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Jagiellonian University inventions for the environment

Caring for the environment is nowadays one of the world's priorities and has a strong impact on economic development. It is due to the risks caused by air pollution, contamination of water and soil, as well as drinking water deficit. The greatest responsibility for the condition of the natural environment is born by the industry; in many enterprises it directly affects both the everyday decisions and the directions of development.

Green investments are often involve expensive modernisation of industrial facilities, which is particularly difficult to accomplish in operating plants. Therefore, the most sought-after technologies are such that can be introduced with low cost and with mild changes to existing production lines.

Inventions of the Jagiellonian University also cover the issues of environmental protection. Some of the new technologies developed at the Faculty of Chemistry are related to air protection and industrial wastewater treatment.

For air protection

Research Group for Catalysis and Solid State Chemistry, in cooperation with the Fertilizers Research Institute in Puławy, developed **two novel catalysts for the decomposition of nitrous oxide** in low and high temperature, respectively. Nitrous oxide, a byproduct of catalytic oxidation of ammonia, is produced in nitric acid installations and has a significant contribution to the greenhouse effect. The new materials surpass the disadvantages of solutions already existing on the market.

The catalyst for low temperature decomposition of nitrous oxide is active at temperatures as low as 50°C and can be used to remove N_2O from the gas. The high-temperature catalyst reduces the losses caused by depletion of nitrogen oxides NOx (the substrate for nitric acid production) from the gas mixture, while maintaining high thermal resistance and excellent activity. Industrial application of the catalyst would not require retrofitting of existing installations.

Subject of the next eco-invention is the **ferrite catalyst for soot particles combustion.** The material resulted from the work of Research Group of Surface and Material Chemistry. Soot particles are formed in the pyrolysis process during generation of power from fossil fuels. The emission of soot particles in the exhaust gas of diesel engines is nowadays one of the major sources of air pollution in urban areas. The higher efficiency and vitality of this type of engines compared to gasoline engines has led recently to a significant increase in their popularity.

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Salmonella against cancer

On June 23rd 2010, a therapeutic technology created at the Jagiellonian University in Krakow was **awarded the title of Polish Product of the Future.** The innovative method employs genetically modified bacteria *Salmonella*, which – when injected into the patient's bloodstream – is able to recognize and colonise the tumour tissue. With its natural ability to invade, **bacteria penetrate tumour cells and trigger apoptosis** – the process of programmed cell death. Simultaneously, immune system of the patient is stimulated to recognise and destroy the tumour.

- Promising results and very low production cost make the Salmonella-based vaccine is an excellent product for industial development – adds Dominik Czaplicki from the Jagiellonian University's CITTRU.

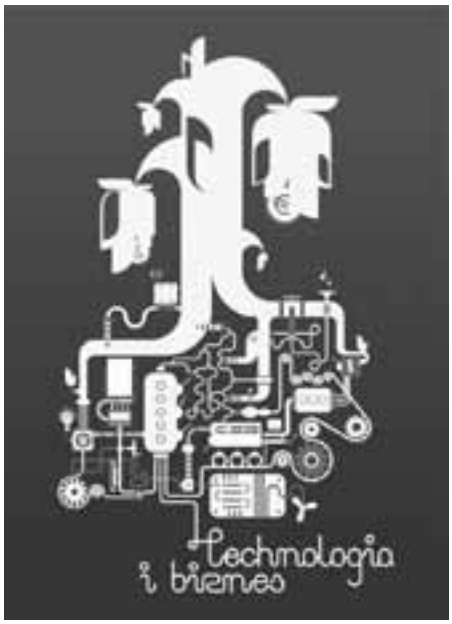
more on page 8

in this issue

A bright future of photocatalysis

We present the new invention from Faculty of Chemistry: materials based on modified nanocrystalline titanium dioxide which exhibit efficient photocatalytic inactivation of microorganisms degradation and of organic pollutants upon visible light irradiation. The materials can find an array of applications, including self-cleaning layers, disinfection agents and contact lens care. Read the full story by one of the co-inventors.

read on pages 3-4



Olga Dąbrowska „Technology and business"

CITTRU Centre for Innovations, Technology Transfer and University Development
Jagiellonian University in Krakow

