RCPTM newsletter
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2020

Nanoballs for testing and sanitizer production: Covid-19 changes priorities in both life and science

Covid-19 is changing our lives, values, and habits. An overburdened health system in some countries, social isolation, and significant economic consequences for many companies and entrepreneurs are the harsh consequences of our ongoing confrontation with this invisible enemy from Wuhan. However, the pandemic has provoked several positive responses in the Czech Republic, including unprecedented social solidarity and help for vulnerable people; the dedication of front-line paramedics, police officers, and firefighters; and spontaneous cooperation among academic and industrial scientists working in different fields. The pandemic has created a clear need for new scientific priorities and rapid solutions, as well as new professional challenges. The Regional Centre of Advanced Technologies and Materials (RCPTM) is rising to these challenges.

Under the supervision of the Institute of Organic Chemistry and Biochemistry (IOCB), RCPTM scientists have engaged in the development of a protocol that will enable testing for SARS-Cov-2 without using commercial chemicals and test kits supplied from other countries, which are currently unavailable because demand greatly exceeds supply. "Without effective and rapid testing, it is impossible to implement the so-called smart quarantine. We would thus be reliant on draconian, large-scale restrictions that stifle the economy and hinder normal social life. The key barrier to increasing testing capacity, and an important step in the entire complex procedure, is the isolation of viral RNA, which is necessary for detecting the presence of the virus in samples taken from patients. In our lab, Pavel Šácha and his collaborators therefore developed an original method for isolating viral RNA, which was the bottleneck of the process. Magnetic nanoballs from RCPTM are crucial for their method," said Jan Konvalinka from IOCB, who is managing the development of the single testing protocol.

Radek Zbořil's team at RCPTM has capitalized on years of experience in research into magnetic nanomaterials for biomedical applications (e.g. Ulbrich K. et al. *Chem. Rev.* 116, 5338–5431, 2016; Sarigiannis Y. et al. *Biomaterials* 91, 128–139, 2016; Hola K. et al. *Biotechnol. Adv.* 33, 1162–1176) by developing a new type of magnetic iron oxide nanoparticle-based sorbent with a thin quartz shell within an incredibly short time. These balls bind nucleic acids (including viral RNA) very efficiently, which allows their repurification and separation from other mixture components using magnetic fields.

"We're glad to participate in this ambitious project. In one synthetic cycle, we can prepare enough nanoparticles for around 100,000 tests. We are thus able to meet all of the Czech demand and even supply foreign customers without any problems. I appreciate the feedback from colleagues at IOCB and the Institute of Molecular and Translational Medicine (IMTM) who evaluated the effectiveness of the nanoparticles," said Professor Zbořil, who praised the excellent work done to optimize the synthesis by his colleague Ivo Medřík.

Successful verification of the technology was carried out by the National Institute of Public Health in Prague. The developed magnetic sorbents are already being tested and used in the laboratories of hospitals such as *in Motol* and *Na Bulovce*, and in academic workplaces including CEITEC, Brno; BIOCEV, Prague; or IMTM, Olomouc. "It is currently being made available to all testing laboratories in the Czech Republic on a non-commercial basis, and a commercial partner is being actively sought to produce and deliver complete RNA extraction kits," added Konvalinka, who appreciates the cooperation between the scientific workplaces.

Similarly, the national testing coordinator Marián Hajdúch, IMTM Director, highlighted the scientists' joint efforts in the so-called *smart quarantine* project. “The coronavirus cannot be eradicated; it will continue to spread until *herd immunity* has been built up or a vaccine invented. Sufficient testing is crucial for designing the right solutions and keeping the spread of the virus under control. It’s great that at this time we can respond so quickly and use our own know- how. The enormous potential of scientific collaboration among major research infrastructures is being clearly demonstrated,” said Hajdúch.

At the same time, RCPTM scientists are trying to capitalize on their scientific know-how in the field of antimicrobial silver nanoparticles. They conducted pioneering studies that demonstrated the high antibacterial (Panáček A. et al. *J. Phys. Chem. B* 110, 16248–16253, 2006) and antifungal activity (Panáček A. et al. *Biomaterials*, 30, 6333–6340, 2009) of silver nanoparticles. However, silver nanoparticles are also effective against a wide range of viruses, and are therefore increasingly being mentioned as a possible tool for long-term disinfection and virucidal surface treatment of filters or face masks, as well as plastic or metal surfaces. To facilitate such uses, RCPTM staff are working with multiple industrial partners to test patented technologies that may enable nanoparticles to be anchored to any surface using appropriate branched polymers with reducing functional groups. “We are currently discussing a licensing agreement with representatives of a company in Brno to use our technology," said Jana Soukupová, the co-author of the European and American patent (J. Soukupová and R. Zboril, EP 3407715; US9505027B2).

„I greatly appreciate our close and effective cooperation with Radek Zbořil and his team; this success would have been impossible without them.“

