Fraunhofer ISC

Annual Report 2021 | 2022

YOUR COFFEE BREAK READING

Welcome

Dear Friends and Partners of Fraunhofer ISC,
Ladies and Gentlemen,

The global social and economic impacts of the Corona pandemic that we witnessed in 2021; the war between Russia and Ukraine that began this year and the consequent energy crisis; and increasingly common extreme weather events are a stark reminder of just how important sustainable action is if we want to ensure a good quality of life not only for ourselves but for future generations too. This is why, this year, Fraunhofer ISC has decided to dedicate its annual report to the topic of sustainability and the many ways in which sustainable action can be incorporated into research and projects.

One of our focuses this year has been on battery research, an area in which the Fraunhofer Research and Development Center for Electromobility Bavaria (FZEB) is playing a leading role throughout Europe. A concerted effort to implement efficient recycling processes as well as new methods for material and process development is of critical importance in transforming the mobility industry, ensuring that the demand for batteries is met, and finding alternatives to the finite and natural resources that this industry currently relies on. As a result, digitalization, machine learning, and the use of artificial intelligence will have an increasingly important role to play in future developments at the ISC.

There is also sustainable progress to be made within biomedical and drug development processes. In vitro testing, for example, can significantly reduce or even completely replace animal testing and enable rapid drug screening. The expertise in this area demonstrated by the Fraunhofer Translational Center for Regenerative Therapies (TLC-RT) was recently awarded with the Ursula M. Händel Animal Welfare Prize by the German Research Foundation. The jury recognized the center's competence and its commitment to finding replacements for animal-based experiments. Building on this success, we have also set up the Würzburg Initiative 3R[1] with the aim of expanding this network and integrating as many research institutions as possible within the 3R concept. I would like to extend my congratulations to the whole team!

The Fraunhofer vs. Corona funding initiative has also supported a number of projects where in vitro testing systems were successfully used to test drugs that had already been approved for other diseases to see if they would also be effective against the SARS-CoV-2 virus and to develop procedures for carrying out this testing. These projects further underlined how digitalization and laboratory automation can accelerate research to market translation.

Another highlight of this year has been the KIC EIT Culture & Creativity program which was founded this fall. This EU funding initiative in the field of culture and cultural heritage preservation will undoubtedly bring with it exciting projects in the year to come. We would like to congratulate our colleagues Dr. Johanna Leißner, who has represented the ISC in Brussels for some years now, and Sabrina Rota, head of the International Convention Center for Cultural Heritage Preservation (IZKK) at Fraunhofer ISC's Bronnbach Branch for playing pioneering roles in bringing this initiative to fruition. In this annual report, you will also discover other innovative research projects working on discovering more sustainable approaches to materials, processes, and technology.

As always at this point, I would like to express my heartfelt gratitude to all employees, friends, supporters, and partners. You have inspired, challenged, and encouraged us this year and it is your interest, feedback, and suggestions which drive us and our research forward. We hope to continue to inspire you and arouse your curiosity in the coming year.

I hope this year brings you opportunities, motivation, and every success in responding to the global challenges we are all facing. Above all, I would like to wish you a happy and healthy 2023.

Yours sincerely, Gerhard Sextl

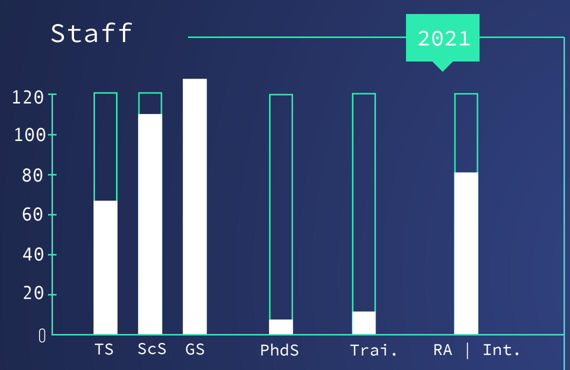
1 3R : Replace, Reduce and Refine

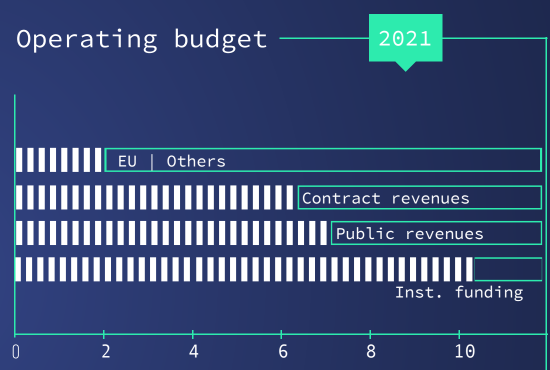
Contents

Find out more online at www.isc.fraunhofer.de/annual-report

INFOGRAPHIC

100% Green electricity in the properties of the ISC



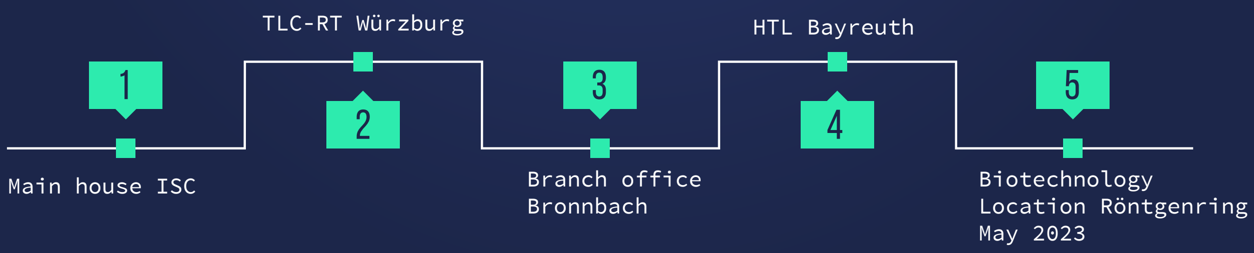


Staff

Technical staff	64
Graduate staff	124
Scientific staff	113
Phd students	13
Trainees	9
Research assistants | Interns	80

Operating budget

EU | Others	3,2 Mio €
Contract renevues	6,5 Mio €
Public revenues	7,1 Mio €
Institutional funding	11,1 Mio €



A clean and sustainable future starts with materials

Fraunhofer-Gesellschaft has set itself the goal of researching and working towards climate neutrality by 2030. With this goal, the FhG hopes to support and make its contribution to the German Federal Government's aim to achieve climate neutrality, the European Green Deal, and the Paris Agreement. The agenda for 2030 lays the foundation for future measures and for global economic progress which fosters social justice and respects the earth's ecological limits. At the heart of this agenda lie the 17 Sustainable Development Goals (SDGs).

Research into social responsibility

The energy transition has meant that recovering and recycling valuable raw materials and replacing them with sustainable alternatives is becoming an increasingly relevant issue within material science. The demand for primary resources, which, in many respects, have become critical resources, means that we are not only facing an energy revolution but a material revolution too. Whether in the field of PV modules for solar power systems or batteries for electromobility, the need for functional materials is putting new demands on the resources that will ensure a successful sustainable energy transition.

Sustainability research at Fraunhofer ISC

For us, sustainability means sustainability-focused research. However, researching and working towards climate neutrality also means paying close attention to environmental factors. At Fraunhofer ISC, we adopt a holistic approach towards research, research infrastructure, and administration, in economic, ecological, and social terms. We focus on strategies and activities that will help us achieve our goals for more sustainable research and work.

To help us do this, we have aligned our objectives with the United Nations' Sustainable Development Goals (SDGs). Our Sustainability Department is responsible for working with each and every employee to ensure that we contribute to achieving these goals through our research and development activities as well as in our day-to-day operations.

Our contribution to the Sustainable Development Goals

At Fraunhofer ISC, we are contributing to the achievement of the United Nations' 17 SDGs through the research we carry out in the field of material science and by means of specific projects. To ensure we fulfil this commitment, the following goals have become focus points in the work of our researchers:

By offering high-quality education and establishing a large educational network, we have made the first step towards achieving these goals.

Quality education
Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Gender equality
Achieve gender equality and empower all women and girls.

Clean water and sanitation
Ensure availability and sustainable management of water and sanitation for all.

»To achieve all the development goals, we first have to understand how water, as a globally limited resource, is related to the other goals.«

Affordable and clean energy
Ensure access to affordable, reliable, sustainable, and modern energy for all.

Industry, innovation and infrastructure
Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Stainable cities and communities
Make cities and human settlements inclusive, safe, resilient, and sustainable.

Responsible consumption and production
Ensure sustainable consumption and production patterns.

Climate action
Take urgent action to combat climate change and its impacts.

Life below water

Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

»We're choking ourselves to death with all the plastic we're throwing away. It's killing our oceans. It's entering our bodies through the fish we eat.«

Life on land

Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.

Partnerships for the goals

Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

»We could be the first generation to succeed in eradicating poverty, but we could also be the last to have the chance to save our planet.«

Head of Institute

Prof. Dr. Gerhard Sextl

Deputy Head of Institute

Dr. Thomas Hofmann

HEAD OF MATERIALS CHEMISTRY
Dr. Martin Peters

Dental | Micromedicine
Dr. Herbert Wolter

Particle technology
Prof. Dr. habil. Karl Mandel

Chemical Coating Technology
Dr. Ferdinand Somorowsky

HEAD OF FZEB
Dr. Henning Lorrmann

Lithium-ion technology
Dr. Guinevere Giffin

Lead-acid technology
Jochen Settelein

Electrochromic systems
Dr. Marco Schott

Analytics | Services
Dr. Sarah Hartmann

Processes
Dr. Andreas Flegler

HEAD OF APPLICATION TECHNOLOGY
Gerhard Domann

Glass | Mineral Materials
Dr. Rick Niebergall

CeSMA | Adapt. Systems
Gerhard Domann

Materials Development
Dr. Daniela Collin

HEAD OF SERVICES
Dr. Jürgen Meinhardt

Center for Applied Analytics
Dr. Alexander Reinholdt

Head of Administration
Patrick Kübert

Human Resources
Anette Rebohle-Mandel

Sales | Marketing
Dr. Victor Trapp

Central Services
Michael Martin

PR | Communication
Marie-Luise Righi

Patents | Licenses
Dr. Carsten Gellermann

You can reach us by e-mail at
firstname.lastname@isc.fraunhofer.de

HEAD OF HTL
PD Dr. Friedrich Raether

Ceramics
Dr. Holger Friedrich

Simulation
PD Dr. Gerhard Seifert

Ceramic fibers
Arne Rüdinger

Precursor ceramics
Dr. Andreas Nöth

Composites Technology
Dr. Jens Schmidt

Textile fiber ceramics
Prof. Dr. Frank Ficker

HEAD OF TLC-RT
PD Dr. Marco Metzger

Laboratory Automation
Thomas Schwarz

Clinical Development
PD Dr. Oliver Pullig

Biomaterials
Dr. Sofia Dembski

Test Systems
Dr. Florian Groeber-Becker

HEAD OF PROJECT CENTER FOR STEM CELL PROCESS TECHNOLOGY SCPT/ISC
PD Dr. Marco Metzger

3D Materials
Sebastian Hasselmann

Microfluidics | Simulation
Patrick Witzel

Actuator systems
Timo Gruneman

HEAD OF 3D-NANOCELL

Biomaterials
Sebastian Hasselmann

Biosensors
Maria Götz

BRONNBACH BRANCH OFFICE
Dr. Andreas Diegeler

International Convention Center for Cultural Heritage Preservation IZKK
Sabrina Rota

Fraunhofer ISC Board of Trustees

PRO
JECTS

»PeroTec« – highly efficient, resource-saving perovskite solar cells

PeroTec – highly efficient, resource-saving perovskite solar cells

The vulnerability of global supply chains, as demonstrated by the Corona pandemic and the war in Ukraine, highlights the need for energy transition. As the shift from conventional to renewable energy increases, so does interest in sustainable energy sources. The photovoltaics industry in particular is feeling the effects of growing demand from end consumers. The modules required for photovoltaic energy consist of silicon solar cells, which are primarily produced in East Asia. As a result, long and polluting transport routes not only have a negative impact on the achievement of climate policy goals, but also create dependence on suppliers.

