2019 Annual Report

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adolphe merkle institute
excellence in pure and applied nanoscience

About the
Adolphe Merkle Institute

The Adolphe Merkle Institute (AMI) is an independent competence center at the University of Fribourg that focuses on research and education in the domain of soft nanomaterials.

We owe our existence to Dr. Adolphe Merkle, a successful local entrepreneur, who established the Adolphe Merkle Foundation with the goal of strengthening research and teaching at the University of Fribourg. His CHF 100 million endowment constitutes one of the most important private donations in Switzerland in favor of academic research.

Founded in 2008, AMI is in many aspects unique in the landscape of Switzerland's research institutions. Our focus on soft nanomaterials is unmatched in Switzerland and beyond. Our research combines fundamental and application-oriented aspects in a multidisciplinary setting. Through collaborations with industrial partners, AMI aims to stimulate innovation, foster industrial competitiveness, and, more generally, improve the quality of life.

Our researchers are currently organized in four research groups, which offer complementary expertise and interests in strategically important areas: BioNanomaterials, Polymer Chemistry & Materials, Soft Matter Physics, and Biophysics. Interdisciplinary collaborations between our researchers are the basis for the successful and efficient execution of complex research projects that transcend the boundaries of traditional scientific disciplines. This environment and our world-class research facilities make AMI a desirable destination for master's and PhD students, postdocs, and senior researchers.

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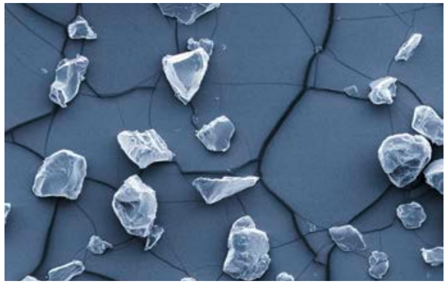

Material hazard
Investigating the impact of microplastics




AMI continues its evolution

_ A message from the director

Professor Christoph Weder

I am happy to present to you the Adolphe Merkle Institute's annual report 2019, in which we share once again our most important activities, accomplishments, and developments.

Significant changes occurred in the board of the Adolphe Merkle Foundation, which was founded in 2007 with the primary goal to set up and support AMI. Inaugural board members Isabelle Chassot and Joseph Deiss, who had also served as the foundation's president since its inception, stepped down from their posts, while Jean-Pierre Siggen, the Canton of Fribourg's Minister of Education, Culture, and Sports, and Chantal Robin, Director of the Fribourg Chamber of Commerce and Industry, joined as new members. Peter Huber, who has been a board member for the past four years, was elected as the Foundation's new president. We saw this period of transition as an opportunity to reflect on AMI's past, present, and future, and invited the former and new presidents to share their thoughts with us and with you.

As every year, a collection of research stories forms the heart of our annual report. The topics that we cover this year include the spit of carnivorous velvet worms, the effects of ingested microplastics on human health, efforts to develop better solid polymer electrolytes for batteries, a new trick for fabricating platinum nanoparticles on demand, the use of nanopores for the characterization of large biomolecules, and a new approach to creating supramolecular polymers with improved mechanical properties.

An important strategic development for our institute was the launch of the Swiss NanoAnalytics (SNA) platform, which aims to provide external researchers, government agencies, and industrial clients with analytical services for nanoparticles. Chiefly driven by our BioNanomaterials group, SNA was created to make AMI's world-class expertise and infrastructure regarding the analysis of nanoparticles in complex environments available to third parties. SNA's competencies are particularly relevant in the context of new legislation that requires the declaration of nanoparticles in consumer products such as food and cosmetics.

Taking research results and translating these into applications has always been one of the Adolphe Merkle Institute's goals. After a decade in business, several research projects have matured to the point where such transfers have become possible. Our Institute's Technology Transfer and Innovation manager maps out the strategies that assist our researchers in taking their work from the laboratory bench to application.

Ironically, the longest section of this report is called "In Brief." This segment covers a broad range of topics that include awards, conferences and workshops, alumni successes, and our contribution to Fribourg's place in *Nature Index*'s latest Materials ranking, highlighting the many accomplishments achieved by AMI's researchers in the last year as well as the wide variety of their activities.

At AMI, we continue to value our partnerships and are once again grateful for all the interest, courtesy, and support that we continue to receive. We hope that this report conveys our passion and enthusiasm for our work and that you enjoy reading it!

Christoph Weder
AMI Director and Professor for Polymer Chemistry & Materials

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Pursuing excellence

Changes

_ Foundation presidents share their thoughts

Peter Huber replaced Joseph Deiss as Foundation president in 2019

The Adolphe Merkle Foundation, which actively supports the Adolphe Merkle Institute, saw important changes in the composition of its board in 2019, with Peter Huber taking over the presidency. The Foundation will continue backing AMI and its future growth.

Former Swiss President and long-term Board Chairman Joseph Deiss stepped down, as did Isabelle Chassot, Director of the Federal Office of Culture and former Minister of Education, Culture and Sport of the Canton of Fribourg. The Foundation elected Peter Huber, already a member of the Board, as the new Chairman, and appointed Jean-Pierre Siggen, the Canton of Fribourg's current Minister of Education, Culture and Sport, as well as Chantal Robin, the Director of the Fribourg Chamber of Commerce and Industry, as new members of the Foundation Board.

The Adolphe Merkle Foundation was founded in 2007 by Fribourg industrialist and entrepreneur Adolphe Merkle. With a capital of CHF 100 million, its mission is to promote research and education at the University of Fribourg. This private donation, the largest at the time in favor of a Swiss university, enabled the creation of the Adolphe Merkle Institute, and helps support other activities within the Faculty of Science and Medicine (Fribourg Center for Nanomaterials FRIMAT), as well as at the Faculty of Arts (Institute of Multilingualism). With the changes taking place at the Foundation, we took the opportunity to talk with its two presidents about AMI's past and future.

Mr. Deiss, did AMI develop as the Foundation expected?

Joseph Deiss: The challenge was to build something from the ground up. The goal was to create a top-ranked institute with an international stature. Because it was launched in Fribourg, it was very important to have top-level people, and I think from an intellectual point of view, we have achieved a very high standard, as demonstrated by publications in the best scientific journals. The arrival of the National Center of Competence in Research Bio-Inspired Materials at the University of Fribourg is also proof of this strength at the national level.

AMI should not be satisfied, however, with this status quo and rest on its laurels. I am convinced that AMI still has the potential to grow, and this has been reflected in recent discussions about the Institute's future for the period from 2023 to 2032. We feel that AMI will have to mesh even more with the community and the economy, especially in terms of applications of the research carried out at the Institute. The first decade was largely dedicated to the creation of an institutional memory at the scientific level, with some applied results, but we can take that further. We have a first start-up, and will be present in the food sector. We hope to create a fifth chair in this domain, that is important not just for the Fribourg region, which has a cluster in agriculture and food processing industries, but also globally because of the need for food security. We hope that AMI and nanotechnology can have a positive impact and help solve issues related to nutrition.

Mr. Huber, were you surprised by AMI's development when you joined the board four years ago?

Peter Huber: I was positively surprised. If you start from scratch, the first decade is focused on reaching a critical mass, integration with the university, and this was already completed by the time I arrived. AMI has achieved a level of international recognition that is truly extraordinary. It is a relatively small institution, but it is in the same league as larger Swiss institutions. Even so, it can still grow. Our objective over the next decade is not to have the maximum number of scientists, but to ensure that the Institute operates at a very high academic level, with the Foundation focusing on support for more spinoffs, and commercialization of products that also benefit the canton of Fribourg.

How do you evaluate AMI's impact on the University and the wider community?

Joseph Deiss: This was definitely one of Mr. Merkle's goals when he launched the Foundation. He wanted to provide a major boost for the University through different initiatives, especially at the Faculty of Science and Medicine. AMI helped create a model of emulation that is needed to help the institution progress.

> “AMI has achieved a level of international recognition that is truly extraordinary.”
> *Peter Huber, President, Adolphe Merkle Foundation*

What have been the highlights for the Foundation?

Joseph Deiss: One of the highlights was the arrival of the NCCR, a very important milestone because it was an external acknowledgement of the work being carried out at AMI. It was also important because the Institute took on a leadership role, even in regard to the other participating universities. This was not just something new for AMI, but also for the University of Fribourg. We have also seen that AMI has become a calling card for the University and the canton, and important visitors are welcomed there because it is a place to discuss the business of the future. Even if people know nothing about nanotechnology, they understand that it is important.

Peter Huber: Another highlight is the fascinating work being carried out at AMI, be it malaria diagnostics, nanostructures for new batteries, or the Swiss NanoAnalytics project, for example. These projects are a motivation for the Foundation to maintain its support for AMI. The capacity of AMI to earn external funding is also a huge success, and shows how a private-public collaboration can create a basis for success that is good for all: the students, the University, and the community at large. That is also a reflection of the original goals set out by the Foundation.

With the changes at the Foundation, will there be a different orientation?

Joseph Deiss: We have been a very stable team, very complementary, with people who can talk science, but also others with skills such as management. Nevertheless, despite renewing the whole team, it has gone very smoothly, as the new members display similar skill sets.

Peter Huber: The mix of skills is very important because it allows us to discuss our strategy from different perspectives. You need to have an understanding of science, industry, and politics to succeed. The Foundation is also in very good financial health, so we want continuity to ensure that sustainability.

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NATIONALITIES

ARE PRESENT AT AMI, WITH STAFF COMING FROM EVERY CONTINENT.

5

PROFESSORS

SPECIALIZING IN POLYMER SCIENCE, MATERIALS, PHYSICS, CHEMISTRY, AND BIOLOGY.