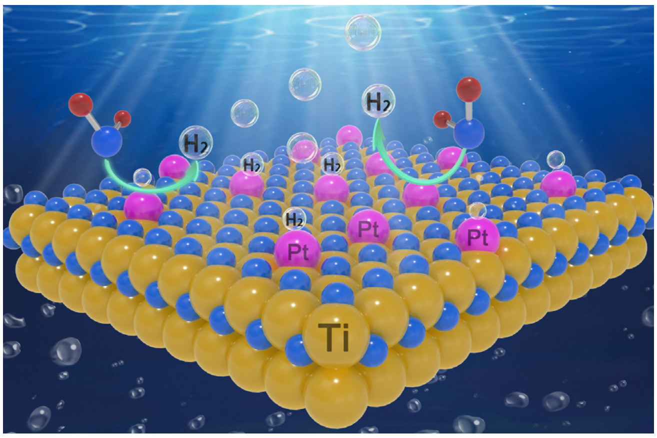
– Jan Konvalinka, IOCB

In its battle against Covid-19, RCPTM has not only relied on its scientific expertise – it has also made great use of the efforts and commitment of its workers, including doctoral students. “It was the doctoral students who were among the first to respond to the lack of hand sanitizer by manufacturing it themselves. We initially took advantage of our own stocks and later drew on the help of colleagues from the Centre of the region Haná for Biotechnological and Agricultural Research,” says Michal Otyepka, RCPTM Deputy Director. One of the RCPTM labs turned into a disinfectant manufacturing facility as early as mid-March. The sanitizer, which is mixed in accordance with the World Health Organization’s recommendations, was subsequently given to organisations including Olomouc Charity and Klokánek, Hospice in Svatý Kopeček, Spa Slatinice, Children’s Home of Chance, nursing homes for the elderly and many other health or non-profit social centres. Shipments were also sent to health care workers in Litovel, which, along with another 20 nearby villages, was locked down due to the fast spread of coronavirus. RCPTM staff decided to share their experience of mixing the disinfectant with others. This resulted in the creation of a new website named *COVID 19; how to outsmart the pandemic* (https://covid.rcptm.com), which provides important information on preventing the disease, especially hand hygiene. Other RCPTM workers are also assisting IMTM with the administration connected with testing. “I extend my sincere thanks for all the work that has been done to handle the crisis,” added Otyepka.

Everyone at RCPTM is now lending a helping hand. The Ph.D. student Lukáš Zdražil, for example, who has been preparing hand sanitizer in the lab for the past few weeks, is not behind on his scientific work either. “My typical day now is divided between preparing the disinfectant and working on testing our carbon dots for use in solar energy,” he said. His research on the development of so-called solar concentrators, along with new grants, facilities, and research projects at RCPTM is discussed in more detail elsewhere in this issue. Enjoy your reading.

Chemically anchored platinum atoms greatly enhance the efficiency of TiO_2 in photocatalytic hydrogen production

Scientists from the RCPTM photoelectrochemistry group, led by Professor Patrick Schmuki, have developed new technology enabling individual platinum atoms to be anchored to the TiO_2 surface. Titanium dioxide is one of the most studied photocatalysts, which is used as a photoanode in the process of producing hydrogen through direct solar water splitting. Platinum represents the most commonly used co-catalyst contributing to increasing the efficiency of converting solar energy into hydrogen. Primarily, platinum is used in the form of nanoparticles of different sizes and shapes. Recent rapid development in synthesis and properties of catalysts at the level of individual atoms (the so-called single atom catalysis) has inspired scientists to develop a unique technology based on partial reduction of TiO_2 in the hydrogen atmosphere under the simultaneous formation of Ti^{3+} and surface defects. These defects act as chemical traps to anchor individual platinum atoms after simple impregnation with Pt^{4+} solution. The method allows elegant control of surface defect density and the rates of TiO_2 layer coverage by individual platinum atoms. Such bound atoms increase the photocatalytic efficiency of titanium dioxide up to 150-fold, compared to the commonly used systems in which platinum nanoparticles are applied to the surface of TiO_2. The work, published in the journal Advanced Materials, follows RCPTM’s systematic research into metal oxides for photocatalytic applications including direct solar water splitting (Kment S. et al. *Chem. Soc. Rev.* 46, 3716–3769, 2017; Spanu D. et al. *ACS Catal.* 8, 5298–5305, 2018; Naldoni A. et al. *ACS Catal.* 9, 345–364, 2019) and into using metals at the level of individual atoms in organic catalysis, electrocatalysis and photocatalysis (Bakandritsos A. et al. *Adv. Mater.* 31, 1900323, 2019; Gawande M. B. et al. *ACS Catal.* 10, 2231–2259, 2020).

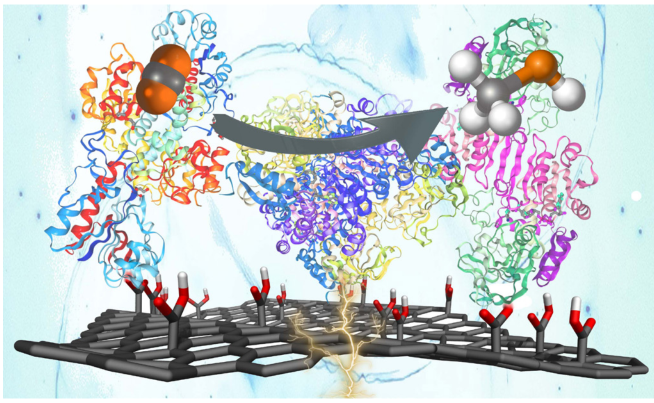


Hejazi S., Mohajernia S., Osuagwu B., Zoppellaro G., Andryskova P., Tomanec O., Kment S., Zbořil R., Schmuki P.: On the Controlled Loading of Single Platinum Atoms as a Co-Catalyst on TiO_2 Anatase for Optimized Photocatalytic H_2 Generation, *Advanced Materials* 2020, in press, DOI: 10.1002/adma.201908505.

Nanobiocatalyst for converting CO_2 into methanol takes advantage of graphene acid

The efficient transformation of carbon dioxide into methanol is an intensively studied chemical reaction because it allows the conversion of a greenhouse gas into a substance that can be used as an energy source or an industrial raw material. The reaction is inspired by nature: living organisms including plants and various microbes convert CO2 into organic substances using enzymes as biocatalysts. Energy molecules such as NADH supply the cells with large amounts of energy to maintain this process. Researchers at RCPTM and Johannes Kepler University, Linz, borrowed three enzymes from the natural world that catalyse the gradual three-step conversion of CO2 into methanol, and anchored them to the surface of graphene acid. Graphene acid is a two-dimensional derivative of graphene that has properties similar to organic acids, is completely biocompatible, conducts electric current extremely well, and readily binds biomolecules to its own surface (Bakandritsos A. et al. *ACS Nano*, 11, 2982–2991, 2017).