Perovskite solar cells

The PeroTec project coordinated by the IWM, ISE and ISC Fraunhofer Institutes provides a future-oriented alternative – switching from silicon solar cells to perovskite solar cells.

Perovskite solar cells: supporting climate policy goals through sustainable and local production

The production of silicon solar cells in East Asia generates a carbon footprint of over 60g/kWh CO_2-eq, which is around 10 times the amount that the production of perovskite solar cells in Germany or Europe would create. The pathway to a more sustainable production of photovoltaic modules would, therefore, involve relocating production to Europe. The necessary technology and processes such as laser structuring, vacuum coating and screen printing have already been established and provide the basis for setting up efficient production processes for PeroTec modules in Europe.

The PeroTec solar cell is created directly on glass by means of reverse manufacturing. Empty modules are produced from structured, printed, and vacuum-coated flat glass panels that provide sufficient space in between for the perovskite absorber.

The photoactive perovskite salt is introduced into the empty module and then activated in situ through crystallization. Glass solders, developed under the guidance of Fraunhofer

ISC, are then used for the gas-tight sealing of the perovskite modules.

Fraunhofer ISC provides expertise for glass solder development

For the development of the glass solders necessary for the PeroTec project, Fraunhofer ISC was asked to provide its expertise. The ISC is now working on the development of the gas-tight sealing process for the flat glass panes of the perovskite solar modules. As the base material for the flat glass pane, both soda-lime glass and borosilicate glass can be used. The type of glass that is used determines the requirements for the glass solder, which is adapted to the expansion coefficient of the base material and applied by screen printing.

The PeroTec projects allows the IWM, ISE and ISC Fraunhofer Institutes to address various areas that are not only important for sustainable, resource-conserving production, but that also strengthen local industry in Germany and Europe.

Perovskites

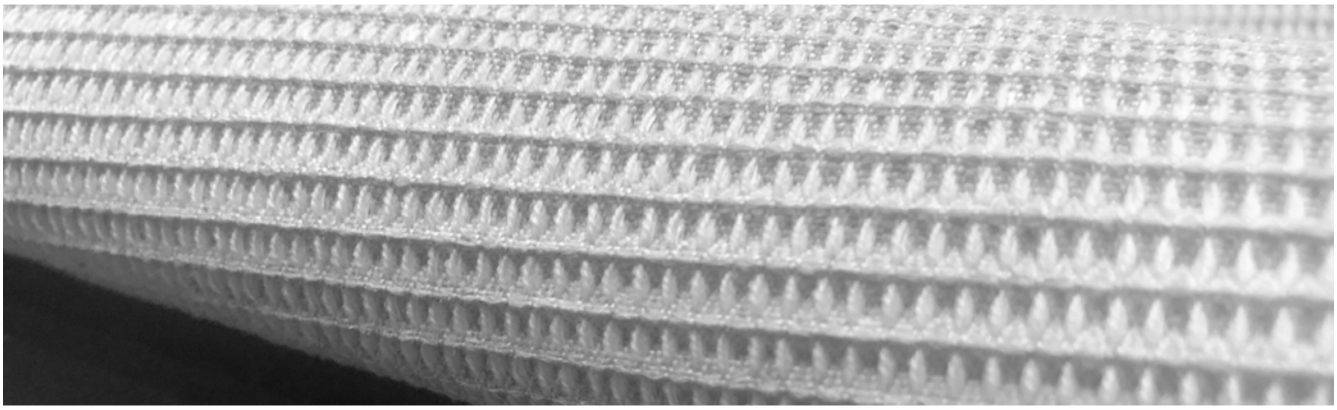
Perovskites are double salts with a crystal structure and photoelectric properties that occur naturally but that can also be produced artificially. In Europe, perovskites can be found in the Eifel Mountains, in the Ural Mountains and in Zermatt. Compared to silicon solar cells, which have an efficiency of up to 26%, according to research, perovskite solar cells should be able to reach an efficiency of up to 34%.

However, one drawback to the use of perovskite modules is their lead content. To date, no alternative has been found that guarantees a similarly high efficiency without the undesirable toxic component. This makes it all the more important to recycle perovskite modules correctly, to prevent lead from getting into soil and water and to efficiently recover valuable raw materials. Research in this area is advancing.

Contact

Dr. Bernhard Durschang
Glass and Mineral Materials
Phone: +49 (0)931 4100-304
bernhard.durschang@isc.fraunhofer.de

»BakeTex« – textile baking mats



Textile products are light and flexible. Consequently, they are becoming an increasingly attractive option for industries and the bakery industry is an example of one sector which has recognized the potential of these products when it comes to saving energy and resources. The BakeTex project is working on the development of a textile baking mat that can be used as an alternative to conventional baking trays.

The aim of this project is to create a baking mat for use in commercial bakeries that is free from harmful substances, saves energy, and that can be washed and re-used many times. Temperature-resistant, lightweight textiles heat up quickly and thus have the potential to reduce oven preheating temperatures and lower energy consumption. These innovative textile baking mats constitute a resource-saving and reusable alternative to baking paper. They generate potential energy savings and are light-weight and highly flexible, making them an attractive choice for bakeries.

The textile baking mat is foldable, therefore saving storage space. In order to assess the baking mat's influence on the product and oven, baking tests are being carried out and the temperature curve is being measured. Initial stages of the project focused on identifying suitable fiber materials and developing a weave. Then, work was carried out on a coating for the baking mat that could prevent baked goods from sticking to the mat. Future stages of the project will see the development of a lightweight frame construction for stretching the material and, finally, the project will focus on individual branding and tracking within the bakery by means of RFID chips or QR codes.

Fickenscher Bakery and Wilhelm Zuleeg Weaving Mill are partners on this project.

The project is supported by the Bavarian Research Foundation.

Bayerische Forschungsallianz

Contact

Timo Fluss
Fraunhofer Application Center
Textile Fiber Ceramics (TFK)
Phone +49 (0)175 1978105

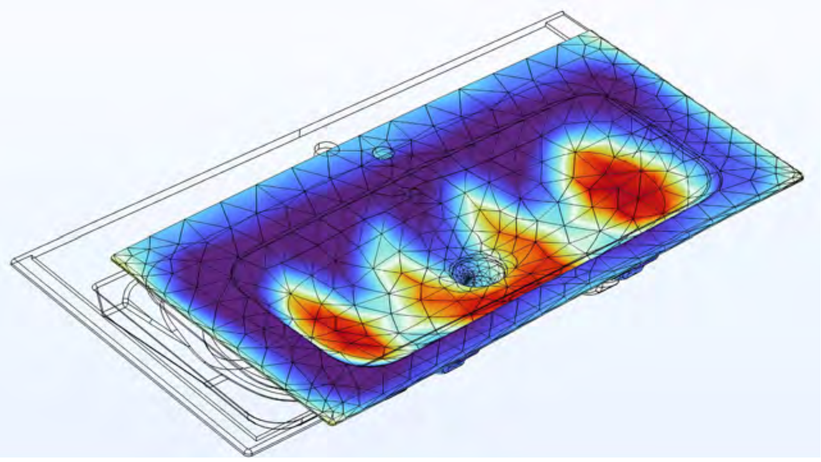
Filigree Finion countertop washbasin, 600 x 350 x 115 mm, white Alpin CeramicPlus, without overflow, unpolished (Foto: Villeroy & Boch AG)

»HTPgeox« – energy efficient high temperature processes for large and geometrically complex components

Within the scope of the HTPgeox project, the HTL is working with three industrial partners to develop digital technology to help achieve significantly higher energy and material efficiency in the kiln processes required for manufacturing large and geometrically complex ceramic components. One example of such components are the sanitation ceramics from Villery & Boch AG. Market requirements, particularly in terms of design and functionality, often mean that, nowadays, there is an expectation for washbasins and similar components to have increasingly unique shapes, to be particularly thin-walled, and to have narrow dimensional tolerances that allow them to fit perfectly into built-in units. This means that even slight variations in the final shape, that may occur due to inadequate process control during the firing process, result in increased production scrap and thus a waste of energy and raw materials.

To prevent this, HTPgeox is working on extensively digitalizing the heat treatment process in the tunnel kiln with the aim of optimizing process control. The project's industrial partners, which, in addition to Villeroy & Boch AG, also include Keramischer OFENBAU GmbH and Meprovision GmbH & Co. KG, are setting up a comprehensive monitoring system for kiln and product data that can be used to track individual product's kiln history. This involves an initial automatic visual recording of the positioning of each product on the kiln car and then matching the corresponding local sensor data as the product travels through the 120-meter-long kiln. Machine learning algorithms then use this data to determine correlations between component defects and kiln issues. This information can be used to correct some of the faults caused by kiln car loading and inadequate kiln control, even without the need for further analysis.

The HTL's role is to provide this further analysis in two stages. The shortest and most energy-efficient firing process can be determined and developed by using tested methodology to carry out predicative simulation of material and component behavior during the thermal process. For this purpose, the process kinetics of several ceramic masses are determined in situ using measurements taken at the HTL TOM facilities and at other sites. Using the same data, damage to the sanitation component discovered at a later stage can then be analyzed using detailed modelling of the actual thermal situation of the component in the kiln in its specific positioning on the kiln car. If, for example, a crack in a toilet bowl has been caused by an excessive temperature curve, the computer is able to determine whether this crack can be clearly traced back to the positioning of the bowl on the kiln car. The knowledge base that results from this analysis will then be translated into concrete



guidelines for kiln car loading operators. In the long term, the findings produced by the ongoing kiln and product data monitoring and the accompanying simulations will be combined to form a predictive kiln control system with actively planned and optimized kiln car loading.

In the short term, the implementation of this developed technology is expected to reduce the amount of energy for heating that is required during production by up to 20%, whilst at the same time significantly improving raw material efficiency by avoiding rejects. Digital process control will also facilitate the future shift from natural gas to hydrogen for kiln firing.

