CATRIN
Czech Advanced Technology and Research Institute

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Atomic antibiotics counter bacterial resistance

Effective against even highly resistant pathogens

INTERMAT encourages efficient crop production

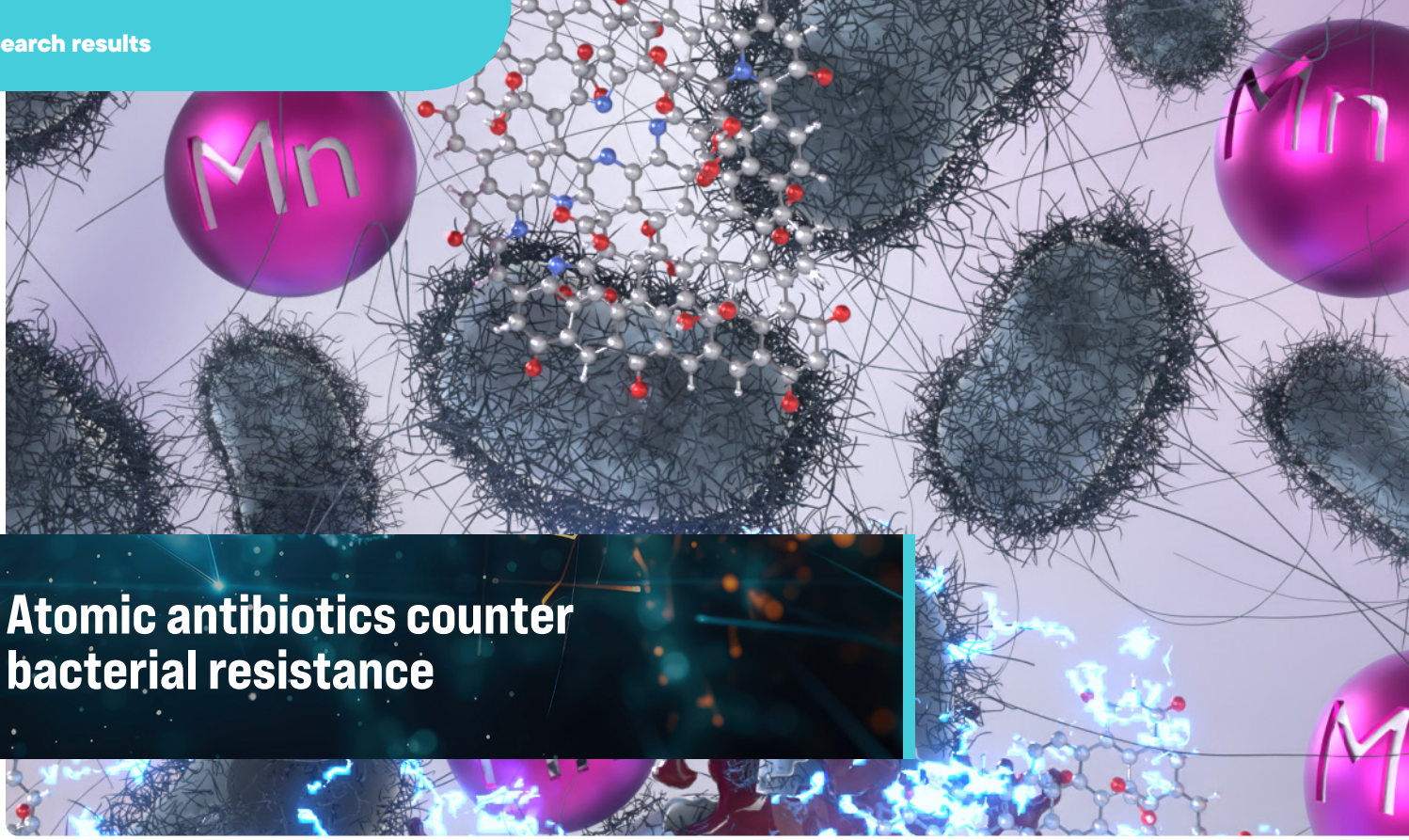
Aims to develop innovative entrepreneurship

New method for glycan analysis

Publication in Nature Communications

Interview with Veronika Šedajová

Working at Cambridge was a great experience



Atomic antibiotics counter bacterial resistance

Scientists from Palacký University Olomouc (UP) and the Technical University of Ostrava (VSB-TUO), in collaboration with colleagues from China, have discovered a groundbreaking method for developing a new generation of antibiotics. By employing atomic engineering, the researchers transformed manganese — a trace element vital for human health — into a potent antibiotic by embedding it in the structure of chemically modified graphene.

"The material we developed successfully killed and inhibited the growth of all bacteria we studied, including highly resistant pathogens. It operates at low concentrations, which are completely harmless to human cells. Furthermore, bacteria cannot develop resistance to it, thus addressing one of modern medicine's most pressing challenges," said Radek Zbořil, a physical chemist and author of the research concept.

In developing this antibiotic, the scientists drew on their expertise in graphene chemistry and atomic engineering. They utilised a graphene derivative enriched with oxygen and nitrogen atoms, chemically incorporating manganese. They chose to target one of the strongest defences of bacteria — the carbohydrates in their cell walls and membranes, which are crucial for their survival. "By chemically binding manganese to specific carbohydrate groups, we suppressed these critical functions, ultimately causing cell death. The graphene carrier plays an essential role by ensuring the delivery of manganese ions to the bacterial surface, which enables a direct chemical attack on the carbohydrate molecules," explained Zbořil.

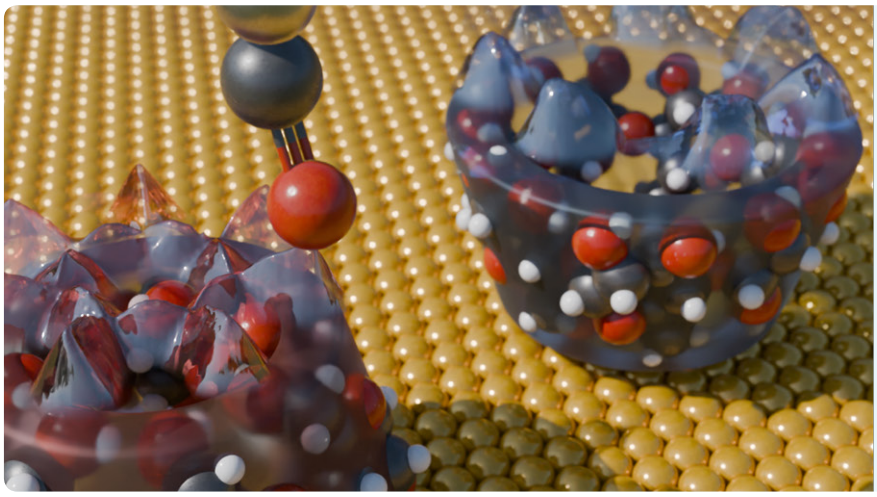
> **The atomic antibiotic was the only agent that proved effective against all resistant bacteria when compared to commercial antibiotics.**
>
> David Panáček

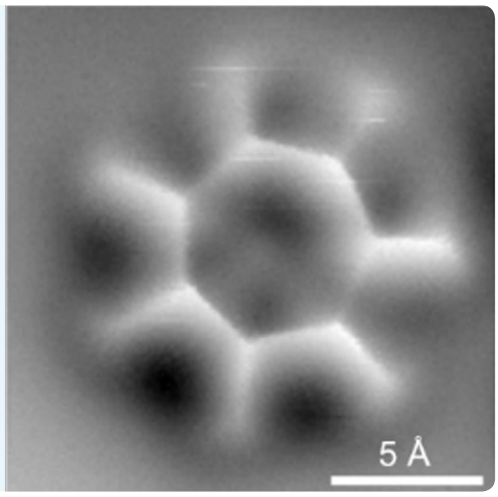
The new material was shown to have remarkable efficacy against bacteria that existing antibiotics struggle to combat. "We observed an excellent bactericidal effect against all bacteria from the ESCAPE group, which includes highly resistant bacterial pathogens. The atomic antibiotic was the only agent that proved effective against all resistant bacteria when compared to commercial antibiotics," said David Panáček, the first author of the paper.