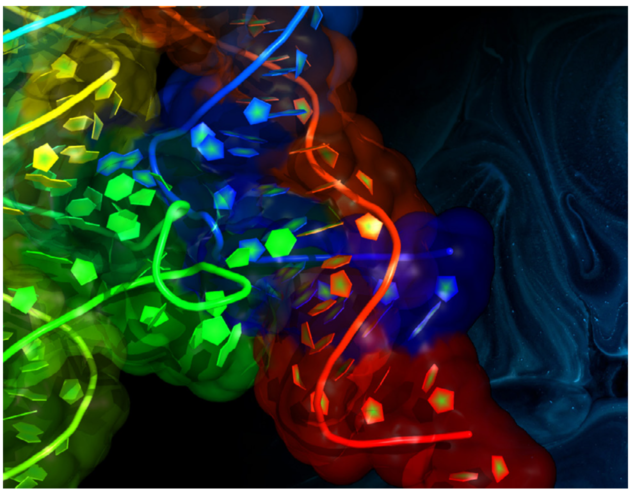
The binding of the three enzymes to this 2D material produces a hybrid nano- bio- catalyst that progressively converts CO2 into methanol. As an energy source, the researchers used an electric current instead of NADH molecules by plugging the nanobiocatalyst into an electrical circuit. They thus exploited two of graphene acid's remarkable properties: its functional groups were used for covalent enzyme anchoring, and its conductivity allowed electrons to be transported from the electrode. The hybrid catalyst was able to operate without detectable power loss for 20 hours and produced methanol without by-products. These results build on previous work at Olomouc that demonstrated the possibility of using carboxylated graphene derivatives in the development of new types of supercapacitors (Bakandritsos A. et al. *Adv. Funct. Mater.* 28, 1801111, 2018).



Seelajaroen H., Bakandritsos A., Otyepka M., Zbořil R., Sariciftci N.S.: Immobilized Enzymes on Graphene as Nanobiocatalyst, *ACS Applied Materials & Interfaces* 2020, 12 (1), 250–259.

International team explains the underlying operating mechanism of RNA switches

A collaboration between scientists from RCPTM, Cornell University, and the University of Michigan has yielded new insights into the functioning of RNA switches (riboswitches), which are parts of RNA molecules that regulate gene expression - the translation of stored hereditary information into real cell structures or functions. By combining three unique techniques, they were able to produce the first description of the operating mechanism of a riboswitch that specifically recognizes the binding of a manganese ion. In a study published in the prestigious journal *Nature Communications*, they showed how the binding of this lone ion can trigger a whole cascade of processes and initiate or stop gene expression.



RNA switches have attracted considerable attention from scientists in recent years. Because they are particularly common in bacteria, including pathogenic strains, they could be attractive targets for the development of new antibiotics. However, a deep understanding of the mechanisms governing their operation would be needed to exploit them in this way. While many RNA switches bind small molecules that affect their activity, Olomouc scientists working with colleagues in the US chose to examine a rare RNA switch that responds to the binding of a single manganese ion. Their study combined three techniques: X-ray crystallography, FRET spectroscopy, and molecular dynamics simulations. This methodological triad provided the first comprehensive description of the operating mechanism of a riboswitch. Crystallographic structures obtained by the Cornell team enabled the researchers to inspect static images of the riboswitch with atomic resolution at key moments during the regulatory process. FRET (fluorescent resonance energy transfer) experiments conducted at the University of Michigan revealed global movements within the RNA switch. The information obtained from these experiments was then integrated into molecular dynamics simulations performed by Olomouc scientists. The Olomouc team thus used its vast experience with molecular dynamics simulations of nucleic acids and the development of methods for their description, which have become globally accepted standards for nucleic acid simulations.