Contact

PD Dr. Gerhard Seifert
Fraunhofer Center for High Temperature Lightweight Construction (HTL)
Phone: +49 (0)921 78510-350
gerhard.seifert@htl.fraunhofer.de

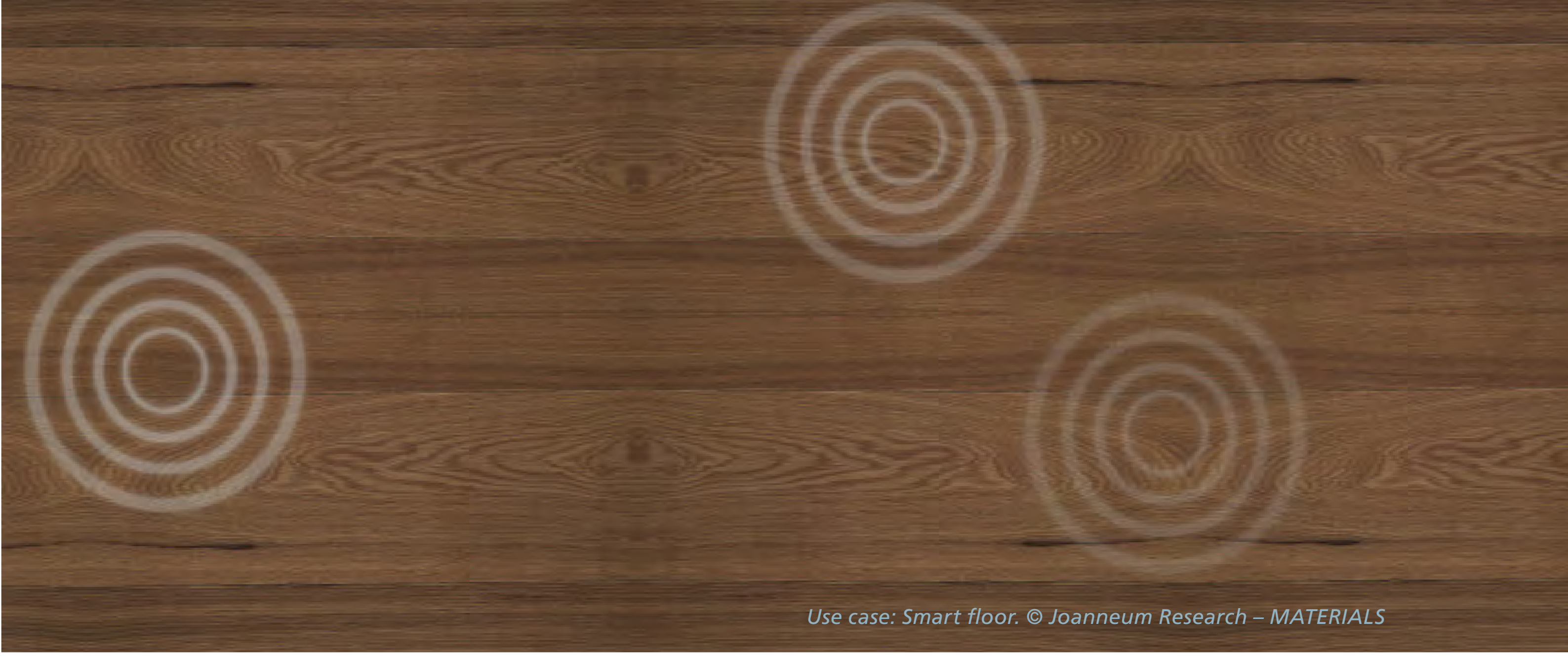
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862095.

»Symphony« – generating autonomous energy on a small scale

Increasing digitalization has meant that electronic systems are becoming more widespread in all areas of life and even in remote locations. As a result, we need to review power generation processes. Current IoT scenarios predict that around 75 billion connected devices will be brought into existence by 2025 and the use of batteries to power these will result in a significant amount of potentially hazardous waste. The EU-funded SYMPHONY (Smart Hybrid Multimodal Printed Harvesting of Energy) project consortium aims to develop cost-effective and scalable methods for printing energy harvesting materials on flexible films and to integrate these within energy-efficient electronic and sensor technology. 13 partners and more than 80 researchers are working together under the SYMPHONY umbrella to develop an innovative, cost-effective, and sustainable energy harvesting solution. This solution will be applicable to a wide range of other IoT-based applications, and companies in industries such as the automotive, logistics, railroad, and small appliance industries have already expressed an interest in the solution.

Use case: Automated pressure control for inner bicycle tubes © Markus Frühmann, Tubolito Gmbh

Fraunhofer ISC is contributing to this project by means of its expertise in developing functional, printable, and stretchable materials such as ORMOCER®, special silicones, piezoelectric materials, and magnetic nanoparticles as well as by means of its process engineering know-how for manufacturing and processing. The approach adopted by the SYMPHONY project uses spatially distributed and disordered energy sources for the development of an innovative autonomous energy sensor system. Whereas thermoelectric and solar-powered generators are dependent on certain environmental factors (such as differences in temperature and the availability of sunlight), electrodynamic and piezoelectric energy converters can use vibrations and deformations which are practically omnipresent to generate the required energy. The energy supply in this system will be composed entirely of printed, recyclable, and non-toxic materials, including the ferroelectric polymer P(VDF-TrFE), printable and silicon-based



Use case: Smart floor. © Joanneum Research – MATERIALS

rectifiers, redox polymer batteries, and cellulose-based supercaps. The combination of autonomous energy harvesters and sensors is being tested in three use cases: real-time condition monitoring of wind turbines; smart floors for controlling room heating/cooling; and inner bicycle tubes with integrated pressure control for demanding applications.

An important aspect of this project is defining a suitable methodology for life cycle assessment and for identifying environmental hotspots that could contribute to the development of sustainable SYMPHONY solutions. The energy-efficient and scalable printing process that the SYMPHONY project is using provides significant cost and energy savings compared to the high temperature processes required for piezoceramics manufacturing. In addition, the materials used in the project (cellulose, polymer batteries, and lead-free piezoelectric materials) have a significantly lower environmental impact.

Use case: Sensor for condition monitoring of wind turbines – autonomous energy eologix sensors are mounted directly on the rotor blade surface. © eologix sensor technology gmbh

Contact

Gerhard Domann
Application Technology
Phone +49 (0)931 4100-551
gerhard.domann@isc.fraunhofer.de

Fraunhofer vs. Corona – a review of the Fraunhofer-Gesellschaft anti-corona research program

Beating the virus together!

#Covid19

As the pandemic began to emerge in 2020, Fraunhofer-Gesellschaft set an important example. Using its own funds, it offered a 50 million euro grant to anti-corona research projects at the Fraunhofer Institutes, with the aim of pooling together different skills in a new way and thus developing rapid and effective methods and solutions for responding to different aspects of the pandemic. In doing so, Fraunhofer-Gesellschaft not only aimed to help tackle the pandemic, but also to strengthen prevention and resilience with the goal of overcoming the medical crisis as quickly as possible and providing the best possible support to the economy during the post-Corona period. Fraunhofer-Gesellschaft also wanted to send the message to employees that everyone has a role to play in overcoming the crisis.

The funding phase ended at the end of 2021 and the 320 or so projects that this funding enabled involved not only a large number of Fraunhofer Institutes, but also more than 20 hospitals, around 20 authorities, a similar number of industrial companies, and nine NGOs and other organizations.

The various projects looked at three key aspects:

RESPOND
These projects targeted acute pandemic containment, ranging from support in the areas of medicine, laboratories, diagnostics, and drugs through to allocation platforms to respond to supply shortages and the use of AI for public, state, and authority information campaigns.

RECOVER
This aspect included projects to help ramp-up/restart SMEs as well as projects researching areas such as digitalization, IT, and supply chains.

PREPARE | PREVENT | PROTECT
In this area, the focus was on preventing future crises and developing recommendations on how to act when such situations occur again.

Research areas ranged from the co-development of the Corona app to the rapid screening of known and approved drugs with regard to their potential effectiveness against Corona. Fraunhofer ISC was also involved in the program and participated in five successful anti-corona projects which have been described in more detail below.

»RoboCure« - automated production of in vitro cell cultures

Drugs that have already been approved for comparable diseases could make a quick and important contribution to the containment of a pandemic. Indeed, a number of clinical trials are testing the efficacy of known drugs against the corona virus (repurposing). However, while the number of COVID 19 studies is an impressive 8,311, to date, only 11 studies have been focused on repurposing (source: clinictrial.gov). A large amount of effort is required to identify suitable drug candidates in advance (at the preclinical stages) and this presents a barrier to the wider implementation of this technique. Given this, in vitro test models (i.e., tissues cultivated in test tubes) can bring significant advantages. The use of human 3D or 2D tissue models of the conducting airways cultured at the medium-air interface and of alveolar lung tissue organoids offers the possibility of rapidly identifying suitable agents during the preclinical phase that could prevent viruses like SARS-CoV-2 replicating in human cells.

This is why the Translational Center for Regenerative Therapies (TLC-RT) and the associated Chair of Tissue Engineering and Regenerative Medicine (TERM) at the University of Würzburg have, within the scope of the interdisciplinary RoboCure Project, focused on exploring the use of flexible and interactive robotic technology in the production of in vitro organoid cell culture models of the respiratory tract. In the medium term, this process is to be carried out under stringent regulatory GMP conditions (medical devices: ISO 13485, pharmaceuticals: GMP (Good Manufacturing Practice)) taking into account relevant quality assurance criteria for individualized diagnostics and therapy.

Robot-assisted production enables rapid and standardized preclinical identification and qualification of substances that have already been approved for other applications (repurposing studies), thus shortening the route to immediate clinical translation.

By automating the complex manufacturing process of these human tissue models, the RoboCure project will not only enable time savings in the generation of these models but will also increase standardization and reproducibility. The project is based on preliminary work such as previously developed cell culture models and the automated system for skin tissue production. Moreover, a different project is already seeing organoid models for intestine models being produced at the facility. Significant barriers have been overcome, such as the handling of viscous media by means of a bioplotter. As a result, it can be assumed that, in the short term, this project is well placed to contribute to tackling the crisis. In the medium to long term, technological know-how will allow for a broadly applicable automated testing platform to be established.


Contact

Thomas Schwarz, Dipl. Ing.
Laboratory Automation
and Bioreactor Technology
+49 (0)931 31-80976
thomas.schwarz@isc.fraunhofer.de

»COVID-Tip« – using new swab kits to enable more accurate test results

Beating the virus together!

#Covid19

The Corona pandemic has shown that rapid and, above all, accurate testing used to identify infected individuals as early and as reliably as possible is essential to slowing the spread of a major epidemic. "Early" and "reliable" are paramount to successful testing because it is only when these two characteristics are combined that citizens are motivated to behave in a correspondingly responsible way. In light of this, the Fraunhofer Translational Center for Regenerative Therapies (TLC-RT) had, in fact, already begun deliberating on how best to increase both sensitivity and reliability in testing when Fraunhofer-Gesellschaft issued its call to participate in the Fraunhofer vs Corona program and proposed its funding opportunities.