53%

OF ALL RESEARCH EXPENDITURES

WERE COVERED BY THIRD-PARTY FUNDING. SOURCES INCLUDED THE SWISS NATIONAL SCIENCE FOUNDATION, THE EUROPEAN UNION, INNOSUISSE, AND INDUSTRIAL PARTNERS.

5,700

CITATIONS

OF AMI PUBLICATIONS IN THE SCIENTIFIC LITERATURE IN 2019.

3

PROJECTS

WITH INDUSTRIAL PARTNERS IN 2019.

107

SCIENTIFIC PUBLICATIONS

IN TOP-RANKED JOURNALS SUCH AS THE JOURNAL OF THE AMERICAN CHEMICAL SOCIETY, ACS NANO, ADVANCED FUNCTIONAL MATERIALS, NATURE COMMUNICATIONS, ACS CENTRAL SCIENCE, NANOSCALE, ENVIRONMENTAL SCIENCE & TECHNOLOGY, SCIENTIFIC REPORTS, AND ADVANCED ENERGY MATERIALS, AND MATERIALS TODAY.

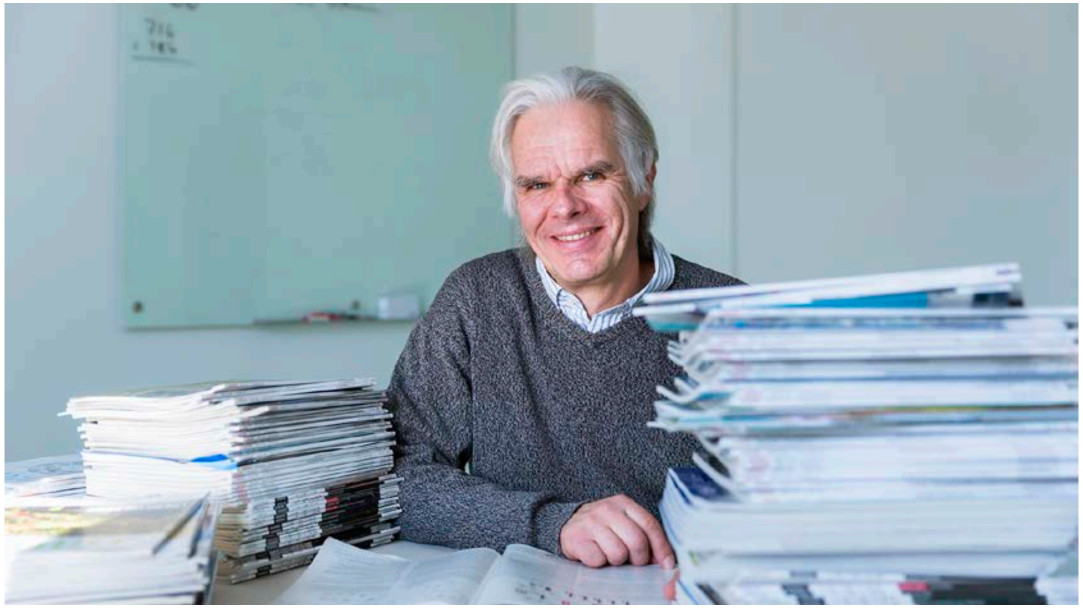
280

ALUMNI

INCLUDING POSTDOCTORAL RESEARCHERS, PHD STUDENTS, AND INTERNS.

Grants

_ Institute researchers secure funding success



Professor Ullrich Steiner is investigating the hidden order behind seemingly chaotic structures

The Adolphe Merkle Institute's researchers have demonstrated time and time again that their research ideas are at the forefront of science by being awarded substantial third-party funding. AMI's Soft Matter Physics chair, Professor Ullrich Steiner, is just one of the latest examples.

Steiner was awarded a prestigious ERC Advanced Grant by the European Research Council in 2019. Worth €2.5 million over five years, this grant, the largest single investigator funding of its kind in Europe, will fund research into furthering the understanding of structural color found in nature. Dazzling color effects are sometimes created by complex nanostructures that cause certain wavelengths of white light to be superimposed and eliminated. The resulting colors arise from such interference effects. Butterfly wings, for example, are covered in complex multilayer structures of thousands of microscopically small scales to create spectacular hues.

"Scientifically, the ERC Advanced Grant enables me to tackle a problem on a much larger scale than before."
Professor Ullrich Steiner, Chair of Soft Matter Physics

In theory, these striking colors should only be produced by ordered structures. In practice, however, they often appear in apparently disorderly structures found in plants and animals. Steiner's project will focus on determining if there is, in fact, some underlying order in these seemingly random morphologies to help explain the presence of structural colors in living organisms. Yet, the goals of Professor Steiner's project PrISMoID (Photonic Structural Materials with Controlled Disorder) go beyond providing just a fundamental understanding of the interplay of structural correlations with optical interference in disordered materials. With the technological importance of structural coloration in mind, he envisions mimicking this effect in artificial systems and establishing design rules for simple manufacturing processes. Advantages of this type of color include brightness, resistance to fading, and that they can be made from non-toxic materials.

“Scientifically, the ERC Advanced Grant enables me to tackle a problem on a much larger scale than before, when I had only one student funded by the NCCR Bio-Inspired Materials to pursue this,” explains Steiner. “I envisage the topic of my ERC grant to develop into the central scientific activity of my research group.”

Earning an ERC Advanced Grant is no small achievement in itself. The success rate for applications is usually around 1 in 10, and the competition is strong – in the physical sciences and engineering alone, 839 proposal were submitted for this series and only 82 were funded. “A large majority of the submitted proposals are certainly excellent, and there is a good measure of luck involved in getting one,” says Steiner, who secured his grant on his fourth attempt.

The Soft Matter Physics chair points out that, even if he will continue to pursue other grants, the ERC funding provides him with a financial cushion. “I intend to use some of it to further the careers of young researchers who are group leaders, for which the combination of AMI money with a healthy grant income is ideal,” he adds.

This is the second time an AMI researcher has been awarded an ERC Advanced Grant. AMI Director and chair of Polymer Chemistry and Materials, Professor Christoph Weder, received a grant in 2012 for his project on mechanically responsive polymers. He says the impact of the grant went far beyond a pure monetary value and that “ERC Grants are a wonderful mechanism to support high-risk, high-reward projects that have a significant footprint in terms of staffing for a duration of five years.”

Original ideas

In 2019, four young AMI researchers were also awarded research grants as part of the Swiss National Science Foundation’s new Spark rapid testing and development program. Postdoctoral researchers Dr. Dedy Septiadi and Dr. Roman Lehner of the BioNanomaterials group, as well as Dr. Esteban Bermudez and Dr. Matthias Saba of the Soft Matter Physics group, were each granted close to CHF 100,000 to support their respective research projects for one year. Their activities cover domains as varied as the development of a laser system for cell imaging and identification, investigating the toxicological responses of microplastics on human immune cells, creating so-called metamaterials with novel optical properties, and placing light-emitting particles inside optical structures to improve their light emission properties.

The aim of the Spark program is to fund the rapid testing or development of new scientific approaches, methods, theories, standards, and ideas for applications, for example. It is intended for projects that show unconventional thinking and introduce a unique approach. The focus is on promising ideas of high originality relying on no or very little preliminary data that are unlikely to be financed by other available funding schemes.

Service platform
— Analyzing nanoparticles in consumer goods, pharmaceuticals, and more

THE SNA team of Professors Fink and Rothen-Rutishauser, and Dr. Christoph Geers, will be collaborating with partners across Switzerland

The Adolphe Merkle Institute's BioNanomaterials co-chairs Professors Alke Fink and Barbara Rothen-Rutishauser have launched the Swiss NanoAnalytics (SNA) platform, which is aimed at providing fellow researchers, official bodies, and industry with services for the analysis of nanoparticles in pharmaceutical formulations, composite materials, and other everyday items.

The service will help clients respond to new legislative requirements. As of 2021, the food industry and cosmetics manufacturers will have to officially declare the presence of nanoparticles in any of their products sold in Switzerland. Examples of nanoparticles that can already be found in food include titanium dioxide nanoparticles used, for example, as whitener in chewing gum, toothpaste, and sunscreen. Silicon dioxide nanoparticles are used as anti-clumping agents in spices, breakfast cereals, and powdered sauces. The presence of macroscopic titanium and silicon dioxide is already announced on packaging, labelled as E171 and E551, respectively. With the introduction of compulsory declarations next May, however, producers will have to specify "nano" on their packaging if components are present at the nanoscale.

"The declaration of nanoparticles in consumer products required by European and Swiss legislation, as well as the information that needs to be provided by companies to the final consumer, represent major challenges for all stakeholders in the near future," says Fink, who has been one of the drivers of the project along with her colleague Rothen-Rutishauser.

This change means compulsory testing for nanoparticles in general. Yet, few laboratories have the instrumentation and know-how required for this type of analysis, adds Fink. "Analysis can be extremely complicated, given that the physical and chemical properties of synthetic nanoparticles can vary significantly depending on the material and product tested."

Based at AMI, SNA provides a platform for nanoparticle analysis aimed at manufacturers, the authorities, and other research institutes. Available services include general particle characterization, analysis of nanoparticles in consumer goods such as food and cosmetics, and testing of nanoparticles' stability in biological fluids such as blood serum. The scientists working for SNA can also test material composites used in electronics or construction materials.

The platform draws on the BioNanomaterials group's expertise to characterize nanoparticles in complex environments and the Institute's infrastructure and array of instruments for nanoparticle analysis, including electron and optical microscopes, light-scattering devices, and spectrometers. "The aggregation of these different techniques allows us to provide a complete analysis of nanoparticles for academia and industry," points out Dr. Christoph Geers, who manages the SNA platform.

