ANSO
Alliance of International Science Organizations

SCIENCE AND TECHNOLOGY FOR HUMAN WELLBEING
OUTREACH

July 2022 No.7

ANSO Outreach is a new publication of ANSO promoting effective technology transfer from research to innovation, from demonstration to market. All the products presented in ANSO Outreach are focused on improving the quality of life and well-being of people all over the world by following the principle of practical, low-cost and user-friendly technologies. We also aim to further strengthen international cooperation on Science, Technology, Innovation and Capacity Building (STIC) by sharing advanced technologies and new products with ANSO members and partners.

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Introduction to SASA

斯洛文尼亚科学人文学院

The Slovenian Academy of Sciences and Arts (SASA), founded in 1938, is the supreme national institution of sciences and arts. It brings together scientists and artists, elected as members for their outstanding achievements in the field of sciences and arts. SASA cultivates, encourages and promotes sciences and arts through its activities, and contributes to the development of scientific thought and creativity in the arts, particularly by:

- addressing basic issues of sciences and arts;
- participating in establishing the policies of research activities and artistic creation;
- giving appraisals, proposals and opinions on the position, development and promotion of sciences and arts, and on the organization of research activities and artistic creation;
- organizing research work, also in cooperation with universities and other research institutions, particularly in the fields crucial for raising awareness of and gaining insight into the natural and cultural heritage of the Slovenian nation and for the development of its language and culture, and
- developing international cooperation in the field of sciences and arts.

Governing bodies of SASA are the Assembly, the Presidency and the President.

The President is assisted by the Vice-Presidents and the Secretary-General in executing her/his duties.

The Executive Board shall perform current tasks between the sessions of the Presidency.

Products Directory

1 | Targeted Phytopharmaceuticals Compounds for Better Protection of Agricultural Crops

Brief Introduction

We have discovered an entirely new approach to agricultural crop protection against microbial pathogens. Pathogenic microbes affecting fruit and vegetables such as potato, soybean, tomato, tobacco and grapevine, secrete a number of harmful molecules that allow the microbes to infect and spread along the plant. The new targeted compounds inhibit those secreted molecules, more specifically NLPs (Nep1-like proteins), which enable the spreading of microbes into the plant, thus preventing infestation of the plant. As the NLPs are secreted out of the microbial cell, the inhibition is extra-cellular. Therefore, this new targeted approach to control pests affects only specific effector proteins secreted by microbes onto the affected plants. This inhibition disables the microbes' ability to infect the plant host. The proposed mechanism presents a completely new branch of plant protection agents.

Technical Advantages

Two potent inhibitors of NLP proteins have been identified and their inhibitory potential has been tested on the biochemical level, as well as in vivo. The inhibitory effect of the new compounds was confirmed on the toxic activity of the infamous potato pest, oomycete Phytophthora infestans. The preliminary tests show no toxicity on human cells.

The main advantages of the technology are:

- Targeted crop protection.
- Broad spectrum of protection from microbes of diverse taxonomic groups.
- Preliminary results show no toxicity on Caco-2 cells.
- Easily scalable production of the protective compounds.

The picture is from unsplash.com

Certification and IP

Patent name:

Use of inhibitors of NLP proteins as phytopharmaceuticals for plant pathogen control (European patent no. 3315028, Article 1880139 (klipingmap.com))

Innovators:

Gregor Anderluh, Marjetka Podobnik, Tea Lenarčič, Vesna Hodnik, Stanislav Gobec, Boris Brus, Izidor Sosič, Thorsten Nürnberger, Isabell Albert, Hannah Böhm

Used for

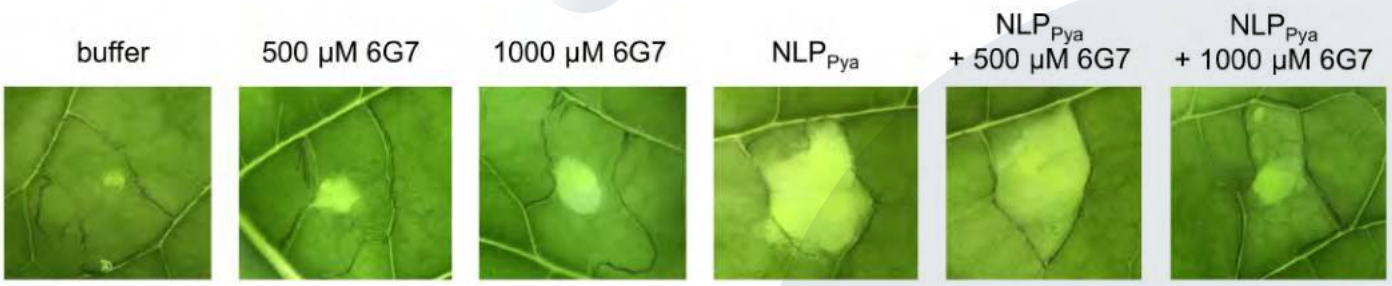
- Prevention of plant diseases caused by plant pathogens, which use NLP proteins in their toxicity mechanism.
- Development of new phytopharmaceutical products as inhibitors of NLPs.
- Control of plant pathogens, e.g. for controlling oomycetes of the genus *Phytophthora* causing potato or tomato blight.

Potential Market

- Sustainable crop protection technologies
- Crop protection products
- Sustainable agriculture
- Healthy food
- Agriculture
- Phytopharmaceuticals

Cooperation Models

- [x] R&D collaboration



Lead Scientist

Gregor Anderluh
PhD, Professor

Prof. Anderluh's research is devoted to understanding the action of membrane damaging proteins with possible applications in nanobiotechnology and synthetic biology. Prof. Anderluh is an associate member of the Slovenian Academy of Sciences and Arts and a member of Academia Europaea and EMBO.