The researchers tested the atomic antibiotic's effect not only in laboratory settings but also in mouse models in collaboration with their Chinese colleagues. Tests showed that the new material has huge potential, especially in local therapy, for example in wound healing. "In in-vivo tests, skin infections caused by resistant strains of Staphylococcus aureus healed quickly and effectively, with all markers of inflammation significantly reduced. We are now considering its use for wound dressings and antibacterial treatments on surfaces of artificial materials. This new material could also help prevent secondary infections, which would have a major impact on healthcare," said Milan Kolář, a microbiologist and Dean of the Faculty of Medicine and Dentistry at Palacký University Olomouc, who played a key role in the research.

Panáček D., Belza J., Hochvaldová L., Baďura Z., Zoppellaro G., Šrejber M., Malina T., Šedajová V., Paloncýová M., Langer R., Zdražil L., Zeng J., Li L., Zhao E., Chen Z., Xiong Z., Li R., Panáček A., Večeřová R., Kučová P., Kolář M., Otyepka M., Bakandritsos A., Zbořil R.: Single Atom Engineered Antibiotics Overcome Bacterial Resistance. Advanced Materials 2024, in press. IF = 27.4

Researchers introduce a new method for glycan analysis





Scientists from CATRIN, the University of Oxford and the Institute of Physics of the Czech Academy of Sciences have developed a high-resolution imaging technique for individual glycan molecules, as detailed in their recent publication in Nature Communications. Utilizing non-contact atomic force microscopy (nc-AFM) with CO-functionalised tips, the team obtained atomic-level structural insights into -cyclodextrin (-CD), a complex biomolecule with a distinctive three-dimensional shape. The study highlighted the potential of the method for precise glycan analysis.

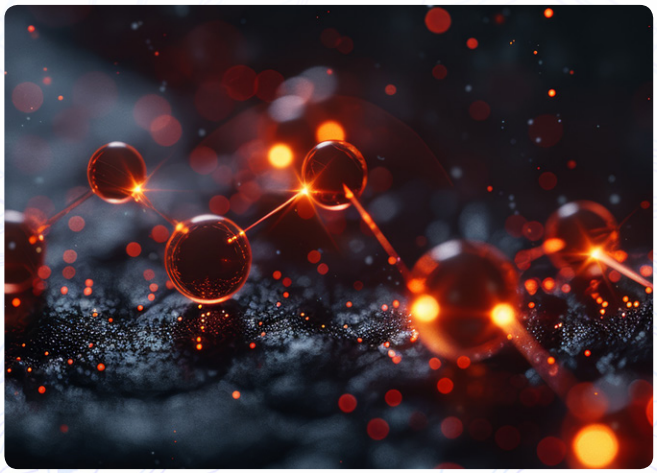
Glycans, composed of covalently linked sugar units, are a class of biopolymers essential to all known living organisms. Understanding their intricate structures is crucial in various fields, from biomedicine to materials science. However, the extraordinary complexity and conformational flexibility of glycans pose significant challenges for existing state-of-the-art glycan analysis techniques, which often fail to deliver structural information with atomic precision.

"In our study, we combined electrospray deposition in an ultra-high vacuum environment with non-contact atomic force microscopy and theoretical calculations to, for the first time, reveal the atomically detailed structure of -cyclodextrin. This innovative approach enabled us to analyse the molecule's adsorption geometries and stabilizing hydrogen bonds, providing new insights into decoding glycans at the single molecule level," explained Bruno de la Torre, one of the study's corresponding authors.

Compared to conventional glycan analysis techniques, nc-AFM offers unmatched spatial resolution and single-molecule sensitivity, allowing detailed visualisation of the internal structure of monosaccharide building blocks in real space.

Grabarics M., Mallada B., Edalatmanesh S., Jiménez-Martín A., Pykal M., Ondráček M., Kührová P., Struwe W. B., Banáš P., Rauschenbach S., Jelínek P., de la Torre B.: Atomically resolved imaging of the conformations and adsorption geometries of individual β-cyclodextrins with non-contact AFM. Nature Communications 2024. 15 (1), 9482. IF = 14,7

Nitrogen-doped graphene: a breakthrough in noble gas separation



A research team from CATRIN and VSB-TUO, in collaboration with the US Pacific Northwest National Laboratory and the Indian Institute of Technology Jammu, has developed an innovative approach for the separation of noble gases using two-dimensional nitrogen-doped graphene materials. These materials have the potential to significantly reduce the costs of noble gas production, potentially revolutionizing industrial processes. The approach also opens avenues for novel medical applications, such as the storage and transport of therapeutic gases. The study was published in the journal Small.

"Thanks to our extensive experience in 2D fluorographene chemistry at CATRIN, we successfully integrated nitrogen precisely into the graphene structure. This modification endowed the material with unique properties, including 'nanochannels' and varying ratios of nitrogen atoms incorporated into the graphene lattice, significantly enhancing its ability to separate xenon from krypton," explained Veronika Šedajová, the first author of the study.

Noble gases like xenon (Xe) and krypton (Kr) are essential in many cutting-edge technologies, including medical diagnostics, semiconductor manufacturing and the space industry. However, xenon is exceedingly rare, representing only about 0.08 ppm of the Earth's atmosphere, making its extraction both energy- and cost-intensive. Current methods, such as cryogenic air distillation, are inefficient, prompting scientists to seek new, more effective techniques for noble gas separation.

"This research demonstrates that advancements in modern materials chemistry can be key to addressing global challenges, such as the efficient utilisation of scarce resources, while also supporting the sustainable development of industry and science. Notably, one of the nitrogen-doped graphene derivatives we used has already found applications in areas like energy storage for supercapacitors," concluded Michal Otyepka, a corresponding author of the study.

Šedajová V., Kim M. B., Langer R., Kumar G. S., Liu L., Baďura Z., Haag J. V., Zoppellaro G., Zbořil R., Thallapally P. K., Jayaramulu K., Otyepka M.: 2D Nitrogen-Doped Graphene Materials for Noble Gas Separation. Small 2024. in press. IF = 13

New approach for studying plant-environment interactions

A new method for simple and fast analysis of plant hormones has been developed by scientists from CATRIN and the Crop Research Institute in Olomouc. They developed and validated a procedure based on a less common type of chromatography (HILIC) that can analyse several different groups of hormones at once without the need for complex sample preparation. Combining this method with large-scale plant phenotyping has provided a new tool for studying plant-environment interactions. They published the results of their research in The Plant Journal.

Plant hormones, which influence almost every aspect of the plant life cycle and control plant responses to the environment, are involved in complex signalling networks. These can be more easily deciphered using complex analytical methods capable of capturing information on several groups of plant hormones simultaneously.