"The aggregation of [...] different techniques allows us to provide a complete analysis of nanoparticles for academia and industry."
Dr. Christoph Geers, SNA manager

However, it should not be considered a solitary effort. Analytical requirements are largely determined by definitions, regulations, and standards, raising complex issues and requiring sophisticated solutions. "Because of this complexity, Swiss NanoAnalytics relies on expertise from all over Switzerland," says Fink. To ensure precise evaluation of nanomaterials, input from experts from the regulatory authorities, industry, and research institutions is a given. Professors Rothen-Rutishauser and Fink collaborate, for instance, with contactpointnano.ch, an independent national platform hosted by Empa (the Swiss Federal Laboratories for Materials Science and Technology) in St. Gallen that pools the scientific and regulatory knowledge and expertise available in Switzerland on the safe handling of synthetic nanoparticles.

"The Swiss NanoAnalytics mandate is to provide industry, the authorities, and other research institutions with the most modern and highest quality analytical methods," explains Geers. "With our leading expertise in nanoparticle synthesis, characterization, and applications in biological systems, we can offer our knowledge to meet customer needs and develop cutting-edge methods and solutions."

Through this project, and with the support of the Adolphe Merkle Foundation, AMI is also making an important contribution towards better transparency in the use of nanoparticles in food and cosmetics in Switzerland.

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ACTIVE RESEARCH PROJECTS

IN FIELDS SUCH AS SHAPE-MEMORY POLYMERS, PLANT-INSPIRED SURFACES, HAZARD ASSESSMENT, MICRO-PLASTICS, POLYMER SELF-ASSEMBLY, DETECTION OF NANOPARTICLES, CELL MECHANICS, BATTERIES, NANOPORE FABRICATION, SINGLE-MOLECULE DETECTION, AND PREVENTION OF PARTICLE-INDUCED LUNG DISEASES.

CHF 9.5 mio

SPENT IN 2019

RESEARCH EXPENDITURES OF CHF 8.3 MILLION CONSTITUTE THE LARGEST SHARE OF THE AMI BUDGET.

40%

OF STAFF AT AMI ARE WOMEN

25

SEMINARS

GIVEN BY VISITING RESEARCHERS, STAFF, AND AMI STUDENTS.

107

PEOPLE

WORK AT AMI INCLUDING PHD STUDENTS, POSTDOCTORAL RESEARCHERS, PROFESSORS, SUPPORT STAFF, AND INTERNS.

46%

OF AMI STAFF

ARE DOCTORAL STUDENTS.

Tech transfer

_ Building bridges between industry and academia

The Hemolytics malaria diagnosis project is currently supported by Innosuisse, the federal innovation agency

Taking research results and translating these into applications has always been one of the Adolphe Merkle Institute's goals. After its first decade of existence, a number of research projects have matured to the point where such transfers have become possible, leading to translation success.

Examples of this are AMI's first startup, NanoLockin, and the Hemolytics malaria diagnosis technology that is currently under development. At the same time, other more discrete collaborations are taking place between the Institute's scientists and industrial partners. To create these partnerships, though, specialist knowledge is a need that has long been recognized at AMI. Dr. Valeria Mozzetti has been the Institute's Technology Transfer and Innovation manager since 2018, helping researchers navigate the difficult path from the laboratory bench to application.

How do you define innovation at the Adolphe Merkle Institute?

Valeria Mozzetti: In its simplest definition, innovating means bringing something new to the market, where many people can enjoy its benefits. No matter how small or well-known, what matters is that it hasn't been used in the same context before. For us at AMI, being innovative is something we do every day, in the sense that when we research, discuss, and write, we always have in mind how the work we do could benefit the wider community on a larger scale, and who our partners should be.

How does technology transfer work at AMI?

Valeria Mozzetti: TT is very involved, since an effective way of innovating is to collaborate with industry. Existing companies know the market, have the distribution channels, and are hungry for innovations. These elements make collaborations with industry very rewarding, because they shorten the path for research to have an impact. Industrial partners can also serve as catalysts for new research projects, because they bring different perspectives and new ideas to the table.

When the research is perhaps too innovative for potential partners, or industry is not ready for it for other reasons, we can help researchers face the challenge of creating new companies. This support includes direct entrepreneurial aspects as well as guidance on how to be successful in the context of broader networks, such as those proposed by the Swiss Innovation Agency, Innosuisse. In 2019, for example, with TT support, Dr. Fabienne Schwab and Dr. Jonas Pollard were both granted research projects by Innosuisse: one for nanofertilizers, and the other for malaria diagnostics, respectively.

How do you square the AMI concept of innovation with academic pursuits?

Valeria Mozzetti: “Publish or perish” is often the mantra in academia, and a scientific paper should be written so that it is replicable. If you want to innovate and be commercially successful, however, you have to develop your technology and products with strict control over what you communicate in order to protect your intellectual property (IP). Researchers can be torn between these opposing forces, tempted to publish groundbreaking research results, which would preclude filing for a patent, or simply developing a company quickly enough to bring the technology to the market. To resolve this situation, and create an appropriate strategy, we try to inform our researchers about these issues through workshops and on one advice. We also have a process in place with an IP board to evaluate all new inventions and collaborations with industrial partners.

So how do you pass on that innovation state of mind to researchers?

Valeria Mozzetti: This mindset hinges on knowledge about products, services, and processes. In this context, the heads of the research groups have invaluable experience, and provide examples when it comes to industrial collaborations. They are the main source of inspiration for AMI researchers. The other source of information about innovation is AMI's Technology Transfer office. I try to maintain a good overview of the industrial landscape, and of how to convert research-level technology into successful innovation projects. This can be done, for example, through workshops on intellectual property and innovation. The door is always open for questions, and all projects with a strong innovative component are closely followed. I think being agile and able to react quickly is also very important when it comes to innovation. Ideally, our technology transfer work is carried out in a start-up mode, allowing us to respond to the needs of the researchers pragmatically.

Innovation strategy

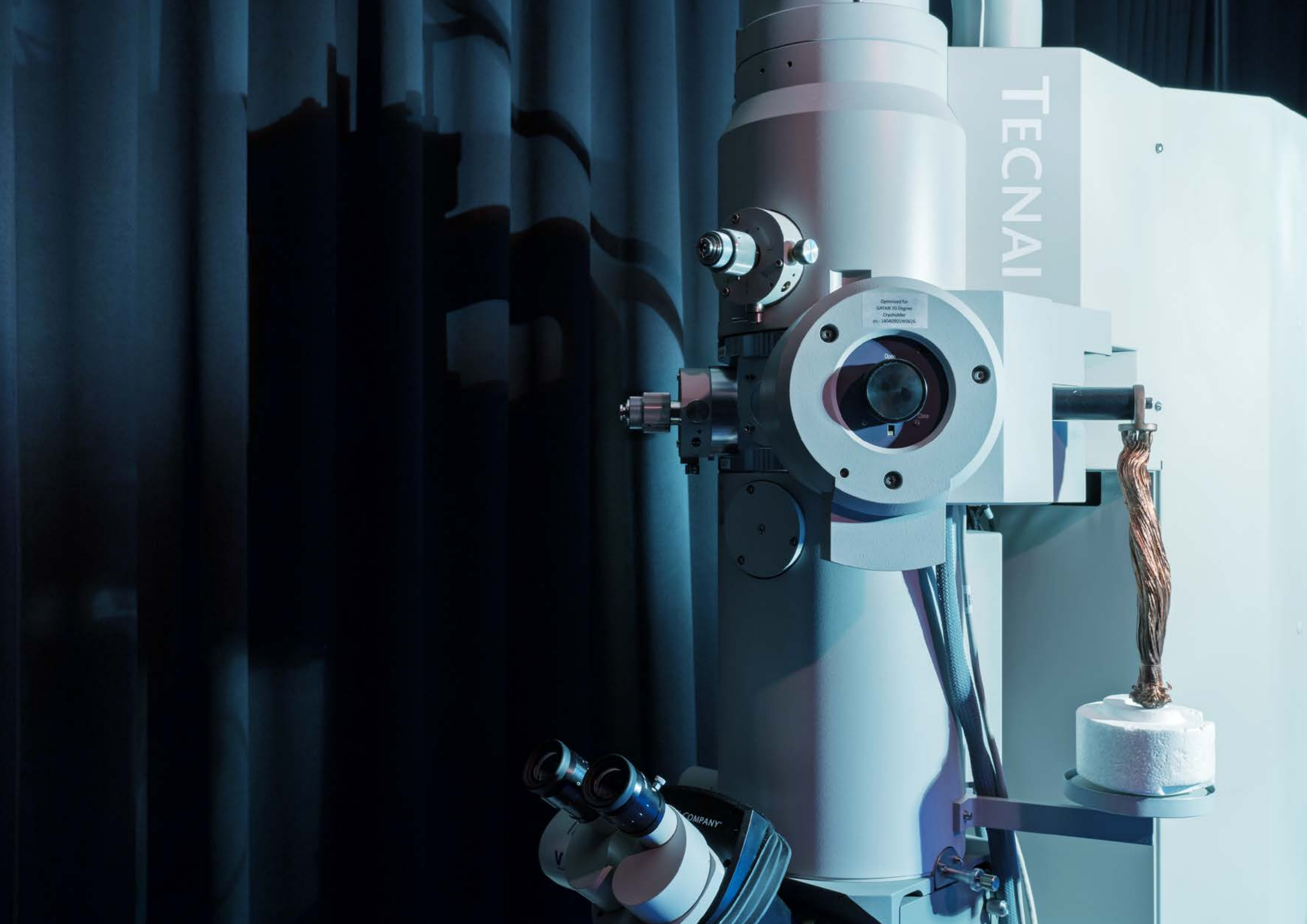
AMI supports an innovation ecosystem that consists of its professors and researchers, local and non-local companies, other research institutions, various networks, university courses, and thematic workshops. The innovation ecosystem approach ensures a constant flow of new research topics and ideas, which are curated by the technology transfer manager to achieve high impact technology transfers to society and the economy. A number of instruments are at AMI’s disposal:

- IP Protection
- Innovation ecosystem management
- Support for local companies and start-ups
- Collaborations
- Business development
- Training researchers
- Communication

Innosuisse projects

Two AMI projects were awarded funding in 2019 by Innosuisse, the Swiss federal innovation agency. The first project, led by Dr. Fabienne Schwab of the BioNanomaterials group, tackles the issue of environmental pesticide pollution. Along with her colleagues, she has developed an efficient and safe solution to stimulate plant resistance with a bio-inspired degradable nanofertilizer. With close to CHF 400,000 in funding, Schwab and her partners are upscaling the synthesis of the nanofertilizer and preparing to perform field trials.

