide, including fine chemicals and organic solvents. “For many industrial applications that doesn’t make financial sense, and from our perspective it doesn’t reflect the bioeconomy era either,” says Christian Schwarz of Numaferm GmbH.

The spin-off from Heinrich Heine University, Düsseldorf, has therefore developed a biotechnological process to manufacture peptides using microorganisms.

## Peptides in protease-free environment

Biotechnologists have always struggled to harness bacteria as biological peptide factories. A key reason for that difficulty is proteases, commonly occurring enzymes that often destroy freshly created peptides during the production phase. There is one specific place that is free from protease: the direct environment of the *E. coli* bacterium.

This is where Numaferm’s technology comes in. The start-up team led by Christian Schwarz and Philipp Bürling has made the bacterium work in a different way so that required peptides can be manufactured in large quantities which are subsequently released in the protease-free environment. It is easy to harvest the products from it.

For the development of new peptide-based products, in addition to the pharmacological and antimicrobial

**An overview of project details**

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| **Project title:** | pep2bond – Developing novel peptide-based bio-conjugates for adhesion on hard-to-access surfaces |
| **Project manager:** | Heinrich Heine University Düsseldorf |
| **Partners:** | Henkel AG & Co. KGaA |
| **Funding:** | Test phase: 2015 (59,000 euros)<br>Feasibility phase: 11/2015 to 10/2017 (480,000 euros) |

properties, Numaferm has also targeted the adhesive power – i.e. the stickiness – of biomolecules.

## Peptides as a component of anti-corrosive agents

That was made possible by funding from the Federal Ministry of Education and Research (BMBF) as part of the ideas contest "New products for the bioeconomy". The "pep2bond" project involved manufacturing special peptides which were used to protect hard-to-access metal surfaces from corrosion. Such anti-corrosion agents are particularly important for the automotive industry. However, it is often the case that they don't reach all parts of the finished metal components or the protective film fails to adhere to the surface adequately.

The two-year feasibility study saw the team from Düsseldorf collaborate with microbiologists from consumer goods group Henkel to develop what are known as peptide-based bio-conjugates. Whereas the biotechnologists from Dusseldorf University made their peptides available as raw materials, the researchers from Henkel combined protein molecules using click chemistry with their internal polymers classed as polyurethanes. "The peptides ensure that the molecules bind to open steel surfaces better and in a more targeted fashion," explains Schwarz. The bio-conjugates were manufactured successfully during the feasibility phase. The products have already proven themselves on steel sheets in dip tanks and will continue to be tested for marketability.

## First round of financing

In addition to funding from the Federal Ministry of Research, Numaferm also benefited from an Exist grant from the Federal Ministry of Economics. Numaferm GmbH was founded as a spin-off of Düsseldorf university in 2017. In the same year, the first round of financing was also secured from big-name investors.

# “Almost endless list of possible products”

**In an interview, Philipp Bürling of Numaferm GmbH explains the potential of the peptide technology developed by the Düsseldorf start-up and how the ideas contest helped to propel the company forward.**

**Philipp Bürling** is co-founder and commercial director of Numaferm GmbH in Düsseldorf. He studied business information technology.

Why has industry been reluctant to use peptides for its applications thus far?

**Bürling:** To put it simply, peptides are too expensive. Chemical synthesis costs 1 million euros per kilogram. Our biotech process allows us to get close to the cost of manufacturing enzymes, which is a fraction of that of the conventional procedure.

How did the grant from the ideas contest help you to develop your company?

**Bürling:** The project proved that the raw material is of relevance to industry. That was a key point in validating our business plan. The market for peptides as active ingredients in the pharmaceutical sector is already enticing enough. There is much more untapped potential in experimental, often industrial applications. Our investors were also convinced of that.

Which industrial applications are most accessible for the technology?

**Bürling:** Peptides have pharmacological, antimicrobial and adhesive properties. If those are combined, an almost endless list of possible products presents itself, e.g. underwater adhesives or antimicrobial coatings for highly specific surfaces such as implants.