"We therefore developed and validated a HILIC method for comprehensive analysis of plant hormones, including a rapid sample preparation procedure. It allows screening of 45 different plant hormones. This method is faster and more efficient because it does not require derivatisation or fractionation, which are usually time-consuming steps in hormone analysis. Moreover, the new approach is more sensitive and can detect even very small amounts of these growth regulators," said corresponding author of the paper Petr Tarkowski.

The paper also highlights the great potential of linking a new chromatographic method with phenotyping of plants exposed to a multifactorial combination of stresses to study plant-environment interactions.

Vrobel O., Ćavar Zeljković S., Dehner J., Spíchal L., De Diego N., Tarkowski P.: Multi-class plant hormone HILIC-MS/MS analysis coupled with high-throughput phenotyping to investigate plant–environment interactions. Plant Journal 2024. 120 (2), 818–832. IF = 6,2

INTERVIR project to provide new solutions for the prevention and diagnosis of viral and bacterial diseases

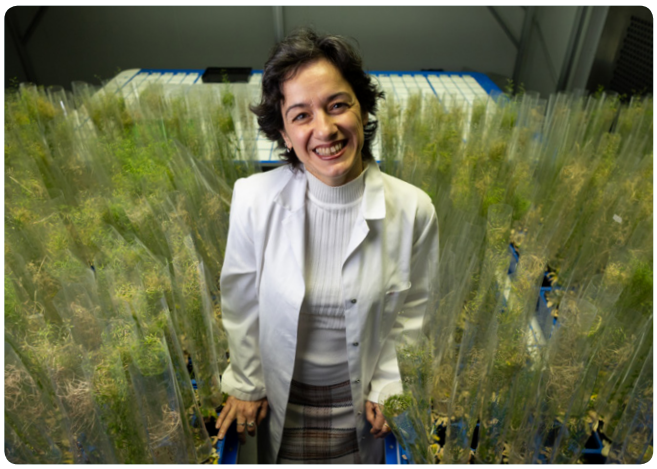
Development of new materials for the prevention and diagnosis of viral and bacterial diseases, production of antimicrobial active substances, as well as support for further development of technological transfer and cooperation of academics with companies in the region are the main aims of the INTERVIR project: Interdisciplinary Approaches to the Prevention and Diagnosis of Viral Diseases. CATRIN scientists will work together with colleagues at FARMAK and MedicProgress. The four-year project received financial support of 63.7 million Czech koruna from the Intersectoral Cooperation call for the ITI Operational Programme Jan Amos Komenský.

"The project responds to the two biggest challenges of contemporary civilisation in terms of population health, which we believe is the unpreparedness of our society to fight global epidemics and the global increase of antibiotic resistance. Therefore, we will focus on developing new solutions in the areas of prevention, early diagnosis and minimisation of the impacts of diseases caused by viral and bacterial pathogens. A number of recommendations can be drawn from the experience gained during the COVID-19 pandemic. It has become clear that collaboration of researchers from universities with experts from industry can enable the very rapid transfer of necessary innovations into

practice," said Petr Jakubec, the principal investigator from CATRIN. In collaboration with partners, the researchers will focus on four main research areas: development of advanced antiviral and antibacterial protection using new materials, diagnosis of viral infections and other serious diseases, antibacterial and antiviral effects of selected proteins and peptides, and analysis of the impact of a pandemic on an individual's life and environment in the context of changes and new procedures.

INTERMAT encourages efficient crop production

Interdisciplinary approaches for the development and application of new materials in industrial, agricultural and medical fields (INTERMAT project) will benefit from collaboration of CATRIN scientists with two regional innovation companies, AGRO Haná and Geschur Medical. The partners were successful in the Jan Amos Komenský Operational Programme in the call for ITIs for intersectoral cooperation, which aims to develop cooperation and innovative entrepreneurship in the Olomouc agglomeration. The four-year research project has received financial support of 63.7 million Czech koruna.



"The main areas of cooperation include the development of new technologies and materials for intensive and efficient crop production in greenhouses and hydroponic systems. We will focus on development and testing of new environmentally friendly growth regulators and new graphene-based materials for monitoring living systems. The project will establish new strategic partnerships between application partners in the region and strengthen cross-sectoral collaboration between academia and industry by 2028," said Principal Investigator Ivo Frébort of CATRIN.

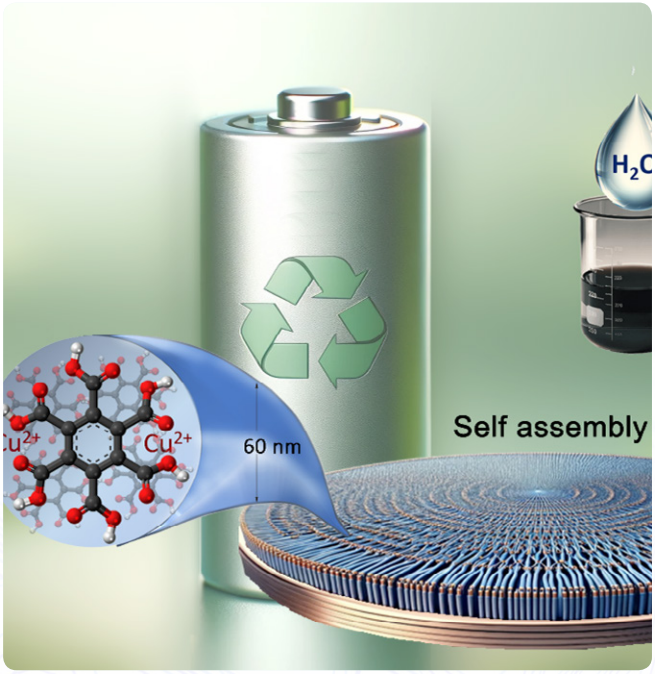
The project is intended to contribute to increasing the competitiveness of companies in the region, especially those involved in innovative crop production, biotechnology and biomedicine, which are key application sectors and innovation themes at regional as well as national level.

Czech scientists develop a new way to store energy in batteries

A more environmentally friendly and energy-safe way to store electricity in batteries and supercapacitors has been proposed by scientists from CATRIN and VSB-TUO, together with colleagues from Germany. In a study published in the journal Energy & Environmental Science, they presented a new method of producing battery electrodes based on organic materials, which show high storage capacity, speed and stability in energy storage without the need to use harmful organic solvents.

The discovery comes at a time when scientists around the world are seeking alternatives to lithium batteries. Despite a number of advantages and their consumption constantly increasing, they have many environmental and safety risks. The new approach addresses many of these problems. "Organic molecules may be a promising alternative due to their availability, environmental benefits and flexibility. Self-organizing organic nanowires significantly improve the transport of lithium ions, producing a battery with a high capacity that is retained even during repeated charging. By eliminating harmful organic solvents in the preparation, we overcame one of the key safety and environmental challenges of the current battery industry," said one of the authors of the study Radek Zbořil.

The organic nanowire anode has other properties contributing to its stability, longer life and safer operation. "It exhibits reduced exothermic activity during charging, which increases safety. In addition, the material gives excellent performance in hybrid supercapacitors with lithium metal ions in conjunction with commercial porous carbon," concluded Aristeidis Bakandritsos, another member of the research team.