SARS-CoV-2 can be detected using three different testing methods:

The WHO did not recommend using antibodies (AB) against the virus which are present in the blood for detection purposes because AB are usually detected in patients after the infectious period of SARS-CoV-2. This means that the spread of the virus during an ongoing epidemic/pandemic cannot be effectively prevented in this way.

The other two types of testing provide information earlier and faster:

A PCR test directly detects the genetic material of the pathogen and is currently considered to be the most reliable and sensitive testing method as it responds to very low viral loads. Since special equipment is required for this, the method has to be carried out in public or company testing laboratories.

A rapid antigen test does not detect the pathogens, but instead detects so-called spike proteins (proteins on the viral envelope). This method is also known as a self-test, since all that is needed for testing is an appropriate test kit. The method is not as sensitive as a PCR test as the viral load must be significantly higher in order to be detected.

In both procedures, samples are taken by using a swab stick inserted in the nasal/pharyngeal cavity in order to obtain samples of the nasal mucosa for analysis. Ultimately, the quality of the test depends on the quality of these samples. The more suitable the material of the swab stick is for collecting the antigens or genetic components of the viruses, the more sensitive and reliable the test result will be. The aim of the COVID-Tip project was therefore to develop an innovative swab stick that absorbs the components required for analysis from the nasal mucosa in a concentrated form and releases them completely during the subsequent analysis process. This selective adsorption was achieved at TLC-RT with the help of fiber technology and specific post-treatment of the fibers produced for this purpose. This research was supplemented by the biomedical know-how of the interdisciplinary project team. Initial talks with interested parties have already opened up fields of application beyond use in the current pandemic.

Swab © Pixabay

Contact

Dr. Bastian Christ
Biomaterials
Phone +49 (0)931 4100 596
bastian.christ@isc.fraunhofer.de

»DRECOR«

Beating the virus together!

#Covid19

Motivation

Since the outbreak of the corona pandemic, there has been an urgent need for medication to treat severely ill corona virus disease 2019 patients. As the development and approval of new drugs is very time-consuming and cost-intensive, scientists worldwide are investigating whether drugs that have already been approved for other medical applications are suitable for treating COVID 19. This process, known as drug repurposing, can significantly shorten the approval process.

As part of the Fraunhofer vs. Corona anti-corona research program, the DRECOR (Drug Repurposing for Corona) consortium tested over 20 previously approved drugs to examine their antiviral properties against severe acute respiratory syndrome coronavirus type 2. Fraunhofer scientists investigated whether these substances could inhibit the entry of the coronavirus into the target cells or prevent the virus from replicating in the cells, and also whether they would be safe to use. A selection of these identified drug molecules were specially packaged so that they could be inhaled through an inhaler device and reach the respiratory tract specifically.

.

The TLC solution and application

Since these drug molecules for novel applications cannot be tested directly on humans, scientists at the TLC-RT produced complex tissue models of the human respiratory tract that resemble the tissue structure and function in vivo (Steinke et al. 2014, Sivarajan et al. 2021, Fig. 1A).

The research team succeeded in incorporating three of these drugs into a synthetic matrix and in spraying them into very fine particles. Spraying in the sub-µ range is crucial in order for the incorporated drugs to reach the deep airways. The TLC team demonstrated that the particles would attach themselves to the mucus of the airway models and reach the target cells in the tissue model (Fig. 1B).

In collaboration with the University of Würzburg (Institute of Virology and Immunobiology, Prof. Jochen Bodem), the team was able to identify a small antiviral effect of the remdesivir and nafamostat drug molecules against SARS-CoV-2 and an interaction of the particle matrix with the virus. We are following up on this exciting observation in current experiments and now need to determine whether the particles inactivate SARS-CoV-2 or inhibit viral entry into the target cells.

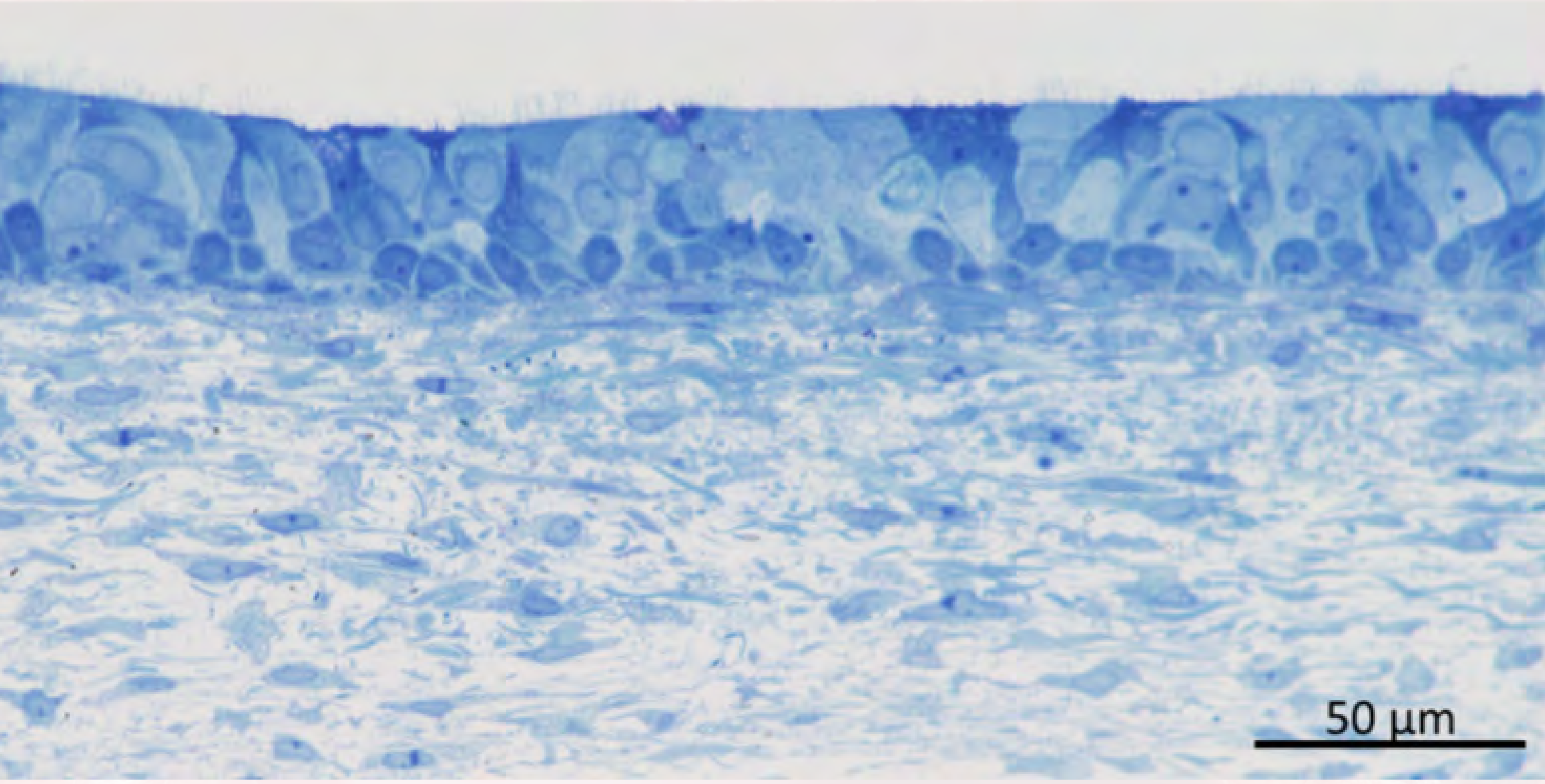
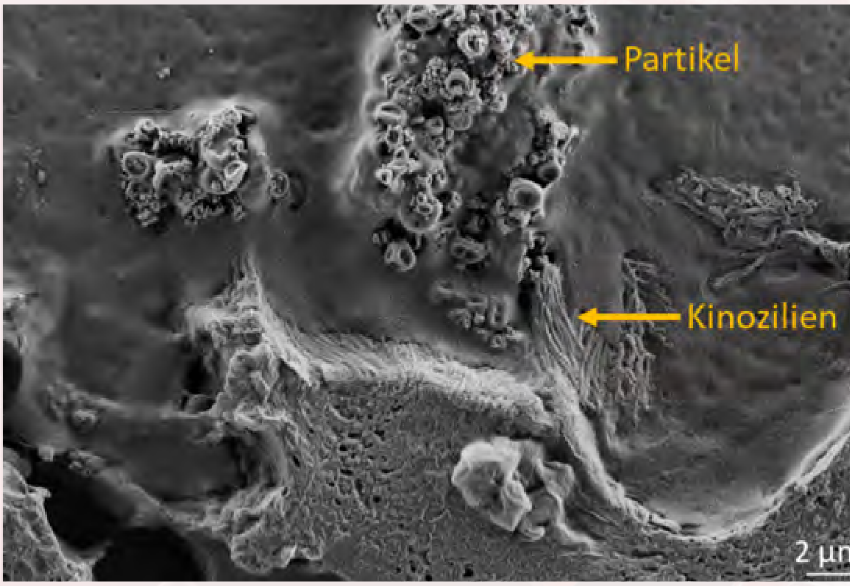


Figure 1. (A) Methylene blue staining of a tissue model of human airway mucosa. The model consists of a mucus-forming and cilium-bearing epithelium sitting on a connective tissue structure with fibroblasts. (B) Scanning electron micrograph shows that the particulate drug carriers interact directly with the mucus and kinocilia of the airway models.



Partner institutes

Fraunhofer Research Institution for Microsystem and Sensor Technology (EMFT)
Fraunhofer Institute for Biomedical Engineering (IBMT)
Fraunhofer Institute for Interfacial Engineering and Biotechnology (IGB)
Fraunhofer Institute for Toxicology and Experimental Medicine (ITEM)
Fraunhofer Institute for Translational Medicine and Pharmacology (ITMP)
Fraunhofer Institute for Cell Therapy and Immunology (IZI)

Contact

Dr. Maria Steinke
In Vitro Test Systems
Phone +49 (0)931 31-80720
maria.steinke@isc.fraunhofer.de

»ANTI VIRAL HERBS«

Beating the virus together!

Anti Viral Herbs – using natural anti-viral substances as a supplementary treatment

Plant extracts and natural substances are often said to have immune-strengthening or healing effects. Diseases caused by viruses, such as measles, herpes, and Covid 19, are also among the infections that can be positively influenced by herbal substances. For the treatment of SARS-CoV-2 viruses, which mainly settle in the pharynx, throat sprays are a suitable means of applying anti-viral extracts. However, to date, the use of throat sprays has not been particularly efficient. The active ingredient that is applied by the throat spray only remains in the pharyngeal or upper throat region for a few minutes, limiting the duration of the effective period.