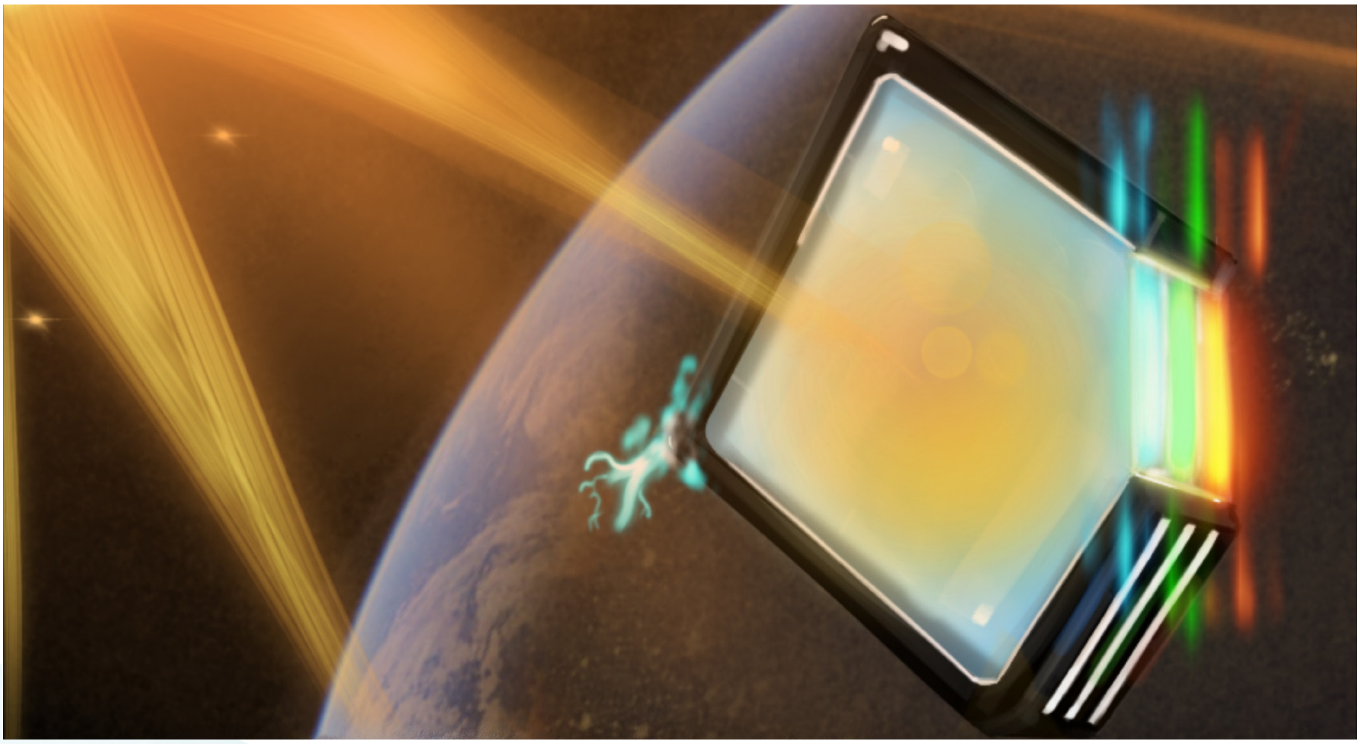
Suddala K.C., Price I.R., Dandpat S.S., Janeček M., Kührová P., Šponer J., Banáš P., Ke A., Walter N.G.: Local-to-global signal transduction at the core of a Mn^{2+} sensing riboswitch, *Nature Communications* 2019, 10 (1), 4304.

Quantum dots show potential in solar energy generation

Carbon dots (CDs) are biocompatible and eco-friendly photoluminescent nanomaterials whose optical properties can be controlled by tuning the particle size, graphite core doping, and the chemical properties of their surface functional groups. RCPTM workers have previously demonstrated the use of different types of CDs for *in vivo* temperature measurements in living cells (Kalytchuk S. et al. *ACS Nano*, 11, 1432–1442, 2017), bioimaging (Li D. et al. *Adv. Mater.* 30, 1705913, 2018), photothermal anticancer therapy (Bao X. et al. *Light Sci. Appl.* 7, 91, 2018) developing LED diodes (Tian Z. et al. *Adv. Opt. Mater.* 5, 1700416, 2017) and effective photocatalysis (Nandan D. et al. *Green Chem.* 20, 3542–3556, 2018).

Recent research on CDs at RCPTM has focused on new optoelectronic applications. In Nanoscale, the journal of the Royal Chemical Society, RCPTM scientists first described the design of a tandem luminescent solar concentrator (TLSC) based exclusively on carbon dots. This device can "collect" sunlight and concentrate it at its edges, where it is converted into electricity by a solar cell. The integration of TLSCs into the glass surfaces of urban buildings could potentially transform passive facades into sustainable energy-generating units. The use of cheap and eco-friendly CDs emitting blue, green, and red light has enabled the construction of a tandem structure capable of operating across almost the entire visible spectrum with an external optical quantum efficiency of 2.3%. These results elegantly pave the way to further applications of carbon dots in solar energy.

Zdražil L., Kalytchuk S., Holá K., Petr M., Zmeškal O., Kment Š., Rogach A.L., Zbořil R.: A carbon dot-based tandem luminescent solar concentrator, *Nanoscale* 2020, 12 (12), 6664–6672.



Other publications from RCPTM

Kment Š., Sivula K., Naldoni A., Sarmah S.P., Kmentová H., Kulkarni M., Rambabu Y., Schmuki P., Zbořil R.: FeO-based nanostructures and nanohybrids for photoelectrochemical water splitting, *Progress in Materials Science* 2020, 110, 100632.

Gawande M.B., Fornasiero P., Zbořil R.: Carbon-Based Single-Atom Catalysts for Advanced Applications, *ACS Catalysis* 2020, 10 (3), 2231–2259.

Sharma R.K., Yadav P., Yadav M., Gupta R., Rana P., Srivastava A., Zbořil R., Varma R.S., Antonietti M., Gawande M.B.: Recent development of covalent organic frameworks (COFs): synthesis and catalytic (organic-electro-photo) applications, *Materials Horizons* 2020, 7 (2), 411–454.

Mohajernia S., Andryskova P., Zoppellaro G., Hejazi S., Kment S., Zboril R., Schmidt J., Schmuki P.: Influence of Ti^{3+} defect-type on heterogeneous photocatalytic H_2 evolution activity of TiO_2, *Journal of Materials Chemistry A* 2020, 8 (3), 1432–1442.

Kalytchuk S., Zdražil L., Scheibe M., Zbořil R.: Purple-emissive carbon dots enhance sensitivity of Si photodetectors to ultraviolet range, *Nanoscale* 2020, in press, DOI: 10.1039/d0nr00505c.

Chronopoulos D.D., Medveď M., Potsi G., Tomanec O., Scheibe M., Otyepka M.: Tunable one-step double functionalization of graphene based on fluorographene chemistry, *Chemical Communications* 2020, 56 (13), 1936–1939.