Obraztsov I., Langer R., Ruthes J. G. A., Presser V., Otyepka M., Zbořil R., Bakandritsos A.: Harnessing enhanced lithium-ion storage in self-assembled organic nanowires for batteries and metal-ion supercapacitors. Energy & Environmental Science 2024, 17 (22), 8874-8884. IF = 32,4

Our latest review articles

Š. Kment, A. Bakandritsos, I. Tantis, H. Kmentová, Y. Zuo, O. Henrotte, A. Naldoni, M. Otyepka, R. S. Varma, and R. Zbořil

"Single Atom Catalysts Based on Earth-Abundant Metals for Energy-Related Applications"

Chemical Reviews 2024, 124 (21), 11767-11847. IF = 51,5

L. Zdražil, A. Cadranel, M. Medved', M. Otyepka, R. Zbořil and D. M. Guldi

"Designing carbon dots for enhanced photo-catalysis: Challenges and opportunities"

Chem 2024, 10 (9), 2700-2723. IF = 19,1

Working at Cambridge was a great experience — the results are products of hard work and teamwork

In April 2023, the physical chemist Veronika Šedajová left to work at the University of Cambridge, UK. At the prestigious Yusuf Hamied Department of Chemistry, she worked on materials research in close contact with industry. Not only did she gain new experience there, but she also capitalised on her previous experience gained at CATRIN owing to her involvement in international projects of the European Research Council and European Innovation Council granted to Michal Otyepka.

How was it working in Cambridge?

It was a completely different microcosm than what I was used to. In the beginning, I had to get used to a different environment and culture. I worked in a research group of over 50 people. Everyone came from a different background, had different experiences and knowledge. But there was a huge collegiality, and whatever problem I had, I knew who to ask for help. Each of us had clearly defined assignments and areas of responsibility.

What was different about the science there?

The approach to science was different, but this is related to the fact that at CATRIN, I was mainly involved in applied research before I left for the UK. We were inventing materials and finding applications for them. In Cambridge, it was mainly fundamental research. We often worked with commercially available materials and investigated them in great detail. For example, I worked with my colleagues on lithium-ion batteries. We meticulously studied how they work and what causes their degradation, unfolding the structure at the atomic level. We tackled the research in a different way. It wasn't necessary to be the best in the field, although my colleagues were engaged in such projects as well, but rather contribute to the overall understanding of the subject. Experiencing this concept of science was very interesting to me. Seeing how top scientists handle research questions and how they seek answers to them was a new experience.

Can you tell us more about what you have been doing?

I am bound by confidentiality, but I can say that we collaborated with a commercial company to understand how active materials in batteries work. I very much appreciate that I was able to do fundamental research with a commercial partner. It also gave me an insight into how it works in their corporate environment. I also learned a number of new techniques and how to operate different instruments. At CATRIN, we employ operators, whereas at Cambridge, everyone does everything by themselves. It's very different when you're sitting at a microscope and you have to come up with the results yourself. The threads start to connect faster, but it may take much longer to acquire the data.

So, was Cambridge a valuable experience even though it was not your first international internship?

Absolutely, although it was often not easy. I have to say that it pushed me in many ways. I am very thankful to Professor Clare P. Grey, because her support and the way she runs her group has been incredibly inspiring. Compared to the Czech academic environment, there is much greater internationalisation, diversity and a different view on the position of women in science. It teaches you about mutual respect. Although the level of internationalisation is high at CATRIN, it is even higher at British universities. In our group of 50, 26 nationalities met at one point. I made friends amongst my colleagues and also outside of work, and I will miss them. What I will not miss though are the sandwiches for lunch. I couldn't cope with them!

Now you're back at CATRIN. Has it changed?

Although I did not lose touch with colleagues at CATRIN during my time in Cambridge, I was surprised upon my return. CATRIN has both changed and not changed. I have found many new people here, and a lot of work has been done, including the organisation of the labs. I'm still involved in developing new materials for electrical energy storage, but I've moved to a different research group. I will definitely stay loyal to graphene derivatives and their applications, but we want to open up new research directions. I'm just getting started, but I've already managed to get some inspiration at an international trade fair. Everything is still very much open.

You've already revealed what you won't miss about Cambridge. But, what did you miss there and can now enjoy to the full?

My family, of course, but also Czech beer, even though it's on tap in some places in Britain too. It's not easy to be in a foreign environment where everything is completely new; you like to come back home. I have friends at CATRIN and I'm looking forward to seeing what great things we'll be able to do and what I'll be able to get involved in. I'm also thankful to Michal Otyepka, whose group I work in now, for giving me this opportunity.

Mgr. Veronika Šedajová, Ph.D. (*1994)

Veronika Šedajová is a physical chemist who has researched graphene derivatives since the beginning of her university studies. During her undergraduate studies, she started working at the Regional Centre of Advanced Technologies and Materials of Palacký University. During her PhD, she studied active materials for use in supercapacitors. She won the prestigious Jean-Marie Lehn Prize for Chemistry in 2022 and is the author/co-author of 30 scientific papers.

She has also gained international experience at prestigious institutes, focusing on energy storage and materials science in, e.g., the United States, France and Spain. After completing her PhD, she obtained a postdoctoral position at the Yusuf Hamied Department of Chemistry, University of Cambridge, where she studied active materials for Li-ion batteries using optical scattering microscopy. She is currently working at CATRIN as a researcher.

CATRIN collaborates in a project for more efficient controlled agriculture

The VALOR-LIGHT (Valorization of Light-Activated Medicinal Plant By-Products for Novel Biotechnologies and Edible Crop Production) project from the European University Network Aurora call is intended to contribute to more efficient and sustainable cultivation of medicinal plants in controlled environments, especially in hydroponic cultivation systems. Under the leadership of the University of Innsbruck, scientists from CATRIN are involved in the project with other international partners.

The main task of the researchers is to develop technologies that ensure the necessary production of medicinal plants, protect the environment and consumers from the possible negative effects of fertilisers and pesticides and comply with the principles of the circular economy. CATRIN will be involved in three of the four research areas.

"Thanks to our unique research infrastructure in the form of phenotyping lines, we have extensive experience in non-invasive plant monitoring in controlled environments. We can test the effects of different biostimulants to enhance plant traits and various ways of applying them. In this project, we will focus on plants used in pharmacology and will try to increase the efficiency of production of phytoactive compounds using different innovative approaches," said CATRIN team leader Lukáš Spíchal.

Scientists from Olomouc in collaboration with colleagues from Pavol Jozef Šafárik University will test the effectiveness of organometallic networks and other nanomaterials as suitable carriers of natural (photo)antimicrobial agents. They will work in close contact with experts from the University of Naples Federico II in Italy to investigate the use of beneficial microorganisms. Another member of the research consortium is the University of Duisburg-Essen.

Application project to verify the efficacy of iron nitride nanoparticles in real-life conditions

The project "Pilot Application of Nanoparticles Containing Iron Nitride for the Reductive Dechlorination of Chlorinated Ethylenes in Groundwater" aims to conduct on-site testing of iron nitride nanoparticles in groundwater contaminated with chlorinated ethylenes to assess their efficacy. Thanks to funding from the Technology Agency of the Czech Republic amounting to approximately 12.6 million Czech koruna, experts from CATRIN, the Institute of Microbiology of the CAS and the EPS biotechnology company will collaborate on the project over the next two years.

"At a locality affected by chlorinated ethylenes, especially trichloroethylene, we will apply iron nitride nanoparticles and monitor whether there is a decrease in levels of contamination, the effect of nanoparticles on microorganisms present in groundwater and the efficacy of the nanoparticles under real conditions," said the main investigator of the project Jana Křížek Oborná from CATRIN's research group Environmental Nanotechnologies.