The Hemolytics team, led by Dr. Jonas Pollard of Professor Nico Brun’s Macromolecular Chemistry group, received a similar amount to pursue work on their malaria diagnostics tool over the course of 18 months. The funding is being used for the development of both a full protocol and of a device for the clinical validation of the presence of malaria. The device relies on the amplification of a malaria biomarker found in blood samples.


TECNAI
COMPANY

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_Research at AMI

Sticky attack

_ Bug-hunting worm provides template for polymeric materials

A worm that spits on its prey to immobilize it could inspire new biodegradable polymeric materials. Researchers from AMI's BioNanomaterials group have been investigating the unique properties of the slime projected by the carnivorous velvet worm.

Small bugs in the rainforest are exposed to many dangers. One of the more surprising threats they face is barely bigger than the insects themselves: onychophorans, typically known as velvet worms, are voracious and active carnivores whose most remarkable feature is a pair of slime glands located on both sides of its head. When hunting, velvet worms use their antennae and chemosensory organs close to their mouths to identify their prey. Once it has found its target, the tiny predator shoots sticky white slime onto its prey to pin it down. This "glue" is ejected quickly at a rate of five meters per second, and as it immobilizes its prey, the worm is then able to inject digestive saliva before consuming the insect. The more the prey tries to disentangle itself from the slime, the stiffer this becomes, as it hardens quickly when mechanically stimulated. The slime is originally viscous like egg yolk, and turns into a solid high-strength polymer comparable to nylon in just mere seconds. This material, however, is biodegradable, as it is composed of water, proteins, lipids, and carbohydrates.

The BioNanomaterials researchers chose to investigate the micro- and nanostructures of the slime of *Epiperipatus biolleyi*, a Costa Rican velvet worm species. "I had learned about this rare and unique mechanoresponsive slime, and one day, I was lucky enough to collect a sample, which I submitted to a microscope analysis," explains Dr. Yendry Corrales, who has been leading the project. "What I observed was a natural material formed by micro- and nanostructures that had not been previously reported in scientific literature." Corrales, who arrived at AMI after receiving the NCCR Bio-Inspired Materials Women in Science postdoctoral fellowship, had worked on protein-based nanomaterials during her PhD studies. For her next career step, she wanted to investigate novel bio-inspired materials using the biodiversity of her native Costa Rica as inspiration.

Further investigations carried out at AMI have now revealed that the slime is a composite material formed by a protein matrix and vesicles containing inorganic salts, requiring two important processes to occur to complete the transition from liquid to solid. In a first step, the proteins contained in the matrix are stretched when force is applied, and water is eliminated. The proteins shift from a ball-like conformation to a fiber-like one. In a second step, the disruption of the vesicles triggers the release of its components, leading to a chemical reaction that catalyzes the gelation and hardening of the slime. "It has the strength of petroleum-derived polymers such as nylon, but it has the added advantages of being protein-based and biodegradable," adds Corrales.

The velvet worm slime composition could be used as a model to formulate bio-inspired biodegradable materials to replace petroleum-derived plastics such as polyester or acrylics, according to Corrales. This could lead to engineering new and efficient processes for drying and molding biopolymeric materials, making them much more attractive for applications and commercialization. The first steps are already underway: "We are now working on the development of bio-inspired mechano-responsive vesicles that could be added to biopolymer solutions used in bio-printing," says Corrales. "We aim to improve the precision of bio-printing processes without degrading the bio-polymers."

Dr. Yendry Corrales joined the BioNanomaterials group at AMI in 2018, after being awarded the NCCR Bio-Inspired Materials' Women in Science fellowship. A native of Costa Rica, where she earned a degree in chemical engineering at the University of Costa Rica, Corrales moved to Brazil for a PhD in materials science and nanotechnology at the São Paulo State University.

BioNanomaterials

Team

Prof. Alke Fink, Prof. Barbara Rothen-Rutishauser, Liliane Ackermann, Mauro Almeida, Dr. Sandor Balog, Hana Barosova, Joel Bourquin, Dr. David Burnand, Jessica Caldwell, Jernej Cebela, Shui Ling Chu, Dr. Yendry Corrales, Irini Dijkhoff, Dr. Barbara Drasler, Manuela Estermann, Bihter Geers, Dr. Christoph Geers, Laetitia Haeni, Daniel Hauser, Dr. Begum Bedia Karakocak, Daria Korejwo, Aaron Lee, Dr. Roman Lehner, Philipp Lemal, Mattia Maceroni, Dr. Roberto Ortuso, Benedetta Petracca, Dr. Fabienne Schwab, Dr. Dedy Septiadi, Dr. Miguel Spuch-Calvar, Lukas Steinmetz, Eva Susnik, Dr. Patricia Taladriz, Dr. Angel Tan, Yuki Umehara, Mathias Weyland

Key Publications

1. Bossert, D.; Urban, D. A.; Maceroni, M.; Ackermann-Hirschi, L.; Haeni, L.; Yajan, P.; Spuch-Calvar, M.; Rothen-Rutishauser, B.; Rodriguez-Lorenzo, L.; Petri-Fink, A.; et al. A Hydrofluoric Acid-Free Method to Dissolve and Quantify Silica Nanoparticles in Aqueous and Solid Matrices. *Scientific Reports* **2019**, 9 (1), 7938.

2. Septiadi, D.; Rodriguez-Lorenzo, L.; Balog, S.; Spuch-Calvar, M.; Spiaggia, G.; Taladriz-Blanco, P.; Barosova, H.; Chortarea, S.; Clift, M. J. D.; Teeguarden, J.; Sharma, M.; Petri-Fink, A.; Rothen-Rutishauser, B.; Quantification of Carbon Nanotube Doses in Adherent Cell Culture Assays Using UV-VIS-NIR Spectroscopy. *Nanomaterials* **2019**, 9 (12), 1765.

3. Moore, T. L.; Urban, D. A.; Rodriguez-Lorenzo, L.; Milosevic, A.; Crippa, F.; Spuch-Calvar, M.; Balog, S.; Rothen-Rutishauser, B.; Lattuada, M.; Petri-Fink, A. Nanoparticle Administration Method in Cell Culture Alters Particle-Cell Interaction. *Scientific Reports* **2019**, 9 (1), 900.

4. Bourquin, J.; Septiadi, D.; Vanhecke, D.; Balog, S.; Steinmetz, L.; Spuch-Calvar, M.; Taladriz-Blanco, P.; Petri-Fink, A.; Rothen-Rutishauser, B. Reduction of Nanoparticle Load in Cells by Mitosis but Not Exocytosis. *ACS Nano* **2019**, 13 (7), 7759–7770.

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Material hazard
_ Investigating the impact of microplastics

Researchers from AMI's BioNanomaterials group have developed a new intestinal model to simulate the impact of microplastics absorbed by humans. Initial results show that these particles do not seem to provoke an immune response in the short term, but further studies are required to evaluate the effects of long-term exposures or of exposures to even smaller particle sizes.

The plausibility of human exposure to microplastics has increased over the past few years. Microplastics have been found in different types of food including seafood, salt, and beverages. In a sense, this is far from surprising. These plastic fragments have been found at the bottom of the ocean as well as on mountaintops – in other words, pretty much everywhere. Yet, less is known about their impact on human health.

"So far, the possible risks of microplastic ingestion by humans are not known and still need to be evaluated," explains Dr. Roman Lehner, a postdoctoral researcher in the BioNanomaterials group. "It has been shown in studies using aquatic organisms, though, that due to their size, microplastic particles can directly harm the organism through intestinal blockage or internal tissue abrasion, depending on the shape and size of the particles." Further concerns include possible intoxication of the organism via the leakage of chemicals such as phthalates that are found in polyvinylchloride (PVC), or brominated flame retardants used in different plastic applications. It has also been shown that microplastics can be translocated to the lymph system of blue mussels, causing strong inflammatory responses.

To evaluate possible human immune responses upon exposure to microplastics, the AMI researchers were asked by collaborators from German chemical company BASF SE to establish a novel 3D intestinal tissue model, as they are interested in increasing their knowledge on the potential effects of polymers on humans. "Ingestion of microplastic particles is likely to represent the main route of exposure in humans, since microplastic particles can be ingested by eating contaminated seafood or drinking water," adds Lehner. "This makes the gastro-intestinal tract the most likely primary exposure site."