Office for Development and Cooperation
Lublin University of Technology

Jagiellonian University inventions for the environment

innovation catalogue

Innovations and technologies from the Jagiellonian University

On this and next pages we present short list of Jagiellonian University inventions ready to offer for business. More details on:
www.cittru.uj.edu.pl

Catalyst for high-temperature decomposition of nitrous oxide in tail gas from nitric acid plants

Offer 119

Research area: new material science / inorganic chemistry

Keywords: catalysis, production of nitric acid(V), decomposition of nitrous oxide, greenhouse gas reduction

Summary: The offer is a catalyst based on nanoporous calcium aluminate for high-temperature decomposition of nitrous oxide produced in nitric acid(V) plants, thus reducing environmentally harmful emissions of this greenhouse gas. Catalyst minimizes the losses associated with the depletion of gaseous mixture of nitrogen oxides NOx, which are the reactants for the nitric acid production, while maintaining high catalytic activity and low tendency to sintering.

Inventors: Group for Catalysis and Solid State Chemistry, Faculty of Chemistry

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Catalyst for low-temperature decomposition of nitrous oxide in tail gas from nitric acid plants

Offer 114

Research area: new material science / inorganic chemistry

Keywords: catalysis, nitric acid(V) production, decomposition of nitrous oxide, greenhouse gas reduction

Summary: The offer is a catalyst based on cobalt, nickel and zinc for low-temperature decomposition of nitrous oxide, which is a by-product in nitric acid(V) installations. Nitrous oxide is a greenhouse gas and the catalyst can be used to eliminate its emissions. Catalysis does not require the use of additional reducing substances and eliminates the losses caused by depletion of gaseous mixture in nitrogen oxides NOx, which are substrates for the production of nitric acid(V).

Inventors: Group for Catalysis and Solid State Chemistry, Faculty of Chemistry

continued from page 1

As a result of increasingly strict regulations on emission of soot particles by motor vehicles, the limits of their concentration in the exhaust gas decreased 10-fold in a few years. One way to remove soot particles is the use of exhaust filters; however, the filters become clogged and require periodic regeneration. Combustion of soot is not efficient due to too low temperature of the exhaust gas. The problem can be solved with catalytic combustion on the soot filter.

The catalyst offered by the chemists from Jagiellonian University is a mixed oxide of iron and potassium, surface-doped with cerium oxide. It effectively reduces the soot combustion temperature to the temperature of the exhaust system, with high catalytic activity and selectivity to carbon dioxide above 98%. Moreover, production cost is low as the material is composed of readily available, inexpensive and environmentally friendly elements.

Industrial wastewater treatment

Another technology dedicated to environmental protection is **photocatalytic degradation of water pollutants.** A family of new materials has been produced by the Nanotechnology of Polymers and Biomaterials Research Group.

Increasing water pollution may soon become limiting to the development of civilisation. Due to the variety of pollutants, it is extremely difficult to devise a universal and affordable method of water treatment. Existing methods have many shortcomings – most importantly high energy consumption and low efficiency. The photocatalysts offered by scientists from the Jagiellonian University are based on layered aluminosilicates modified with organic compounds capable of absorbing light. The materials efficiently degrade environmental pollutants by oxidation with singlet oxygen and can be used to photo-degradation of toxic compounds such as phenols, chlorinated aromatic compounds, pesticides and cyanides. Also water contaminants of pharmaceutical and hospital origin can be tackled. The family of new photocatalysts is an alternative to technologies currently used in the industrial wastewater treatment. The advantages are: high efficacy in visible light (no UV irradiation required), natural and non-toxic components, spontaneous separation in water by sedimentation (easy after-use removal).

All of the eco-technologies described above have been **presented at international trade fairs** related to environmental protection and kindled great interest. The invention of hybrid photocatalysts for water purification was awarded at the New Materials Forum in Valencia, while the catalyst for soot particles combustion was highlighted during POLLUTEC trade fair as one of the five most significant developments in air protection.