# Smart dives into the bioreactor

**A collaborative research project co-ordinated by engineers in Dresden has developed sensor spheres with the size of a cherry pit which transmit important measurement values in bio-production processes to a base station.**

Bioreactors are the production facilities for the bio-economy. Microorganisms or cells are cultivated in a culture medium in shake flasks or huge steel containers to generate drugs, enzymes or chemical substances. The bio-processes rely on quality control using cutting-edge measurement technology. Conventional methods have their weaknesses, however. Typically, rod shaped sensors are employed. These are screwed tightly to the bioreactor and must be connected with cables. Yet those sensors are an inflexible system: They cannot be used everywhere in the bioreactor.

**Bioreactors are the production facilities for the bioeconomy**

### Mobile measurement system transmits from the culture medium

In future a mobile sensor in the form of a small sphere could come to the rescue. A team under the leadership of engineer Felix Lenk of Technische Universität Dresden developed such a miniature measurement system in the research partnership “Sens-o-Spheres”. The platform can independently collate key process parameters such as the bioreactor’s temperature and transfer them to a base station where the data is ultimately analysed.

The “Sens-o-Spheres” research consortium has six partners in total and was formed during the test phase of the ideas contest “New products for the bioeconomy”. One of the challenges was to determine the correct size for the sensor sphere. “Simulation showed us that we can use 1.2 times the density of water to ensure that it continues to float,” explains Lenk.

### Cherry-pit-sized spheres fitted with cutting-edge technology

The end result was a sensor sphere measuring 7.8 millimetres on average – around the size of a cherry pit. Cutting-edge micro-electronics are fitted inside the device. A sensor records the temperature of the fluid in the bioreactor and translates the physical effect into an electrical one. It is further processed by a micro-controller and transmitted to the outside via an internal antenna. The data is received there by a base station, where it is analysed. The user can view the results on a tablet using an app.

**An overview of project details**

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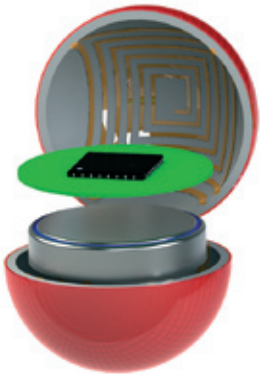
| **Project title:** | Sens-o-Spheres – Location-independent recoding of process measurement signals in novel bioreactor systems. |
| **Project manager:** | Dr. Felix Lenk, Technische Universität Dresden |
| **Partners:** | Fraunhofer ENAS, SAAS GmbH, IMST GmbH; Ökoplast GmbH; e-nema GmbH |
| **Funding:** | Test phase: 2014 (58,000 euros)<br>Feasibility phase: 10/2015 to 03/2018 (approx. 1.2 million euros) |

## Rechargeable spheres

"The small Sens-o-spheres are hugely advantageous, as they don't interfere with the bioprocess. All you need to do is drop them in, and they'll begin to measure," says Lenk. The spherical micro-sensor subsequently moves around the fluid independently, reaching each part of the bioreactor. The system is suitable for bioreactors with volumes ranging from 10 millilitres to 50 litres. The period for which the device can be used also meets real-life needs. "Currently, the sphere can transmit a measurement value every second for a whole day." And not forgetting about sustainability, the high-tech marbles can be charged using an inductive charging station for repeated use.

## More measurement functions and a positioning system

The two-year feasibility phase resulted in a demonstrator system which can simultaneously track the measurement values of 24 spheres. The Sens-o-Spheres project was such a success as part of the ideas contest that the association were able to procure another grant under the BMBF's funding initiative "Innovative SMEs: biotechnology". Their objective: Not only should the sensor spheres be able to determine the temperature, but also the pH value and the concentration of dissolved oxygen. What's more, the researchers have also been tinkering with a positioning system for the spheres in the bioreactor.



The inside of the Sens-o-Spheres fitted with high-tech micro-electronics.