Encapsulated active ingredient formulations for long-term efficacy

The research team at the Fraunhofer Translational Center for Regenerative Therapies (TLC-RT) based at the Fraunhofer Institute for Silicate Research (ISC) has found a solution to the problem of a limited effective period. By encapsulating the plant extracts, the active ingredient is immobilized in the area of infection enabling a delayed release that can extend over a period of hours or even days. During this project, ethanolic extracts of the medicinal plants Echinacea, Cistus and Artemisia vulgaris were encapsulated in absorbable inorganic materials. The active ingredients could then be electrosprayed in the form of silica gel and titanium oxalate particles combined with brine sprays. Subsequently, the corresponding particles could be dispersed in an ethanolic or silica-saturated aqueous phosphate buffer solution and applied to the pharyngeal or upper throat region.

To spray the encapsulated natural anti-viral substances, the research team has also designed and built an electrospraying system. It enables particles with a size of 1 µm to 2 µm (the nasal and pharyngeal target size) to be applied. With the development of the pharyngeal spray, the Anti-Viral Herbs project offers an over-the-counter supplement to existing preventive and therapeutic measures.

Delayed release of active ingredients in pharmaceutical and cosmetic products

The results of the project can also be applied to other natural substances, irrespective of their anti-viral effect since other ethanol-soluble, plant-based active ingredients are also able to be used in the newly developed particle systems. This allows a delayed release of the active ingredient for pharmaceutical ointments and cosmetic products in order to achieve the desired effective period.

Contact

Dr. Maria Steinke
In Vitro Test Systems
Phone +49 (0)931 31-80720
maria.steinke@isc.fraunhofer.de

»BEAT-COVID« – new therapies to combat the pandemic

SARS-CoV-2 has clearly demonstrated the need for new therapeutic approaches to rapidly changing and fast spreading infectious diseases. A large consortium of five Fraunhofer Institutes (including the ISC) and partner universities have joined forces to develop new therapeutic strategies and platform technologies that can be used to counter »new« diseases quickly and reliably.

The BEAT-COVID project decided to focus on three main therapeutic process development objectives: prevent the virus from entering host cells, combat the virus directly, and control the excessive immune response triggered by the virus (which has, in many cases, contributed to the severe progression of the disease). Work on the first two objectives involved investigating a therapeutic approach based on viral vectors and siRNA (small interfering RNA). The third objective – to control the excessive immune response – was achieved by using anti-inflammatory antibodies that can be inhaled and so able to reach the lungs quickly and directly.

Various in vitro testing methods were used to validate the efficacy of these therapeutic strategies. The advantages of these methods are two-fold. On the one hand, in terms of efficiency, they are quick and accurate. On the other hand, they reduce the need for animal experiments by using human cell material. As a result, screening for potential drugs (including those that have already been approved for other diseases) can be carried out more easily and can provide more substantive results.

The ISC Translational Center for Regenerative Therapies contributed to this project by providing its expertise in tissue engineering and in vitro test models. In vitro tissue culture models were developed which are able to reproduce the functionality and three dimensionality of mucosa from the upper respiratory tract and lung from human cells as naturally as possible, both as healthy control tissue and as infected, diseased tissue. These in vitro models of the respiratory tract make it possible to obtain a comprehensive picture of the processes that are likely to occur in humans after a viral infection and, therefore, enable both the infection process itself and the effect of the therapeutic approaches developed within the framework of the BEAT-COVID project to be observed.

Contact

Dr. Florian Kai Groeber-Becker
In Vitro Test Systems
Phone +49 (0)931 31-86
florian.groeber-becker@isc.fraunhofer.de

#FraunhofervsCorona

KNEIPP – studying the effect of plant oils on 3D skin models

Back to nature: the use of plant oils in natural cosmetics

Skin care has been around since ancient times. The ancient Greeks used natural active ingredients in plant oils such as olive oil to care for their skin. In modern times, these vegetable oils have been replaced by refined mineral oils, which although less expensive, also pollute the environment. Recently, we have witnessed an increased social awareness surrounding resource conservation and natural products. This has also impacted the cosmetics industry where we can see a return to plant-based, natural substances that is curbing the use of refined mineral oils.

Systematic investigation of natural oils

Whilst the fact that vegetable oils can have positive effects on skin is no new discovery, to date, no systematic investigation into the different effects generated by different natural oils has been carried out. To remedy this, the Fraunhofer Translational Center for Regenerative Therapies at the Fraunhofer Institute for Silicate Research has decided to develop a systematic testing method for different natural oils to help identify what impact they have on the skin and subsequently facilitate their use in the cosmetics industry.

The aim of the project is to create a fact sheet for up to 100 natural oils. These will be tested for their general, protective, and regenerative effects. In vitro skin models will serve as the basis for the testing which involves using a modular system to recreate different skin types with different properties. In vitro skin models for both healthy skin and damaged skin (in the sense of cosmetic damage such as damage caused by aggressive hand washing) are being used. The oils are then applied to the different skin models and analyzed by means of a specific testing procedure in order to identify their general, protective, and regenerative effects.

After testing 13 oils, the research team came to an important conclusion: there are serious differences in the effects that the oils have on the skin. Natural oils not only have a positive effect on the skin but can also have negative effects under certain circumstances.

Since 2013, there has been a ban on animal testing in the cosmetics industry. The Fraunhofer TLC in vitro skin models offer a suitable alternative method for finding out how far natural oils penetrate through the uppermost layer of the skin. This is essential as cosmetics, by definition, must act only on the epidermis and not in the lower layers of the skin.

Contact

Dr. Florian Kai Groeber-Becker
In Vitro Test Systems
Phone +49 (0)931 31-86
florian.groeber-becker@isc.fraunhofer.de

»IDcycLIB«

An innovation platform for a green, detectable and directly recyclable lithium-ion battery

Industrial sectors in Europe and throughout the world are facing major challenges. These include technological sovereignty and job security in Germany and sustainably rethinking and redirecting the use of raw materials (based on the most efficient use and resource-conserving utilization concepts). In particular, the shift away from fossil-fueled mobility and towards sustainable electromobility powered by renewable energy has intensified discussions concerning battery resource requirements. The IDcycLIB collaborative project aims to tackle this issue with future -orientated concepts.

The five pillars of a sustainable and economical battery cycle

Within the IDcycLIB project consortium, 12 industry and research partners have joined forces to develop a coherent and sustainable concept for battery cell production, recycling, and reprocessing that is suitable for and that can be easily implemented within industry. The concept is built on five pillars:

»Green« battery cells

Water-based manufacturing processes for battery electrodes and functional materials (no solvents or dangerous process chemicals).

Design for Recycling

The design of and components contained in battery cells allow them to be easily and automatically dismantled. The functional materials are able to be sorted and processed easily and cost-effectively for reuse in new batteries.

Detectability | battery passport | digital twin

Cell components are coded with tamper-proof particulate markers that can be easily read. This enables automated pre-sorting according to cell chemistry and components, enables separation and reprocessing processes to be simplified, and allows material flows to be recorded digitally.

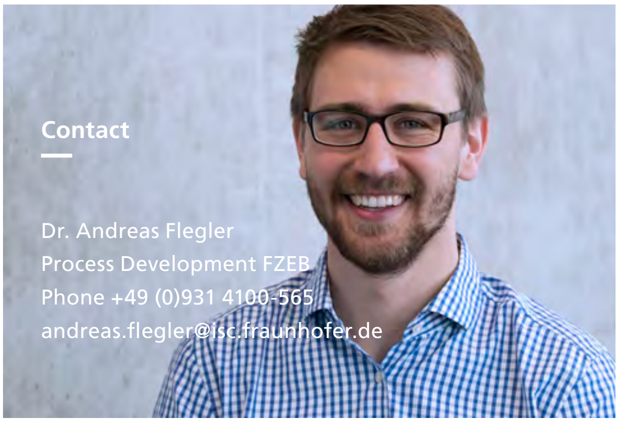
Efficient recycling processes

Gentle water-based electrohydraulic disintegration and material-sensitive sorting with novel centrifuge technology ensure that recovered material fractions for subsequent regeneration have a high purity.

Life cycle assessment

Life cycle assessment, life cycle costing, deriving parameterized models, and developing suitable software tools (including the LCA calculator and data exchange platform) for the evaluation and control of digitally recorded material flows all pave the way for sustainable battery development and recycling.

With these five pillars, the IDcycLIB collaborative project aims to build and test a toolset that will enable the sustainable fabrication, use, and economic recycling of battery cells as well as digital data management in the future. This means that the resource-saving circular economy for lithium-ion batteries (LIB) will not just be an option but will be an economically attractive one too. In addition to this, the project also opens up interfaces for future innovations such as digitally recording the cell condition.


Contact

Dr. Andreas Flegler
Process Development FZEB
Phone +49 (0)931 4100-565
andreas.flegler@isc.fraunhofer.de

BATTERY RESEARCH

Project partner

Carl Padberg Zentrifugenbau GmbH (Koordinator)
Fraunhofer Institute for Silicate Research (ISC)
Fraunhofer Institute for Integrated Circuits (IIS)
Friedrich-Alexander University, Erlangen-Nuremberg
Polysecure GmbH
Pure Devices GmbH
MAB Recycling GmbH
iPoint-systems GmbH
IFU Institute for Environmental IT, Hamburg GmbH
EurA AG
BASF SE (Associate Partner)
Leclanché GmbH (Associate Partner)

»HydroLIBRec« – battery cells made from recycled material

In recent times, battery recycling has not only become a huge business, but with increasing production figures, it is now also a necessity. Although there are already two general processing routes for recycling lithium batteries, the achievable recycling rate of these is limited. This is precisely where the HydroLIBRec project comes in.