The 3D intestinal tissue model, consisting of human intestinal epithelial cells, as well as human blood monocyte-derived macrophages and dendritic cells, involves aerosolizing microplastic particles directly on the cells' surface. Cytotoxicity and immune response was investigated after 6, 24, and 48 hours of exposure. "We used environmentally relevant microplastic particles provided by the collaboration partners at BASF SE, including polymers representing tire wear and polyolefins, for example particles of polypropylene used for packaging material, which represent major sources of micro-plastic in the EU," explains Lehner. "We also compared these with other polymer classes, such as polyamide used for fishing nets, and harder cross-linked or softer thermoplastic versions of polyurethanes found in shoe soles or used to reinforce shorelines to prevent coastal erosion."

This initial study showed no induction of cytotoxicity and did not generate any kind of inflammatory response, according to Lehner. This conclusion holds for the composition and size of the microparticles studied, ranging from 50 to 500 micrometers. But the absence of a biological response should not be generalized to all microplastics, since it cannot be ruled out that smaller sized particles or different polymers could still induce effects.

"Given that this is the first study trying to assess the possible effects of microplastics on human health, extrapolation of these results to humans is critical," emphasizes Lehner. Further research will be required to determine the effects of smaller plastic fragments, he reckons, while chronic exposure of the particles to the intestine barrier should also be considered. Possible scenarios under consideration may mimic daily food intake, including three to four exposures of the polymer particles per day.

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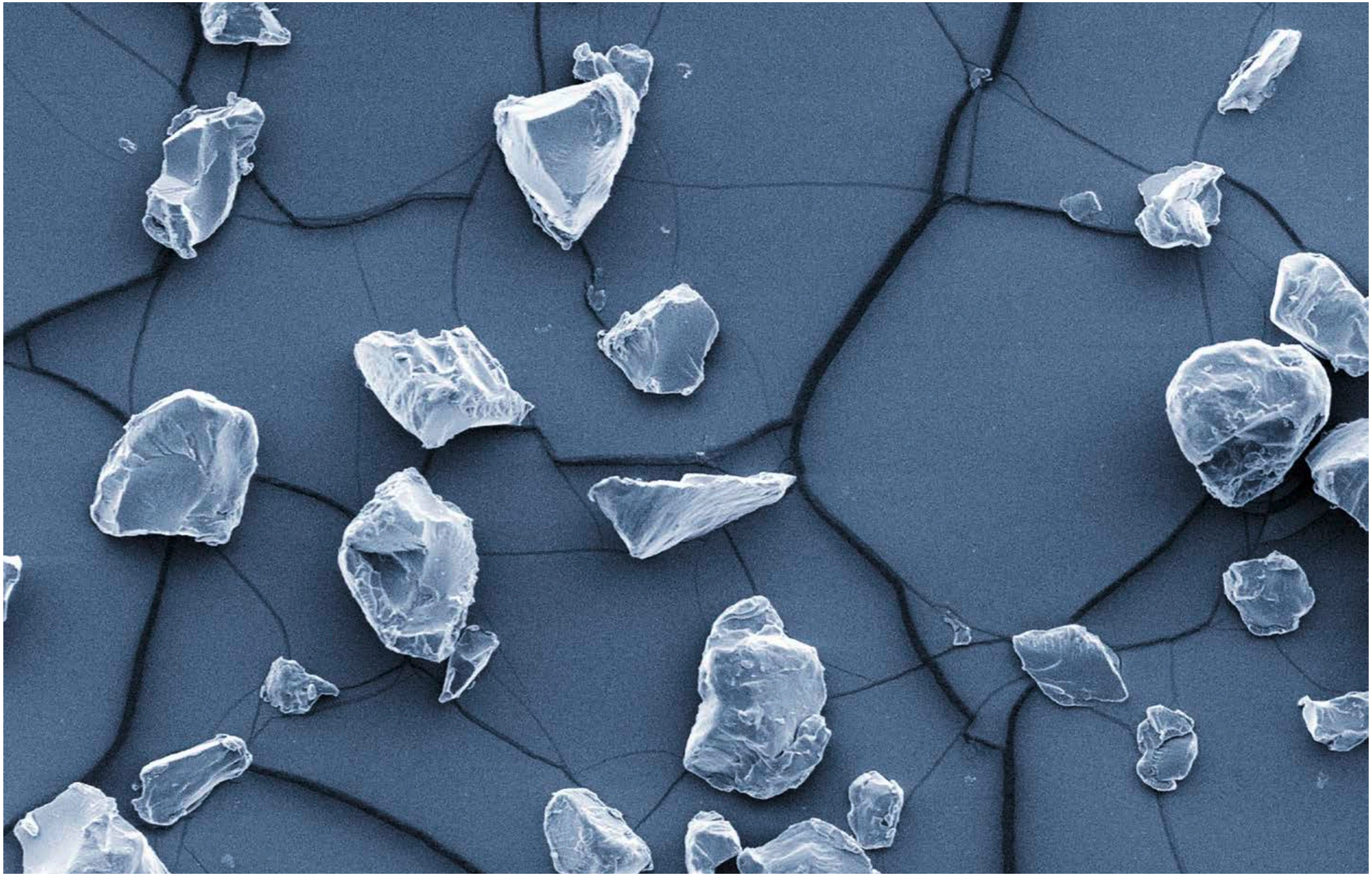

Bond breaking

_ Making supramolecular polymers tougher

Researchers from the Adolphe Merkle Institute's Polymer Chemistry and Materials group have developed a new approach to toughen supramolecular polymers and have demonstrated the usefulness of such materials as adhesives that enable bonding and debonding on demand when heated or exposed to intense UV light.

Unlike conventional polymers, which consist of long, chain-like molecules with thousands of atoms, supramolecular polymers are composed of smaller molecules that are equipped with "sticky" binding motifs. These moieties bind to one another and assemble the building blocks into polymer-like structures. Because the interactions between the binding sites are reversible, supramolecular polymers can be readily disassembled into their building blocks by applying an external stimulus, such as heat, intense light, or a chemical. This transforms the originally solid material into a low-viscosity liquid that flows more easily than a conventional polymer. When the stimulus is removed, the supramolecular material re-assembles and the original properties are restored. The ability to disassemble supramolecular polymers offers many attractive opportunities: it facilitates processing and recycling such materials, renders them easily healable, and allows creating adhesives that can be (de)bonded on command. But the downside of these materials is that their mechanical properties are typically inferior to those of conventional polymers. This includes being too brittle or lacking sufficient stiffness.

Addressing this issue, AMI researchers have been investigating a previously little explored family of glass-forming supramolecular polymers. These materials consist of disordered networks that are formed by the association of building blocks that contain three or more supramolecular binding motifs. "The supramolecular glasses that our group recently developed were probably the stiffest supramolecular polymers known so far, but they were also very brittle and broke when experiencing the slightest forces," explains PhD student Diana Hohl. "We were therefore interested in finding ways to toughen them in order to create materials with more useful properties."

Hohl and her colleagues found that supramolecular glasses can be made less brittle by the formation of blends with a second component involving a rubbery phase. This approach enabled the researchers to adjust the material's properties by simply varying the ratio of the two supramolecular building blocks, and made it possible to tune both toughness and stiffness. The new materials could serve, for example, as reversible adhesives.

"A good adhesive needs to form a strong bond. For easy and efficient debonding (and bonding), low-melt viscosity is a beneficial characteristic," says Hohl. "Because the supramolecular polymers that we developed contain a large number of reversible bonds formed by the sticky binding motifs, they form liquids with a relatively low-viscosity when heated, but the original properties are retained when cooled. In the context of adhesion, this means that we can easily de-bond molecules by simply heating them above a certain temperature, while the adhesive bond is restored upon cooling back to room temperature."

According to Hohl, the new blends have improved properties when compared with other supramolecular adhesives previously investigated by the Polymer group. But she adds that there is plenty of room for improvement. "We observed that the blends slowly separate into the two components when melted, so they are not the best candidates for multiple bonding and debonding scenarios," she says, adding that "both thermal stability and adhesive strength leave room for further improvement."

The two-component approach should allow for the tailoring of the mechanical properties of supramolecular glasses over a considerable range. For the AMI researchers, this technique should also be applicable to other systems, giving rise to new functional materials with tunable property combinations.

Reference

Hohl, D.K., Ferahian, A.-C., Montero de Espinosa, L., Weder, C. Toughening of Glassy Supramolecular Polymer Networks, *ACS Macro Letters*, **2019**, 8 (11), 1484–1490.

Platinum control

_ Creating nanoparticles at the right time and the right place

Researchers from Professor Christoph Weder's Polymer Chemistry and Materials group have developed a metallosupramolecular polymer that, when activated with the right stimulus, allows the formation of platinum nanoparticles when and where needed within a material. The polymer can serve as the basis for creating nanocomposites that contain metallic particles in patterns that can be created on demand.

Nanocomposites that contain metallic nanoparticles are particularly interesting because they combine the functional, structural, and mechanical properties of their two components, the polymer matrix and the metallic filler, and are useful for applications that range from catalysis to soft electronics. Gaining spatial control over the nanoparticle incorporation is useful, for example, to confine catalytic sites or create electrically conducting pathways. This approach enables the highly targeted formation of platinum nanoparticles at a designated time and place within the material, rather than randomly or all at once. "The precise placement and distribution of the nanoparticles is important for the performance of devices, but very challenging to control," says group leader Dr. Stephen Schrettl. In a paper that was featured on the cover of the influential *Journal of the American Chemical Society*, the AMI researchers show that this can be achieved by the controlled decomposition of a so-called metallosupramolecular polymer.