In the past two years, scientists from this research group have published two papers in prestigious journals on the topic of iron nitride nanoparticles. Based on their excellent laboratory results, the next step is to examine whether the efficacy of iron nitride nanoparticles can be translated from the laboratory into practice.

Trichloroethylene (TCE) is a known carcinogen; long-term exposure can lead to kidney and liver cancer, whereas short-term can cause neurological problems. When released into the environment, TCE progresses through the rock environment to groundwater, where it occurs in a dissolved form or forms an organic phase. Remediation of such contaminated groundwater requires a comprehensive approach.

Nanocon conference held again under the auspices of Radek Zbořil

The 16th annual Nanocon conference, held in Brno from October 15 to 17, focused on cutting-edge research into nanomaterials, their applications and environmental impact. As in previous years, the event was organised under the auspices of Radek Zbořil, Scientific Director of CATRIN-RCPTM, who served as the expert guarantor. Several CATRIN researchers contributed their expertise to the programme and took part in the poster session.

"I am pleased that we were able to attract leading scientists as plenary speakers again this year. One of the highlights was our collaboration with Bengt Fadeel, a renowned nanotoxicology researcher from the Karolinska Institutet, who focuses on the toxic mechanisms of nanomaterials, particularly their effects on the immune system. Together, we are developing materials with anti-cancer properties. Another standout presentation was delivered by Iván Mora-Seró from Universitat Jaume in Spain, who is advancing new concepts in photovoltaic conversion and light emission — another area of significant focus for us," explained Zbořil.

This year's conference brought together 200 participants, featuring 81 lectures and 108 posters. The programme included five lecture sessions, a workshop from the NanoEnviCz large research infrastructure and, for the first time, a Czech-Taiwanese symposium.

Graphene Week marks the 20th anniversary of graphene's discovery

This year's Graphene Week, an international conference dedicated to graphene (and 2D materials) research and its applications, marked the 20th anniversary since the discovery of this groundbreaking, Nobel Prize winning 2D material. Hosted in Prague, the event saw active participation by CATRIN, with its scientists playing key roles in the programme. Notably, Aristides Bakandritsos, one of CATRIN's leading researchers, served as one of the three Chairs of the conference. The organisation was managed by Graphene Flagship in collaboration with three European projects: 2D-BioPAD (coordinated by Bakandritsos), Next-2Digits and 2D-PRINTABLE.

"This year's Graphene Week once again pushed the boundaries of innovation. Through expert workshops and knowledge sharing, the event helped to shape the future of advanced materials. The five-day conference featured five plenary sessions led by world-renowned experts, alongside an Innovation Forum, exhibitions and sessions dedicated to diversity, career development for young scientists, future funding opportunities from the European Commission and 2D materials of the future," said Bakandritsos.

Among the keynote speakers was Michal Otyepka, Head of CATRIN-RCPTM, who delivered an invited lecture on graphene derivatives and their potential applications in energy storage, sensing and catalysis. The 2D-BioPAD

project, coordinated by CATRIN, organised a parallel session — Biomed — in partnership with the MUNASET project. During the session, CATRIN researchers David Panáček and Petr Jakubec presented developments in the use of graphene materials for biosensor printing and combating antibiotic-resistant bacteria.

Taiwanese delegation expresses interest in CATRIN's research and collaboration opportunities

On November 5, representatives from leading Taiwanese universities, including the National Taiwan University, National Chung Hsing University, Taipei Medical University and National Central University (NCU), visited CATRIN. The purpose of the visit was to exchange knowledge and explore potential avenues for collaboration.

Radek Zbořil, the Scientific Director of CATRIN–RCPTM, presented the institute's key research directions and highlighted its most significant scientific achievements. He also led the delegation on a guided tour of the laboratories, showcasing CATRIN's cutting-edge research infrastructure.

"We are part of the University Academic Alliance in Taiwan (UAAT) and have been seeking collaboration opportunities with CATRIN. Our visit was highly productive. We were impressed not only by the research outcomes but also by the advanced nanomaterials research facilities," said Jiun-Haw Lee, Associate Vice President for International Affairs at the National Taiwan University's Office of International Affairs. Several members of UAAT have expressed strong interest in partnering with CATRIN.

Cannabis debate breaks down prejudice

A debate on cannabis in November provided the fifth opportunity to bring together experts to discuss the possible utilisation of this crop. The main guest was Jana Michailidu, assistant professor at the University of Science and Technology and member of the Government Council for Coordination of Policy on Addictions. Pavel Kubů, an expert in medical informatics and addiction medicine, and Pavel Vojtko, a veterinarian, also accepted the invitation. The moderator was, as in previous years, Petr Tarkowski from CATRIN and the Crop Research Institute.

"We want to contribute to the destigmatisation of this medicinal plant by sharing scientific knowledge. We are convinced that by communicating the results of evidence-based science, we can encourage a change in society's attitude, which must necessarily lead to a change in conditions of cannabis use via modifications to legislation. Our society has been confused for decades by false or inaccurate information about the zero therapeutic potential of cannabis, the toxicity of its components and their high addictiveness," said Petr Tarkowski, who has been researching modern cultivation methods, valorisation of waste from cannabis production, processing of cannabis extracts and the therapeutic potential of cannabis products since 2015.

Prototypes of graphene materials presented in Berlin

Prototypes of graphene materials developed at CATRIN were demonstrated by Vojtěch Kupka and Jiří Navrátil at the October exhibition TechBlick in Berlin, which focused on printed electronics. Company representatives were introduced to nitrogen-doped graphene, which is now being piloted by the EIC project Trans2D-Chem, and to graphene ink, developed by the European Research Council (ERC) Proof of Concept GradeInk.

The fair attracts major global companies such as Airbus, Meta, Fujifilm, Agfa and Forvia, as well as smaller spin-off companies that present advanced solutions and materials in electronics and bioelectronics. TechBlick is held twice a year in Boston and Berlin, USA.

TECHSCALE conference in Liblice showcases top results

How has the TECHSCALE project, part of the Jan Amos Komenský Operational Programme, advanced after its first year? This question, among others, was addressed at a conference held from September 17 to 20 in Liblice, with the participation of all partners. The event aimed to not only reflect on progress but also strengthen collaboration. Presentations by international guests informed participants about the latest trends in single-atom catalysis and the integration of artificial intelligence.

The conference hosted 62 participants from the Czech Republic and abroad. The programme was organised into nine sections. A total of 22 lectures were delivered, including three plenary sessions. An invited talk by Gianfranco Pacchioni from Università Milano-Bicocca on "A Few Questions About Single Atom Catalysts: When Theory Helps" was a highlight. Lars Schaaf from the University of Cambridge discussed machine learning's role in a new era of catalyst modelling, while Kristina Tschulik from Ruhr-University Bochum presented advanced electrochemical techniques for electrocatalysts.

"The conference was a true melting pot of ideas from the diverse scientific areas encompassed by TECHSCALE. I greatly appreciated the contributions of our international colleagues, whose involvement was invaluable. I left feeling energised and inspired," said Martin Pumera from CEITEC – BUT, a lead scientist in the work package on sensing, biosensing, and biomedicine.

The TECHSCALE project is tackling some of the most pressing global challenges, including climate change, the energy crisis and enhancing the quality of life. It is a consortium of three universities —Palacký University Olomouc, Charles University and CEITEC Brno University of Technology.