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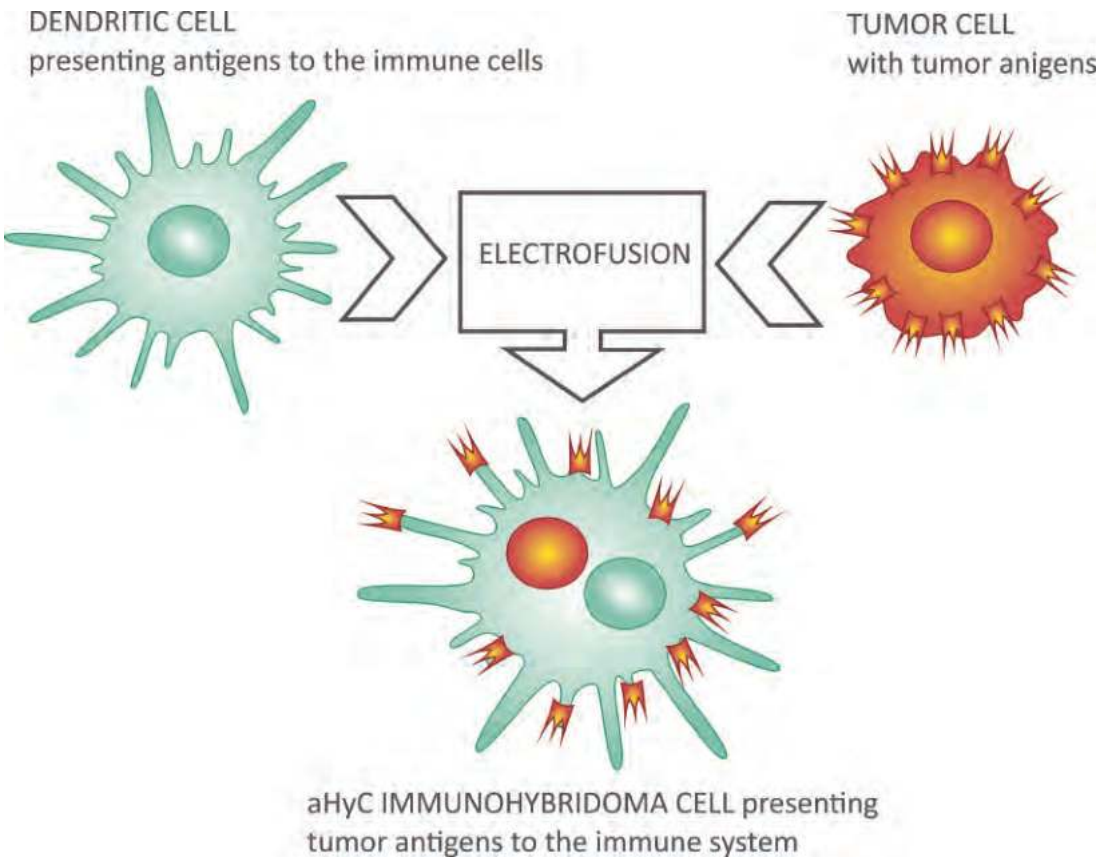
Brief Introduction

Researchers at the University Medical Center, University of Ljubljana-Faculty of Medicine, Celica Biomedical and the Blood Transfusion Center of the Republic of Slovenia have developed and clinically tested a new generation of autologous cell-based medicine for prostate cancer. The results showed that the survival of prostate cancer patients treated with autologous immunohybridomas (aHyC) prepared by fusion of dendritic and tumor cells correlated with a decrease in the subpopulation of natural killer cells in the peripheral blood, which has prognostic value.

Technical Advantages

Since 2009, new legislation in the field of biological medicines for advanced therapy medicinal products (ATMPs) has been in force in the EU, consisting of tissue-engineered products, gene therapies and cell-based therapies. The first cell-based medicine to treat castration-resistant prostate cancer was approved in the United States in 2010 (sipuleucel-T), but despite the relative success of treatment, patients experienced quite a few serious adverse events.

In order to reduce the latter, a fully autologous cell-based vaccine, consisting of dendritic, antigen presenting cells, and combined with the patient's own (autologous) cancer cells to form immunohybridoma (aHyC) cells by electro-fusion. In such a completely personalized way, the process of presenting all, even unknown, antigens of the cancer cell to the patient's immune system starts in the body, since the cancer has an individual development of mutations in each patient. The results, published in the prestigious journal Clinical and Translational Medicine, show that no serious side effects have been reported in patients and that the efficacy of aHyC immunohybridoma therapy, as measured by patient survival, is robustly correlated with a decrease in peripheral blood NK leukocyte subpopulation. This is of particular value for monitoring disease progression. In addition, it opens up the possibility that the new technology for the preparation of aHyC immunohybridomas by electrofusion (HybriCure) can also be used to treat other forms of solid tumors.



Schematic diagram of cell vaccine preparation with immunohybridomas aHyC.

Certification and IP

Technology is ready to be out-licensed. The treatment by aHyC is now available in Slovenia with certificated GMP production. The EU legislation in the field of ATMPs allows treatment under the so-called hospital exemption for medicines prepared on a non-routine basis (prepared for each patient individually) as there are only a few hours of shelf life before the immunohybridomas are administered into the patient intradermally. The lab preparing such a cell vaccine must be close to the hospital/clinic where it is administered.

Technical Parameters

Suspension of autologous cell-based vaccine to treat castration-resistant prostate cancer consists of patient's own dendritic cells, electrofused with the patient's own (autologous) cancer cells to form immunohybridoma (aHyC) cells, which patient receives intradermally.

Potential Market

The market is global, but production of aHyC should be close to a hospital.

Cooperation Models

In China and other countries a central laboratory of production of aHyC is proposed to be established (with licensed-out technology).