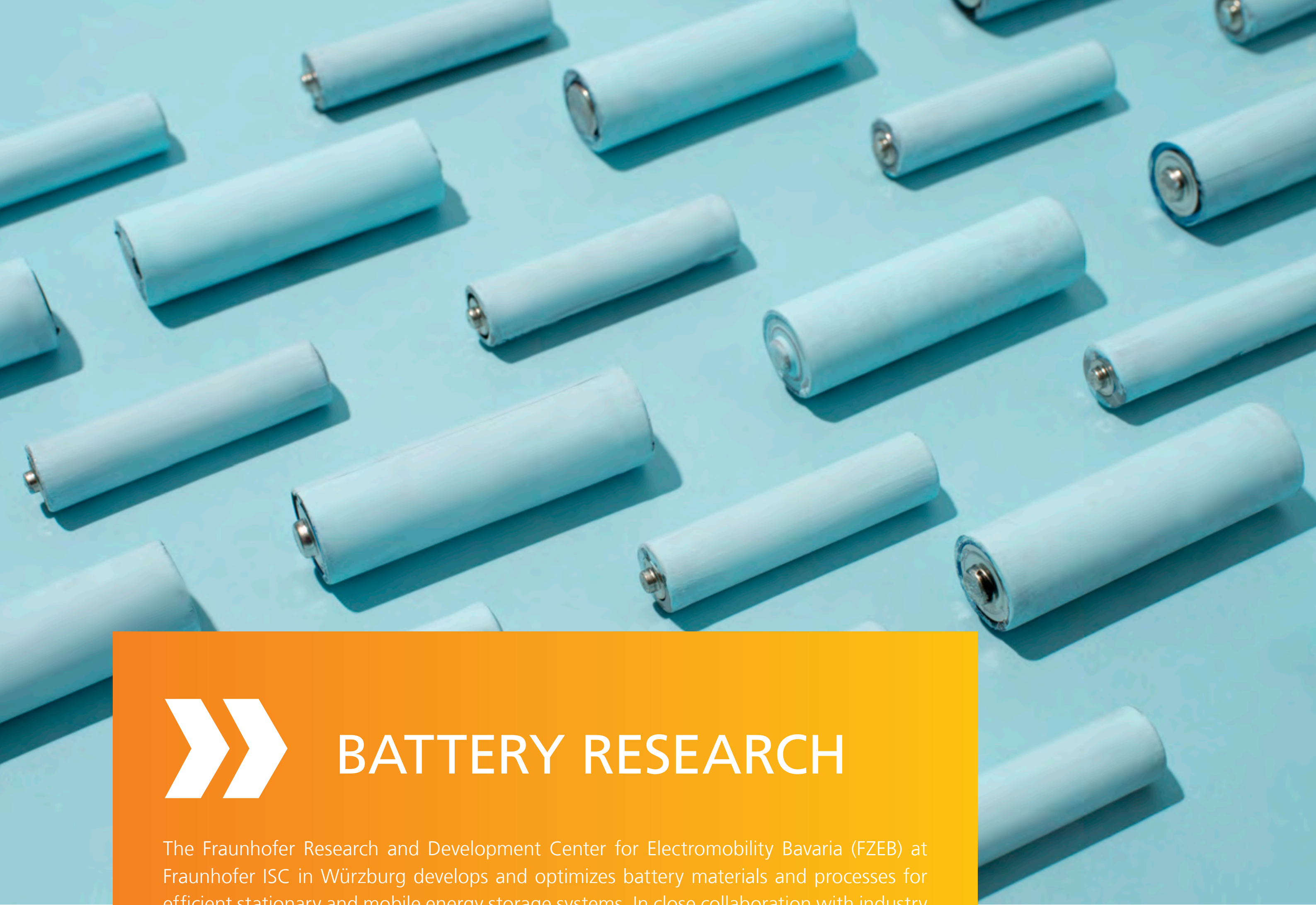
Aim

This research project aims to produce battery cells from recycled material by recovering the active materials in a function-preserving manner and through subsequent chemical processing; to qualify these cells; and then to evaluate them with regard to their reuse in sustainable battery cell production. In this way, the project links recycling and design at the construction and material level with the objective of recycling nearly all the materials contained in a battery. In particular, the project hopes to enable the reuse of resource-critical electrode materials in new batteries. From dismantling battery packs to the qualification of active materials, this project will develop and optimize the entire process chain, thereby establishing the technological prerequisites for effective, economically viable, sustainable, and function-preserving battery recycling that will ensure that lithium battery resources are available throughout Germany and Europe.

Broad field of application: using and circulating resources efficiently

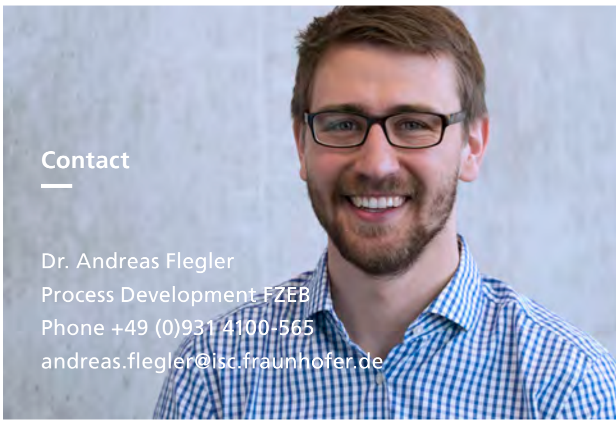
The project will ensure that material cycles are effectively closed and that processes are further optimized. HydroLIBRec aims to create a tested basis with alternative process chains and a comparison with variations that are both modeled and evaluated within the framework of the project and assessed by means of life cycle assessment and profitability analysis. This also includes comparison with established processes. In this way, the project will show what practical options are available for efficient battery material recycling within Germany. Consequently, conclusions regarding recyclability will be drawn based on example batteries, which will bring about modifications to design in order to increase recyclability. The concept of simulation-based and recycling-optimized design provides a universal tool that can also be applied to other batteries of any type and size, enabling efficient resource use and recycling in a wide range of applications.

The unique selling point of this project is that design concepts are derived directly from simulation results regarding battery architecture and the associated process technology. Digital models make it possible to specifically analyze and optimize the (re)design process, product properties, and process parameters. The objective is to optimize the process parameters and process chains so as to qualify the properties of black mass recyclate for use in recyclate batteries (proof-of-concept).



BATTERY RESEARCH

The Fraunhofer Research and Development Center for Electromobility Bavaria (FZEB) at Fraunhofer ISC in Würzburg develops and optimizes battery materials and processes for efficient stationary and mobile energy storage systems. In close collaboration with industry partners and partners from other research institutes, FZEB is investigating and developing future-oriented electrode materials, electrolytes, and other cell components as well as processes for their manufacture and processing on a pilot plant scale. The FZEB has access to all the project-relevant infrastructure needed for automated small-scale production of lithium-ion cells from recycled materials, for the synthesis and regeneration of functional materials, and for the analysis of these materials. As part of the process, special »marker particles« are being developed to establish online process monitoring of the centrifuge process.



Contact

Dr. Andreas Flegler
Process Development FZEB
Phone +49 (0)931 4100-565
andreas.flegler@isc.fraunhofer.de

»DiRecLIB« – direct recycling of active materials from lithium-ion batteries

We have already looked at why recycling is so important when it comes to ensuring sustainable batteries in the future. This importance is also reflected in the numerous ongoing projects at the Fraunhofer Research and Development Centre for Electromobility Bavaria (FZEB) at Fraunhofer ISC which are also investigating various aspects of battery recycling. Project partners working on the DiRecLib project are developing a continuous, digitally supported process for directly recycling active material from lithium-ion batteries which looks to offer very high levels of resource efficiency. For this purpose, research is taking place into the recovery of industry-relevant active materials such as NMC (lithium nickel manganese cobalt oxide), NCA (lithium nickel cobalt aluminum oxides), and LCO (lithium cobalt oxide). The process includes electrohydraulic fragmentation of electrodes and lithium-ion battery cells, deagglomeration and processing of black mass, fractionation of the active materials as completely as possible in a classifying centrifuge, and analysis of the recovered active materials.

The core mission of the project is to develop a digital twin that maps the entire process chain as the basis for a model-based control strategy. This is complemented through the development of online measurement technology and its integration into a soft sensor environment. Soft sensors are virtual sensors that use machine learning algorithms to provide output information that is suitable for use in optimization. The project's core mission will then be completed through both the creation of a data-driven model based on machine learning methods that enables the entire process chain for different battery materials to operate autonomously and the increasing of performance to achieve industry quantities with the classifying centrifuge.

The DiRecLIB demonstration plant is being set up at Fraunhofer ISC where a continuous process for the direct recycling of LIB active materials is being created – something which already has high industrial relevance (TRL 5-8). Further, the ISC team is responsible for carrying out a comprehensive life cycle assessment of the entire recycling process in terms of resource efficiency and sustainability and will compare the results with established processes. This involves examining the reprocessing of process water as well as the recyclability of commercially available cathode materials that have been recovered by the DiRecLIB process. The results will then be integrated into a material database.

Alongside the joint development of the demonstration plant, project partners are providing a comprehensive process for the direct recycling of batteries on a pilot scale and with high

BATTERY RESEARCH

Carbon Black © Orion Engineered Carbons GmbH

Project partner

Carl Padberg Zentrifugenbau GmbH (Coordinator)
Sympatec GmbH
MAB Recycling GmbH
Fraunhofer Institute for Silicate Research (ISC)
Institute for Mechanical Process Engineering and Mechanics at the Karlsruhe Institute of Technology for Technology (KIT)

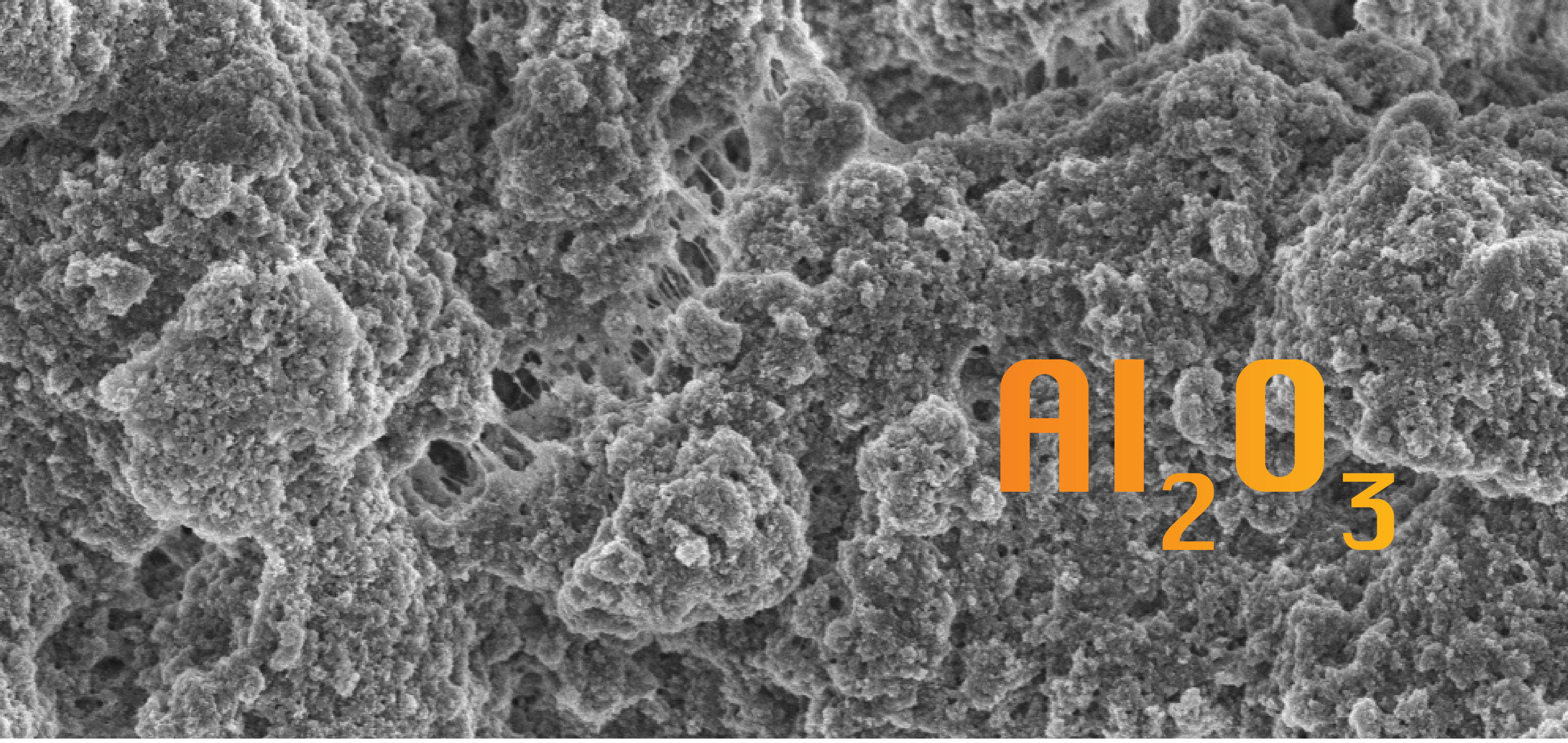
Find out more online at https://digitalgreentech.de/projekte

resource efficiency. This not only opens up large market areas but also brings ecological process management to the fore with the aim of offering sustainable solutions to current challenges within the mobility and energy industry.