# “Straight from idea to project launch”

**Biotechnologists dream of cultivating microorganisms in optimum conditions in a bioreactor and being able to follow the production process in detail. Engineer Felix Lenk from Dresden explains how the spherical “Sens-o-Spheres” can help as smart suppliers of measurement data.**

**Dr. Felix Lenk** is an engineer and head of the SmartLab-systems group at the Technische Universität Dresden.

Why are data from the inside of a bioreactor increasingly important to the biotechnology industry?

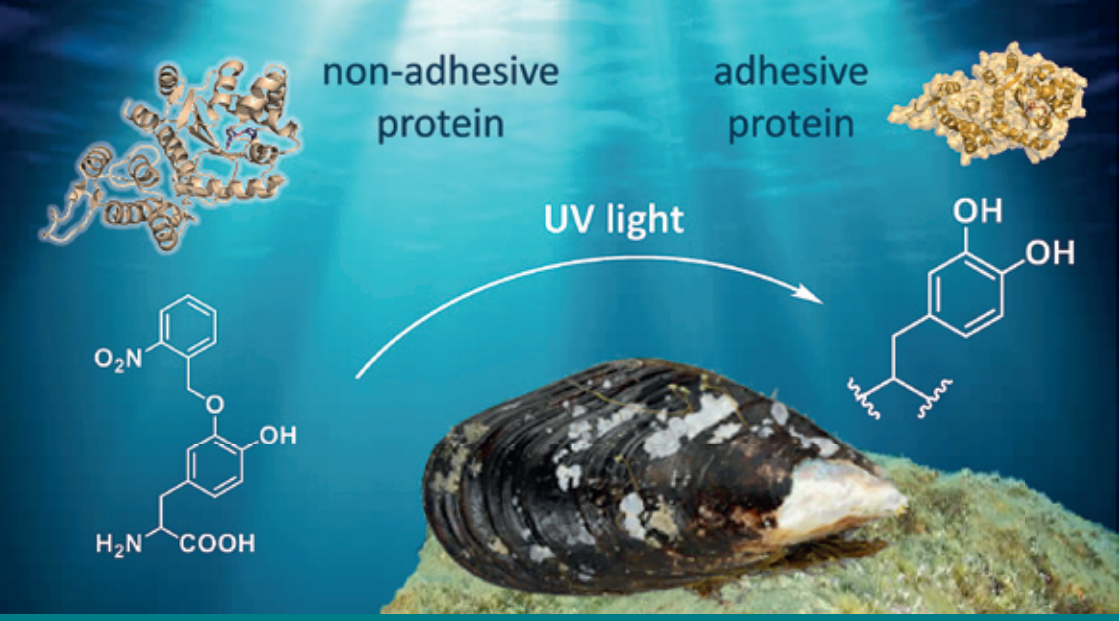
**Lenk:** Biotech production processes are extremely complicated; after all, we are working with living organisms. Data were always important in such processes but were difficult to generate. Conventional measurement systems are not suitable for the latest bioreactors. We are seeing an ongoing trend towards continued quality monitoring in real time. That requires innovative measuring technology.

What is so innovative about the Sens-o-Spheres?

**Lenk:** The spheres are the size of a cherry pit and can record measurements independent of location and with minimal interference. They can even be used in 100-millilitre shake flasks. We were flying blind up until now and had to take a sample to learn more about the culture.

How did the BMBF grant help you?

**Lenk:** The great thing about the funding was that we didn’t need to do any groundwork and were able to move directly from the idea to development of the Sens-o-Spheres. The test phase offered us the space to find excellent partners and put together a large consortium. And the demonstrator developed during the feasibility phase was so impressive that we were able to procure further funding from the BMBF.




# Mussel style superglue

**Scientists in Berlin have developed an adhesive protein inspired from mussels and are able to produce the substance from reprogrammed microbes. The adhesive can be used as superglue to treat wounds and bone fractures.**

## Underwater glue of the highest order

They sit tight on the seabed, and even the waves hitting the coast can't harm them – mussels. The shellfish's feet produce a protein that sticks underwater like no other substance. Be it stone, metal, or plastic: the mussel adhesive sticks extremely well to almost any surface.