Robert Zorec
PhD, Professor

Robert Zorec is Professor of Pathophysiology at the University of Ljubljana, Medical Faculty, a Member of Academia Europaea (London), The Norwegian Academy of Science and Letters and the Slovenian Academy of Sciences and Arts (est. 1693 as Academia Operosorum), and has been a Member of the Committee for Advanced Therapies at the European Medicine's Agency (London), 2009-2013. Since 1991 he has been the Head of the Laboratory of Neuroendocrinology-Molecular Cell Physiology (LN-MCP) at the University of Ljubljana, and in 2000 established the Cell Engineering Lab (LCE) at Celica BIOMEDICAL (becoming CEO in 2006) and extended the activity of the Carl Zeiss Reference Center for Confocal Microscopy to operate in the Tech Park. He is heading the Core Research Program "Cell Physiology" at LN-MCP, Institute of Pathophysiology, University of Ljubljana, Medical Faculty and LCE, Celica Biomedical, Technology Park Ljubljana, Slovenia.

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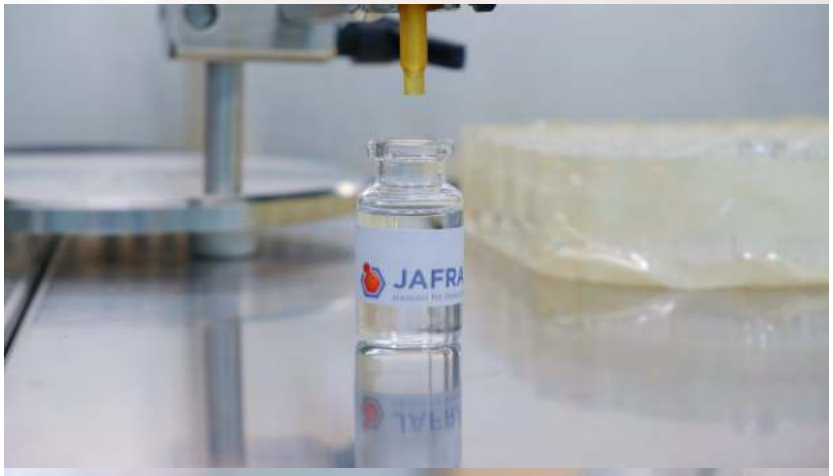
Lead Scientist

Brief Introduction

Gene therapy is entering into clinical testing of several diseases, predominantly cancer where immunomodulatory cytokines are especially interesting for treatment. Naked DNA plasmids are suitable for non-viral gene delivery to tissues, by electroporation as an effective and safe delivery method. The SmarGene.si platform is offering full development of plasmid DNA based vector/vaccine including construction of vector, manufacturing process development, analytical methods and assays development, pre-clinical testing, GMP manufacturing and clinical trial design according to EMA preference within European Union.

Technical Advantages

The construction of antibiotic free plasmids has safety advantages, as advised by European Medicinal Agency. Furthermore, the production of the naked plasmid DNA is cheaper than the viral based therapeutics. The delivery by electroporation is safe and effective, and can be employed for tumor or normal tissues delivery. And finally, the pre-clinical testing for the use in cancer treatment requires skilled staff in certified laboratories, which is all available with the Smart-Gene.si platform.



Technical Parameters

- Plasmid construction for single or multiple therapeutic genes.
- Pre-clinical testing on tumor cells in vitro.
- Toxicity, pharmacology and effectiveness testing on relevant tumor models in laboratory mice.
- Development of manufacturing process and accompanied analytical methods and assays.
- Design and technical equipment of modular manufacturing facility.
- Production of Clinical Trial Drug Substance and Drug Product.
- Design of clinical trial in EU.

Potential Market

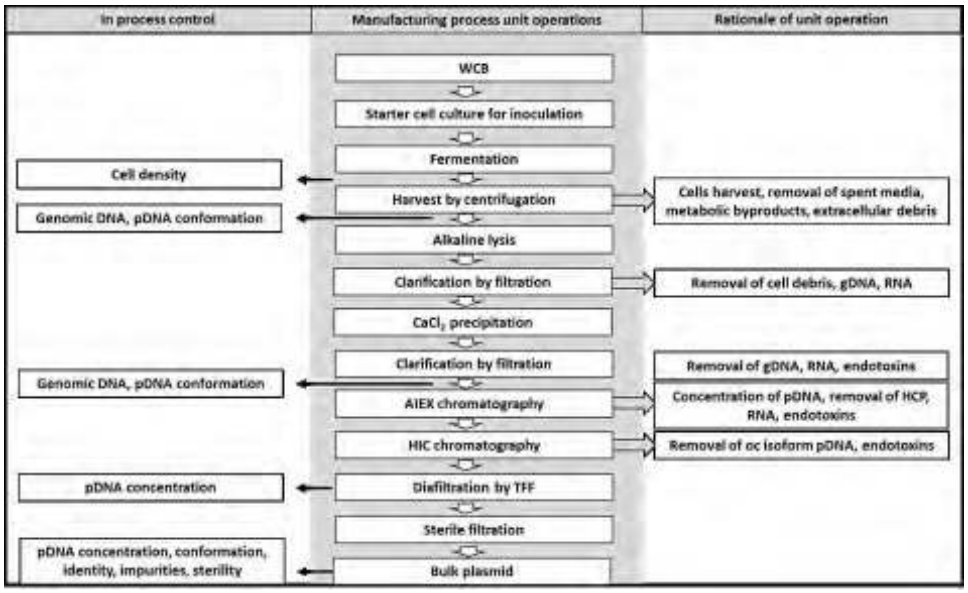
Biotech companies developing the anticancer therapeutics based on DNA therapeutics and companies developing DNA vaccines.

Certification and IP

GMP certificate for production of ATMP products.