The project is funded by the »Digital GreenTech - Environmental Technology Meets Digitalization« funding initiative from the German Federal Ministry for Education and Research (BMBF).

Contact

Dr. Andreas Flegler
Process Development FZEB
Phone +49 (0)931 4100-565
andreas.flegler@isc.fraunhofer.de



»SisAl« – process control and raw material chains to minimize CO_2 in silicon and aluminum oxide production

Pure silicon (Si) and high-purity aluminum oxide (HPA) are essential to many technical and electronic applications. Si is used both in the semiconductor electronics industry and in photovoltaics to generate solar power. HPA is used as a raw material, for example, in light-emitting diode production and lithium-ion battery manufacturing. However, the production of Si and HPA is currently unsustainable. Every ton of Si produces significantly higher volumes of CO_2 as well as harmful waste materials. The production of HPA from high-purity primary aluminum is also very energy-intensive, leaving behind a large carbon footprint. The SisAl project, funded by EIT RawMaterials, aims to find solutions to this problem by sophisticatedly linking together and recycling the processes and the CO_2 that is produced.

The SisAl process begins with carbon, which it replaces with secondary aluminum sources (e.g., scrap) as a reducing agent for Si production from quartz (SiO_2). At the same time, this produces slag that functions as a perfect preliminary product for HPA recovery. The introduction of an integrated CO_2 cycle further improves the already outstandingly low CO_2 footprint of the SisAl process. Fraunhofer ISC is supporting the SisAl project by providing its expertise on batteries and is using the HPA produced in the SisAl process to coat anodes and separators in lithium-ion cell production, which is expected to increase service life and cycle stability. To this end, extensive tests and analyses are being carried out on HPA and on the SisAl cells.

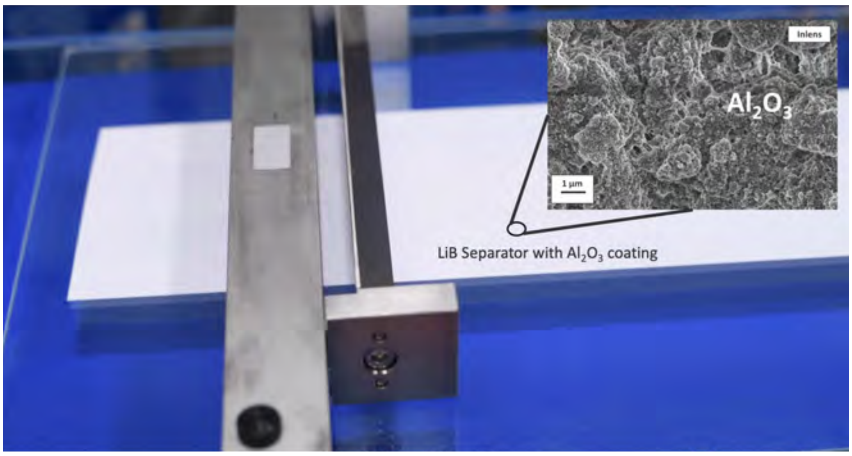
Thanks to the SisAl process, the transition to a low-carbon circular economy and other major challenges will be transformed into an opportunity to produce key technical raw materials within Europe in a sustainable manner with low CO_2 emissions. Replacing a single traditional silicon smelter in China with a new SisAl smelter in Europe would save €50 million annually in social costs of carbon, according to the SisAl consortium's estimates. So, instead of shifting production to countries with less stringent emissions regulations (so-called carbon leakage) and negatively impacting on global emissions, SisAl aims to create technological opportunities that are both sustainable and economically attractive and that will allow this production, which although energy-intensive, is also crucial to the European economy, to be brought back to Europe.

BATTERY RESEARCH

BNW Energy, Norway
Consorzio per la ricerca e lo sviluppo delle Applicazioni industriali del Laser E del Fascio elettronico e dell'ingegneria di processo, materiali, metodi e tecnologie di produzione, (CALEF) Italy
Elkem AS Technology Kristiansand, Norway
ENALOS Research and Development, Greece
Fraunhofer Institute for Silicate Research (ISC), Germany
MYTILINEOS S.A., Greece
National Technical University of Athens - NTUA, Greece
Rheinisch-Westfälische Technical University, Aachen, RWTH Aachen, Germany
SiQAl UG, Germany
WALTER TOSTO, Italy
Norwegian University of Science and Technology (NTNU) (Lead Partner), Norway

Find out more online at https://www.sisal-pilot.eu/

eit RawMaterials Connecting matters
Co-funded by the European Union



Contact

Dr. Uwe Guntow
Phone +49 (0)931 4100 415
uwe.guntow@isc.fraunhofer.de

»HybridPEARLS«

Functional encapsulation through multiple coating

Environmental pollution is one of the major global problems of our time. One cause of this pollution comes from microplastics which end up in the soil and in oceans via wastewater. The European Chemicals Agency defines microplastics as small particles formed during the decomposition of macroplastics contained in cosmetics or agrochemicals. In particular, encapsulations of active ingredients, usually made of synthetic polymers and found in fertilizers, pesticides, and cleaning products, break down into microplastics and enter the environment. Whilst the function of these encapsulations is essential for everyday life as well as for agriculture and industry, in the long run, they cause significant damage.

bioORMOCER® as a coating material for active ingredient carriers

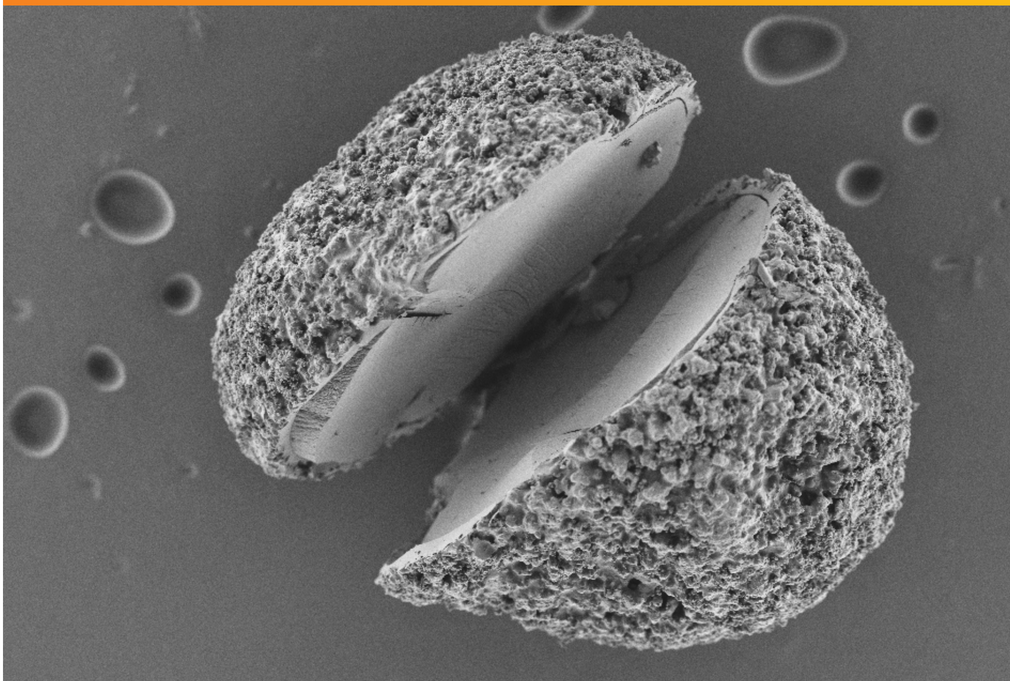
Given the impact of these microplastics, Fraunhofer IAP and Fraunhofer ISC are working to find replacements for synthetic polymer coatings. The material must, on the one hand, have very good application properties in terms of chemical and thermal stability, barrier properties, and storage stability, and, on the other hand, be fully biodegradable under natural environmental conditions. The search for a material that fulfils both these requirements has led to a functional barrier coating material developed by Fraunhofer ISC – bioORMOCER® coatings.

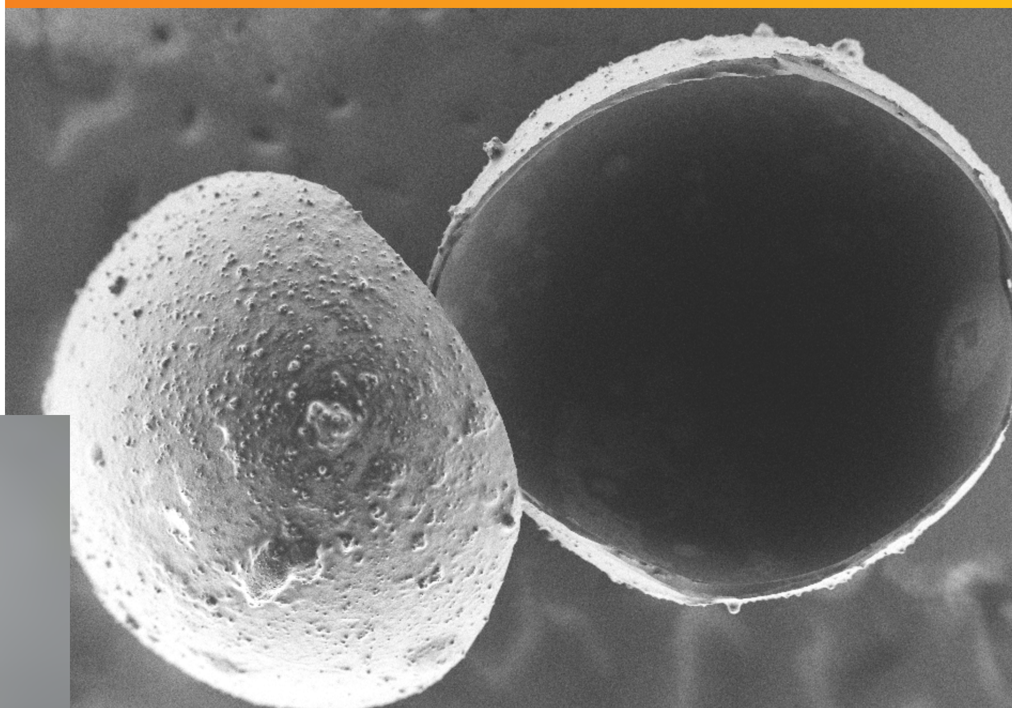
The HybridPearls project aims to establish a functional encapsulation by means of multiple coatings. These coatings must exhibit improved application properties compared to the current state of the art and must be able to break down completely. The structure is to be based on commercially applied encapsulation techniques already used in the production of packaging materials. Microcapsules of this type ultimately consist of three components: (1) the active ingredient core, (2) the biodegradable capsule material, and (3) the functional biodegradable barrier layer – the bioORMOCER®.