This kind of glue is in high demand for surgery and regenerative medicine. In place of time-consuming treatment involving screws, nails or plates, complicated bone fractures can be sorted quickly using biocompatible glues. Wounds to the skin and other tissues can also be closed using such wet glues.

## Generating mussel glue from bacteria

The superglue made from the protein found in mussels' feet has been a target of material science researchers and medical product manufacturers for a long time. Yet generating large quantities of adhesive protein from the sea creatures is a particularly complicated task. To date, attempts at chemical synthesis have either failed or were not cost-effective. And it brings with it a further challenge: The mussel glue begins to adhere immediately as soon as it's mixed together. That makes it difficult to handle.

As part of their ideas contest project, a team led by Nediljko Budisa of Technische Universität Berlin developed a biotechnological procedure to produce the superglue in the lab in an user-friendlier format. The biotechnologists have reprogrammed the bacterium *E. coli* so that it is able to produce the mussel foot protein. Chemical analyses revealed that the amino acid L-DOPA is responsible for the paste's excellent adhesive powers. L-DOPA is a non-canonical amino acid, however it doesn't occur naturally in the repertoire of protein synthesis within cells. In natural proteins, L-DOPA is generated in downstream stages through a biochemical process known as post-translational modification.

## Photoactivatable switch makes for easy application

To transform the bacteria into mussel protein factories capable of using L-DOPA as a building block, the researchers extended their genetic code – with methods taken from synthetic biology. From now on, the

**An overview of project details**

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| **Project title:** | XenoGlue – a novel mussel-based photoactivatable bio-glue for biomedical applications |
| **Project manager:** | Prof. Dr. Nediljko Budisa, Technische Universität Berlin |
| **Partners:** | FG Bioverfahrenstechnik TU Berlin, EloSystems GbR; Chiracon GmbH, Dendropharm GmbH, Cellbricks GmbH |
| **Funding:** | Test phase: 2017 (50,000 euros)<br>Feasibility phase: 04/2018 to 03/2020 (approx. 1.2 million euros) |

Mussels offer a natural model to biotechnologists

microbes can integrate the amino acid directly in their protein synthesis process. The scientists in Berlin took their research a step further by screening the reactive catechol group of L-DOPA with the protecting group ortho-Nitrobenzyol (oNB). The trick: oNB-DOPA functions much like a photoactivatable safety switch. Its adhesive properties are only activated once the mussel protein has been irradiated with UV light. “This protecting group is what makes the glue suitable for a real-life setting at all”, says Christian Schipp, a member of the project team.

For the feasibility phase of the “XenoGlue” project, Schipp formed a consortium of six partners to rapidly turn the idea into a market-ready medical product. The wet glue is to be tested for the treatment of surface wounds in veterinary medicine. If the glue proves a hit, the biotechnologists also hope to commence the first clinical studies and establish a company called “XenoGlue”.

# “Natural formula for mussel glue refined”

**With their process, Berlin-based researchers wish to make their mussel superglue available to the healthcare sector. Christian Schipp explains how the ideas contest “New products for the bioeconomy” has helped him and his team.**

**Dipl.-Ing. Christian Schipp** is a bioprocess engineer at Technische Universität Berlin.

Why have you opted for a biotechnological process when manufacturing the mussel superglue?

**Schipp:** The process of extracting the adhesive protein from mussels is very time-consuming and inefficient. We refined the natural formula. Our procedure – a sample application for xenobiology – allows for efficient production using bacteria as cell factories.

How did the BMBF grant help you?

**Schipp:** This ambitious project certainly wouldn’t have progressed without the BMBF grant. The test phase offered us the opportunity to create as extensive a consortium as possible for the implementation of our idea. The creative workshop offered at the time was also incredibly helpful.

What are the next steps in making the product ready for the market?