Cooperation Models

- ☑ Product sales
- ☑ Technology development



Draft plasmid DNA manufacturing process

Gregor Serša
PhD, Professor

Prof. Gregor Serša Ph.D. together with Dr. Matjaž Peterka and Dr. Frenk Smrekar coordinated the consortium of partners in the SmartGene.si platform to develop all the listed activities. Prof. Serša is the head of the Department of Experimental Oncology at the Institute of Oncology Ljubljana, Dr. Peterka is the CEO of the COBIK, and Dr. Smrekar is CEO of the biotech company Jafral.

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Lead Scientist

Dr. Matjaž Peterka

Dr. Frenk Smrekar

4 | Cannabis in Combination with Ginger in Soap as a Supportive Therapy for Autoimmune Skin Diseases

Brief Introduction

Cannabis combined with ginger soap as a supportive therapy for autoimmune skin conditions is a natural, herbal product developed by LSPPD and "Love zeleno". It has multiple effects: Antibacterial, anti-inflammatory, anti-cancer, skin conditioning, etc. According to the test results of the National Laboratory of Health, Environment and Food (NLZOH), the antibacterial effect has been confirmed against three types of bacteria (*Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*).

Natural eco-hemp oil and the natural extract in soap provide the best care for sensitive skin. Since it does not contain essential oils, it can also be used for the protection of sensitive baby skin.

Technical Advantages

This product is a combination of natural extracts (ginger and hemp), vitamin E, hemp oil and a soap base. The natural ingredients are combined with a simple homogenisation process. The soap has an antibacterial effect, nourishes the skin, relieves itching and prevents secondary infections of in the cases of dermatitis and psoriasis. This product has the advantages of fast technology, quick mass production with low investment cost and large market potential.

Cannabis products of the "Love zeleno" company

Potential Market

Home, hotel, hospital, school, public garden, nursing home, travel.

Certification and IP

Certification by NLZOH for bacteriostatic activity, anticancer action; please see the manuscript below.

Patents:

- Natural product extraction, EP2166878, WO2009012852.
- Process for selective extraction and separation of organic materials by means of high pressure, CN101588852, WO2008061716.
- Process of obtaining natural antioxidants from plants, EP1144561, WO0049115.

Publication:

T. Žitek, M. Leitgeb, A. Golle, B. Dariš, Ž. Knez, M. Knez Hrnčič, The Influence of Hemp Extract in Combination with Ginger on the Metabolic Activity of Metastatic Cells and Microorganisms, Molecules. 25 (2020) 4992. https://-doi.org/10.3390/molecules25214992.

Cooperation Models

- [x] Product sales
- [x] Technology transfer

Technical Parameters

- **Ingredients:**

Hemp-ginger supercritical CO_2 extract, vitamin E, hemp oil, soap base.

- **Main efficacy:**

Bacteriostatic, skin care, relieves itching.

- **Used for:**

Prevents secondary infections in cases of skin diseases such as dermatitis and psoriasis to soothe the skin.

- **Caution:**

For external use only. Use according to the instructions. Avoid contact with the eyes, rinse immediately with water when contacted accidentally. Use with caution for people with allergies. Children must use this product under adult supervision.

- **Shelf life:**

24 months.

Soap with Cannabis and Ginger Extract

Brief Introduction

Cannabis Cream is an innovative cream for the care of normal to problematic facial and body skin. It contains only 100% natural hemp oil, hemp CO_2 extract, shea butter, vitamin E, chamomile macerate and beeswax. According to the test results (of the extract) of the National Laboratory of Health, Environment and Food (NLZOH), the antibacterial effect was confirmed on three types of bacteria (*Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*). The main ingredient of the cream is hemp extract produced by super-critical CO_2, which makes up 20% of the total mass of the cream. Scientific studies have also proven the anti-cancer effects of the extract.

Cream with Cannabis supercritical CO_2 extract

Technical Advantages

The extract is produced by a technologically developed process in which the first step is isolation of the powder of the crystals (cannabinoids) from a natural dried eco-material. The process itself contains a green handle, as all products are used for further products, so there is no waste. For the cream, the crystal powder of hemp was extracted by supercritical CO_2 extraction. The obtained extract contains 60% of the CBD component.

Cream with Cannabis supercritical CO_2 extract

Technical Parameters

- **Ingredients:**

Hemp powder extract, vitamin E, hemp oil, shea butter, chamomile macerate, beeswax.

- **Main efficacy:**

Bacteriostatic, skin care, relieves itching.

- **Used for:**

Skin care affected by dermatitis and psoriasis, soothing effect.

- **Caution:**

For external use only. Use only according to the instructions. Avoid contact with the eyes, rinse immediately with water when contacted accidentally. Use with caution in the case of allergies.

- **Shelf life:**

5 months.

Potential Market

Home, hotel, hospital, school, public garden, nursing home, travel.

Cooperation Models

- [x] Product sales
- [x] Technology transfer

Certification and IP

Certification by NLZOH

Patents:

- Natural product extraction, EP2166878, WO2009012852.
- Process for selective extraction and separation of organic materials by means of high pressure, CN101588852, WO2008061716.
- Process of obtaining natural antioxidants from plants, EP1144561, WO0049115.

Publication:

T. Žitek, B. Dariš, M. Finšgar, Ž. Knez, D. Bjelić, M. Knez Hrnčič, The Effect of Polyphenolics in Extracts from Natural Materials on Metabolic Activity of Metastatic Melanoma WM-266-4 Cells, Applied Sciences. 10 (2020) 3499. https://doi.org/10.3390/app10103499.