Dr. Eng. Gabriela Konopka-Cupiał
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A bright future of photocatalysis

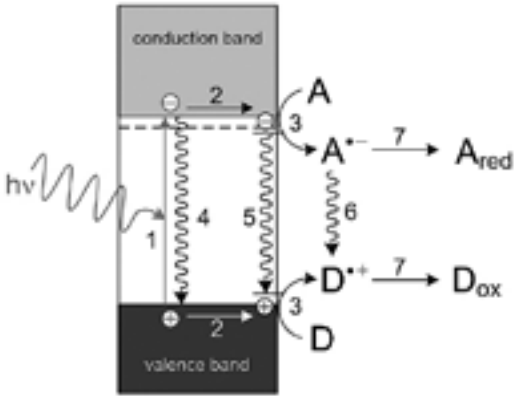
Renewable energy sources have become very trendy, so more and more efforts are undertaken to **utilize solar energy** in various processes, in particular related to its **conversion into electrical or chemical energy.** The use of photovoltaic cells is limited by the variability of sunlight, high dispersion of solar energy, efficiency of conversion processes and the cost of the equipment itself. The issue of converting solar energy into the chemical one is even worse. Attempts of hydrogen photogeneration or artificial photosynthesis of fuel compounds generally did not go far beyond the walls of laboratories and the process of plant photosynthesis still remains an unequalled design. So should the attempts to use solar energy be abandoned? I am convinced that solar energy could and should be used to everyone's benefit, and **photocatalysis is one of the ways to reap the benefit.**

History

It all began in the 1960. with several articles showing oxidation of organic substances in the presence of titanium dioxide irradiated with UV light. However, those works did not focus too much attention and it was not until the seventies when research data on photocatalytic decomposition of water initiated the rapid development of heterogeneous photocatalysis. Unfortunately, to date researchers failed to develop a photocatalyst that could be readily applied in hydrogen production. Nevertheless, the work carried out over the years have resulted in **many important discoveries and technologies.** I will come back to them in a moment.

Theory

Heterogeneous photocatalysts are usually oxides and sulfides of transition metals. The basic processes resulting in the photocatalytic effect are shown in the figure. Absorption of light leads to the generation of hole and electron in the valence and conduction bands, respectively (process 1). Those charges may migrate within the semiconductor particle, and can be trapped at surface sites (process 2). They can also participate in the interfacial electron transfer processes involving the molecules of electron acceptor A and donor D (process 3). Subsequent reactions of primary reduction/oxidation products, $A^{\bullet-}$ and $D^{\bullet+}$, lead to stable end products A_{RED} and D_{OX}. The unwanted side processes include: charge recombination (processes 4 and 5) and redox reaction between $A^{\bullet-}$ and $D^{\bullet+}$ resulting in reproduction of the acceptor and the donor (process 6).



Primary physical and chemical processes occurring in the presence of irradiated photocatalyst.

Practice

So much for theory. **How can it be used in practice?** If the processes 3 in the figure would be the reactions of water reduction and oxidation, then they could be used for hydrogen production. This is a difficult task and so far cannot be realised with satisfactory efficiency. If the reactants A and D in the process 3 are organic substances, the reaction generates free radicals, which can combine to form new C-C or C-N bonds. Such „photosynthesis" can be performed with fairly good efficiency and selectivity in the presence of cadmium or zinc sulfides as photocatalysts. But most frequently oxygen and water play the role of A and D, respectively. In this case usually titanium dioxide or zinc oxide are used as the photocatalyst while superoxide anion $O_2^{\bullet-}$ and hydroxyl radical $OH^{\bullet}$ are the primary redox products. Those reactive radicals are responsible for most of the oxidation of organic substances. Importantly, oxidation under these conditions is usually complete, giving H_2O and CO_2 as the final products. The reactions can therefore be used in the processes of water, air or surface purification.

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innovation catalogue

Ferrite catalyst for soot particles combustion

Offer 121

Research area: new material science/ inorganic chemistry

Keywords: catalysis, soot combustion, diesel engines

Summary: The subject of the offer is a ferrite catalyst for soot particles combustion, particularly in the exhaust gas of diesel engines. Advantages of the material are: high catalytic activity and high selectivity to carbon dioxide. The main component of the catalyst is a ternary iron potassium oxide surface doped by ceria. It can be used to remove soot particles from the fumes at temperatures below 300°C.

Inventors: Group for Catalysis and Solid State Chemistry, Faculty of Chemistry

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Ferrite catalyst for styrene synthesis

Offer 118

Research area: new material science/ inorganic chemistry

Keywords: catalysis, styrene, ethylbenzene dehydrogenation

Summary: The offer is a composite ferrite catalyst with enhanced thermal stability, activity and resistance to carbon deposition. The catalyst can be used in industrial installations for synthesis of styrene by ethylbenzene dehydrogenation. Styrene is one of the most important materials for the plastic industry.