Researchers' Night saw record attendance

This year again, CATRIN participated in the largest domestic event popularizing science and research — the September Researchers' Night. In addition to laboratory tours, entertaining experiments and quizzes, visitors were able to enjoy an exhibition of scientific cartoons and actively participate in a competition for the best scientific comic strip. The reward for the organisers was a record attendance of about 700 people.

"Researchers' Night has become an established event at CATRIN because the communication of science and dissemination of our research activities and results is one of our priorities. We consider that research is not finished until it has been communicated. I am glad that at this event, the public can learn about how science can contribute to solving global problems. The materials and technologies developed at CATRIN are designed for applications that aim to improve the quality of life and health of society, ensure sufficient food through sustainable agriculture, contribute to the efficient use of energy resources, including 'green energy', as well as improve the state of the environment," said CATRIN director Pavel Banáš.

CATRIN takes part in 3 Universities Symposium

A second year of the 3 Universities Symposium, an expert meeting of Palacký University Olomouc, the University of Florida and the University of Naples Federico II, took place in October at Fort Science with the participation of researchers from CATRIN. Ivo Frébort was a member of the organizing and scientific committee. The main purpose of the symposium, according to the organisers, was to deepen the strategic cooperation between the three universities in environmental and agricultural sciences.

"I am pleased that CATRIN played a significant role at the symposium and that we had the opportunity to meet colleagues from Aurora, a consortium of nine research universities, with whom we already collaborate in the research and development of new technologies for making plant growth more efficient," said Head of CATRIN-CRH Lukáš Spíchal. This three-day event was organised by Palacký University in cooperation with the Aurora consortium and brought together about forty experts from Italy, the United States and the Czech Republic. The agenda covered issues such as regulation in new breeding technologies, molecular farming, pathogenic and invasive organisms, and societal impacts of global change, but participants also discussed developments in artificial intelligence in agriculture and environmental sciences.

Nano4Tarmed project is a success story

In collaboration with colleagues from Maynooth University in Ireland and the Consiglio Nazionale delle Ricerche in Italy, scientists at CATRIN have developed a graphene-based nanoplatform capable of binding and delivering multiple drugs directly to tumour cells. This innovation is part of the Nano4Tarmed project, funded by the prestigious Horizon 2020 programme. The research primarily targets osteosarcoma — a type of bone cancer common in adolescents and young adults — but its potential applications may also extend to breast cancer and brain tumours. The effectiveness of this nanoplatform has been demonstrated in living cells and 3D models, but additional research is necessary before it can be utilised in clinical settings.

"Thanks to collaboration within the Czech-Irish-Italian consortium, we have developed an efficient nanosystem for delivering anticancer drugs targeting three distinct types of cancer over the three and a half years of the project," said Václav Ranc, the project's coordinator from CATRIN. "The project has helped enhance existing treatment approaches and develop new ones that could be impactful in the diagnosis and treatment of cancer, potentially improving the health of populations across Europe and globally."

This project also significantly contributed to setting up CATRIN's Grants Office and facilitated success in the European grants competition. The European Commission evaluators reflected these findings in their Final Report, classifying the project as a "success story".

Petra Kührová

I do science with passion and devotion

At high school, Petra Kührová was torn between pursuing a career in medicine or teaching mathematics and chemistry, but she eventually excelled as a theoretical chemist. In CATRIN's Carbon Nanostructures, Biomolecules and Simulations research group, she tries to understand the behaviour of DNA and RNA — molecules that carry genetic information. Using molecular dynamic simulations, she models interactions between atoms in these biomolecules.

While she completed her master's degree in teaching mathematics and chemistry at Palacký University, she also engaged in theoretical chemistry and devoted her thesis to it, continuing in this discipline as a doctoral student. She is now a prominent member of a team that ranks among world leaders in elucidating the behaviour of nucleic acids and pushes the frontiers of their simulations.

"Theoretical chemistry gives me a lot of flexibility. The only condition is to have an internet connection, which enables me to work from anywhere. This allows me to combine work with family life," explained the scientist, who is also active in the FemCOSY international group, which supports women in science.

Dynamic simulations enable not only changes in the structure of molecules to be studied but also the effects of these changes on their biological functions. An important part of her work is to observe how nucleic acids interact with their environment, for example with nanoparticles. "This research is crucial not only for understanding the basic biology of living organisms but also for developing new therapies. The constantly improving performance of computers plays a crucial role. We use the computer infrastructure at VSB-TUO and within the EuroHPC entity," said the scientist. Petra does not dream of scientific awards or articles in prestigious journals, even though she has these accomplishments under her belt. "The important thing for me is to do science with passion and devotion. I don't work just to keep myself busy, but for the adventure of exploring the unknown," she concluded.

This is how evolutionary biologist Dominik Kusý from CATRIN's Biodiversity and Molecular Evolution research group describes his work. Despite only recently completing his PhD, he has made a significant contribution to understanding beetle evolution. The young scientist has become fascinated by two remarkable evolutionary phenomena — neoteny, the preservation of juvenile traits into adulthood, and bioluminescence, the ability of organisms to produce light.

Dominik Kusý

Science is not just a job, it's a passion

"My work involves combining modern methods of genome sequencing and bioinformatic analysis with classical insect systematics and morphological analysis. All this is complemented by field observations. It is thanks to this comprehensive approach that we can investigate evolutionary processes in great depth. My goal is to contribute to a deeper understanding of the evolutionary mechanisms and processes that shape biodiversity on our planet," explained the scientist, who says he has been fascinated by nature and modern technology since childhood.

He has already had many successes, including more than 30 publications in prestigious journals and several awards. For example, he and his colleagues have used the latest phylogenomic methods to uncover previously unknown relationships between beetle lineages. By applying state-of-the-art sequencing technologies, they have made a significant contribution to the identification of beetle biodiversity centres in tropical regions, which is crucial for effective conservation of these unique and species-rich habitats at a time of ongoing biodiversity crisis.

"I appreciate immensely the freedom that science provides. The opportunity to explore my own research questions, design experiments and interpret the results is extremely stimulating. I enjoy being able to combine lab and computer work with field research. In addition, I enjoy being able to share my enthusiasm for science with the public, especially young people, at various outreach events."

For the molecular biologist Karel Koberna, the path to science was fairly straightforward. During his studies at the Faculty of Science of Charles University, he became fascinated by electron microscopy, which showed him a completely new and until then hardly imaginable view into the cellular microworld. Gradually, he became more focused on biomedical research and the development of new approaches that can accelerate and simplify various biomedical applications. Today, at CATRIN - IMTM, he focuses on cell biology and medicine.

Karel Koberna

I'm fascinated by the sheer range of possibilities

"My current main scientific focus is investigation of the influence of cytidine metabolic pathways on cytarabine therapy of haematological cancers and development of new methods for their analysis. I am particularly interested in DNA replication, chromatin structure and transport of bioactive molecules. In addition, I am involved in the development of technologies applicable to biomedical research," said the scientist, who has also worked in laboratories in Germany and Spain.

The amazement with modern technology in electron microscopy still persists. "If I were to talk about fascination in the context of science, I must mention the current tremendous burst of possibilities that were previously unthinkable. For example, the use of computer technology in biology allows analyses to be completed within minutes, whereas just a few years ago, it took days or weeks," explains the man who has been involved in describing the replicon arrangement in mammalian cells using electron tomography and has contributed to the development of a new method for quickly, cheaply and easily testing the effect of various substances against, for example, cancer cells.