Željko Knez
PhD, Professor

Professor Željko Knez is one of the leading researchers in the field of Supercritical fluids. His contributions can be classified into three groups: Research on the production of particles and composites in supercritical fluids, enzymatic reactions in sub- and supercritical media, and separation processes with sub- and supercritical fluids. The first group includes publications dealing with a new process for production of particles with sizes of a few micrometres (PGSSTM process). In 1985, he founded the Laboratory for Separation Processes at the Faculty of Chemistry and Chemical Technology, University of Maribor, and was the first Slovenian researcher of supercritical fluids. Later, he helped establish research groups and industrial laboratories (TKI Pinus Rače, Vitiva Markovci). Since 1997 he has held many administrative posts at the University of Maribor, including Vice-Dean for Scientific Research, Vice-Rector, Acting Rector and Dean of the Faculty of Chemistry and Chemical Engineering. He has received several awards and recognitions for his research achievements: The Selingman APV Fellowship / Bursary in Food Engineering, 1997, UK, American Society for Fatty Chemistry Award (AOCS Prize), 1997, USA, Innovation Prize Messer Griesheim Prize, 1998, Zois Award, 1998 and the Zois Award for Outstanding Scientific Achievements 2006. He was elected as an Associate Member of SAZU in June 2017. The bibliography of the Head of the Laboratory is presented in the description of LSPPD.

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Lead Scientists

Maša Knez Marevci
Assoc. Professor

Associate Professor Maša Knez Marevci has numerous publications in Chemical Engineering. She has published 43 original scientific articles and 11 review articles in journals with high Impact Factors. She has co-authored 4 chapters in scientific monographs published by leading publishers of science information. Her publications have gained high scientific visibility, reflecting more than 1,284 citations, which have raised her H-index to 16. Maša Knez Marevci has carried out research on supercritical fluids, associated with national and European research projects. She has participated actively in the FP7 project Supermethanol project and MOSS (Supercritical Aqueous Reforming of Moist Sewage Sludge). She is currently leading two basic research projects, involved in a bilateral research project, and mentoring three PhD students. She has been a guest lecturer and a researcher at the Graz University of Technology and University of Alabama in Birmingham, USA. Her recent research interest is oriented towards investigation of the extraction of biologically active substances from biomaterials using sub- and supercritical fluids, isolation and/or fractionation of substances using supercritical fluid chromatographic techniques, and processing new formulations containing various formulations' active substances. Indeed, the developed world has shifted from studies of unit operations and energy optimisation concepts to new "product engineering" research. This is mainly well oriented to the interface among Biotechnology, Material Science and Chemical Engineering.

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The picture is from unsplash.com

Taja Žitek
PhD Student

Research Assistant Taja Žitek (MSc. Chem. Eng.) is currently completing her PhD studies. Her research interests include Process Design, the study of thermodynamic, transport data systems in the presence of supercritical fluids, statistical data processing, and the study of the extraction of biologically active compounds from biomaterials using sub- and supercritical fluids. Currently, her research focuses on the design of "green" processes for biomass processing, and further use of the optimal extraction procedure (supercritical and conventional methods). She also focuses on another biotechnological step: The exploration (analysis) of the extract, new types of extract formulation and their effects on the human body, particularly, on the metabolic activity of human melanoma cells.

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The picture is from unsplash.com

6 | CRISPR/Cas Tethered with Exonuclease for Enhanced Genome Editing

Brief Introduction

The CRISPR/Cas system is widely applicable in human germline editing, engineering advanced therapeutics, plant genome editing, and other fields of biotechnology such as industrial biotech. One of the key uses of CRISPR is gene inactivation, where it is desired to have high efficiency.

To improve the efficiency of gene inactivation we developed a strategy to couple function of Cas9 to the exonuclease activity to promote deletions at the specific target genomic site that prevents the repair of non-modified DNA. The exonuclease cleaves off nucleotides one at a time from 3' or 5' ends of the polynucleotide chain truncating the chain (DNA or RNA).

This strategy enables promising results in specific applications such as targeting primary cells for therapy (e.g. cancer therapy but also for some other genetic disorders).

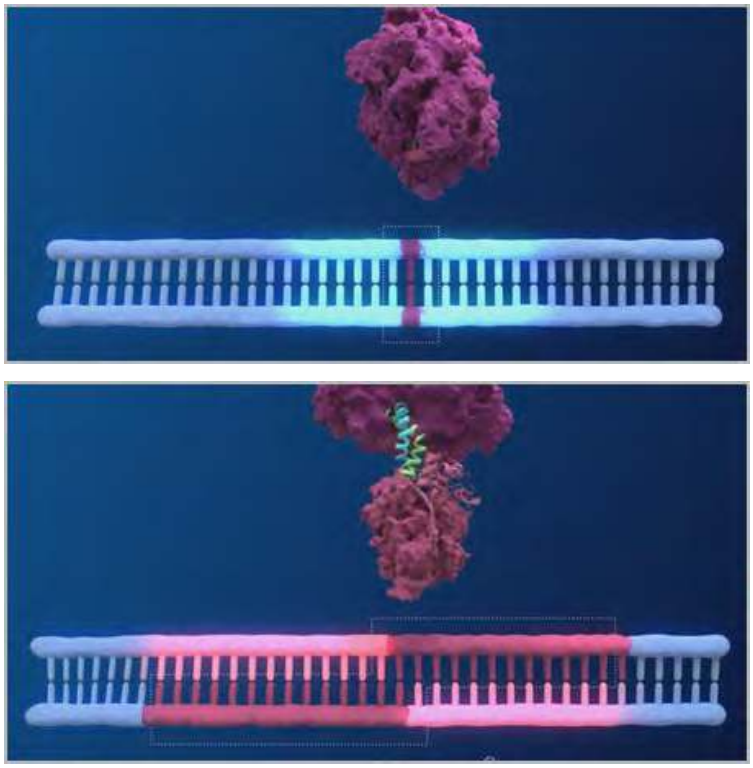
Technical Advantages

- 70% vs. 25% increased efficiency of gene inactivation (depending on gene of interest) and improved DNA recession
- Modular tethering of exonucleases with Cas9 and its variants via coiled-coils (tested with 4 combinations of coiled-coils)
- Functional with different Cas nucleases (demonstrated with Cas9 and Cas12)
- No additional increase in off-target effects, no cytotoxicity
- The possibility of delivery as nucleic acids or as RNPs