Inventors: Group for Catalysis and Solid State Chemistry, Faculty of Chemistry

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Biocompatible implant for controlled drug release

Offer 094

Research area: new materials science

Keywords: dentistry, hydroxyapatite, biocompatible implant, controlled drug release

Summary: The invention is a biocompatible hydroxyapatite-based implant designed for local, controlled drug release and regeneration of bone tissue. The implant may include antibacterial medicines for the treatment and prevention of infections in the development of craniofacial surgery and dentistry.

Inventors: Group for Crystal Chemistry of Drugs, Faculty of Chemistry

Science Innovation Marketing Business

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Hybrid photocatalysts based on nanoclays for water purification

Offer 101

Research area: new material science

Keywords: water purification, wastewater treatment, photocatalysis, nanoclays

Summary: The offer covers hybrid photocatalysts based on nanoclays and their application to photocatalytic reactions, in particular in environmentally friendly methods of water purification. Hybrid photocatalysts are especially well-suited for photodegradation of pesticides, aromatic compounds, phenols and cyanides. They are based on non-toxic natural minerals and are suitable for photocatalytic applications in aqueous environment, where they form a suspension and can be easily removed afterwards by filtration or decantation.

Inventors: Nanotechnology of Polymers and Biomaterials group, Faculty of Chemistry

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Visible light photoactive materials based on modified nanocrystalline titanium dioxide for disinfection and sterilization

Offer 108

Research area: new material science

Keywords: photocatalysis, titanium dioxide, degradation of organic compounds, disinfection

Summary: The offer covers materials based on modified nanocrystalline titanium dioxide which exhibit efficient photocatalytic inactivation of microorganisms or organic pollutants degradation upon visible light irradiation. The materials can find an array of applications, including self-cleaning layers, disinfection agents and contact lens care.

Inventors: Coordination and Bioinorganic Physicochemistry Group, Faculty of Chemistry

Titanium dioxide materials offer

A bright future of photocatalysis

continued from page 3

Since microorganisms also find the reactive radicals difficult to bear, ZnO and TiO_2 can be useful in photodisinfection.

One key feature of TiO_2 and ZnO should be emphasised: those materials can absorb only ultraviolet radiation (photon energy above ~3.2 eV), and this fact significantly limits their application in photocatalysis. However, there are methods of „activation", or photosensitisation of TiO_2 towards visible light – then the photocatalyst gains a colour.

Another method of photosensitisation **involves a TiO_2 surface modification with compounds** which, upon excitation with visible light, yield electrons to the conduction band. Further fate of the electrons is similar to that shown in the figure. This type of photosensitisation could be achieved with complexes of platinum(IV). The resulting materials may be used as a photocatalytic resin in air conditioners for purification and deodorization of air. We have also shown

Wojciech Macyk, PhD

Invention

In our work carried out at the Faculty of Chemistry, Jagiellonian University and a fellow group of Professor Horst Kisch at the University of Erlangen, **we have successfully applied a number of methods for TiO_2 photosensitisation.** One of them is based on synthesis of TiO_2 in the presence of various organic compounds that are precursors of highly unsaturated carbon compounds. Excitation of such material with visible light (e.g. blue or green) results in generating holes in the valence band and electrons in the conduction band, which in turn reduce the adsorbed oxygen molecules. Redox reactions produce a number of reactive oxygen species at the surface of the material. The discovery of carbon-doped TiO2 (that is how the type of materials is usually called) initiated an intensive development of other TiO_2-based photocatalysts of this type. Such photocatalysts have already been applied as ingredients of the photoactive paints for indoor painting, where the intensity of ultraviolet light is negligible.

their phototoxicity against microbial and tumour cells. Similar properties are exhibited by materials of TiO_2 modified with surface complexes of titanium(IV). Due to the high phototoxicity against bacteria, the materials bring high hopes for commercial applications. Perhaps in the future semiconducting photochemotherapeutics could be developed on this basis?

It is worth noting that the photosensitisation methods described above can also be used in processes of current photogeneration, that is in photovoltaics or optoelectronics. As one can see the light may certainly be usefully explored in many ways, while photocatalysis is a bright tool to use it.

Wojciech Macyk, Ph.D., D.Sc.
Researcher in the Group of Coordination and Bioinorganic Physicochemistry at the Faculty of Chemistry, Jagiellonian University.