Until now, attempts to create nanocomposites with non-randomly placed nanoparticles were met with limited success. The AMI researchers, however, have managed to solve this problem by synthesizing a polymer that contains complexes of individual platinum atoms. These complexes are stable at ambient conditions, but they can be dissociated upon heating or exposure to ultraviolet light. The platinum atoms released in this process assemble into platinum nanoparticles whenever and wherever they are needed, without additional reagents or the formation of byproducts. This approach was exploited to create flexible films with well-defined platinum-containing areas or patterns with a resolution down to 10 µm. "We picked platinum for this study, because it is electrically conductive and also serves as catalyst for many chemical reactions," explains Schrettl. "The method that we developed now enables us to control where and when the nanoparticles are formed, and we demonstrated that this allows one to 'write' electrically conductive pathways into an otherwise insulating object or to create objects that contain catalytically active spots," he adds.

For this study, the researchers focused on metallosupramolecular polymers with platinum complexes, but the concept promises to be readily applicable to different metals and systems that allow production of the corresponding nanocomposites.

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Dr. Stephen Schrettl joined the Polymer Chemistry & Materials group at AMI in 2015, not long after receiving his PhD in Materials Science from Lausanne's Federal Institute of Technology (EPFL), and a first post-doctoral experience there. Stephen Schrettl's science career began at the Freie Universität Berlin (Germany), where he studied chemistry.

Polymer Chemistry & Materials

Team

Prof. Christoph Weder, Dr. José Berrocal, Véronique Buclin, Claudio Cappelletti, Gwendoline Delepierre, Dr. Visuta–Kan Engkakul, Dr. James Hemmer, Anne-Cécile Ferahian, Diana Hohl, Patricia Johnson, Aris Kamtsikakis, Dr. Feyza Karasu Kiliç, Derek Kiebala, Marco Mareliati, Franziska Marx, Baptiste Monney, Livius Muff, Laura Neumann, Luis Olaechea, Dr. Carlo Perotto, Chris Rader, Anita Roulin, Felipe Saenz, Julien Sautaux, Dr. Philip Scholten, Dr. Stephen Schrettl, Hanna Traeger, Sandra Wohlhauser.

Key Publications

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On the surface

_ Using polymers to build better batteries

Rechargeable lithium-ion batteries have become ubiquitous in recent years, appearing in widely used products such as mobile phones. The Adolphe Merkle Institute's Soft Matter Physics group is investigating solid polymer electrolytes (SPEs) for use in these batteries to make them safer and more powerful.

Typical lithium-ion (Li-ion) batteries use a volatile liquid electrolyte. This entails risks, occasionally leading to short circuits or even fire, and reduces a battery's cycle life. Liquid electrolytes are also incompatible with higher energy metal anodes such as lithium metal, the use of which would increase the battery's energy density – the amount of energy stored in a given system per unit volume – compared to currently employed graphite anodes. For batteries to grow into larger transportation and grid storage roles, where they are forecast to be a disruptive force in favor of the green economy, fundamental safety and energy density issues therefore need to be resolved. SPEs effectively address these, according to AMI alumnus Dr. Preston Sutton. "Nanostructured SPEs have the potential to provide both good ionic conductivity and good mechanical properties," he explains. Unlike other electrolyte systems, such as liquids, gelled polymers, and inorganic solids, the benefits of nanostructured SPEs include relatively low volatility (increased safety), compatibility with metallic lithium (increased energy density), and relatively low-cost materials and manufacturing.

SPEs have not been widely adopted thus far because their ambient temperature conductivity is found to be lacking for more general-purpose usage. Researchers are therefore usually targeting conductivity improvements, while also maintaining the energy and safety advantages of polymer electrolytes. The Soft Matter Physics researchers investigated the suitability of a block copolymer, specifically a triblock terpolymer, as an electrolyte for Li-ion batteries. Block copolymers (BCPs), consisting of two or more different polymers connected at each end, can self-assemble into various nanostructures.

"We chose the terpolymer because of its 3D continuous conductivity network, which offers conceptual advantages compared to conventional structures. But we were surprised by the outcome," says group leader Dr. Ilja Gunkel.

The Li-ion conductivity across very thick samples fell short of the anticipated performance, and appeared to be limited by the nature of the surfaces between which the electrolytes were sandwiched. Inspired by this observation, the AMI researchers showed that modifying the surface area of the electrode that comes into contact with the SPE surface with a specific polymer brush results in higher and more reproducible conductivity values. "The importance of this discovery is also the increased resolution in accurately identifying conductivity so that better designs can be established," says Sutton. "While it is only one piece of the SPE puzzle, it is extremely relevant for reliable characterization."

These results are of practical relevance for next-generation solid-state energy storage devices. They demonstrate that the properties of the electrode surface, previously ignored, are important for the design of SPE-containing devices with high energy density.

Reference

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Dr. Ilja Gunkel was born in Halle/Saale, Germany, where he earned both his Diploma and PhD in Physics at the Martin Luther University of Halle-Wittenberg. After postdoctoral work with Tom Russell at the Lawrence Berkeley National Laboratory (Berkeley Lab), he joined AMI in 2014.

Soft Matter Physics

Team

Prof. Ullrich Steiner, Doha Abdelrahman, Narjes Abdollahi, Johannes Bergmann, Dr. Esteban Bermúdez-Ureña, Kenza Djeghdi, Parnian Ferdowsi, Dr. Reza Ghanbari, Antonio Günzler, Dr. Ilja Gunkel, Cédric Kilchoer, Mirela Malekovic, Dr. Guillaume Moriceau, Tri Minh Nguyen, Dr. Efraín Ochoa-Martínez, Andrea Palumbo, Alessandro Parisotto, Cristina Prado Martínez, Alexandre Redondo, Dr. Matthias Saba, Dr. Michael Saliba, Sandy Sanchez, Preston Sutton, Dr. Bodo Wilts

Key Publications

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Characterization

_ Slowing down to improve nanopore measurements

Synthetic nanopores are a promising method for characterizing individual molecules such as proteins, but interactions between the pore and the molecules being studied often interfere with the outcome. Researchers from Professor Michael Mayer's Biophysics group have sought inspiration from nature to make the process more efficient and precise, ultimately yielding more accurate measurements.

Nanopores – surface passages just 10 to 30 nanometers wide – are useful tools for characterizing single molecules such as DNA strands, nanoparticles, or proteins. There are two types: biological nanopores found in nature, and synthetic nanopores, which are made in the lab out of materials such as silicon nitride. When they are present in an electrically insulating membrane, synthetic nanopores allow for the characterization of a wide variety of molecules because their size can be adjusted during fabrication. Detection of molecules requires monitoring the ionic current passing through the nanopore as a voltage is applied across the membrane. A molecule passing through the nanopore causes fluctuations in the current that can be interpreted, giving details of its shape, volume, electrical charge, rotation speed, and propensity to bind with other molecules. This information, in turn, allows researchers to identify the molecule.

Synthetic nanopores suffer from one major downside, though: their material tends to interact with the proteins being studied, leading to adsorption to the pore wall and clogging. To overcome this, the AMI researchers investigated lipid coatings to ease the translocation of proteins through the pore, allowing for more advanced characterization than previously possible.

In the context of sensing and characterizing single proteins with synthetic nanopores, these coatings provide at least four benefits: first, they minimize unwanted protein adhesion to the pore walls. Second, they can slow down protein translocation and rotation through their ability to tether proteins with a lipid anchor to the fluid bilayer coating. Third, they provide the possibility of imparting analyte specificity by including lipid anchors with a specific receptor or ligand in the coating. Finally, they offer a method for tuning nanopore diameters. The AMI study, which considered a wide variety of lipid membrane compositions, focused on changes of the nanopore signal noise properties with the application of a lipid coating, the stability of the lipid coating, its viscosity and translocation time, and the success rate of applying the lipid coating to a nanopore.

The most significant results from this study relate to exceptionally robust lipids inspired by nature, in this case those produced by archaea, single-celled microorganisms that thrive in the most extreme environments, such as volcanic vents; even bacteria could not even survive there. "These membrane-spanning lipids were the most viscous of those tested and led to the longest translocation times – a critical improvement with regard to advanced characterization of proteins," explains BioPhysics alumna Dr. Olivia Eggenberger. "Additionally, we expanded our previous analysis to account for the lower event frequency that resulted from this high viscosity, allowing for the analysis of multiple populations within one dataset."

According to Eggenberger, these findings are of particular use in the synthetic nanopore field, but the principles are universal and apply to lipid coatings in any function. In the long term, synthetic nanopores could be used to detect proteins such as amyloids that are markers of Alzheimer's disease.

Reference

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Michael Mayer joined the Adolphe Merkle Institute in 2015 as the Chair of Biophysics. Previously, he was a professor of biomedical engineering and biophysics at the University of Michigan in the US, where he had been working since 2004. He completed his PhD at the EPFL in Lausannne, followed by postdoctoral research at Harvard University.