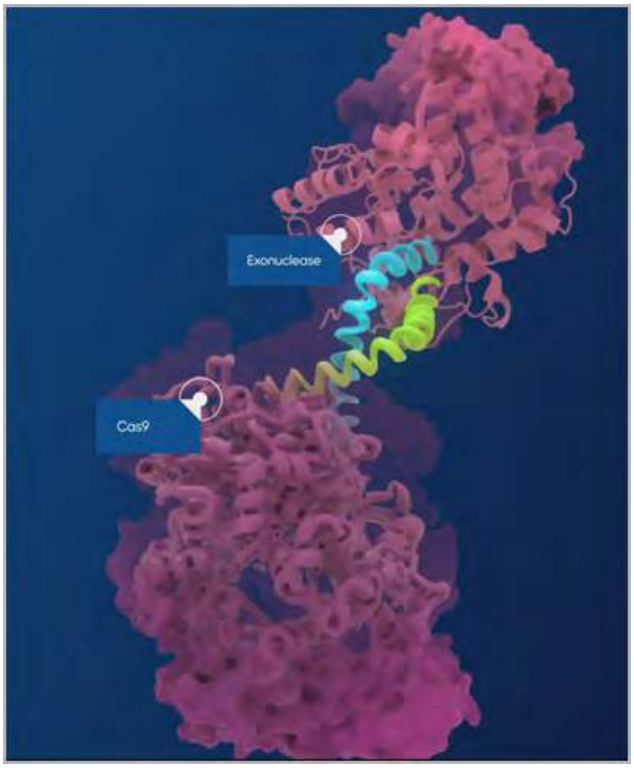
Technical Parameters

Type of delivery:

DNA, RNA, ribonucleotide complex, delivered via electroporation, LNP or viral delivery



CRISPR/Cas (left) compared to CRISPR/Cas-CC-exonuclease (right). Large deletions at the cancer-specific target genomic site increases the efficiency of gene inactivation.



Coiled-coil mediated tethering of CRISPR/Cas and an exonuclease.

Certification and IP

Initially applied for the EP patent (priority date 20.08.2019) and continued with the PCT phase.

International Application No. PCT/EP2020/073143

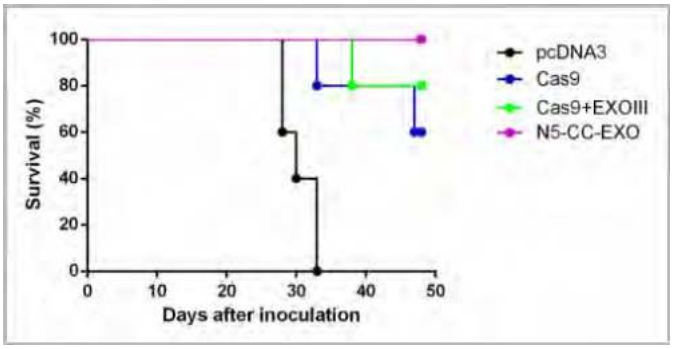
Cooperation Models

We have established cooperation with the Ljubljana University Medical Centre, Department of Hematology to perform advanced preclinical research on human cells. We look for cooperation in the following:

- ☑ Technology transfer
- ☑ R&D collaboration in the field of therapeutics
- ☑ IP protection and co-ownership (APAC region)

Potential Market

- Therapeutics in vivo and ex vivo gene inactivation (e.g. to prevent T cell exhaustion, and demonstrated as a potential CML therapy)
- Plant Genome Editing (improved efficiency in plants)
- Gene editing tools (new cell and animal models)
- Industrial Biotech



In vivo demonstration for anticancer therapy, targeting BCR-ABL translocation in a mouse model. The result was improved survival rate and reduction in tumor size.

Lead Scientist

Roman Jerala
PhD, Professor

Roman Jerala is head of the Department of Synthetic Biology and Immunology at the National Institute of Chemistry in Ljubljana. He is member of the Slovenian Academy of Sciences and Arts, EMBO member, member of Academia Europaea, recipient of the ERC advanced grant. His research areas include synthetic biology, biological engineering, bionanomaterials, genetic editing and the molecular mechanism of natural immunity. He is one of the leading synthetic biologists in Europe and the world.

Research Gate:
https://www.researchgate.net/profile/Roman-Jerala

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Brief Introduction

The new generation sound insulation exceeds everything that currently exists on the market by at least 3 to 10 times. Its functionality is based on a completely new physical principle the so called “force-networks technology”. The technological breakthrough is based on the scientific realization that the formation of a “force-network”-a set of pairs of forces (3NL) is the most effective dissipative mechanism that exists in nature. The invention relates to the process of forming the optimal size of a network of forces created by complex interactions of solid particles in a granular system.

Technical Advantages

The new insulation is at least 3 to 10 times better than any other currently existing sound insulation. Insulation can be made of any (waste) granular material, including metals. In this case, we get a unique sound insulation that is thermally and electrically conductive. The new insulation is applicable in all forms of transportation, industrial systems and construction. Thus, the new generation sound insulation is environmentally friendly and simulatneously solves two major environmental problems: noise pollution, and pollution with waste materials.