Chemistry at the Jagiellonian University: for better batteries

Lithium-ion batteries over the last several years have become very common in all applications that require storage of electricity. With high energy storage capacity per weight and volume, the batteries are widely used for example in electronics, measurement equipment, satellite communications and cars with hybrid or electric drive.

The Faculty of Chemistry at the Jagiellonian University actively participates in new developments in this field. Joint forces of the **Technology of Materials and Nanomaterials Group** and the **Polymer Chemistry Group** delivered a technology of direct production of conductive carbon layers on powdered supports (oxides, silicates, phosphates, etc.) designed especially for the electrode layers in **lithium-ion batteries.**

The challenge

Conductive carbon layers used in production of electrode materials are usually obtained by pyrolysis of organic compounds or polymers; usually physical mixtures or organic solvents are used for this purpose. Layers obtained by those methods lack appropriate morphology of the surface and a sufficiently high electrical conductivity. Moreover, the carbon layers for lithium-ion batteries should have a small surface in contact with the electrolyte and should closely cohere to the electrochemically active material. The layers should not restrict the transport of lithium ions between the electrolyte and the active material during charge and discharge cycles.

Photo by Alessandro Paiva

The solution

Those problems have been solved with the **new method of carbon layer production developed by the university chemists.** Novelty of the materials lies both in the process of carbon precursor application, which is performed entirely in the aquatic environment, and the carbon precursor composition, which allows for obtaining a strictly adherent layer with a controlled porous structure. The carbon precursors themselves are nontoxic, which makes the technology safer than the currently used and more friendly to the environment. An appropriately selected composition of the carbon precursor can also produce a carbon layer of chosen physicochemical parameters, such as thickness, integrity or porosity. **The result is a material of significantly improved chemical stability and desirable electrical properties.**

The innovation developed at the Department of Chemistry has been presented and promoted by the Centre for Innovation, Technology Transfer and University Development (CITTRU) at numerous international trade fairs and exhibitions with some success. **The invention won a gold medal at the international exhibition of inventions „BRUSSELS INNOVA 2009"** in the category of electricity and electronics, and during the 38th International Exhibition of Inventions, New Techniques and Products „GENEVA 2010" it was awarded with a silver medal. Polish Minister of Science and Higher Education Prof. Barbara Kudrycka honoured the invention with the award for international achievement during the 17th Invention Fair in Warsaw.

Dr. Eng. Gabriela Konopka-Cupiał

innovation catalogue

Conductive carbon layers for composite electrode in lithium batteries

Offer 100

Research area: chemistry, new material science

Keywords: lithium-ion batteries, electrodes, conductive carbon layers

Summary: A method for direct production of conductive layers on the powdered support (oxides, silicates, phosphates, etc.) is offered, suitable especially for electrodes in lithium-ion batteries. Hydrophilic polymers with N-vinylformamide are used to produce carbon layers and films of a defined surface morphology. Experimental studies confirmed advantageous electrical properties of the layers and high thermal/chemical stability required for manufacturing of high-quality batteries.

Inventors: Department of Chemical Technology, Faculty of Chemistry

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A new instrument for qualitative analysis of aqueous solutions

Offer 093

Research area: inorganic chemistry

Keywords: teaching aids, qualitative inorganic analysis

Summary: A new instrument for chemical analysis of aqueous solutions is offered, which can be an affordable and cost-effective teaching aid for schools and academies. In comparison to other systems available on the market, the instrument's advantages are: minimal amount of reagents needed, simple construction, safe operation and easy visualization of performed experiments.

Inventors: Laboratory of NMR Spectroscopy, Faculty of Chemistry

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Thermosensitive polymer of natural origin with anti-adhesive properties for biomedical applications

Offer 095

Research area: new material science

Keywords: surface modification, anti-adhesive polymer, implants, medical devices

Summary: The subject of the offer is a new thermosensitive polymer with anti-adhesive properties based on modified hydroxypropyl cellulose, as well as the method of its production. The offered material can be used in a range of biomedical applications, including implant manufacturing, as well as production of semi-permeable membranes, contact lenses and microcapsules for controlled release of medicaments.