Mallada B., Edalatmanesh S., Lazar P., Redondo J., Gallardo A., Zbořil R., Jelínek P., Švec M., de la Torre B.: Atomic-Scale Charge Distribution Mapping of Single Substitutional p- and n-Type Dopants in Graphene, *ACS Sustainable Chemistry & Engineering* 2020, 8 (8), 3437–3444.

Niyazi Serdar Sarıçiftçi:

„Materials science and nanotechnology can help fight viruses“

Two years ago, following an invitation from the then RCPTM General Director Radek Zbořil, Niyazi Serdar Sariciftci delivered a lecture to students in Olomouc as part of Rudolf Zahradník lecture Series. As a result, this world-renowned physical and materials chemist from Johannes Kepler University, Linz, Austria, became motivated to begin a close collaboration with RCPTM. His research interests include electrochemical reduction of carbon dioxide and bioorganic electronics. It was therefore no surprise that he quickly identified several research areas where collaboration with RCPTM could be mutually beneficial.

How and when did your collaboration with RCPTM begin?

One day I received an invitation from Prof. Zbořil to visit Olomouc and RCPTM. I am ashamed to say that until two years ago I had never visited the beautiful city of Olomouc or learned about its great Austro-Hungarian historical heritage.

The visit made such a strong impression that I decided to start an intensive collaboration with Olomouc, and RCPTM in particular. I realized that not taking advantage of a top research institute right across the Austrian border would be a shame. This is truly advantageous for intensive collaboration.

How does this collaboration benefit your research and has it produced any specific results yet?

We were only marginally involved in graphene research before we began our collaboration with RCPTM. The graphene functionalization research done at this institute has greatly benefited our work. The first joint publication on the development of a new type of nanobiocatalyst for carbon dioxide transformation has already been published in the leading journal of the American Chemical Society.

You recently visited RCPTM and had the opportunity to meet not only the centre's management, but also group leaders, researchers and doctoral students. What impression did it make on you?

The RCPTM research team is highly competent and forward-looking. The turbulence around the establishment of the new university institute is unfortunate and very counterproductive for science, however. One of the outcomes of our meeting is an agreement on how our collaboration will work in the future, especially in relation to the use of graphene derivatives in nanobioelectrocatalysis. The group established by Kateřina Poláková, which focuses on the toxicity of nanomaterials also plays a major role in my plans for research on new bioelectronic materials. Additionally, the work of Aris Bakandritsos's team on graphene functionalization is directly relevant to our research efforts. Our publication in the journal ACS Applied Materials & Interfaces, which describes the use of enzymes immobilized on functionalised graphene as nanobiocatalysts, has already attracted considerable attention around the world.

We are currently dealing with the Covid-19 pandemic. Can this situation also pose new challenges?

This situation is the most unusual one I have yet experienced. There is a clear need for further research into the types of viruses with the potential to cause such epidemics in the future. Outbreaks of this kind are bound to occur periodically, partly because half of the human population lives in megapolises and this is unlikely to change in the foreseeable future. Overcrowded living spaces are perfect for disease transmission. We as scientists can contribute to the fight against such outbreaks not only through medical research but also by working on materials science and nanotechnologies.

Various carbon or iron-based nanomaterials have the potential for preventive or diagnostic use.

One very promising area is the use of silver nanoparticles that kill and inhibit viruses. These nanotechnologies could be used in materials for sanitary purposes and to prevent infections in hospitals, for example. Of course, considerable work will be needed to make this possible, but in this pandemic I see both a major challenge for scientists and a stimulus for collaboration with RCPTM.

RCPTM awarded the highest mark for an NPU project

Excellent! This was the assessment given to RCPTM during the final evaluation of the NPU I Project entitled Development of the Centre of Advanced Technology and Materials. According to the project's opposition committee, RCPTM has successfully established itself as one of Europe's leading centres for chemical, materials, and optical research with the assistance of a five-year award granted by the Ministry of Education (MŠMT).

According to the final report, the fundamental outcome of the project is the successful creation of a stable research and education centre that excels in all key respects and has proved its sustainability. "The proposed targets have not only been met but significantly exceeded, in some cases by hundreds of percent. For example, the high success rate in commercialising results and obtaining superior funds from contract research and patent licensing is crucial," said Vít Kavan, Chairman of the opposition committee of MŠMT.

Another member of the opposition committee, Bohuslav Rezek from CTU, also noted that all of the expected outcomes had been achieved: "At RCPTM, they managed to hire the right people, have a great sense of relevant topics, establish an excellent network of international contacts and are able to sell their results worldwide. This means getting published in high-impact journals and publicising their results effectively. Foreign scientists come to Olomouc, which has helped promote the city, and the university is seen as a key hub of science and technology transfer within the Czech Republic."

RCPTM's results were also highly rated by another member of the opposition committee, Jaromír Pištora from the VSB - Technical University of Ostrava. "All these accomplishments demonstrate the visionary selection of topics by the project's Principal Investigator, Professor Zbořil," he added.

Over the course of the project, which ran from 2014 to 2019, RCPTM significantly increased its level of internationalisation; foreign workers now comprise 35% of its research personnel. Additionally, the centre is working with over 40 foreign scientific partners and dozens of companies. Compared to the target of 500 publications over the reporting period, RCPTM has published 1500 papers with an average IF of 5. 33.

"The project was extremely important to us. It enabled us to stabilise and internationalize the research team, and to equip the centre with cutting-edge technologies. Moreover, the project was not burdened with excessive bureaucracy: our colleagues at MŠMT displayed great flexibility and our communications were smooth," said the principal investigator Radek Zbořil.

The total funding awarded was 236.1 million CZK.