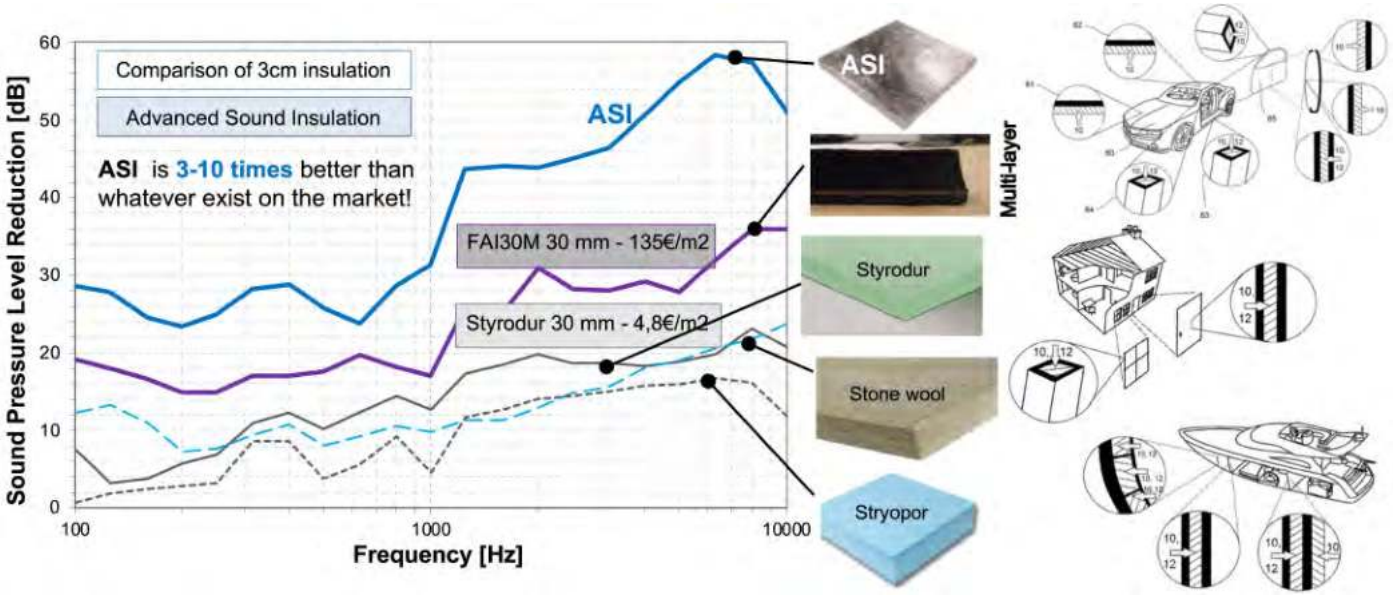
Video 1: https://www.youtube.com/watch?v=oku-1x6YnxA

Video 2: https://www.youtube.com/watch?v=-6bZ9F03hc0

Technical Parameters

Insulation can be made of any size and form, and manufactured from any (waste) granular material, including metals or their mixtues.

“100 Best Innovation Technology for International Transaction” prize at the 2021 ZGC Forum



Comparison with existing insulations

Certification and IP

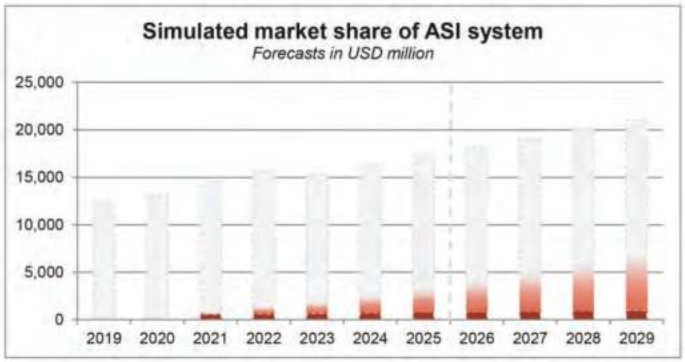
- I. EMRI, B. von BERNSTORFF, P. OBLAK, and A. NIKONOV. Sound insulating element: European patent application EP 3 570 274 A1, 2019-11-20.
- I. EMRI, B. von BERNSTORFF, P. OBLAK, A, NIKONOV. Sound Insulation Element; World Intellectual Property Organization, code: WO 2019/219474 A1, 21.11.2019.
- I. EMRI, B. von BERNSTORFF, P. OBLAK, and A, NIKONOV. Sound Insulation Element; CN Intellectual Property Organization, code: CN 112119452 A, 2020, 12. 22.
- I. EMRI, B. von BERNSTORFF, P. OBLAK, and A, NIKONOV. Sound Insulation Element; US Intellectual Property Organization, code: US 20210217397A1, July 15, 2021.

Cooperation Models

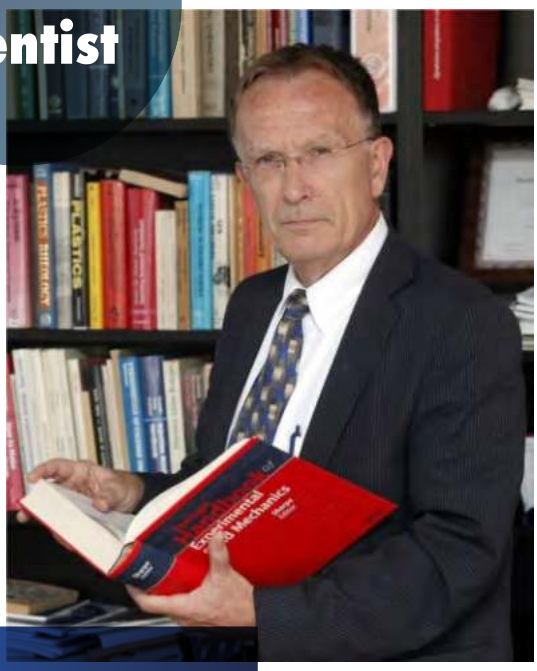
- ☑ Product sales
- ☑ Technology transfer

Potential Market

The new insulation can replace any existing insulation in all areas of application. Its market potential in construction has been evaluated by an independent Intellectual property office in Germany-VALNES (https://valnes.de/en/home.html):



Lead Scientist



Igor Emri
Dr. Sc., Professor, NAE Intl.