Inventors: Nanotechnology Polymers and Biomaterials group, Faculty of Chemistry

worth to know

New positron emission tomography (PET)

Offer 112

Research area: quantum physics, medical physics

Keywords: PET, organic scintillators, medical devices

Summary: The offer covers a new design of PET diagnostic systems and new methods of signal analysis required for tomographic image reconstruction. The new idea of PET construction is based on affordable organic scintillators, which have a significant impact on reducing unit production costs and increasing the diagnostic chamber, allowing for simultaneous observation of the whole patient.

Inventors: Department of Nuclear Physics, Faculty of Physics, Astronomy and Applied Computer Science

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Global system for testing, monitoring and forecasting of storm activity

Offer 091

Research area: weather forecasting

Keywords: storm activity, weather forecasts, ELF

Summary: The offered technology is a global system for testing, monitoring and forecasting of storm activity in real time based on propagation of electromagnetic signals of extremely low frequency (ELF, 3-3000 Hz). Information on storm activity is especially important for early warning of lightning hazard.

Inventors: Astronomical Observatory of the Jagiellonian University

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New stimulant of dendritic cell migration

Offer 117

Research area: pharmacology, immunology

Keywords: peptides, immunomodulation, dendritic cells

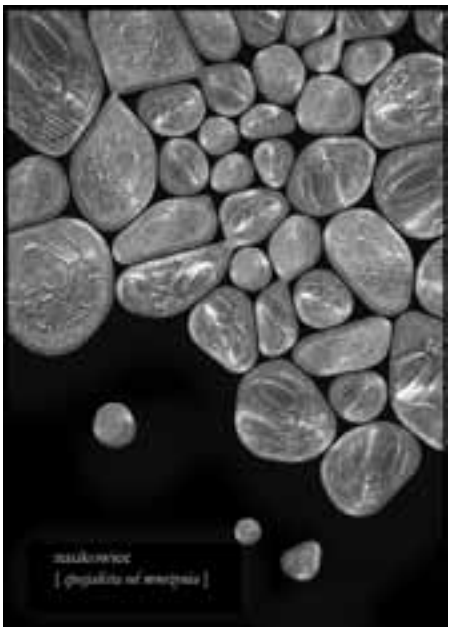
Summary: The subject of this offer is an application of a biogenic peptide to stimulate chemotaxis of dendritic cells, and thereby to modulate the immune response. The increase in migration capacity of these cells is of clinical relevance and may be useful in treatment of autoimmune diseases, viral infections and atherosclerosis, as well as during preparation of cancer vaccines *ex vivo*.

Inventors: Department of Pharmacology, Jagiellonian University Medical College

NOT ONLY PATENTS

Innovations from the other side

Traditionally understood mission of universities has always been the dissemination of knowledge in society, regardless of economic factors. For most European universities the major source of funds for university research has been the State, so publishing was considered to be the main way of sharing results of the research. Today, however, **universities are not only the temples of science, but also the birthplace of modern technologies, which** (whether we like it or not) **can be delivered to the customers only through collaboration with business.**



Tomasz Gancarczyk - The scientist [Multiplication expert]

Contract research - science, business, society

The easiest way of cooperation between science and practice are the **contract research** agreements. The university, in response to an inquiry from the business, undertakes to perform certain tests or other services to an external entity in exchange for remuneration agreed in the contract.

Outsourcing of research to a scientific unit gives a chance to develop innovative products for those companies that do not have their own R & D department or their research division lacks the equipment and expertise needed. University earns by sharing of knowledge and skills of its employees and authorising the results with the stamp of its reputation.

Contract research is also profitable to the society – it can facilitate development of new products and services based on scientific thought. Moreover, the contracts often require strict adherence to schedule and budget, which is an excellent course of project management.

Jagiellonian University academic regulations

Recently a new **procedure for contract research** was introduced at the Jagiellonian University in Krakow. Offers from the business clients are submitted to the Centre for Innovation, Technology Transfer and University Development (CITTRU). Researchers who decide to perform the assignment appoint a manager who is responsible for its proper implementation. Furthermore, conditions of the agreement are subject to approval by head of the research unit and the financial authorities of the Jagiellonian University. Each order is performed under a written contract to protect the interests of the university and the researchers. The agreement is prepared by the specialists from CITTRU.

The procedure applies to all employees of the Jagiellonian University (except for employees of Medical College). It refers to contract research and other research services, and therefore will be of particular importance for researchers.