In the first subproject, Fraunhofer ISC has set out a number of research areas related to bioORMOCER® and the coating processes. An important requirement for the bioORMOCER® coatings is their ability to adapt to different areas of application. The development of tailor-made bioORMOCER® coatings should enable a modular system that promises variability (e.g., with regard to the encapsulated materials and their controlled degradation) and versatility with a wide range of applications in areas such as in agriculture and industry. To successfully produce the capsules, the active ingredient carriers and production processes must be coordinated with each other.

Homogeneous coatings, low layer application, and layer abrasion are essential criteria within the manufacturing processes. Accordingly, the HybridPeals project is working on developing and testing suitable coating technologies.

BioORMOCER® coatings are biobased, biodegradable, and REACH-compliant hybrid polymers developed at Fraunhofer ISC. They are used, among other things, as functional coatings for packaging in the food, cosmetics, and pharmaceutical sectors.





Contact

Dr. Ferdinand Somorowsky
Chemical Coating Technology
Phone +49 931 4100-256
ferdinand.somorowsky@isc.fraunhofer.de

»Safe Vulca«

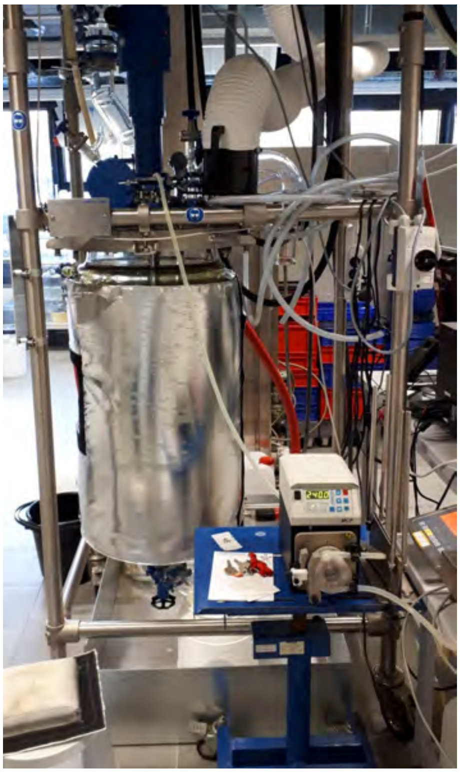
Vulcanization is an important process in tire production in which rubber is converted into an elastomer. ZnO, currently the most efficient vulcanization activator, is used in this process to improve and control the reaction rate. However, ZnO poses potential environmental risks that cannot be ignored: According to the U.S. Environmental Protection Agency (EPA), zinc ions can be released from zinc oxide through various mechanisms, and zinc ions are expected to be toxic to aquatic organisms. Therefore, reducing ZnO content in elastomers is a global challenge, especially in tire manufacturing. In addition, large amounts of ZnO also make it difficult to recycle used tires.

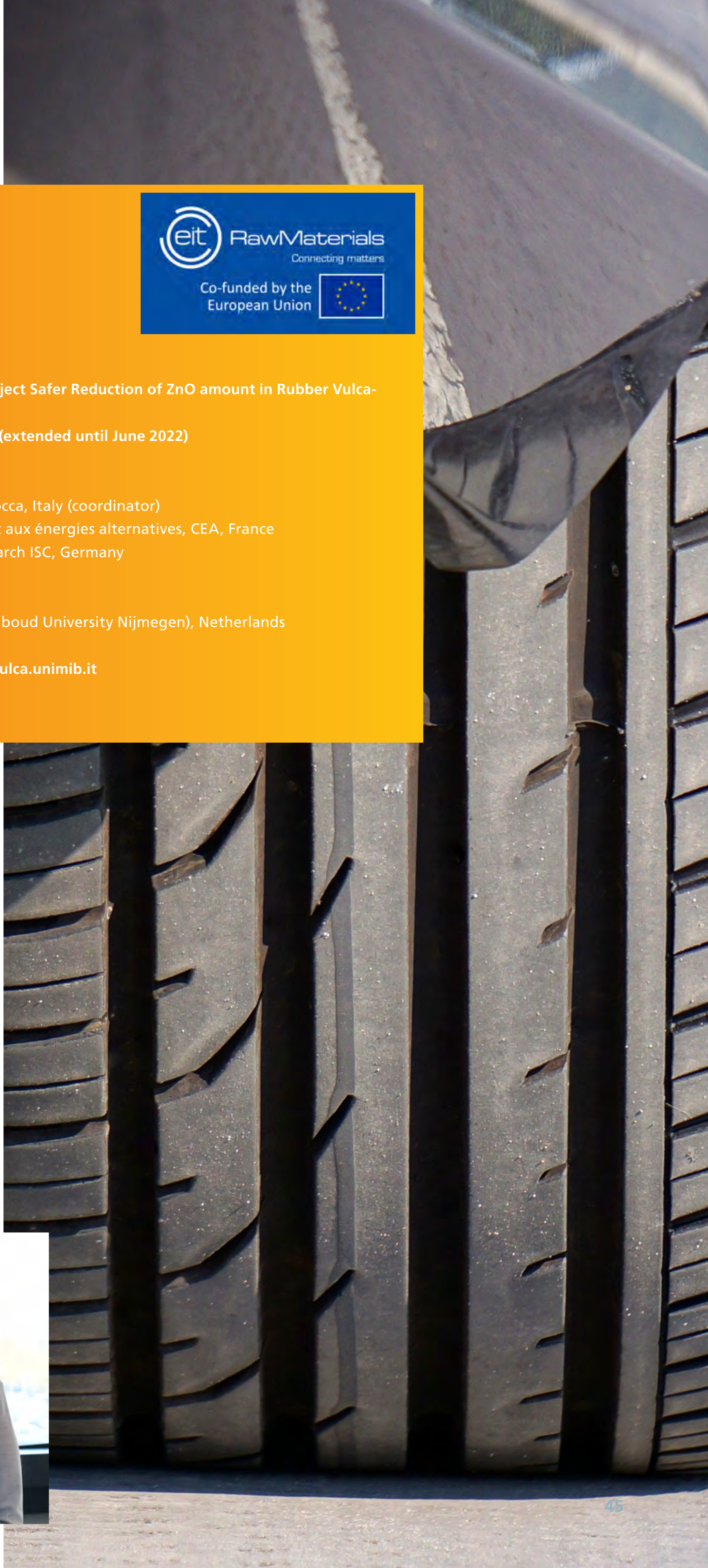
The "Safe Vulca" project, funded by EIT RawMaterials, aims to reduce the amount of conventionally used microcrystalline ZnO activator while improving the efficiency of the crosslinking process by replacing ZnO with a novel bifunctional filler ZnO-NP@SiO_2-NP. The idea is to anchor amorphous ZnO nanoparticles on the surface of the silica reinforcing fillers and thus achieve a more homogeneous distribution throughout the rubber matrix compared to microcrystalline ZnO. This leads to an increase in reactivity and, consequently, to an increase in efficiency during rubber vulcanization. The bifunctional filler is produced via an easily scalable and environmentally friendly sol-gel process. This specific process has already been validated for the successful production of elastomer composites with high mechanical performance using ZnO-NP@SiO_2-NP in conventional tires.

The substitution of crystalline ZnO activator with ZnO-NP@SiO_2-NP leads to remarkable vulcanization efficiency, as the dispersed zinc nuclei can react with the vulcanizing agents in the rubber matrix during vulcanization. This enables a reduction of the conventional amount of ZnO by about 50 % and the production of rubber composites for tire applications with up to 10 % better vulcanization and mechanical properties than with the conventional activator.

The Fraunhofer ISC's "Particle Technology" group was responsible for upscaling the wet chemical synthesis and the accompanying characterization for quality assurance. In this way, the "Save Vulca" project was able to take the decisive step from the gram to the kilogram scale in the production of the bifunctional filler. Particularly important for cost-effective and environmentally friendly production on a larger scale is the conversion of the synthesis route from an ethanol-based to a water-based system. The ISC team made this conversion possible thanks to its extensive synthesis expertise. In the process, it was also possible to increase the synthesis yield and improve the overall scaling potential.

Synthesis approach for Safe-Vulca in the isolated 100l reactor © Fraunhofer ISC





Project information
EIT KIC Raw Materials Up-scaling Project Safer Reduction of ZnO amount in Rubber Vulcanization Process SAFE-VULCA
January 1, 2019 - December 31, 2021 (extended until June 2022)

Project partner
Università degli Studi di Milano - Bicocca, Italy (coordinator)
Commissariat à l'énergie atomique et aux énergies alternatives, CEA, France
Fraunhofer Institute for Silicate Research ISC, Germany
Monolithos Ltd, Greece
Pirelli Tyre S.p.A, Italy
Stichting Katholieke Universiteit (Radboud University Nijmegen), Netherlands

Find out more online at **https://safevulca.unimib.it**

Contact

Dr. Claudia Stauch
Particle technology
Phone +49 (0)931 4100-597
claudia.stauch@isc.fraunhofer.de

You will find the complete Annual Report on the Internet at

https://www.isc.fraunhofer.de/jahresbericht

Legal information

Editorial office
Marie-Luise Righi
Sandra Köhler
Susanne Kuballa
Katrin Selsam
Prof. Dr. Gerhard Sextl

Graphics and diagrams
Katrin Selsam

Layout and production
Katrin Selsam

Printing
Farbendruck Brühl Marktbreit

Origin of photo material
Fraunhofer ISC illustrations and photos or the copyright notice next to the image.

Editorial address
Fraunhofer Institute for Silicate Research IS
Neunerplatz 2
97082 Würzburg

Phone +49 (0)931 4100-150
marie-luise.righi@isc.fraunhofer.de
https://www.isc.fraunhofer.de

Fraunhofer-Institut für Silicatforschung ISC

Fraunhofer ISC

Fraunhofer_ISC

Fraunhofer ISC

EVERYTHING COFFEE

Grab a hot fragrant cup of coffee and make yourself comfortable.

This year, our annual report is devoted to many projects that are dedicated to sustainability. We need to be prudent with our resources in these times. That is why we have again reduced the printed version of the annual report to the project section. We have also put sustainability at the forefront of the printing process. Naturally, we refrain from using varnishes and other finishes, but now we have even chosen a paper made from - yes you read right - coffee pomace.

This means that the coffee carton significantly reduces the amount of water and resources used in its production. The inner paper is made from 100% recycled paper, is FSC-certified and has been awarded the Blue Angel and the EU Ecolabel.

For more information about the work behind the projects and what else is going on, visit our website at **https://www.isc.fraunhofer.de/jahresbericht**

Follow us on LinkedIn and Twitter!