RCPTM wins a prestigious European grant to support international collaboration in cancer research

The establishment of a platform for international collaboration in research into the targeted treatment of osteosarcoma is the goal of the NANO4TARMED grant awarded to Václav Ranc from RCPTM. The grant was funded under the Twinning call, which is part of the prestigious Horizon 2020 programme. The Olomouc scientists will collaborate with colleagues from the Consiglio Nazionale delle Ricerche in Italy and the National University of Ireland, Maynooth. Only four proposals from the Czech Republic succeeded in obtaining funding via this call.

The above-mentioned institutions have joined forces to advance research into the treatment of osteosarcoma, which is the second most common malignant bone disease. Václav Ranc, who is one of the project's coordinators, described the three participants' contributions as follows: "Our colleagues from Ireland are experts in drug development. We at RCPTM will provide nanoparticles that could be used to transport their drugs to the affected tissues, which is something we have studied for some time. Our partners from Italy will then use their experience to test this targeted treatment on cancer cells."

Alongside the research, the project aims to promote mutual cooperation. "The most important thing is to establish a research cluster, a kind of platform for cooperation. We must learn to cooperate with one another and share our knowledge and experience via activities such as exchanges, seminars, and workshops. This will significantly increase our chances of winning major European grants in the future, which will enable us to bring the research to a successful conclusion by developing an effective strategy to treat this cancer," added Ranc. The total funding for this three-year grant exceeds 19 million Czech Crowns.

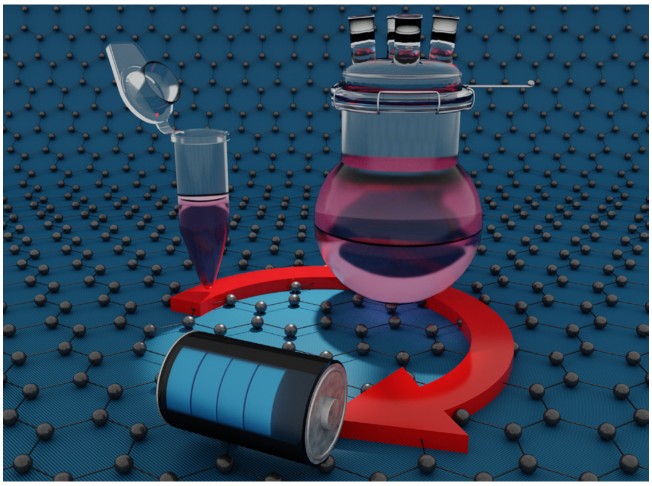
A total of 439 proposals were submitted for the *Twinning* call, which closed last November, and 437 proposals were evaluated. The total funding allocated to the call is EUR 69 million, allowing 77 projects to be supported. The call's aim is to help overcome disparities between member states and regions with respect to developing and harnessing research and innovation potential, to promote participation in Horizon 2020, and to help stimulate excellent research in the European research area.

First ERC Proof of Concept grant awarded to Michal Otyepka

An historic first *Proof of Concept* grant funded by the European Research Council has gone to the Czech Republic thanks to the work of RCPTM Deputy Director Michal Otyepka. His main objective will be to perform the large-scale preparation of a new carbon electrode material and, in collaboration with a commercial partner, evaluate its use in supercapacitors for energy storage. Major manufacturers from both the US and Europe have already expressed interest in testing it.

This one-year project will allow the physical chemist to capitalize on the results he and his team achieved through the *ERC Consolidator* grant obtained in 2016. "The goal of my first ERC grant is to understand the chemical rules of the two-dimensional world of carbon materials and to use that understanding to identify new, super-functional graphene-derived materials for specific purposes. Among other things, we have shown that targeted chemical treatment of graphene makes it possible to prepare suitable electrode materials, which are key components of so-called supercapacitors used, for example, in the automotive industry or electrical engineering. Now, one of the developed materials that shows very promising results in laboratory conditions will be produced in larger quantities and tested in real parts in collaboration with a foreign partner," explained Otyepka.

According to him, graphene derivatives lend themselves to being used for energy storage in supercapacitors. They are light, conduct electric current, and allow large amounts of electric charge to accumulate. The new material was developed by chemical synthesis from readily available fluorographite. "The material contains no heavy metals, is relatively simple to prepare, and has significantly lower energy costs than existing commercial materials – whereas existing materials are normally prepared at temperatures between 600 and 1000 °C, the new material is synthesized at temperatures not exceeding 150 °C. We have also achieved excellent results with respect to the number of charging and discharging cycles, which is another important parameter. While similar materials exhibit losses of capacity after thousands of charging cycles, our material is stable even after tens of thousands of cycles," added Otyepka.



The research will follow RCPTM's previous activities and collaborations with foreign partners in the field of carbon nanomaterials for energy storage (Bakandritsos A. et al. *Adv. Funct. Mater.* 28, 1801111, 2018; Jayaramulu K. et al. *Adv. Mater.* 30, 1705789, 2018; Vermisoglou E. C. et al. *Chem. Mater.* 31, 4698–4709, 2019; Yang X. et al. *ACS Nano* 12, 7397–7405, 2018); it will also take the team's research closer to real applications.

So far, the scientists have prepared and tested only gram quantities of the material; however, the commercial partner will need at least half a kilogram. The financial support provided by the ERC, which amounts to 3.7 million Czech Crowns, will enable a streamlined transition from the laboratory to real conditions. According to the member of the ERC Scientific Board Tomáš Jungwirth, *Proof of Concept* grants provide less financial support than major ERC grants but are very prestigious. "*Proof of Concept* grants are awarded with the aim of moving some results, achieved within the major ERC grant, closer to applications so that they can attract (financial) interest from potential investors. It means that ERC considers the research important not only from the scientific point of view but also from the perspective of their practical use within a much shorter time," said Jungwirth.