Practice

While the Medical College for many years has been co-operating with companies (mostly pharmaceutical), for the other units of the University it is still something new, as is the patent protection issue. **Last year 21 contract research projects were completed at the Jagiellonian University; they were worth 175 000 euro in total.** Several agreements cover ongoing research work of a few next years. Research on demand is mostly done by academics of the Faculty of Chemistry, Faculty of Biology and Earth Sciences and Faculty of Biochemistry, Biophysics and Biotechnology, but also Faculty of Philosophy (Centre for Evaluation and Analysis of Public Policy).

The contract research agreements are often **related to very interesting, innovative topics** - one of them covers development of novel drugs for cancer treatment. In the case of another agreement concluded by the Jagiellonian University, contact with the practice resulted in an idea to open own company by the scientists. On the other hand, contract research conducted by the Centre for Evaluation and Analysis of Public Policy significantly involves students of sociology, for whom it is an opportunity to gain invaluable experience.

Krystian Gurba
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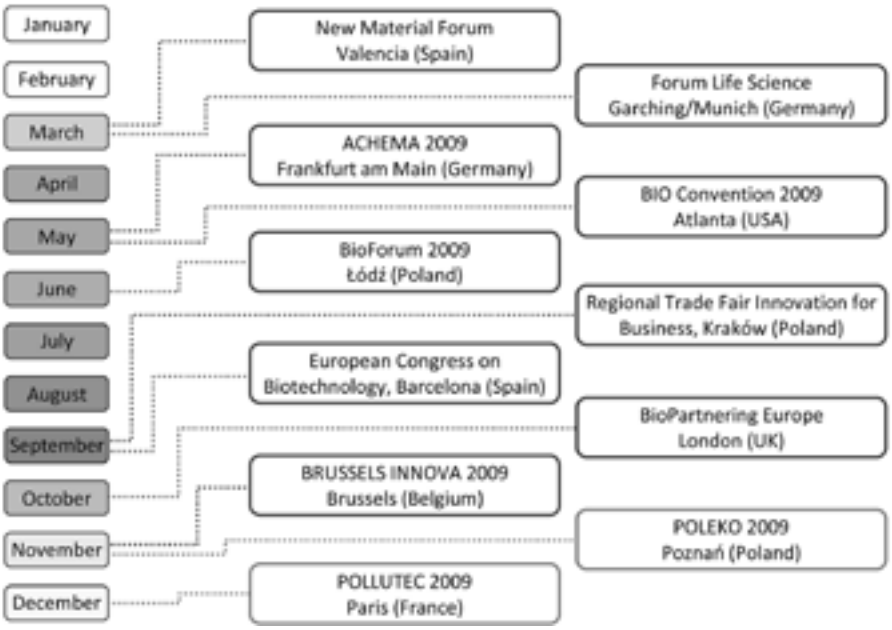
Trade fair calendar 2009

In 2009, representatives of the Jagiellonian University presented technology offers at 11 international events of various profile.

The events included both the congresses of science and technology and the trade fair events. Very valuable in terms of establishing contacts with the business are so-called partnering conferences, which give an excellent opportunity for bilateral meetings and discussions on specific technologies. In addition, the formula of many events is a combination of scientific conference and meetings with industry. Another category are innovation fairs, where new inventions and technologies are being presented and awarded. Participation in trade fairs is a new, but very promising activity of the Jagiellonian University.



Jagiellonian University's booth at the exhibition „Science for the Environment" during POLEKO International Trade Fair of Environmental Protection held in Poznań, Poland (November 24th - 27th 2009).

innovation catalogue

Fluorescent probe for collagen staining

Offer 089

Research area: biochemistry

Keywords: medical diagnostics, microscopy, fluorescent probe, collagen

Summary: The offer is a new fluorescent probe for collagen staining suitable for use in medical diagnostics and research. This marker allows selective observation of collagen *in vivo* in the intact tissue, which was not previously possible using existing methods for visualizing these proteins.

Inventors: Cell Biophysics Laboratory, Faculty of Biochemistry, Biophysics and Biotechnology

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Composite material for prolonged release of heparin

Offer 106

Research area: new material science

Keywords: drug delivery, heparin, implants, medical devices

Summary: The subject of the offer is a new material in gel form that allows for prolonged release of heparin. The material is a matrix of algin and hydroxypropyl cellulose, that contains immobilised heparin. Prolonged release of heparin is maintained for as long as two weeks and the rate of the process can be controlled both by the composition and temperature. The offered material have potential applications in medicine for controlled administration of heparin, as well as in tissue engineering.