BioPhysics

Team

Prof. Michael Mayer, Dr. Saurabh Awasthi, Dr. Louise Brown, Jessica Dupasquier, Olivia Eggenberger, Dr. Aziz Fennourl, Anirvan Guha, Stéphane Hess, Jared Houghtaling, Trevor Kalkus, Edona Karakaci, Dr. Jonathan List, Melissa Mcguire, Dinish Miranda, Dr. Peter Nirmal-raj, Marian Reincke, Dr. Maria Taskova, Shuran Xu, Dr Cuifeng Ying

Key Publications

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In brief

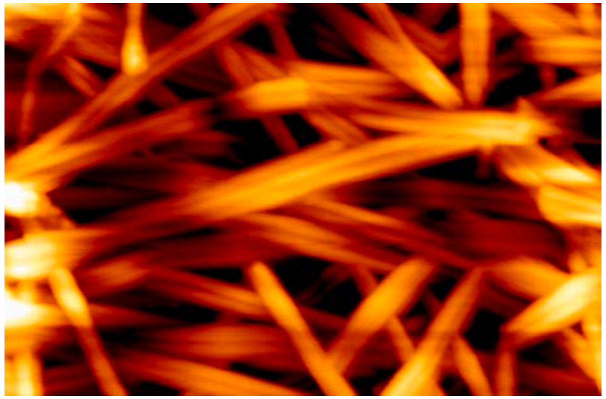
European project

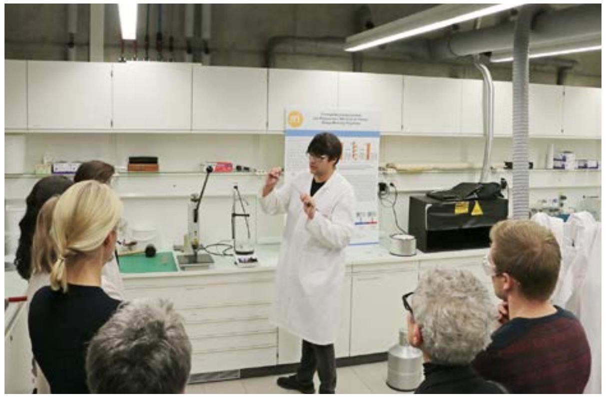
In November, AMI hosted the general assembly of PATROLS (Physiologically Anchored Tools for Realistic nanOmateriaL hazard aSsessment), an international project seeking to deliver advanced and realistic tools and methods for nanomaterial safety assessment. Funded under the European Union's Horizon 2020 research and innovation program, the consortium's researchers are developing tools and techniques to predict potential human and environmental hazards resulting from engineered nanomaterial exposure. AMI's BioNanomaterials co-chair Professor Barbara Rothen-Rutishauser is a member of the steering committee, and two postdoctoral positions at the Institute are financed by the project.

Materials index

A 2019 ranking from *Nature Index* has put the University of Fribourg, which includes AMI's researchers, among the fastest rising institutions in materials science, making it one of just two Swiss institutions in the top 50 of this list (along with the Federal Institute of Technology in Zurich), as well as one of only three in Europe.

The University of Fribourg also cracked the top 200 institutions in materials science, along with the Federal Institute of Technology in Lausanne (EPFL) and Zurich (ETHZ), the Federal Laboratories for Materials Science and Technology (Empa), and the Paul Scherrer Institute (PSI).





VIP visitors

The Adolphe Merkle Institute once again hosted many visitors from outside the University of Fribourg.

AMI welcomed eight groups, most notably the Swiss House of Representatives' Science, Education and Culture Committee, the Euresearch Association, and the Swiss Federal Chancellery's strategic analysis group.

Alumni success

AMI alumnus Professor Yoan Simon (formerly of the Polymer Chemistry and Materials group and currently an assistant professor at the University of Southern Mississippi, USA) was awarded a Faculty Early Career Development (CAREER) Award presented by the US National Science Foundation, along with a $581,000 research grant.

Former AMI postdoctoral researcher Dr. Ilja Voets (Soft Nanoscience) was awarded the 2019 Royal Netherlands Chemical Society Gouden Medaille, the most important award in the Netherlands for researchers who have done groundbreaking work in chemistry. The prize is awarded to scientists under the age of 40, not only to honor previous accomplishments, but also to predict future achievements. Voets is a full professor of Self-Organizing Soft Matter at the Eindhoven University of Technology.

PhD prize

Adolphe Merkle Institute graduate Dr. Céline Calvino was awarded the 2019 Chorafas Prize for the best doctoral thesis in natural sciences at the University of Fribourg.

Calvino completed her PhD thesis on “Mechanochromic Materials Based on Non-Covalent Interactions” as a member of Prof. Christoph Weder’s Polymer Chemistry and Materials group. Her research was conducted within the framework of the National Center of Competence in Research Bio-Inspired Materials.

Her thesis, which she successfully defended in 2018, focused on the development of mechanophores, molecular motifs that change certain properties upon application of a mechanical force, and on their incorporation into polymers with the goal of creating new mechanoresponsive materials. In these materials, specific functions, such as a color change, can be triggered through mechanical force.

The Dimitris N. Chorafas Foundation awards scientific prizes at partner universities for outstanding work in selected fields in the engineering sciences, medicine, and the natural sciences. It rewards research characterized by its high potential for practical application and by the special significance attached to its possible future use.

Distinguished Lectureship

AMI Director Professor Christoph Weder was invited to give the Covestro Distinguished Lectureship at Texas A&M University in October.

This lectureship was established in 2012 by the university’s College of Engineering and College of Science to host speakers from outside the United States whose research programs focus broadly on the science and engineering of macromolecular systems.

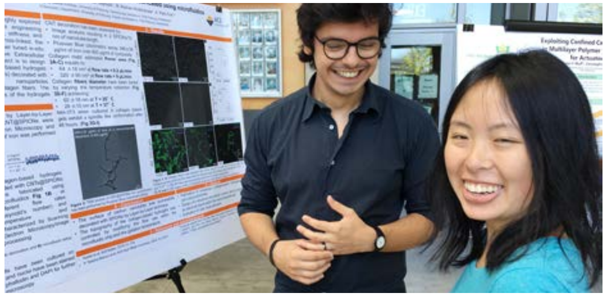
Innovation award

The Adolphe Merkle Institute's Hemolytics malaria diagnosis project was awarded the third prize at the Ypsomed Innovation Fund's Innovation Award for research, development, and technology transfer.

Dr. Jonas Pollard, Dr. Omar Rifiae Graham, Samuel Raccio, and former AMI Macromolecular Chemistry Professor Nico Bruns were awarded CHF 20'000 to further develop their new detection platform. Hemolytics is currently establishing a low-cost diagnostic method for malaria. This new tool, which relies on the detection of a specific biomarker in the bloodstream at extremely small concentrations, could lead to fewer false positives, subsequently improving treatment protocols for patients and helping to reduce healthcare costs, and fills a market niche in the diagnostic sector. The test is specifically designed to discover asymptomatic carriers at risk of transmitting the disease, who could otherwise hinder complete eradication of the disease.

Bio-inspired PIRE

In August, the Bio-inspired Materials and Systems partnership held its second annual meeting on the campus of the University of California San Diego (USA). Representatives from all of the PIRE sites, including from AMI, the University of Delaware, the University of Chicago, Case Western Reserve University (all USA), and the University of Strathclyde (Scotland) were present at this meeting, where research updates were shared and student work was showcased.



Cell culture workshop

In early July, AMI hosted a two-day workshop on 3D cell culture models within the framework of the CityCare Innovative Training Network and PATROLS projects. The 17 industrial and academic participants from all over Europe were given an overview of advanced culture models, as well as applications and results from their use. Attendees were also offered laboratory modules with demonstrations and hands-on training. Specific themes addressed included skin cultivation and nanomaterial aerosolization techniques within different air-liquid interface exposure systems.

Foundation changes

The Adolphe Merkle Foundation, which actively supports the Adolphe Merkle Institute and is one of its main stakeholders, saw major changes in its board in 2019.

Former Swiss President and long-term Board Chairman Joseph Deiss stepped down, as did Isabelle Chassot, Director of the Federal Office of Culture and former Minister of Education, Culture and Sport of the Canton of Fribourg.

The Foundation elected Peter Huber, who was already a member of the Board, as the new Chairman, and appointed Jean-Pierre Siggen, the Canton of Fribourg's current Minister of Education, Culture and Sport, as well as Chantal Robin, the Director of the Fribourg Chamber of Commerce and Industry, as new members of the Foundation Board.

Aerosol conference

PhD student Hana Barosova (BioNanomaterials) was the winner of the International Society for Aerosols in Medicine's (ISAM) Ted Martonen Student Research Award.

She was recognized during the ISAM congress held in May in Montreux (Switzerland) for demonstrating outstanding independent research in the field of aerosols. Welcoming approximately 400 international attendees, the ISAM meeting is one of the largest pulmonary drug delivery and respiratory health conferences in the world. AMI's BioNanomaterials co-chair, Professor Barbara Rothen-Rutishauser, who chaired the congress, was also chosen as the society's President-elect.

Special issue

The Swiss Chemical Society handed over the reins for the first 2019 issue of its bimonthly journal *Chimia* to NCCR Bio-Inspired Materials researchers to mark the beginning of the Center's second phase.

The issue, which presented a selection of original contributions and reviews illustrating the NCCR's activities since its launch along with future perspectives, was an opportunity for AMI research groups to highlight their contributions to the Center's development through projects focusing on themes such as functional polymers, nanoparticle stability, and structural color.

Boosting confidence

Adolphe Merkle Institute Professors Alke Fink and Barbara Rothen-Rutishauser, along with the outreach coordinator of the NCCR Bio-inspired Materials, Dr. Sofia Martin Caba, form one of two groups to receive the inaugural 2019 Materials Today Agents of Change Award.

The award, worth $10,000, recognizes their project aimed at boosting the professional role confidence of female scientists. Their proposal, based upon their own observations and those of other female academics, addresses the issue that women researchers often lack this confidence as they attempt to climb the academic ladder, which must be recognized as a major hurdle for career progression. Lacking confidence can also engender a negative feedback loop, leading to lower publication rates as well as decreased grant and professional success.

Different courses of action have been put forward to boost the success of female researchers. These include round table discussions on the topic of professional role confidence as well as an extended workshop on the same topic for women scientists at all levels, organized by female professionals and role models.

Student entrepreneurship conference

In May 2019, the Adolphe Merkle Institute hosted the second-ever National Conference for Student Innovation.

Organized by the Association for Student Innovation (ASI), the conference compared and contrasted experiences and ecosystems around innovation support and entrepreneurship for Swiss cantonal universities and universities of applied sciences. It also provided insights into methods for encouraging an innovation culture for students interested in intra- and entrepreneurship, and sought to help build a network of innovation experts interested in developing best practices for student support. The keynote speaker this year was Tine Van Lommel, Innovation Manager at KU Leuven.