He plans to continue his involvement in developing therapies that could help cancer patients. But rather than scientific dreams, he speaks of a desire to keep learning and discovering new things. "I would also like to make science more accessible and understandable to the general public, showing how fundamentally it affects our daily lives and how it opens up new possibilities," he added.

CATRIN gains a prestigious partner for biomedical research from Taiwan

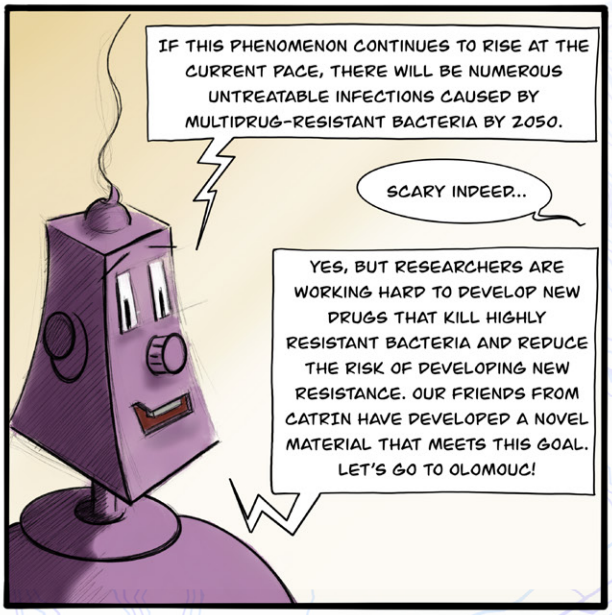
CATRIN and the National Health Research Institutes (NHRI) in Taiwan have agreed on scientific cooperation, preparation of joint programmes, exchange of researchers and other activities focusing on the use of nanomaterials in medicine. The agreement has been confirmed by both parties by signing a Memorandum of Understanding effective for five years.

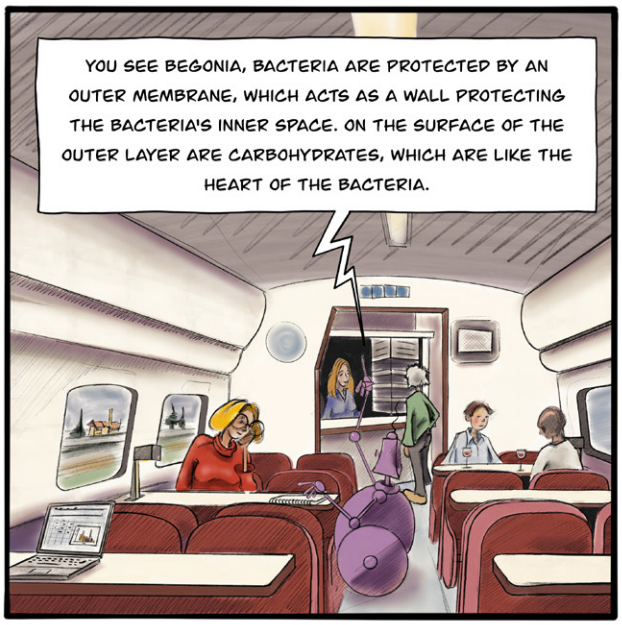
"The NHRI is a major research institution whose main objective is to develop medical research and improve healthcare. Like CATRIN, it is dedicated to research into human diseases, including cancer. So, we consider our cooperation to be mutually beneficial. Already at the first meeting, we identified specific research activities in which our institutes complement each other and on which our scientists have already started working. We are honoured to be working with another partner of such importance and standing. We believe that together we can make further significant steps towards understanding, preventing and treating certain diseases," said CATRIN Director Pavel Banáš.

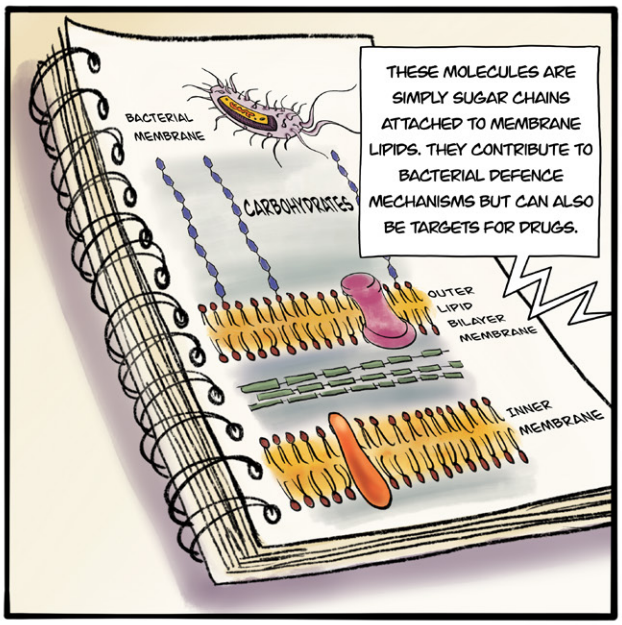
The NHRI is a non-profit foundation established by the government in 1995. Scientists there conduct research on many aspects of fundamental biomedical sciences and specific diseases.

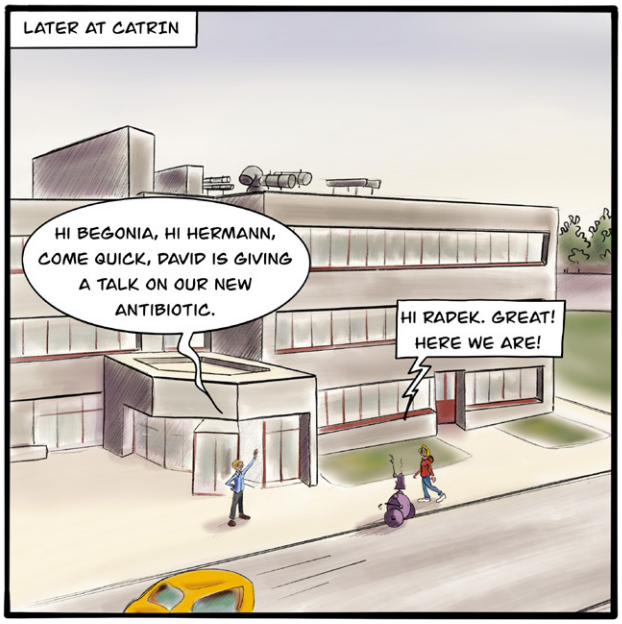

HERMANN AND BEGONIA
AND THE ATOMIC ANTIBIOTIC
P.TROUILLAS
HI BEGONIA, HOW ARE YOU TODAY?
I'M FINE, HERMANN, BUT I'M PRETTY SCARED BECAUSE I'VE READ IN THE NEWS THAT BACTERIAL INFECTIONS ARE GOING TO BE THE LEADING CAUSE OF DEATH IN THE WORLD SOON!!!