Inventors: Nanotechnology Polymers and Biomaterials group, Faculty of Chemistry

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Polymer material based on chitosan for heparin removal and neutralisation in medical applications

Offer 110

Research area: new material science

Keywords: chitosan, heparin, protamine, medical devices

Summary: The subject of the offer is an application of modified chitosan, in water solutions or in the cross-linked form of microspheres, for removal of heparin from blood and body fluids. The offered method allows for heparin neutralisation in the patient's organism, but could also be used for constructions of devices for extracorporeal heparin removal.

Inventors: Nanotechnology Polymers and Biomaterials group, Faculty of Chemistry

Polski Produkt Przyszłości

Polish Product Of The Future 2010

Anti-cancer therapy from Jagiellonian University

On June 23rd 2010, a therapeutic technology created at the Jagiellonian University in Krakow was awarded the title of Polish Product of the Future (in category: technology in the pre-implementation phase). The novel antitumour therapy is based on a modified bacterial strain of *Salmonella* which gets into a tumour and destroys it from the inside. We present a brief description of this invention published in the "Catalogue of the Winners".

From the left: Dominik Czaplicki (CITTRU), Prof. Joanna Berata (research coordinator), Paulina Chorobik, Maciej Czarnik (CITTRU)

Authors

Michał Bereta, Ph.D.
Paulina Chorobik, M.Sc.
Joanna Bereta, Ph.D.

Introduction

The technology is related to a new method of treatment of solid tumours in humans and animals using a genetically modified strain of *Salmonella* that are able to penetrate the cancerous cells and induce their death by triggering apoptosis. Modified bacteria target the tumour tissue, then penetrate into the cancer cells, where they initiate the process of self-destruction that leads to activation of the immune system. To ensure safety of the therapy, pathogenic traits of the *Salmonella* strain have been heavily attenuated. The proposed anticancer therapy exerts a therapeutic effect by combining the direct action of bacteria on tumour cells and the mobilisation of anticancer response from the immune system.

Application:

The technology can provide a new therapeutic option for patients with solid tumours, primarily colorectal, lung, breast and stomach, and possibly other types of cancer (including melanoma). The solution is based on the genetic alterations of Salmonella strain that provide two important and therapeutically desirable features:

- the ability to colonise the tumour tissue due to preferential expression of anti-CEA antibody fragment on the surface of the bacterial cells,
- the possibility to induce apoptosis of the cancer cells through controlled expression of a proapoptotic protein.

The use of suitably modified bacteria is focused on utilisation of the mechanisms responsible for tumour penetration, followed by activation of the anticancer immune response within the tumour tissue. The resulting therapy will benefit from a combination of direct toxic effect of bacteria on the tumour cells with local and systemic immune response against those cells, which is an approach unique for this method.

Implementation status:

Efficacy of the prototype therapy, as confirmed in animal studies, combined with the anticipated low cost of production and application are key arguments for transferring this technology into clinical trials. This requires genetic optimisation of the bacterial strain, and therefore further *in vitro* studies confirmed with *in vivo* experiments. As a result, a therapeutic protocol will be developed which would become the basis of clinical research. Given an estimated productivity of minimum 1000 therapeutic doses per 1 liter of bacterial culture, the technology has excellent prospects for industrial use. In addition, it was covered by patent application „New strain of *Salmonella enterica* s. Typhimurium, its use and a method to obtain a therapeutic vaccine vector" filed by the Jagiellonian University on February 23rd 2009; the application was also extended internationally.

Comparison with the current state of the art:

Current strategies of cancer treatment are mostly based on radio- and chemotherapy, which are often ineffective and at the same cause serious and devastating adverse effects. The breakthrough promised by the advent of biological therapies has been limited only to some cancer types targeted with specific antibodies. Cancer vaccine strategies based on defined antigens have suffered several major setbacks and are still under development. *Salmonella*-based therapy combines the specificity of antibody targeting and natural invasiveness of the bacteria with proapoptotic and immunostimulating effects. The technology is modular, and therefore has great potential for development e.g. by changing the antibody fragment used to target the therapy.

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editorial board

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- Science, Innovation, Marketing, Business

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