The aim of the *Proof of Concept* call is to support successful investigators holding ERC grants during the earliest stages of commercializing their research results. The total funding awarded to support proposals under this call was EUR 30 million in 2019. A total of 498 proposals were evaluated, with an average success rate of 40%. Researchers in 22 countries obtained 200 grants.

Other grants launched between 10/2019 and 4/2020

MŠMT ERC_CZ: A light-driven biorefinery using metacatalysts (LL1903)
Total budget: 15 697 410 CZK / *Investigation period:* 1.10.2019–30.9.2021 / *UPOL:* Alberto Naldoni, Ph.D.

MŠMT: Modernization and upgrade of large research infrastructure "Nanomaterials and nanotechnologies for protection of the environment and sustainable future" (Pro-NanoEnviCz II; CZ.02.1.01/0.0/0.0/18_046/0015586)
UPOL budget: 9 730 215 CZK / *Investigation period:* 1.1.2020–31.12.2022 / *Principal Investigator:* J. Heyrovský Institute of Physical Chemistry / *Co-Investigator at UPOL:* RNDr. Václav Ranc, Ph.D.

GAČR Std: Plasmonic catalysts with titanium nitride nanocrystals for sustainable chemical reactions
Total budget: 6 747 000 CZK / *Investigation period:* 1.1.2020–31.12.2022 / *Principal Investigator:* Alberto Naldoni, Ph.D.

TAČR TREND: Development of a hybrid magnetic component based on iron oxide nanoparticles to replace solid permanent magnets used in magnetic closures
UPOL budget: 10 232 431 CZK / *Investigation period:* 1.1.2020–30.6.2023 / *Principal Investigator:* GZ Allure, s.r.o. / *Co-Investigator at UPOL:* Prof. RNDr. Radek Zbořil, Ph.D., Ondřej Malina, Ph.D.

TAČR TREND: Next Generation of Integrated Atomic Force and Scanning Electron Microscopy
UPOL budget: 5 261 760 CZK / *Investigation period:* 1.4.2020–31.3.2023 / *Principal Investigator:* NenoVision, s.r.o. / *Co-Investigator at UPOL:* Prof. RNDr. Michal Otyepka, Ph.D.

Representatives of an American agency discussed future collaboration

Representatives of the US National Science Foundation (NSF) and RCPTM discussed, last December, the possibilities of close collaboration. The meeting was attended by the management of the centre along with the group leaders and postdoctoral and PhD students.

During their week-long stay in the Czech Republic, a delegation of four programme directors from the US National Science Foundation expressed an interest in familiarizing themselves with the work of Palacký University, and, primarily, with RCPTM's research activities in nanotechnology. "The delegation from the American Grant Agency was introduced to the organization of our research, the network of international collaborations and our research activities in nanotechnology and nanomaterials. At the meeting, we outlined the advantages and challenges of future collaboration between the Czech Republic and the US. Postdocs and Ph.D. students working at our centre were also involved in this stimulating discussion, alongside the leaders of the research groups. They shared their experience and asked about possible support. I believe some of the ideas will be implemented in the future," said the RCPTM Deputy Director Michal Otyepka.

The National Science Foundation is an independent government agency in the US responsible for supporting fundamental research in particular by providing funding. They arrange research grants for universities or individuals.

RCPTM lends Colombia a helping hand with water remediation

RCPTM may help to remediate water in Colombia in the future. The centre's representatives have established a joint project with their partners at Universidad Central, Bogotá, Colombia, that will seek to develop nanomaterial-based technologies for treating waters contaminated with heavy metals.

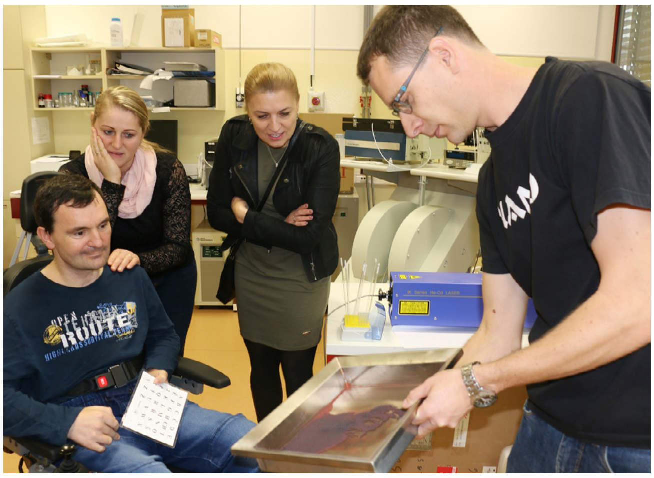
The idea of active collaboration began to form about a year ago during a visit to Olomouc made by the Vice-Rector of Universidad Central, Óscar L. Herrery Sandoval, who was very impressed by the presented technologies for water remediation using iron nanoparticles. "Water contamination is a critical issue in Colombia. Because of its rapidly growing leather industry, the country is facing the problem of its watercourses being contaminated with hexavalent chromium; additionally, illegal gold mining is causing the environment to be contaminated with toxic mercury," said Jan Filip, RCPTM group leader of the environmental nanotechnologies team.

Last fall, he and a colleague attended a conference at Universidad Central and agreed to collaborate in a project that his Colombian colleagues are preparing. "We may provide our expertise, test our nanoparticles in the target environment, or perhaps develop new materials tailored to the environmental problems there. Our Colombian partners have expressed a keen interest in the collaboration, and it's clear that it could produce tangible outcomes benefitting Colombia in general," added Jan Filip. The forthcoming project is intended to verify the potential of nano- bioremediation strategies for water remediation; the scientists will first design an appropriate technology and then verify it on laboratory and pilot scales.