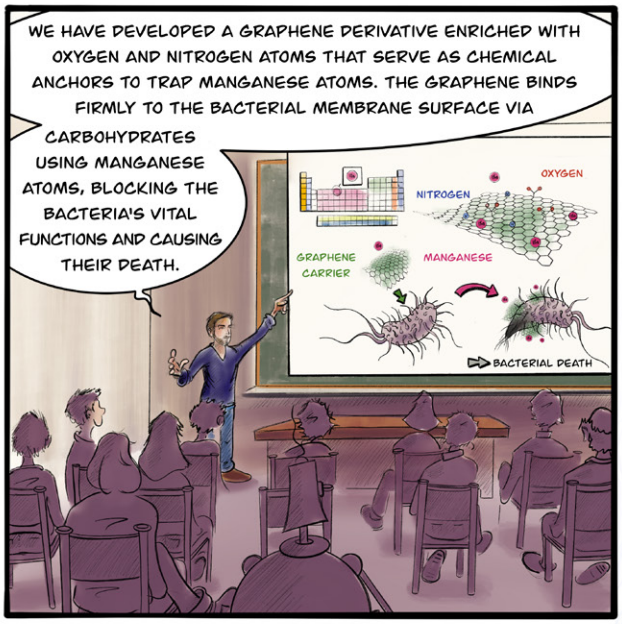

YES, THIS IS DUE TO THE EVOLUTION OF BACTERIAL RESISTANCE, WHICH DEVELOPS IN BACTERIA MAINLY AS A RESULT OF WORLDWIDE OVERUSE OF ANTIBIOTICS.
MMM, THAT SMELLS GOOD..
TRDELNÍK

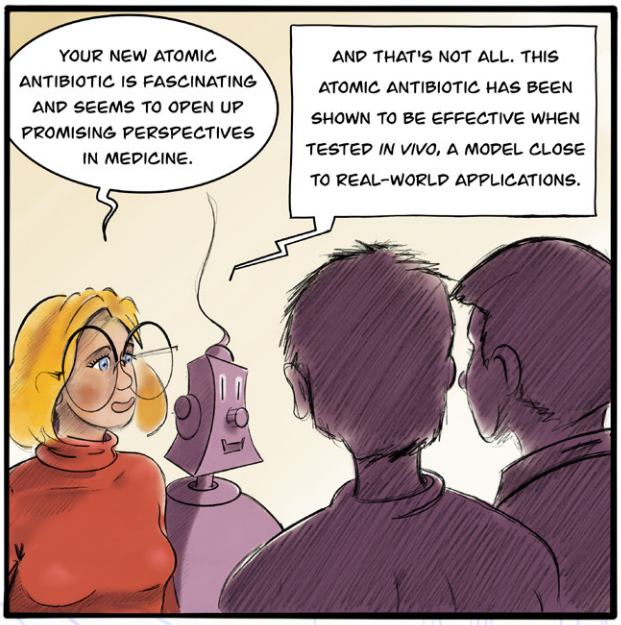

IF THIS PHENOMENON CONTINUES TO RISE AT THE CURRENT PACE, THERE WILL BE NUMEROUS UNTREATABLE INFECTIONS CAUSED BY MULTIDRUG-RESISTANT BACTERIA BY 2050.
SCARY INDEED..
YES, BUT RESEARCHERS ARE WORKING HARD TO DEVELOP NEW DRUGS THAT KILL HIGHLY RESISTANT BACTERIA AND REDUCE THE RISK OF DEVELOPING NEW RESISTANCE. OUR FRIENDS FROM CATRIN HAVE DEVELOPED A NOVEL MATERIAL THAT MEETS THIS GOAL. LET'S GO TO OLOMOUC!

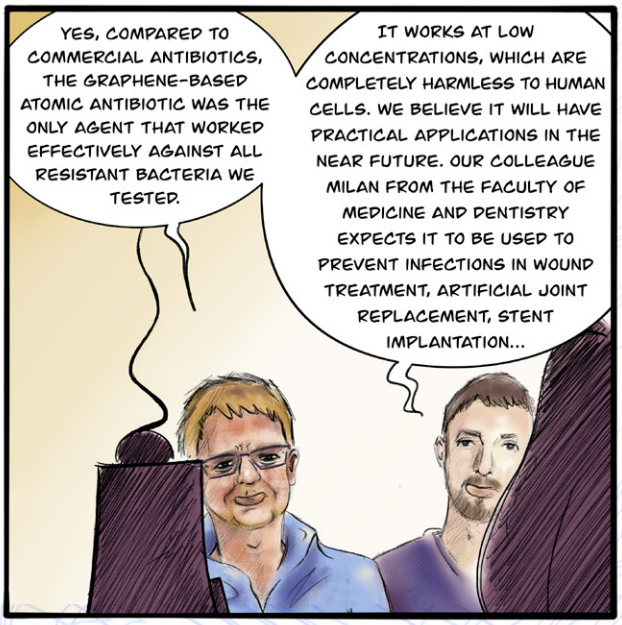

YOU SEE BEGONIA, BACTERIA ARE PROTECTED BY AN OUTER MEMBRANE, WHICH ACTS AS A WALL PROTECTING THE BACTERIA'S INNER SPACE. ON THE SURFACE OF THE OUTER LAYER ARE CARBOHYDRATES, WHICH ARE LIKE THE HEART OF THE BACTERIA.


BACTERIAL MEMBRANE
CARBOHYDRATES
OUTER LIPID BILAYER MEMBRANE
INNER MEMBRANE
THESE MOLECULES ARE SIMPLY SUGAR CHAINS ATTACHED TO MEMBRANE LIPIDS. THEY CONTRIBUTE TO BACTERIAL DEFENCE MECHANISMS BUT CAN ALSO BE TARGETS FOR DRUGS.


LATER AT CATRIN
HI BEGONIA, HI HERMANN, COME QUICK, DAVID IS GIVING A TALK ON OUR NEW ANTIBIOTIC.
HI RADEK. GREAT! HERE WE ARE!


WE HAVE DEVELOPED A GRAPHENE DERIVATIVE ENRICHED WITH OXYGEN AND NITROGEN ATOMS THAT SERVE AS CHEMICAL ANCHORS TO TRAP MANGANESE ATOMS. THE GRAPHENE BINDS FIRMLY TO THE BACTERIAL MEMBRANE SURFACE VIA CARBOHYDRATES USING MANGANESE ATOMS, BLOCKING THE BACTERIA'S VITAL FUNCTIONS AND CAUSING THEIR DEATH.
OXYGEN
NITROGEN
GRAPHENE CARRIER
MANGANESE
BACTERIAL DEATH


YOUR NEW ATOMIC ANTIBIOTIC IS FASCINATING AND SEEMS TO OPEN UP PROMISING PERSPECTIVES IN MEDICINE.
AND THAT'S NOT ALL. THIS ATOMIC ANTIBIOTIC HAS BEEN SHOWN TO BE EFFECTIVE WHEN TESTED *IN VIVO*, A MODEL CLOSE TO REAL-WORLD APPLICATIONS.


YES, COMPARED TO COMMERCIAL ANTIBIOTICS, THE GRAPHENE-BASED ATOMIC ANTIBIOTIC WAS THE ONLY AGENT THAT WORKED EFFECTIVELY AGAINST ALL RESISTANT BACTERIA WE TESTED.
IT WORKS AT LOW CONCENTRATIONS, WHICH ARE COMPLETELY HARMLESS TO HUMAN CELLS. WE BELIEVE IT WILL HAVE PRACTICAL APPLICATIONS IN THE NEAR FUTURE. OUR COLLEAGUE MILAN FROM THE FACULTY OF MEDICINE AND DENTISTRY EXPECTS IT TO BE USED TO PREVENT INFECTIONS IN WOUND TREATMENT, ARTIFICIAL JOINT REPLACEMENT, STENT IMPLANTATION...

Univerzita Palackého
v Olomouci

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