Master students

Three more students graduated from the Specialised Master in Chemistry and Physics of Soft Materials program at AMI:

Jessica Caldwell - Preparation and Characterization of Fluorescent Nanoplastic Particles for Use in In-Vitro Experiments.
Isabella Mombrini - Solid Polymer Electrolyte Reinforced with Cellulose Nanofibers for Lithium Ion Batteries.
Martino Airoldi - Investigation of PEG-2-HEA-IBA Network Forming Solid Polymer Electrolytes for Lithium Batteries.
Jessica Caldwell and Martino Airoldi both remained at AMI to start their doctoral studies in the BioNanomaterials and Soft Matter Physics groups, respectively.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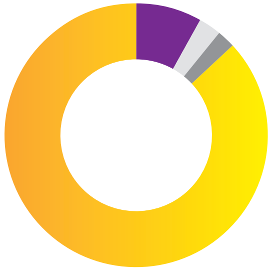
Finance & Organization

Finance

_ Cost structure at AMI

The Adolphe Merkle Institute's overall expenditures in 2019 were CHF 9.5 million. 87% of this sum was spent on research, while an additional 2% was invested in research equipment. Around 3% of the budget supported valorization activities such as technology transfer and communication & marketing, with another 8% used for administration costs.

Overall expenses 2019
CHF 9.5 million



- Research / 87%
- Administration / 8%
- Valorization / 3%
- Research equipment / 2%

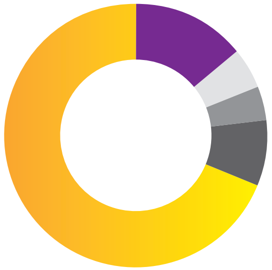
Funding sources of overall expenses 2019

- Adolphe Merkle Foundation / 37%
- Grants / 50%
- University of Fribourg / 10%
- Industry / 3%

Funding sources of research projects 2019
CHF 8.3 million

- Adolphe Merkle Foundation / 35%
- Public Funding / 46%
- University of Fribourg / 12%
- Industry / 2%
- Other / 5%

Third-party funding of research projects 2019
CHF 5.0 million



- SNSF / 69%
- EU / 14%
- Industry / 5%
- Innosuisse / 4%
- Other sources / 8%

Organization

In late 2007, Adolphe Merkle set up the Adolphe Merkle Foundation and donated CHF 100 million to support the University of Fribourg. The donation has been used primarily to establish the Adolphe Merkle Institute.

The Institute Council plays an important role in controlling and supervising the development of the Institute at the University of Fribourg's science faculty. It guarantees optimal communication and coordination between the University and the Foundation and helps the Institute to fulfill its mission and to smoothly integrate into the university.

The Scientific Advisory Board is an independent team of experts with backgrounds and expertise in fields that are relevant for AMI. It provides an external view to help position the institute in its national and international environment.

The Executive Board oversees daily operations at AMI and meets once a week. All AMI professors are members of this management body along with the Associate Director. They are responsible for ensuring that the strategy approved by the Institute Council is implemented.

The Administration team provides support in many aspects of the Institute's daily work and acts as an interface between the University of Fribourg and AMI.

Foundation Board

Members

Prof. Joseph Deiss (President, until December 2019)
Former member of the Swiss Government, former President of the General Assembly of the United Nations, Professor at the University of Fribourg

Peter Huber (President since December 2019)
Administrator, Sublevo AG, Kloten, Switzerland

Isabelle Chassot (until December 2019)
Head of the Federal Office of Culture, former State Minister in charge of Education, Culture and Sport of the canton of Fribourg, former President of the Swiss Conference of Cantonal Ministers of Education

Jean-Pierre Siggen (since December 2019)
State Minister in charge of Education, Culture and Sport of the canton of Fribourg

Chantal Robin (since December 2019)
Director, Fribourg Chamber of Commerce and Industry

Prof. Rolf Mülhaupt
Managing Director Freiburg Center of Interactive Materials and Bioinspired Technologies

Prof. Claude Regamey
Former chairman of the Department of Internal Medicine, Hôpital Cantonal Fribourg, former President of the Ethical Committee of the Swiss Academy of Sciences

André Broye (Managing Director)

Institute Council

Members

Prof. Astrid Epiney (President)
Rector of the University of Fribourg, Professor at the Faculty of Law, University of Fribourg

Peter Huber (Vice-president)
Administrator, Sublevo AG, Kloten, Switzerland

Prof. Rolf Ingold
Vice-Rector for Research, University of Fribourg, Professor, Department of Informatics, University of Fribourg

Prof. Rolf Mülhaupt
Managing Director Freiburg Center of Interactive Materials and Bioinspired Technologies

Scientific Advisory Board

Members

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Senior Research Fellow, DuPont Central Research and Development, USA

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Head of Department “Materials meet Life”, Empa, St. Gallen, Switzerland

Prof. Paula Hammond
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Former head of the Powder Technology Laboratory, EPFL, Switzerland

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Head Institute of Solid State Research, Forschungszentrum Jülich, Germany

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Former Head of Biointerface Group at Department of Materials, ETH Zürich, Switzerland

Prof. Ben Zhong Tang
Chair Professor of Chemistry, Hong Kong University of Science and Technology, China

Executive Board

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Director and Chair of Polymer Chemistry & Materials

Prof. Alke Fink
Co-Chair of BioNanomaterials

Prof. Michael Mayer
Chair of Biophysics

Prof. Barbara Rothen-Rutishauser
Co-Chair of BioNanomaterials

Prof. Ullrich Steiner
Deputy Director and Chair of Soft Matter Physics

Dr. Mohammed Benghezal (until June 2019)
Managing Director

Administration

Dr. Mohammed Benghezal (until June 2019)
Managing Director

Scott Capper
Responsible for Communications & Marketing

Melissa Forney-Hostettler
Administrative Assistant

Carine Jungo
Administrative Assistant

Catherine Jungo
Responsible for Human Resources

Samuel Laubscher
Responsible for IT Support

Thierry Mettraux
Responsible for Finance & Controlling

Dr. Valeria Mozzetti
Head of Knowledge and Technology Transfer, Grant Writing


UNI
FR
Certificate for a PhD exam in Biology
Hana Barosova
from Czech Republic

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PhDs & Alumni

PhDs

Our new doctors

Edward Apebende
(Macromolecular Chemistry)
"Force responsive block copolymers, amphiphilic co-networks and self-assembled polymer nanoparticles2"

Hana Barosova
(BioNanomaterials)
"3D human co-cultures for predicting nanomaterial possible adverse effects on human health with a focus on multi-walled carbon nanotubes"

Joël Bourquin
(BioNanomaterials)
"Intracellular fate of non-biodegradable nanoparticles"

Olivia Eggenberger
(BioPhysics)
"Lipid-coated solid-state nanopores for characterization of single proteins"

Anne-Cécile Ferahian
(Polymer Chemistry & Materials)
"Exploring and exploiting phase segregation in hydrogen-bonded supramolecular polymers"

Daniel Hauser
(BioNanomaterials)
"Synthesis and applications of polydopamine / protein nanoparticles"

Marc Karman
(Polymer Chemistry & Materials)
"Mechanically triggered fluorescence changes in polymers"

Philipp Lemal
(BioNanomaterials)
"Magnetic nanoparticles: a multifunctional approach to modern cancer therapy"

Worarin Meesorn
(Polymer Chemistry & Materials)
"Bio-inspired composites with adaptive mechanical properties"

Laura Neumann
(Polymer Chemistry & Materials)
"Structure-property relationship of stimuli-responsive metallosupramolecular polymers"

Apiradee Nicharat
(Polymer Chemistry & Materials)
"Melt-processing of polymer nanocomposites with cellulose nanocrystals"

Julien Sautaux
(Polymer Chemistry & Materials)
"Stimuli-responsive supramolecular networks"

Preston Sutton
(Soft Matter Physics)
"Solid polymer electrolytes for lithium batteries: wetting, structure and additive effects"

Alumni

People who left AMI in 2019

Edward Apebende
(Macromolecular Chemistry)

Mohammed Benghezal
(Adminstration)

Joël Bourquin
(BioNanomaterials)

David Burnand
(BioNanomaterials)

Jernej Cebela
(BioNanomaterials)

Olivia Eggenberger
(BioPhysics)

Visuta-Kan Engkakul
(Polymer Chemistry & Materials)

Aziz Fennouri
(BioPhysics)

Anne-Cécile Ferahian
(Polymer Chemistry & Materials)

Samayyeh Gholipour
(Soft Matter Physics)

Daniel Hauser
(BioNanomaterials)

Jared Houghtaling
(BioPhysics)

Philipp Lemal
(BioNanomaterials)

Jonathan List
(BioPhysics)

Mattia Maceroni
(BioNanomaterials)

Carmen Martin
(BioNanomaterials)

Simon Mayer
(BioPhysics)

Melissa McGuire
(BioPhysics)

Laura Neumann
(Polymer Chemistry & Materials)

Luis Olaechea
(Polymer Chemistry & Materials)

Marjorie Raboud
(Adminstration)

Kyle Rodriguez
(Macromolecular Chemistry)

Michael Saliba
(Soft Matter Physics)

Sandy Sanchez
(Soft Matter Physics)

Julien Sautaux
(Polymer Chemistry & Materials)

Miguel Spuch
(BioNanomaterials)

Pongsatorn Sriboonpeng
(Polymer Chemistry & Materials)

Preston Sutton
(Soft Matter Physics)

Yuki Umehara
(BioNanomaterials)

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