Support for Kamil

"A memorable experience" and "a beautiful day." This is how Kamil Otčenášek, who recently suffered a stroke that impaired his speech and mobility, described the visit to RCPTM that he made last November. He is facing his fate with admirable perseverance and optimism, and with huge support from his family. The courage of Kamil and his wife Zdeňka was also a great inspiration to RCPTM staff, who therefore supported the family with a pre-Christmas financial contribution.

The couple went on a guided tour of the labs including top microscopes. Using a high-resolution transmission electron microscope, they were able to observe individual atoms for the first time, along with looking at the structure of their hair under a scanning electron microscope. They learned about nanoparticles and what they are used for, and watched demonstrations of burning iron nanoparticles and a levitating magnet with awe. "I can't believe my eyes," Kamil responded to the new information with a smile, communicating with the scientists using a paper notepad.



Zdeňka also could not hide her enthusiasm. "I'm fascinated by science, and Kamil enjoys such things as well. We're so happy to be able to make a visit like this," said Zdeňka. She is taking care not only of Kamil but also of her two sons. Thanks to their support, Kamil, whose initial prognosis was very unfavourable, is making tremendous progress. "We are grateful for every bit of help. Although Kamil is trying hard and getting better day after day, it's tough. A lot of people say that we're role models for them. That's hugely motivating," she concluded.

Professor Zbořil joins the editorial board of the new journal VIEW

The new interdisciplinary journal published by *Wiley* focuses on *in vitro* and *in vivo* biodiagnostics using biomaterials. Its first issue came out on 23 March, 2020. The journal publishes experimental and theoretical works as well as review articles in areas such as targeted drug transport, bioimaging, biomarkers, biosensors, bioinformatics, computational diagnostics and new diagnostic tools.

Professor Zbořil has a longstanding research interest in the use of photoluminescent carbon quantum dots for bioimaging and theranostic applications (e.g. Li D. et al. *Adv. Mater.* 30, 1705913, 2018; Bao X. et al. *Light Sci. Appl.* 7, 91, 2018; Holá K. et al. *ACS Nano* 11, 12402–12410, 2017; Kalytchuk S. et al. *ACS Nano* 11, 1432–1442, 2017; Georgakilas V. et al. *Chem. Rev.* 115, 4744–4822, 2015), and in imaging techniques using nuclear magnetic resonance and targeted drug transport using magnetic nanoparticles

"My role will primarily be in assessing articles dealing with the use of nanomaterials in bioimaging, sensing, and related applications," says Radek Zbořil, who is also a member of the editorial boards of *Applied Materials Today* (Elsevier) and *Scientific Reports* (Nature Family).

The chemists Zbořil and Varma again rank among the world's most highly cited researchers

RCPTM was well represented on the global list of Highly Cited Researchers in 2019. The physical chemist Radek Zbořil has maintained his place in this elite group for two consecutive years, along with the chemist Rajender Varma, who also retained his ranking from previous years. The list of the world's most highly cited researchers is published annually by Clarivate Analytics in the US; its most recent edition includes 23 Nobel laureates.

"This means recognition for RCPTM's superb researchers and their innovative ideas. We conduct multidisciplinary research with a strong focus on practical applications. A citation index adjusted for specific scientific categories (the CNCI index based on the Web of Science database) shows that thanks to the RCPTM's scientific performance, Palacký University has become the Czech Republic's highest ranked research institution in the fields of multidisciplinary materials science and nanotechnology. We have been even better at physical chemistry for the past couple of years than the universities of Cambridge and Oxford," said Professor Zbořil, who was behind the discovery of the thinnest insulator known to date, non-metal magnets, the first two-dimensional Carboxylic Acid, and bacterial resistance to nanosilver. He features in the Cross-field category.

Rajender Varma, who is also on the staff of the U.S. Environmental Protection Agency (US EPA), considers this ranking a great honour. "It has always been a very humbling experience to see my name on this highly prestigious list. I also represent RCPTM and Palacký University, Olomouc, where I cooperate with distinguished colleagues. The quality of research institutes is determined by individual scientists working there and the opportunity they're given to develop their talent," he said.

The Highly Cited Researchers List 2019 contains the names of over 6,000 researchers from nearly 60 countries. These are scientists whose papers received significant citation responses in 21 fields, or possibly across fields, and are therefore of great benefit to the development of society as a whole. The list was based on an analysis of publications from the years 2008 to 2018 drawn from the Web of Science database.

Introducing scientific infrastructure

Cryomagnetic system for Mössbauer spectroscopy

A new cryomagnetic system was recently installed in RCPTM's laboratories. Combined with a Mössbauer spectrometer of our own design, it will enable Mössbauer experiments to be performed at extremely low temperatures of up to 1.5 K and in strong magnetic fields of up to 7 T.

Mössbauer spectroscopy is a precision technique that is widely used in RCPTM to study iron-containing materials with applications in medicine, energy, or environmental technologies. RCPTM scientists have long been engaged in the development and design of these spectrometers for their own use and for commercial purposes. The ability to perform analyses at low temperatures and in strong magnetic fields will make it possible to study structural and binding ratios including spin and valence conditions in iron-containing materials, even in samples where only trace iron is present. The new system will also enable comprehensive description of the magnetic properties of Fe-materials, including the determination of internal magnetic field values and magnetic transition temperatures, as well as the differentiation of magnetically unequal fractions. Its strong magnetic fields will also make it possible to describe and quantify individual structural positions in the spinel structures of iron oxides and to differentiate so-called isostructural substances.

The cryomagnetic system was developed and manufactured by the British company *Oxford Instruments*. Unlike its predecessor, it is a so-called closed system that does not require regular refilling with liquid helium, thus significantly reducing operating costs.

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