**Schipp:** We want to advance production quantities from milligrams to grams. Together with the bioprocess engineers at TU Berlin and EloSystems, we are developing production processes that also satisfy clinical quality standards. Our partner Cellbricks develops skin models which allow us to test the product extensively. And Dendropharm is developing the right composition for mussel glue, which will subsequently be tested on small animals.

# Forecast: New ideas shape the future of the bioeconomy

**Further improvements have made the ideas contest "New products for the bioeconomy" even more attractive. The successful concept, which has already seen its fair share of copycats, has brought many extraordinary ideas to the market.**

Dozens of ideas for bio-based products or processes, a huge diversity of topics, and first products prior to market launch: Five years after this funding measure was established, the BMBF's ideas contest "New products for the bioeconomy" is a real success story.

In addition to the projects introduced in this brochure, the ideas contest has unearthed an impressive variety of new ideas and has brought together players from the most diverse disciplines. A wealth of products, for example, were dedicated to developing sustainable solutions for agriculture and nutrition – such as those on recovering nitrogen, cultivating

## Wide range of topics and disciplines

saffron in German latitudes, generating fatty acids from algae, or the development of a recycling transport box for foodstuff.

**Ideas contest paves the way for similar projects**

One thing is certain: The concept of early funding for promising ideas has fallen on fertile ground in the fields of science and industry and has given further impetus to bioeconomy research in Germany. The ideas contest has already set a precedent as a funding instrument and it has been replicated in some federal states. Baden-Württemberg, for example, has set up the "Innovationsgutschein Hightech Start-up" to allow entrepreneurs to develop research activities in promising areas of growth at an early stage.

The grant format is unique in that getting started is very straightforward: Interested parties with a promising concept can progress straight to the test phase, without the need for extensive groundwork or data sets. That means they can take their time developing their idea and fleshing out a sustainable project plan whilst also having the necessary funding.

**Plentiful ideas for the future**

The wide range of projects funded thus far as part of the ideas contest is testament to how successful this BMBF funding measure has been in invigorating the bioeconomy. To date, product ideas from the fields of agriculture, health and nutrition, in particular, have made it to the feasibility phase. They are as diverse as mussel-based glues for healthcare and new, bio-based lubricants for industrial applications through to substances generated by microbes to be used in foodstuff or materials. Another funded project hopes to generate energy using microbial biofuel cells, and we also have the IT platform for bee keepers that enables a careful inspection of bee colonies. Other projects wish to develop approaches to harness unused waste and residue material – from corn cultivation, pulp mills or fish farms. There's even a bio-based product idea for the older generation: a modular walker system made from renewable resources such as wood.

### Further improvements for product developers

Further improvements have made the ideas contest even more attractive to interested researchers. The fifth call for proposals at the end of 2017 saw the test phase extended from nine to twelve months and the budget was increased to 65,000 euros. As a result, the developers had more time to work on their ideas and it also suited schedules at the technical universities, e.g. by corresponding with advertised project positions.

### Financing as needed

An important change has also been made to the feasibility phase: Rather than the hitherto maximum grant of 250,000 euros per participating partner, a new flexible approach has been introduced which focuses on project needs. It should give researchers the opportunity to let their creative ideas flow. After all, previous projects have shown that each idea requires its own financial leeway. In certain circumstances, it is also possible for potential applicants to skip directly to the feasibility phase.

A bonding agent for thermoset plastic is made from waste material from the pulp industry.

Fish tanks in a circulation system with Lake Constance whitefish and noble crayfish.

### Ideas contest now also open to big business

The ideas contest is not only open to players in research institutes or small and medium-sized enterprises (SMEs). Since the fifth call for proposals, applications have also been accepted from researchers working for large companies who would like to use the ideas contest to finance a percentage of their costs. All of these changes lay the groundwork for giving original business ideas the opportunity to become a reality. For a sustainable bioeconomy to flourish, we need innovative approaches to bio-based products and processes. It is, therefore, worth keeping an eye on extraordinary ideas.

## Contact organisation and further information on the ideas contest

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