Dr. Emri is one of the world leaders in mechanics of time-dependent materials. His research-based invention, the high-pressure force-networks technology, resulted in several technological breakthroughs, e.g., sound and impact insulation, orthopedic and dental implants, new generation nano-structured membranes for industrial and medical applications. He is a member of several academies, among them Russian Academy of Engineering, Russian Academy of Natural Sciences, European Academy of Sciences and Arts, European Academy of Sciences, and National Academy of Engineering (NAE) of the United States of America.

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Introduction to

Organizations
Contributed to this Issue

The National Institute of Chemistry, Slovenian Academy of Sciences

The National Institute of Chemistry (NIC) is a scientifically excellent, established and a breakthrough research institution in the European area. With our cutting-edge research, we are enriching the global treasury of knowledge and working together to solve the most pressing challenges faced by society. Health, sustainable energy, climate change, a circular economy and safe food are the most important among them.

The Institute has 374 employees. Of these, 269 are researchers in 8 research departments and 2 infrastructure centers. Basic and applied researches are oriented towards fields, which are of long-term importance to global challenges:

- Health, environmental protection, circular economy, sustainable energy, low carbon technology, climate change

and analytics;

• Biotechnology, environmental protection, structural and theoretical chemistry, analytical chemistry, materials research, and chemical engineering, through which the Institute is in line with the needs of the domestic and international mainly chemical and pharmaceutical industry.

NIC has a history of successful collaborations with industrial partners in form of R&D collaborations as well as in the form of consulting. Such collaborations lead to an improved efficiency and benefit for companies, e.g. implementation of new technologies and knowledge for optimizing work processes, establishing new or improving existing products. The main goal of NIC is building long-term strategic alliances with industrial partners, through which we co-develop new technologies. The company's own R&D capacities are therefore enriched with the creativity and comprehensive knowledge of our researchers. At the same time, the company has an opportunity to use top-notch infrastructure, which is essential for new breakthroughs.

The Institute's work is consistent with the priorities of the EU Framework Programme for Research and Innovation, which places the Global challenges and European industrial competitiveness at the top of the strategic planning process. At the forefront are the development of new technologies and advanced materials to facilitate the transition of the society towards the sustainable, low-carbon and sustainable circular economy.

FKKT UM and LSPPD

1. Faculty of Chemistry and Chemical Engineering, University of Maribor (FKKT UM)

The Technical College in Maribor was established in 1959 by the Act on the Technical College Maribor, which was adopted by the People's Assembly of the People's Republic of Slovenia at a session of the National Assembly. After several years of scientific research and development work the Technical College was developed into the Faculty of Engineering of the University of Maribor, which also provided training for Masters and Doctors of Technical Sciences. In 1996, the Faculty of Engineering was divided into the Faculty of Electrical Engineering, Computer Science and Informatics, the Faculty of Civil Engineering, the Faculty of Chemistry and Chemical Technology and the Faculty of Mechanical Engineering.

2. Laboratory of Separation Processes and Product Design (LSPPD)

The LSPPD Laboratory was established in 1985. The main activity of the lab is the development of processes from the lab to the industrial scale. Since the formation of the lab one of its key activities has been the development of separation and formulation techniques using sub- and supercritical fluids.

The Head of the Laboratory is Prof. Dr. Željko Knez; he is a member of the Slovenian Academy of Sciences and Arts, a member of the European Academy of Sciences and Arts and the Croatian Academy of Engineering. He was also in the top 1% of highly cited researchers in 2017 (https://clarivate.com/hcr/). The bibliography of the Head of the Laboratory is extensive, with 312 original and 30 review scientific articles, 30 book chapters, more than 25 patents and patent applications (EP, USA, Canada, Japan, Slovenia, etc.), more than 8,875 pure citations from the Scopus collection, altogether more than 9,900 citations, and the H-index is 52.

Plant Materials as a Source of Bioactive Compounds

Extracts from plants, or even animal organs, are used more and more for pharmaceutical and medicinal purposes. In addition to the isolated bioactive substances used directly as therapeutics, they are also raw materials for synthesis–the chemical production of new biologically active substances.

Many clinically approved anticancer drugs contain ingredients of natural origin, i.e. extracts-extracts that are properly purified naturally from other substances present in the plant, their derivatives or isolated compounds that are the starting material for further synthesis of more complex molecules. Some well-known anticancer drugs contain ingredients such as the alkaloid cantarantus from the plant *Katarantus ampelous* (lat.), etoposide from *Podophyllum peltatum* (lat.), the alkaloids vincristine and vinblastine from pink evergreen and taxol from the bark of the pacific yew (*Taxus brevifolia* (lat.)).

Plant secondary metabolites, such as polyphenolic compounds, alkaloids and terpenes, are known to have various pharmacological properties, including cytotoxic and chemopreventive effects on cancer cells. The latter may occur at different stages of malignant tumour development and involve various mechanisms, such as protection of the cells' genetic material (DNA) from oxidative damage. Numerous clinical studies have demonstrated the antiproliferative effect (the effect of a drug that prevents the proliferation of cancer cells) of natural extracts on various cancer cell lines.

The research has been, or is being done, "in vitro", that is, in the laboratory. In addition, some studies have shown that various dietary factors affect cancer rates and even prevent malignancy. Some fruits, vegetables and herbs contain large amounts of nutrients and non-nutrients of plant compounds that are effective antioxidants. It is known that plant extracts have been used on various cells to study their antiproliferative activity.

In collaboration with the Faculty of Chemistry and Chemical Technology and the Faculty of Medicine at the University of Maribor, the National Laboratory of Health, Environment and Nutrition and the Maribor University Medical Centre, we are investigating how plant extracts can inhibit the growth of cancer cells or cause their decay. Within these studies, we have also focused on cannabinoids.

The research is funded by the Slovenian Research Agency and different international projects.

Part of the research is commercialised by the "spin off" company "Love zeleno" which was established by the postgraduate student Taja Žitek MSc. Chem. Eng.

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